Understanding Why We Preserve Some Things and Discard Others in the Context of Interaction Design

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ABSTRACT
This paper takes up the problem of understanding why we preserve some things passionately and discard others without thought. We briefly report on the theoretical literature relating to this question, both in terms of existing literature in HCI, as well as in terms of related literatures that can advance the understanding for the HCI community. We use this reading to refine our frameworks for understanding durability in digital artifice as an issue of sustainable interaction design in HCI. Next, we report in detail on our ongoing work in collecting personal inventories of digital artifice in the home context. We relate our prior and most current personal inventories collections to the framework that owes to our reading of the theoretical literature. Finally, we summarize the theoretical implications and findings of our personal inventories work in terms of implications for the design of digital artifice in a manner that is more durable.

Author Keywords
Sustainability, Sustainable Interaction Design, Personal Inventories, Design Theory.

ACM Classification Keywords
H5.m. [Information interfaces and presentation (e.g., HCI)]: Miscellaneous. J.7. [Computers in other systems]: Consumer products. K.1. [The Computer Industry]: Markets. K.4.m. [Computers and society]: Miscellaneous.

INTRODUCTION
Why do we preserve some things passionately and discard others without thought? In this paper, and in our ongoing research, we are trying to understand this question particularly for the context of interactive technologies and their connection to sustainable practices. First, we briefly develop a theoretical perspective and framework for understanding this problem. Next, we report in detail and apply our framework to interpreting objects we uncovered in fieldwork that involved an ongoing method of collecting personal inventories of digital and non-digital artifice in

peoples' homes. Finally, we postulate some general takeaway design principles for which our field research provides some evidence and which we intend as inspiration for future discourse. This paper builds on an approach by Blevis & Stolterman [3].

THEORETICAL FRAMEWORK
When addressing the question of how people relate to objects in their everyday environments, it is possible to build on several theoretical foundations. Most of the work has been done within psychological research, with the book "The Meaning of Things" [9] as a seminal work. Another strand of research comes from philosophy of technology, with influential thinkers such as Latour, Borgmann, Mitcham, and Illich. All these authors do provide insights into how people relate to objects, but they do not come from, nor present, a design perspective. We have therefore chosen Verbeek [31] as our inspiration and theoretical source. The work of Verbeek relates closely to all of the above mentioned thinkers and his work can be seen as a modern and more design-oriented approach that incorporates many of the philosophical assumptions about the relation between people and objects that is developed especially by Borgmann, Latour, and Csikszentmihalyi. What we find especially useful in Verbeek is his perspective of objects as *designed* and his combination of philosophy of technology with design thinking.

As a design theorist, Peter-Paul Verbeek has greatly influenced thinking about products in general in terms of what makes some things enduring, while other things are easily disposed. In [31], Verbeek distinguishes three design perspectives that affect durability. Our framework is based on taking these three perspectives as factors for our analysis of our field research. In our naming—a renaming for simplicity, we have

1. **Function**—what an object does. In Verbeek's terms, the *functionalist perspective* refers to the traditional industrial design notion that a *"product must first of all be functional; it must do what it is designed and manufactured to do."* [31]:204.

2. **Symbolism**—what an object means. In Verbeek's terms, the *semiotic perspective* refers to another traditional industrial design notion that *"[a product] has meaning or sign-value: human-beings are drawn to particular product styles and not to others, and use a

product to express the lifestyle to which they (want to) belong." [31]:204.

3. **Material Qualities**—what an object is made of and its broader sensual appeal. In Verbeek's terms, the *material aesthetic perspective* refers to both materials as mediators of the relationship between people and things, and to *"the sensorial in the broadest sense"* [31]:211. In Verbeek's treatment, the material aesthetic perspective stands in contrast to traditional industrial design notions and is part of a more modern philosophical perspective of technology, an *"approach which aims to make a contribution to the ongoing discussion of environmentally sound industrial design, and thus to demonstrate the practical value of the postphenomological perspective"* [31]:204.

This framework of function, symbolism, and material qualities is intended as sound rather than complete. We could as well have included notions like form, color, meaning, mediation, affordance, affect, and other notions to describe objects and it would be possible to argue that many aspects of these other notions are captured in the notions of function, symbolism, and material qualities.

Verbeek emphasizes material qualities over symbolism and function as explanation and prediction of *durable relationships between people and things*. This point is central to understanding Verbeek's writing. In contrast to traditional industrial design's emphasis on function and symbolism, the material aesthetics approach emphasizes the importance of designing to direct attention towards the material object itself, rather than what it provides in terms of its utility, or what it refers to in terms of meaning. Verbeek writes: *"The bond that arises between people and products will have to concern the concrete object that is present in the here and now, and not only the meaning or symbols it carries or the functions it fulfills. If someone's attachment to an object is only based on the way it expresses his or her lifestyle, then the object is vulnerable to being replaced by any other one with the same sign characteristics. The same holds true if the attraction is based only on the functionality of products… "* [31]:225.

We consider all three factors—function, symbolism, and material qualities—with respect to interpreting our observation work and conclude that Verbeek's emphasis on material qualities is sound, in part because it is so deeply implicated in the way in which our relationships with things are mediated by means of the choices of material qualities in design.

Verbeek's emphasis on material qualities targets and scaffolds a perspective of sustainability. We have elsewhere reported on our empathy with Verbeek's philosophical reasoning, because we see it as a philosophical argumentation that makes the case for studies of people's attitudes towards particular things [3]:6. We have also argued for the benefits of constructing personal inventories of things and attitudes for particular people, since such inventories can tell us about the mediation between people and the world, and that we in that can find some of the answer to the question of how to act more sustainably [3]:6.

Other Sources and Considerations

Our purpose in writing this paper is primarily to interpret our field research with respect to notions of sustainability for interactive technologies. Nonetheless, there are many other sources that inform our thinking about this issue and which we articulate in this section of the paper.

Sustainability in HCI and Related Literatures

There is a growing HCI literature implicating interaction design and interactive digital artifice with sustainability. Blevis [2] introduces the notion of Sustainable Interaction Design (SID) and lists and describes some of the prior related and motivating literature. The 2008 CHI conference presented three papers on the topic, namely Hanks et al. [14], Huang & Truong [17], and Woodruff et al. [35]. As well, several special interest groups and panels have occurred at the 2007 and 2008 conference, Mankoff et al. [20], and Nathan et al. [22]. In addition to the CHI venue, recent ubicomp and pervasive workshops continue to explore the role pervasive technology might play in facilitating more sustainable ways of being, for example Foth et al. [11], Hasbrouck, et al. [15]. and Paulos et al. [27].

Apropos of design-oriented HCI or the adoption of design literature within HCI, we especially rely on Verbeek's notions as described above [30, 31], as well as Nelson & Stolterman's notion of ensoulment [23], Blevis' notion of achieving heirloom status [2], and to T. Cooper [7, 8] and Walker's [34] notions of current approaches to product durability.

The challenge of designing artifacts that are pleasurable, meaningful, and engaging has been and remains a significant focus. Business press examples include Durgee [10]. Issues of fun, attachment, and affect that may promote durability are exemplified by Blythe et al. [4], Norman [24], Chapman [6], and others. Scholarly writing outside of HCI, but worthy of mention *apropos* of durability and affect includes Jordan [19], van Hinte [29], Walker [34], and Woolley [36]. The symbolic or affective meaning of everyday objects has been a theme of Norman [24] within HCI from a cognitive science perspective, and Csíkszentmihályi & Rochberg-Halton (C&R) [9] more generally from a social sciences perspective. Petrelli et al. [28] in particular, have interpreted C&R in the context of HCI. We have elsewhere reflected on C&R's foundational role in these methods and wanted to use a different but not unrelated frame for this paper, which concerns mundane everyday objects that vary in strength of attachment [26]. C&R's studies from the 1970's are relevant to the issue of understanding durability and attachment—what has changed is the need for emphasis on understanding behaviors in relation to sustainable ways of being, a pressing need in the face of global climate change and one that varies with the transformations that have accrued from the widespread consumption and disposal of digital

products. Thus, new data about present behaviors are needed.

Sustainability and Life Cycle Analysis

Life cycle analysis (LCA) emerged first in the 1990s [1] and became increasingly popular as a tool to estimate the environmental impact of products, partially to substantiate claims related to "eco-product" branding [8]. LCA is described as "*a method to account for and evaluate the environmental impacts of products, from the extraction of the raw materials through manufacturing, distribution, use to disposal*" [16]:2. Essentially, LCA resulted in an increasing trend among designers to include less environmentally damaging materials in the products they design. Similarly, McDonough & Braungart's "*cradle to cradle*" framework [21] advocates a zero waste system in which products are designed with their full life cycle in mind, intending to ensure all resources are re-usable, as does Lovins and others [33]. Collectively, these approaches mark a critically important movement toward consciously incorporating design choices to reduce the ecological footprint of new products. Verbeek & Kockelkon [32] have criticized the LCA approach by suggesting it focuses on addressing the symptoms of unsustainable practices, rather than the deeper issues enabling these behaviors: "*Life Cycle Analysis may make it possible to design products that are friendlier to the environment, but leaves a fundamental problem unaddressed: the short lifetime of our products. We live in a throwaway culture ... The environmental crisis is not only a technological problem, but a cultural problem as well.*" [32]:28. Woolley [36] has echoed such criticisms, as has Walker [34], Fry [12] and Cooper [8, 9].

THE THEORETICAL FRAMEWORK APPLIED TO PERSONAL INVENTORIES DATA

In order to better understand why we preserve some things passionately and discard others without thought, we developed a method we call *personal inventories* collection [3]. Specifically, we went to participants' homes and asked a number of questions about their likes, loves, and dislikes with respect to things they own, especially things constructed with the materials of digital technologies (IRB #07-12036). A sample of the questions we asked (where appropriate) includes: *What things do you have that you love? What things do you have that you thought you would love but don't? What things do you have that you didn't expect to love but do? What things do you have more than one of? What are the oldest things you have? That you still use? That you no longer use but would not discard? What are the newest things you have? What do you acquire most frequently?*

These questions were intended more as prompts than as a rigid set of questions. Although very similar to the central questions asked in C&R's study, the goal of our questions was not to objectively identify the most "special" objects in the home, but rather to initiate conversation about various objects in the home to better understand varying degrees of strength of attachment with them. C&R were explicitly interested in symbolic function (p.254), and we interpret Verbeek as an expansion of this frame.

We conducted personal inventories in 32 separate homes with 38 participants, of which 22 were women and 16 were men. We recruited participants from two regionally co-located US cities, which offered populations representing major consumer demographics with respect to interactive technology. Although our participants ranged in age, all were adults and exhibited a range of occupations (e.g. teacher, artist, system administrator, musician). Our inventory sessions typically lasted between 2 to 4 hours and consisted of conducting in-home contextual interviews to probe participants' reflections on the range of relationships they have with objects in their home, and to investigate the underlying reasons and motivations behind these orientations.

Our study produced rich data consisting of handwritten field notes, sketches, audio recordings, and several hundreds of photographs. We also listened to recordings and transcribed relevant segments. We then organized these relevant portions into themes and coded the collective textual and visual documents using these emergent themes. Figure 1 provides a space-limited, representative sample of the raw personal inventories data.

Limitations of the Data

The research protocol we use here was first used by authors Blevis and Stolterman in a paper presented at the 2007 Design Research Society Conference [3], involving only 5 participants. Based on the success of the approach, author Odom collected inventories from an additional 8 households to serve as the basis for his entry into the 2008 CHI student research competition [25]. Odom used only those inventories he himself collected for the competition. Author Odom worked with Blevis and Stolterman to report on the motivations for the protocol itself in an article for ACM interactions [26]. For this paper, authors Odom and Pierce have independently collected 19 additional inventories, and it is the collected pool of 32 inventories by all authors about which we now report, all of which were collected under the initial IU IRB Study #07-12036 filed by Blevis and Stolterman. About our data, we should say that it is not the work of ethnographers, but rather of designers attempting to be more rigorous than designers typically are in observation work targeted at informing design theory. We ourselves believe that this data can serve to create insights to help frame further research and theoretical insights, but—owing to these different contexts of collection—that it has not been collected in a rigorous or consistent enough way to qualify as conclusive evidence about general practices as opposed to its acceptable value as evidence of specific instances of particular relationships between particular people and things. We are perhaps being overly cautious in our explanation here, since there are a lot of good examples uncovered in our use of the protocol, but our data should not be taken as general evidence. That is, Verbeek's frame is a lens and our data provides existence

	P7	P23	P9	P3	P15	P13	P26
What things do you have that you love?	diamond earrings, alto saxophone, pewter squirrel nutcracker, kitchen hand utensils	iPhone, Mp3 music collection, firearm collection (3 pistols, 2 rifles, 1 shotgun), photographs	antique clock, ceramic clown faces, lawyer bookcase, film camera	typewriter (Corona), book collection, chest, VHS movie collection, photographs, digital music files (MP3s)	home-made computer, custom desktop computer (Windows), custom server computer (Windows), video game system collection	digital photographs, iPhone	Turkish eye medallion, wooden statue of Germanic man
What things do you have that you thought you would love but don't?	5 disc CD player (Sony), widescreen television (Sony)	laptop (HP), mac mini, 5.1 surround sound system, garlic press	widescreen HD television (Samsung), dining room suite	cell phone (Nokia), television (Sony), digital camera (Sony), digital camera (Canon)	electronic massage chair, Sony Playstation 2 controller	laptop (Dell), digital camera (Casio)	stereo speakers (Sony), MP3 player (Dell)
What things do you have that you didn't expect to love, but do?	several hand mixers	iPhone, Nintendo Wii	vhs/dvd player (Sony)	jewelry box, portable DVD player,	cell phone (Samsung)	electric tea kettle, Nintendo 64	television (JVC), antique stereo system, wooden desk

Figure 1. Sample of the personal inventories data.

evidence of particular people and object relationships that align with this lens, but not general evidence to support Verbeek's frame.

Interpreting Strength of Attachment
In what follows, we report on our personal inventories data by describing specific examples of things we uncovered in the personal inventories research. For each example, we describe the **strength of attachment** of the owner to the object—how much the owner cares about the durability of the particular object or how easily the owner would readily discard the particular object. Also for each example, we describe **function, symbolism,** and **material qualities** according to the theoretical framework based on Verbeek. We discuss each object in relation to each of the three aspects of our framework independently for analytic purposes. However, our interpretations of our findings do suggest that it is often the mutually reinforcing interrelations among function, symbolism, and material qualities that contribute to the formation of a high strength of attachment to an object. Moreover, material qualities appear to play an extremely important role in relationships characterized by a high strength of attachment, as predicted by our theoretical framework. This is especially apparent when particular material qualities are tied to meaningful symbolic representations or useful functionality—often in ways that are perceived to be difficult or impossible to replace. In many cases, material qualities appeared to encourage (or not encourage) the formation of more meaningful and useful relationships over time. We present some **general interpretations** for each example and describe interrelations between function, symbolism, and material qualities.

An important general takeaway interpretation of our observation work is the contrast between the ensoulment of things non-digital and the unensoulment of things digital: for the most part, things **ensouled**—things with a high strength of attachment—were not digital things and digital things were things **unensouled**—things with a low strength of attachment.

The relationships between an object, a person, and that person's attachment to an object are complex. We have chosen to report particular examples that we feel highlight both the complexities of these relationships and suggest opportunities for designing products that engender a higher strength of attachment. Nonetheless, general relationships that appear strongly correlated with and characteristic of strength of attachment did emerge from our analysis. In particular, we clustered our finding into four areas denoting relationships between owner and object, namely

1. **engagement**—the extent to which an object invites and promotes physical engagement with its owner during use;
2. **histories**—the extent to which the materials of an object preserve personal histories or other memories, either by explicitly showing physical signs of use or implicitly by virtue of its persistence over time;
3. **augmentation**—the extent to which an object has been reused, renewed, modified, altered or otherwise made to be a part of something augmented beyond its original intended use and as such has become a symbol of the resourcefulness and/or creative expression of its owner; and
4. **perceived durability**—the extent to which an object's owner regards an object as long lasting either in terms of function or in terms of longevity or both.

For each of the four relationship clusters, we present a brief overview of our findings followed by a description of several noteworthy examples.

Engagement: Overview
The kinds of things we found which endure in part due to engagement included, among other things, a figure modeling set (**P18**), pottery wheel (**P31**), socket wrench set (**P19**), saxophone (**P7**), and typewriter (**P3**). These specialty tools each require a degree of skilled use and direct physical involvement; participant responses illustrated deeper attachment to these objects. In what follows we present detailed examples of (i) a commonplace tool requiring skilled use, which exhibited a high degree of attachment and (ii) an everyday object that did not require skilled use, but nonetheless resulted in deeper attachment by virtue of materially engaging interactions.

Engagement: Kitchen Utensils

As an example of an object of engagement, we found a collection of high quality kitchen hand tools that were the pride of a participant (**P7**).

Strength of attachment: Several times the owner of the kitchen utensils explicitly noted the deep-seeded attachment that he had developed with the objects: *"These are my favorite"* and *"I'll probably have them for the rest of my life."* **Function:** This strong sense of attachment was highly related to the function of the tools, which were (i) used for various daily cooking activities, and (ii) have proved to be very reliable and effective, particularly in relation to more sophisticated kitchen tools: *"Others* [electronic mixers in kitchen] *I have are decent, but have to be fixed and it's harder to find people to do it. I can always count on them* [utensils] *to work."* **Symbolism:** The participant's sense of attachment appeared less strongly related to symbolism. The participant made no reference to how these products reflected his lifestyles or values. **Material qualities:** The participant's sense of attachment and perception appeared most shaped by the utensils' material qualities. In reflection, the participant described that the tools (i) were pleasurable to use—*"They feel good in my hand"* (ii) facilitated engagement in an enjoyable and useful activity (cooking)—*"I just enjoy cooking with them; it feels more like I'm putting myself into what I'm making. A more real experience"* and (iii) were constituted by their quality construction—*"I appreciate their craftsmanship and good design."* **General interpretations:** In the preceding quotes, the participant's use of the term '*real'* is implicated in the integration of a deeper level of involvement with the material objects themselves and the task at hand, in contrast to the electronic mixers, which operate independently in completion of the task. The relatively open and transparent design of the utensils afforded the participant the ability to both understand and directly interact with the objects' functionality. These design choices collectively open a space where the owner came to a deeper understanding of the object through its experience-of-use and, consequently, developed deep, potentially life-long attachments.

Engagement: Wind-Up Flashlights

Wind-up flashlights appear across three of our inventories and represent an example of an object of engagement.

Strength of attachment: The three wind-up flashlights encountered in our study were described in terms of strong attachment by their owners (**P5**, **P19**, **P30**). For example: *"I immediately loved this one; it's one of my favorite things in the house"* (**P5**), *"It's so cool!"* (**P19**), and *"Absolutely!* [I prefer the wind-up flashlight]*"* (**P30**). **Function:** Participants principally attributed the emergent strong feelings of attachment to the unique function of the flashlights. In particular, participants found functional value in (i) the convenience and monetary savings resulting from not having to purchase and replace batteries (**P30**) (ii) the increased reliability of the flashlights—for example, **P5** stated: *"The crank makes it easy to produce light and I could go anywhere with it."* and, in one particular case (iii)

the ability to charge other electronic devices with the charging mechanism of the flashlight—for example, **P5** stated: "*I sometimes use it to charge our* [her and husband] *cell phones. I plug it in* [a phone] *and start to crank; it starts charging just like that."* **Symbolism:** With each of the three participants, attachment to the flashlights appeared less strongly related to symbolism. The participants made no reference to how this product reflected their interests, lifestyles or values. **Material qualities:** Material qualities again played a key role in facilitating meaningful attachment, which is reflected in the apparent delight **P19** expressed in the increased function resulting from generating power by hand—*"It's so cool! Look...* [winding up flashlight] *it doesn't need batteries!"* On a deeper level, **P5** describes an intimate bodily understanding of and connection to the material device and power generation—*"I think about it* [flashlight] *when I'm charging the phone and how my energy is going into the phone. ...Sometimes I think about it* [the phone] *when I'm using it. ...I guess feel more connected to it* [the phone]*, you know, how my body recharged it.*" **General interpretations:** Rather than being perceived as a burden, participants felt there was added value in the functionality provided by the self-sufficient hand-powered models. This situation represents an exemplary instance of an electronic product involving users directly in its functionality by virtue of the nature of the direct, sensorial interaction with it. Moreover, in the case of **P5,** an unintended interaction emerged, modeling a nurturing process, potentially endowing a common electronic device with deeper meaning and attachment.

Histories: Overview

The kinds of things we found which endure in part due to histories included, among other things, artwork (**P11**), a firearm collection (**P23**), a jewelry box (**P3**), a music box (**P2**), a pewter squirrel nutcracker (**P7**), record collections (**P26, P36**), a Turkish Eye medallion (**P26**), and Waterford Crystal glassware (**P34**). These heirloom objects were of great importance to our participants; they had implicitly acquired histories as they passed between people through space and time. Nonetheless, the majority of these objects were no longer in frequent everyday use. In what follows, we present examples of objects that had acquired rich histories while still remaining in use—representing exemplars of high strength of attachment resulting from strongly interwoven characteristics of function, symbolism, and material qualities.

Histories: Wooden Chair and Cabinet

As examples of objects with rich histories, we found in a particular personal inventory (**P28**) a set of pieces of wooden furniture: an heirloom wooden chair and a cabinet made of salvaged wood. The cabinet was designed by the participant and built by her close friend, who also salvaged the wood used in its construction.

Strength of attachment: The participant indicated these two pieces were among her most cherished possessions. We consider both pieces to be ensouled to the participant.

Function: The attachment to both pieces was strongly related to function. Despite being an heirloom, the chair was still frequently used, in particular, by her grandchildren. The cabinet was used on a daily basis for storing kitchen items. **Symbolism:** The ensoulment of both pieces was strongly related to symbolism. The symbolic value of the chair was described in terms of (i) the way it represents a long history of family use—for example, the participant stated *"I sat in it as a little one and my children sat in it as little ones and now my grand children are sitting in it as little ones. So of course it has meaning to me"*, (ii) the way that using the product serves as a reminder of this history—for example, the participant stated: *"and the kids now* [**P28**'s grandchildren]—*are just beginning to understand when I say 'that belonged to great grandpa,'"* and (iii) the general wear and tear represents the age and history of the piece, while particular marks represent particular events in its history—for example, the participant stated: *"it went through a point where it was in my grandfather's workshop...you can see someone was sawing here at some point, and someone was nailing here."* The symbolic value of the second piece—the cabinet—was described in terms of (i) the history of the materials representing the city she has lived in for over 30 years—for example, the participant stated: *"This piece is not old, but the wood came from a building in* [the participant's city] *that used to be a restaurant,"* (ii) the history of the materials representing a meaningful relationship between the participant and her friend who built the piece—for example, the participant stated: *"the man who built it has now passed away so it's a cherished thing for me, too,"* and (iii) how the meaning related to the materials gave the particular piece "soul"—for example, the participant stated: *"it gives us a piece **soul*** [referring to the materials]…*When you're lucky enough to have a permanent place to live, if you can have pieces like that, it's comforting to come home to them."* **Material qualities:** The material qualities were strongly related to the ensoulment of both pieces of furniture. The material qualities of the chair were reflected in (i) how the materials (wood) recorded histories of wear and tear naturally as a byproduct of use, and (ii) this wear and tear was not perceived as a functional or aesthetic flaw, but instead acquired deep meaning—the participant indicated she did not intend to refinish or repair these signs of wear and tear. The material qualities of the cabinet were reflected in (i) the "quality" of the material—for example, the participant stated the wood was *"good stuff"*, and (ii) the material itself was explicitly described as being unique and significant owing to its history before the piece was built. **General interpretations:** In the case of each piece of furniture, the participant was devoted to the unique and particular materials. In the case of the heirloom chair, the materials recorded **histories of use**, which served as meaningful records of rich experiential histories that had accumulated as her family had used the piece over several generations. In the case of the cabinet, the piece carried **histories of reuse** for the participant, which also served as meaningful records of experiential histories. These functional pieces were irreplaceable to the participant owing to their unique **material histories**.

Histories: Film and Digital Cameras
Across our inventories, we commonly encountered multiples of particular devices, often with contrasting digital and non-digital objects. While most digital objects had not been in possession as long as the non-digital ones, participants' responses indicated digital objects generally did not show signs of attaining similar histories. In particular, an illustrative a set of film and digital cameras—containing objects both with and without rich histories—emerged as a compelling case.

Strength of attachment: The participant was strongly attached to one of the film cameras, which had been in his possession for over 30 years. However, she was not attached to the remaining cameras, which included one film camera and three digital cameras. **Function:** The strong attachment to the film camera was related to its function. The participant indicated that this camera still functioned well and that she continued to use it, albeit less frequently than in the past. This change in behavior was primarily because the digital cameras offered increased convenience. **Symbolism:** The strong attachment to the film camera was strongly related to its symbolism. The symbolism of the camera was described in terms of (i) its long history of use—over 30 years, (ii) the way this history of use represents the origins of the participant's passion for photography—for example, the participant stated: *"I got it when I became interested in photography during college. ...I still use it today"* **(P9).** In contrast, the digital cameras were not described by the participant in terms of symbolism. **Material qualities:** The participant's deep attachment to the film camera was strongly related to the material qualities of the camera. In particular, when describing why she continued to obtain digital cameras, **P9** conveyed she was *"still looking for the **right feel**,"* which would be similar to that experienced with the film camera. Moreover, the film camera material richly recorded histories that acquired symbolic value over time, *"My favorite thing about it is the leather* [case]*, it's worn to fit the shape of my hand; it's kind of become a companion over the years."* **General Interpretations:** Digital products, such as the cameras in the previous example, did not seem to strongly encourage emergent material histories, perhaps partially due to plastic material generally not recording use as richly as leather or wood. Nonetheless, common digital products are often embedded with recording or data collection capabilities, suggesting a major, largely unexplored design space.

Augmentation: Overview
The kinds of things we found which endure in part due to augmentation included, among other things, materially-adorned cell phones (**P23**, **P13**), a desktop computer and repainted bike (**P29**), a light-fixture fitted cabinet with an external controller (**P15**), and a home-made mailbox &

table (**P28**). Generally, these objects were characterized by their owners' intentional modification and in many cases included materials augmented beyond their original purpose. This process relied on participants' varied skill sets and creative intuition to resourcefully complete such augmentations. In what follows, we present two case instances exemplifying diverse applications of augmentation and illustrating a trajectory of increasingly sophisticated technical outcomes.

Augmentation: Annotated Chess Books

A set of examples of a more commonplace type of augmentation was annotated chess books belonging to the husband of **P30**.

Strength of attachment: The participant described the chess books in terms of her husband's strong attachment to them, as well as her own attachment to the books. The participant indicated that the collection had grown over the years and many of the books had been in her husband's possession since he was in college. **Function:** The strong attachment to the books was strongly related to their function. The participant described the chess books as useful references, stating: *"he still uses* these [chess books].*"* The participant indicated the books had helped her husband win chess tournaments, at one point placing among the top in the nation. **Symbolism:** The strong attachment to the books was related to their symbolism. The participant described her husband as an avid chess player, and the books reflected (i) her husband's interest in chess, and moreover, (ii) the annotations represented dedication and mastery of chess over time—for example, the participant stated: *"I swear he knows what every single book is. He'll go back and read these…see, he's got little notes in here…see, that's his writing. Now could you imagine reading a book like this?"* **Material qualities:** The material qualities of the books played an important role in the participant and her husband's strong attachment to them. In particular, the margins of the book allowed and perhaps encouraged the owner to make annotations for functional purposes, which came to serve symbolic purposes. **General interpretations:** Although these annotations appear to be created primarily for functional purposes, the participant discussed them by associating their meanings with her husband's mastery of chess, thus tying to notions of material histories discussed previously. The space provided in the margins of a book may initially appear as a trivial detail of the book design. Although annotating is a common practice, margins are not explicitly designed for such use; they do not come with explicit instructions on how to use them for making annotations. Appropriations of margins allow people to in some sense become involved in the design of the book.

Augmentation: Home-made Computer Device

Nearly all instances of augmentation encountered in our study were related to non-digital products. A notable exception was a device **P15** had constructed from a miscellaneous collection of computer parts.

Strength of attachment: The participant expressed strong attachment to this device, indicating that it was among his most loved possessions. **Function:** Attachment to this device was strongly tied to its function. The function of the device was primarily to service as a desktop PC, although the participant indicated that he was constantly exploring other uses of the device: *"After I finally finished it, I started experimenting with ways to use it other than my main* [desktop] *computer. ...Now we* [roommates and **P15**] *use it all the time in the house and I take it on long trips with me* [in the car] *to play music and movies. ... I have to use my other computer more, but this is definitely my favorite. ...because I made it from old stuff* [i.e. parts] *and it made me figure out new ways to use it* [referring to desktop-model computer] *that I had never thought of."* **Symbolism:** The participant's attachment to this device was also strongly related to symbolism. In particular, the meaning associated with the device owed to (i) the uniqueness of the device and the participant's personal involvement in its design and manufacture: *"At first I was interested in how I could use leftover parts that I had been holding onto for a long time. ... I had modified computers in the past, but this one felt totally unique. ... the stickers on it reminded me of my childhood; the case is from the first computer that my parents gave me."* **Material qualities:** The material qualities of the computer hardware used in the device are relatively opaque in that they are difficult to understand based on material and sensorial interaction. However, to this participant these materials were understandable and, ultimately, craft-worthy for a concrete, functional purpose. **General Interpretations:** The participant's description of building this device and the subsequent experience-of-use was characterized not only by engaging with the device on rich material levels, but also by a deeper understanding of how this digital object could be integrated into his life in unique, intriguing, and, ultimately, rewarding ways. The fundamental impetus for and creative process through which material augmentation occurred in this example largely mirrored what we observed in non-digital instances. Nonetheless, the sophisticated technical knowledge required to augment the often non-transparent, inaccessible nature of computer technology might have prevented more widespread occurrences of digital material augmentation.

Perceived Durability: Overview

The kinds of things we found which endure in part due to perceived durability included, among other things, cartridge-based video games (**P13**, **P15**, **P26**), cast iron skillets (**P23**, **P35**), kitchen mixers (**P18**, **P29**, **P31**), a music box and vintage audio equipment (**P2**), and 12 inch records (**P26**, **P36**). While in many cases the material components constructing these objects were relatively fragile, participants perceived them as long lasting, often denoting a high amount of trust in their respective ongoing persistence. In what follows we present two exemplars of high perceived durability, the later of which contrasts digital and non-digital objects.

Perceived Durability: Non-Electric Sewing Machine

A distinguished example of a product with high perceived durability is a sewing machine that is powered by a mechanical foot-pedal belonging to **P28**.

Strength of attachment: The participant showed devotion to this sewing machine, indicating that she planned to never get rid of the machine even though she rarely used it for sewing. **Function:** Interestingly, the function of the sewing machine played an indirect yet important role in the participant's devotion to the machine. Despite being quite old, the sewing machine (i) was still functional and the participant had used it to sew in the past, and (ii) was very reliable—for example, the participant stated: "*There's very little to go wrong on it! The leather belt that runs the thread. All you have to do is attach that. The leather belt goes right around this. There's the foot pedal down there. And, Singer still makes the leather belt, because I guess all around the world they still use these.*" However, the participant also stated *"I have used it, but probably not for a couple of years."* Instead, the participant used two newer electronic machines she owned for her everyday sewing tasks. The older machine was currently being used as a table to support other objects. **Symbolism:** The participant's devotion to the machine was strongly related to symbolism. The symbolism of the sewing machine was related to (i) the sentimental value of the machine, which had belonged to her aunt—for example, the participant introduced the machine to the interviewer by stating: *"and then I have this one, which was* [my aunt's], *which I just like... I don't think I'll ever get rid of it—I just like having it here,"* and (ii) the participant's values of self-sufficiency—for example, the participant stated: *"This will work, you know, without power. It's non-electric. There's a certain, and I don't know if it's ever gonna serve me well, but **survival instinct** that you wanna have. You wanna be able to say 'well if I don't have any power* [laughs], *I can still* [sew].*'"* **Material qualities:** The participant's devotion to the machine was strongly related to its material qualities. Material qualities were reflected in (i) the pleasurable use of the machine, which the participant described as having a *"pleasing rhythm....and sound"*, and (ii) an apparent aesthetic value in the transparency of the design. **General interpretations:** Although she had not used the machine in several years, the perception that it continued to function and would continue to function indefinitely appeared to be a significant factor contributing to the product enduring in the participant's household. This perception was most likely shaped by her understanding of the sewing machine as a material entity. Similar to the flashlight example, when **P28** did interact with her aunt's sewing machine she was directly involved with its functionality and, by consequence of the transparent design, came to a deeper understanding of the object.

Perceived Durability: Timers

A contrasting example of a non-digital product with a high perceived durability and a digital product with low perceived durability is the set of timers belonging to **P2** (originally described in [26]).

Strength of attachment: The participant conveyed deep attachment to an hour-glass timer—an object prominently featured in her kitchen—while a non-digital timer she owned had taken on little significance. **Function:** While the hour-glass timer had persisted across multiple generations of the participant's family and had become an heirloom object, it nonetheless continued to fulfill the same function as it did when originally constructed and is expected to continue working. The participant's low level of attachment was entirely predicated on the function of the digital timer, which had been replaced annually over the past 6 years due to malfunction. **Symbolism:** While the poor quality digital timer had no discernable symbolism, the participant's attachment to the hour-glass timer was heavily influenced by its symbolic, sentimental value. The participant describes how through using it, she is able to connect to other family members that had previously owned it, *"I attached it to a special place on the wall in the kitchen where grandmother had it. I like it better than the other timers because it can't malfunction. I mostly use it for short things because it only lasts for three minutes, but I like it because I have to pay attention to it while it counts down, and it makes me think about the other people* [i.e. grandmother and aunt] *that have had it before me."* **Material qualities:** The participants' devotion to the hour-glass timer and conversely low level of attachment to the digital timer are strongly tied to their respective material qualities. The accessible nature of the hour-glass timer caused it to be carefully handled over time, and intimately involved its owner in its functionality through experience-of-use. Contrastingly, the concealed and comparably complex design of the digital timer paired with a poor quality casing resulted in a low level of attachment and high level of disposability. **General interpretations:** In this case, the transparent functionality of the hourglass egg timer reveals its internal operations, resulting in both an increased trust in the functionality of the product and an aesthetic experience related to the product's perceived durability that has persisted over time. In contrast, the opaque design of the digital timer prevents the perceived trust and aesthetic value derived from the hourglass timer, in this case.

IMPLICATIONS FOR DESIGN

We conducted personal inventories and we have described several distinguished examples of the relationships between objects and their owners in terms of function, symbolism, and material qualities as factors affecting the strength of attachment of a relationship. For designers who want to construct artifice—digital or otherwise—which inspires a high strength of attachment, our interpretations suggest the following design principles are worthy of continued investigation:

Function—an object's function is more prone to obsolescence in the presence of new technologies than its

symbolism or material qualities, in general. Nonetheless, a strongly single-purpose functional object is more likely to continue to endure if it has a strong sense of engagement, or relates to personal history, or can be used in a new way, or simply still works in a perceived durable way.

Symbolism—the development of an object's symbolism is harder to predict than the way in which it is likely to be used, the endurance of its function, or the lifespan of its material qualities. Nonetheless, symbolism can engender a high strength of attachment when it arises from personal history as a byproduct of use over time or when it arises from augmentation that reflects back on its owner in a personal way.

Material qualities—certain materials inspire durability, especially wood, or metal, and the perceived quality of materials in an object engender a high strength of attachment, in general. We could speculate that digital materials, especially those aspects of digital artifice that are not physical in nature, may be able preserve memories and can therefore afford the enduring qualities that other quality materials add to an object.

Similarly, we suggest design principles and questions for further research based on the four clusters of relationship styles that can also motivate a high strength of attachment, and longevity and durability as a consequence, namely:

Engagement—as in the hand-cranked flashlight example, it is important to look for opportunities to increase an owner's involvement in the motor-tactile nature of using an object for a function. How can we engender deeper and more aesthetically pleasing physical engagement with interactive digital products? How can such engagement lead to more useful and satisfying interactions with technology?

Histories—as in the patina that develops on the loved furniture, it is important to look for opportunities to use materials that can record in the form of patina or otherwise histories of use that enrich the ensoulment of an object rather than just cause the appearance of something that is used and needs to be replaced. In the context of digital devices, the data associated with a history of personal use could be used to establish a non-physical, or perhaps physical in some way to be imagined but certainly digital, patina which makes a particular physical computing device and its associated personal data history hold personal and nostalgic value. How can unique histories evolve over time and be tied to a particular object, increasing the significance of this object? How can signs of everyday use be represented digitally—either on a screen or through physical manifestations of digital information? Moreover, how can such emergent digital signs of use help contribute to ongoing narrative between an object and its owner or owners? Some research in HCI supports the importance of *material histories*, such as the history tablecloth [13] and, more broadly, the notion of using patina in software design has appeared in [18].

Augmentation—as in the computer constructed from salvaged and spare parts, the use of materials to reconstitute, reuse, renew, customize, or otherwise augment an object may lead to high strength of attachment. For example, materials like wood invite reconditioning with means like paint or varnish. In the context of digital objects, what is needed is more modular and reconfigurable and adaptable design of the physical components of digital artifice. In which ways can digital products promote resourceful and creative physical augmentation with respect to reuse, renewal, or customization? Established and emerging areas of HCI research—including end-user programming, modular computing, and DIY culture [5]—may consider the implications of their work in terms of product attachment.

Perceived durability—perceived durability owes to the perceived quality of materials and their ability to hold up to use or perception of holding up over time. In the context of digital objects, what is needed is to construct the casing materials of much higher quality materials, even if the insides of such objects change frequently. Protocols such as USB or universal power supply adaptor kits make it easier to modify and update existing digital objects in a less device dependent way than before and such universal ways to attach computing objects together need to be foreground in the minds of designers. Such universal device independence needs to carry over to other aspects of digital artifice, including at the chip level and software and operating system levels. To what extent is it possible to design interactive digital products that are perceived to endure functionally and in terms of longevity? Can new technologies and materials, such organic user interfaces and transitive materials, allow us to construct digital products with a higher perceived durability? How can modularity and upgradability contribute to perceived durability? How can people be given greater control over the repair, maintenance, and customization of their digital artifice?

Factors like function, symbolism, and material qualities as well as relationship properties like engagement, histories, augmentation, and perceived durability may be used by designers of interactive technologies as principles to guide the design of high strength of attachment digital artifice. On an ongoing basis, we plan to continue our collection of personal inventories. We plan to use these collections to further refine the design implications and theoretical understandings of why we preserve some things passionately and discard others without thought, as a matter of critical need for more sustainable design.

ACKNOWLEDGMENTS

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Contribution Statement

Applies a theoretical framework to observed examples in the service of construction of sustainable design principles.