

# Designing Meaningful Products in the Digital Age

## How Users Value Their Technological Possessions

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### ABSTRACT

Devices such as phones, laptops and tablets have become central to the ways in which many people communicate with others, conduct business and spend their leisure time. This type of product uniquely contains both physical and digital components that affect how they are perceived and valued by users. This article investigates the nature of attachment in the context of technological possessions to better understand ways in which designers can create devices that are meaningful and kept for longer. Findings from our study of the self-reported associations and meaningfulness of technological possessions revealed that the digital contents of these possessions were often the primary source of meaning. Technological possessions were frequently perceived as systems of products rather than as singular devices. We identified several design opportunities for materialising the associations ascribed to the digital information contained within technological products to more meaningfully integrate their physical and digital components.

### CCS CONCEPTS

• **Human-centered computing ~ User studies** • **Human-centered computing ~ Empirical studies in HCI** • **Human-centered computing ~ Interaction devices**

### KEYWORDS

Attachment, Physical objects, Digital media, Technological products, Associations, Design, Devices, Qualitative methods

## 1 Introduction

Technological advances have rapidly created opportunities for designers to integrate digital functions into physical products. This new category of products has become increasingly integral in people's day-to-day lives, seen in the vast prevalence of devices such as smartphones, laptops, tablets, e-book readers, game consoles and digital cameras. These devices have become central to the ways in which many people communicate with others, conduct business and spend their leisure time. Ongoing advances in the Internet of Things and cloud-based services continue to expand the breadth and prevalence of this physical-digital category of products moving forward into the future.

While this fusion of physical and digital components has great potential for improving the harmony between humans and products, it requires consideration of how the combination of tangible and intangible form influences the ways in which we as humans develop emotional relationships with our belongings. Despite their significant role in people's lives, technological products are often replaced far before their

functional lifetime expires [Huang and Truong 2008]. The Consumer Technology Association [2014] report the average smartphone functional life expectancy to be 4.7 years however several studies show the average consumer replaces their smartphone in the first 12-24 months [Deng et al. 2017; Read 2015]. This rate of consumption referred by Huang and Truong [2008, p. 323] as a “*disposable technology paradigm*” amplifies a number of sustainability issues such as resource scarcity and e-waste management [Deng, Giesy, So and Zheng 2017]. From a sustainability perspective, promoting emotional user-object relationships through design has been considered as a viable strategy to address issues with the rate of product consumption [Gegenbauer and Huang 2012; Huang and Truong 2008]. When attached to an object, people are more likely to handle it with care, to repair it when needed and to postpone its replacement [Belk 1991].

Several researchers within the HCI community have looked at the role of a possession’s form in the development of attachment by comparing the ways in which people develop emotional ties to their physical, physical-digital, and digital possessions [Denegri-Knott et al. 2012; Golsteijn et al. 2012; Odom et al. 2014; Petrelli and Whittaker 2010; Turner and Turner 2013]. The findings of these studies suggest that people are less likely to value their digital or physical-digital possessions as highly as their physical possessions. The underlying causes for these differences in emotional value are not yet fully understood. It remains unclear why people develop less of an emotional connection with technological products such as smartphones than non-digital products. Early work has suggested this is a result of the concealed functionality of technological products such as the hidden components and processes that allow a camera to capture a scene and store it as a digital photo. This is argued to cause a conceptual separation between what a thing *is* (a camera) and what a thing *provides* (digital photos), thus diminishing the emotional value of the thing itself [Borgmann 1984; Verbeek 2005] however there is limited empirical evidence to support this view.

This article explores the ways in which people perceive and value their technological possessions to better understand the nature of attachment when both physical and digital forms are integrated within a single possession. Within this, we aim to address a question posed by Feinberg [2013, p. 7] in her conceptual look at possessions in the context of HCI: “*at what level of abstraction does attachment lie?*”, drawing distinctions between a person’s attachment to a particular device versus the digital information stored within the device. We address this question by isolating and comparing the physical and digital components of technological possessions to determine the source of their value and at what level of abstraction it is assigned. We asked 20 participants to list the associations that come to mind when engaging with either physical or digital components of their technological possessions. We then conducted semi-structured interviews that elaborated on the listed associations and concluded by asking our participants to comparatively rate and discuss the meaningfulness of physical and digital components of these possessions. We use these findings to generate insights for designers seeking to create lasting technological devices by promoting the development of attachment within this increasingly prevalent design space.

## 1.1 Terminology

Attachment in physical and digital contexts has been the focus of several studies within the Consumer Behaviour [e.g. Belk 2013; Denegri-Knott, Watkins and Wood 2012] and HCI [e.g. Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom, Zimmerman and Forlizzi 2014] communities, however the terminology used to describe this relationship between a person and a *thing* varies greatly. Possessions that a person feels attachment towards are interchangeably described as meaningful [Denegri-Knott, Watkins and Wood 2012], cherished [Golsteijn, van den Hoven, Frohlich and Sellen 2012], emotionally significant [Meschtscherjakov et al. 2014] or special [Petrelli and Whittaker 2010], reflecting the abstract nature of attachment as a construct. Terminology distinguishing the nature of the *thing* itself is similarly divergent. In this article we refer to three categories of products based on Kirk and Sellen’s [2010] format classification. *Physical objects*, also referred to as non-digital artefacts [Turner and Turner 2013] (e.g. a coffee mug or chair), *digital items*, also referred to as digital objects [Golsteijn, van den Hoven, Frohlich and Sellen 2012], digital virtual goods [Denegri-Knott, Watkins and Wood 2012] or virtual possessions [Odom, Zimmerman and Forlizzi 2014] (e.g. an email, photo or app) and *technological products* that are physical objects containing digital information, also referred to as hybrid objects [Golsteijn, van den Hoven, Frohlich and Sellen 2012], digital artefacts [Odom and Pierce 2009] and technological artefacts [Kirk and Banks 2008]

(e.g. a smartphone, MP3 player or desktop computer). We adopt these three product categories to align our work with prior studies that differentiate between attachments to physical vs digital possessions [Atasoy and Morewedge 2017; Feinberg 2013; Gerritsen et al. 2016; Petrelli and Whittaker 2010] and attachments to objects with vs without digital functions [Kirk and Banks 2008; Odom et al. 2009; Turner and Turner 2013]. In this article we use the term *physical-digital* in place of *technological* to avoid ambiguity when comparing product categories. We distinguish between our use of the term *product* to refer to something that is *designed* and *manufactured* and our use of the terms *possession* and *belonging* to refer to something that is perceived by an individual to be *owned*. While the idea of *digital materiality* has been explored in recent years [Jung and Stolterman 2012; Leonardi 2010], we use the term *materiality* in the traditional sense to refer to the quality of being composed of matter.

## 2 Related Work

In this section, we address the prior work that informed our study and outline how a greater understanding of the ways in which people value their technological possessions can inform HCI and design practitioners seeking to address unsustainable consumption behaviours. We provide an overview of attachment as a consumer behaviour construct and discuss the need for a better understanding of how meaning is assigned to technological possessions. We frame this in relation to our current understandings of attachments to both physical and digital belongings stemming from both consumer behaviour and HCI literature. Finally, we discuss the consumption behaviours that result from various forms of attachment and examine existing strategies for designing technological products to address issues with current rates of consumption.

### 2.1 Attachment and the Self

People develop an attachment to their belongings for a range of reasons. They can be valued for the memories they bring to mind, enabling the achievement of goals, the enjoyment they provide through their use or the self-expressive opportunities they offer [Schifferstein and Zwartkruis-Pelgrim 2008]. These belongings can contain ties to significant people, places, experiences, values or beliefs that bring about a rich range of emotions [Mugge et al. 2005]. We adopt the definition of attachment originally developed by Bowlby [1977] as “*an emotional-laden bond connecting an individual with a specific target*” [Jiménez and Voss 2015, p. 363]. Attachment is often further defined by its associations to the self [Ball and Tasaki 1992; Belk 1988; Kleine et al. 1995; Schultz et al. 1989]. There is general agreement in existing literature that people develop an attachment to a belonging for its role in the construction, maintenance or development of an aspect of their self-identity [Ball and Tasaki 1992; Belk 1988; Csikszentmihalyi and Rochberg-Halton 1981; Schultz, Kleine and Kernan 1989]. Belk’s [1988] work further developed the idea of the *extended self* in which an individual’s sense of self extends beyond *what is me* to *what is mine*, including *my belongings*. Possessions are used to characterise and communicate who we are, who we were and who we wish to become. They provide links to our past and enable development from our present-self towards our ideal anticipated-self, gaining emotional significance for their involvement in our life narrative [Kleine, Kleine and Allen 1995]. The closeness between attachment as a construct and the ways in which people use possessions to reaffirm who they are as a person reflects the associative nature of internal processes involved in ascribing meaning to an external entity. Possessions cannot be inherently meaningful, but rather they acquire meaning by triggering associations to mental concepts that hold personal significance for the individual.

### 2.2 Abstraction of Attachment within Technological Possessions

#### 2.2.1 Digital Possessions.

In recent years, the HCI community has sought to more deeply understand the relationships people develop with their digital possessions. Studies have found digital possessions to be valued in similar ways to their material counterpart as they allow us to express individuality [Bryant and Akerman 2009], reflect our social ties [Martin 2008], connect us to our past [Kirk and Sellen 2010], and remind us of loved ones [Watkins and Molesworth 2012]. Whilst the value these possessions provide may be similar in nature, there are distinct differences in the ways we perceive our physical and digital possessions that ultimately influences the value

they attain. Several studies have found that people often do not value their digital possessions as highly as their physical possessions [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom and Pierce 2009; Odom, Pierce, Stolterman and Blevis 2009; Petrelli and Whittaker 2010]. Findings suggest possible causes for this to include difficulties faced in presenting, displaying and re-visiting digital possessions due to their immaterial nature [Brown and Sellen 2006; Petrelli and Whittaker 2010] as well as complex issues relating to ownership, singularity, uniqueness and control [Cushing 2013; Denegri-Knott, Watkins and Wood 2012; Odom, Zimmerman and Forlizzi 2014].

Many of these issues relate to the blurred nature of what constitutes a digital possession. Prior work from the field of consumer behaviour discusses how cloud-based storage and online streaming services dissolve the boundaries between ownership and access of digital media [Belk 2013]. Forming possessory relationships with digital media can be further complicated by subscription-based services [Watkins et al. 2016] and hosted content [Molesworth et al. 2016] that restrict user control and are at the discretion of corporate activities. Research from the field of HCI more narrowly explores how the characteristics of digital information influences internal processes of assigning meaning to digital media. In exploring the abstraction of attachment to digital possessions, Feinberg [2013] refers to the concept of the *intellectual work* using the example of Shakespeare's *Hamlet*, a play that exists in many varying editions and forms but in all cases, is still seen as one piece of work—*Hamlet*. This line of thought similarly applies to digital items such as songs, photos, video games, apps, programs and e-books in which meaning may be assigned to the *work* or a specific manifestation of it such as an MP3 file or CD. Further complications arise when these digital items are seen collectively as one. Much like the thousands of components that make up a single car, digital items often blur boundaries between individual and collective value [Feinberg et al. 2012; Marshall 2007]. A social media app may be viewed as a collection of photos and messages or as a single piece of software. Marshall [2007] proposes that a digital photo is characterised as more than just the image itself but also its membership within a set of photos taken at the same event. These digital items may be valued not as individual things, but for their place within a collection that as a whole is considered meaningful such as songs found within a personal music library or a collection of photos from a family vacation [Belk 2013]. Conversely, the value of a particular digital item can be obscured when meaningful and meaningless media are stored and accessed from the same location [Gerritsen, Tasse, Olsen, Vlahovic, Gulotta, Odom, Wiese and Zimmerman 2016].

### **2.2.2 Physical-Digital Duality.**

The question of abstraction and attachment has been well considered in physical objects with conceptual boundaries established between attachment to a specific thing versus a product category [Costley 1988], brand [Fournier 1998] or possessions in general [Belk 1988]. As discussed above, strides have been made in addressing this matter in the context of digital possessions despite the complexity in doing so. Similar issues are faced in discovering where attachment lies in technological possessions as they fit within the context of physical objects yet also contain digital media within them that can also be considered meaningful.

Early work from the HCI community investigating people's attachment to their mobile phones suggested it was not the device itself but rather the relationships with others it embodied that gave it meaning [Vincent 2006]. More recent work looking at mobile phones argue that attachment to the device and the brand or software system overlap and therefore result in attachment that may be transferred to a newer version of the same device [Meschtscherjakov, Wilfinger and Tscheligi 2014]. A number of studies have distinguished between attachment to a *thing* itself versus attachment to what it *provides*, describing technological possessions to often be perceived as highly useful but merely tools [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Kirk and Sellen 2010; Odom and Pierce 2009]. These studies are limited in their ability to address whether it is the content (digital media) or carrier (physical object) that is the source of value. Kirk and Sellen [2010] found that VHS or cassette tapes held no sentimental value as physical objects yet their contents were considered highly significant. The nature of products containing digital media has since expanded beyond their storage capabilities to incorporate a range of other features and functions that may lead to differing results.

Studies from the field of consumer behaviour have identified ways in which perceptions of the materiality and digitality of technological products become entangled through various transformative practices adopted

by users. A digital possession may be copied and stored on a new physical device, linking it with new material forms, interactions and experiences [Magaudda 2011]. Similarly, it may be re-materialised by its owner, imbuing it with desirable material qualities such as rarity [Mardon and Belk 2018] or singularity [Denegri-Knott, Watkins and Wood 2012] that facilitate stronger possessory relationships [Watkins, Denegri-Knott and Molesworth 2016].

Prior work from both the HCI and consumer behaviour field examining people's attachments to their technological possessions identified several ways in which digital technologies create new distinct forms of possessory relationships and provided summative comparisons between the meanings assigned to different categories of possessions. These studies however are limited in their ability to provide deep insight into the complex and unique nature of attachment when both physical and digital forms are integrated within a single possession. In our study, we intend to more directly address the division and entanglement of meaning assigned to the physicality and digitality of technological possessions by comparing the thoughts and meaning evoked at various levels of abstraction.

### **2.3 Abstraction of Attachment and Consumption Behaviours**

The level of abstraction to which a person assigns meaning to a possession provides an indication of the consumption behaviours that are likely to result from these feelings of attachment. Emotional ties with the physical components that make up a possession plays an important role for consumers postponing the replacement or disposal of a device. When a possession's physicality is seen merely as a carrier for its digital contents or when a technological possession is valued only for its functional value, it is vulnerable to being replaced by another device that provides the same capabilities [Battarbee and Mattelmäki 2004; Odom, Pierce, Stolterman and Blevis 2009]. From a sustainability perspective, there is value in ensuring the meaning associated with a possession is linked to the specific object as this can lead to long lasting emotional value that delays replacement or disposal [Chapman 2009; Mugge et al. 2008]. Mugge et al. [2008, p. 428] describe this as the *irreplaceability* of an object, proposing that a possession's meaning should "*have a factual connection with the object itself*". Verbeek's [2005] framework proposes function (what an object does), symbolism (what an object means) and material qualities (what an object is made of) as three core factors that affect an object's durability.

Recent work in the field of consumer behaviour has addressed several ways in which the assignment of meaning to digital technologies influences user behaviours. Denegri-Knott, Watkins and Wood [2012] found instances in which attachment to a product category such as mobile phones led individuals to engage in a transfer of meaning from an old device to a newer upgrade but in doing so sought to maintain continuity in the settings and interface of the replacement device. Belk, Wallendorf, Sherry and Holbrook's [1991] work on collecting has been built upon to consider the emergence of digital collections and digital collecting practices [Mardon and Belk 2018; Watkins et al. 2015; Woodward and Greasley 2017]. Several of these studies uphold Belk et al.'s [1991] definition of a collection as a interrelated set of differentiated objects that are actively selected and acquired, noting that this does not encompass the passive accumulation of digital possessions such as photos, messages and emails that is prevalent in day-to-day usage of digital technologies [Van House 2011]. In this framework, possessions within a collection are redefined as *special*, no longer used for their ordinary functions and kept by the owner for the rest of their life. This however excludes the more common everyday collections of digital media such as photo albums and music libraries that are used or accessed on a daily basis yet still hold collective value [Woodward and Greasley 2017]. These collections are curated to facilitate practices such as choosing music to listen to or viewing photos to reflect on past experiences. Lastly, in instances when meaning is ascribed to access rather than ownership of digital items, people are less likely to exhibit behaviours associated with possessory relationships such as exhibiting control through modifying or personalising the item [Watkins, Denegri-Knott and Molesworth 2016] and taking protective measures such as creating backup copies of the item [Denegri-Knott, Watkins and Wood 2012]. Developing a greater understanding of how users assign meaning to valued technological possessions would provide further insight into the consumption behaviours that people exhibit in their engagements with technological devices. In our study, we focus our attention on different forms of assigned meaning within

technological possessions as a means of generating insights into how design practices can address unsustainable consumption behaviours.

## 2.4 Designing Lasting Technological Products

Studies investigating the longevity of technological products propose several design strategies for promoting attachment. Both Golsteijn et al. [2012] and Odom and Pierce [2009] advocate for more meaningful integration of the physical and digital components of these products to strengthen their emotional value over time. This relates to Vallgård and Redström's [2007] notion of *computational composites* that suggests digital information should be treated as a material with unique properties that can be combined with other physical materials to create new and innovative forms. A second strategy proposed by Odom and Pierce [2009] involves the creation of associations between an object and stories that are personal and meaningful to the owner. Meaningful associations are more broadly proposed by Battarbee and Mattelmäki [2004] as one of three overarching categories for meaningful product relationships. Associations can develop from an object's material properties, the history of ownership and use or from beliefs held by the user about the type of person who would own or use the product [Allen 2002; Kujala and Nurkka 2012].

Several researchers have used insights from attachment theory to inform the construction or conceptualisation of novel technological designs. Zimmerman [2009] presents a range of designs that intend to aid people in moving closer to their ideal-self in a specific role. Gegenbauer and Huang [2012] use categories of attachment to generate a range of design concepts related to modification, personalisation and personal histories. Golsteijn et al. [2014] create a kit that allows people to engage in *hybrid crafting* to create objects that integrate physical form with digital media. Baytas et al. [2018], give greater attention to the longevity of not just the material device, but also the digital technologies it employs. They do this by proposing a concept for a *computational heirloom* that makes use of a distributed blockchain data structure, affording a high degree of reliability and survivability, and pairing this technology with the form of a mechanical wristwatch to act as a new type of intergenerational artefact. These examples provide inspiration for designers seeking to promote attachment towards technological products, yet still leave room for further exploration of how designers can meaningfully integrate tangible and intangible form.

It is worth acknowledging that product longevity and the formation of emotional ties between users and their technological possessions is influenced by several market and cultural factors that are beyond the scope of decisions made within design processes. This includes mobile phone service provider contracts providing incentives to replace and upgrade [Huang and Truong 2008] and rapid product cycles that drive consumer demand for new devices [Blevis 2007], among other commercial incentives for increasing product sales. The emergence of possessory feelings towards a device may also be hindered by usage behaviours. Technological devices are often used in conjunction with one another, for example someone might check their emails on their laptop, tablet or phone depending on their location. Similarly, pictures taken with a digital camera might be edited or stored on a desktop computer. This has led several HCI researchers to examine the relationships between devices to broaden our understanding of the meanings people assign to their technological possessions and better understand the ways in which people incorporate new technologies into their lives [Bødker and Klokose 2012; Brodersen et al. 2007; Jung and Stolterman 2012]. These 'ecologies' of artefacts that users engage with can inhibit the perceived singularity of an individual product that the above design strategies aim to foster [Denegri-Knott, Watkins and Wood 2012]. Regardless, the goal of creating technological products that are kept for longer can and should be a central focus for design practitioners [Blevis 2007]. To address unsustainable rates of resource consumption, designers must create products that develop unique personal meanings imbued within their materiality. This requires a greater understanding of means for both facilitating the assignment of meaning to an external entity and of ways to restrict this meaning to be tied solely to a particular physical device.

In this article, we build on the findings of prior studies by addressing gaps in our understanding of the complex and unique nature of attachment between people and their technological possessions. The structure of our study was informed by insights derived from prior literature; namely that the assignment of meaning is personal and associative in nature, the value ascribed to technological possessions can be both divided and entangled at various levels of abstraction and that attachment can lead to more sustainable consumption

behaviours. In building upon these findings, we intend to provide insight for designers seeking to create technological devices that are assigned lasting meaning.

### 3 METHOD

Our research interests primarily involved exploring differences and similarities in the ways in which people perceive and value the physical and digital components of their technological possessions. Our emphasis on dividing and isolating the physical and digital stems from the reported differences in meaning across these product categories and a need for more sustainable technological product consumption. Designing technological products with greater emotional value has potential for extending their lifetime, but only if this value is assigned to the specific object. Our intention to explore the nature of attachment and its level of abstraction within people’s relationships with certain possessions contains several challenges. It can be difficult for people to describe the idiosyncratic complexities of the attachment felt towards a possession [Richins 1994]. This issue is amplified by the difficulty of conceptually distinguishing between multiple aspects of a singular possession. To address this, we devised two prompting activities to aid participants by structuring a process of isolating and comparatively rating various components of their technological possessions. We then conducted semi-structured one-on-one interviews with participants to discuss their responses to the prompting activities and aid our understanding of their underlying thought processes.

Our method was inspired by probe methodology, a design-oriented user research process first introduced by Gaver et al. [1999] and since adapted to a variety of research purposes within the design and HCI communities [Boehner et al. 2007; Mattelmäki 2005]. Probe methodology generates deeply personal data that we felt effectively aligned with the highly subjective nature of attachment experiences and the need for more in-depth explorations of these experiences to compliment the summative findings of previous studies [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom, Zimmerman and Forlizzi 2014; Petrelli and Whittaker 2010]. While our prompting activities align with the three fundamental qualities of probe methodology—being design oriented, concerning the users’ subjective world and being based on self-documentation [Mattelmäki 2005], our method deviates from the original function of probes in several ways. We use prompting activities to generate *information* rather than *inspiration* and to act as an agent for insightful dialogue with our participants, much like Crabtree et al. [2003] and Hemmings et al. [2002]. Unlike probe methodology, we remain collocated with our participants while they respond to our prompting activities and involve them in our process of sense making. In this section, we provide an overview of our procedure and the activities and materials that formed our study.

#### 3.1 Participants

Research sessions were conducted with 20 individuals (11 female, 9 male, aged 22-63) across September and October 2017 in Sydney, Australia. Recruitment was restricted to people who used technological products for both personal and professional purposes. We aimed to recruit a participant pool that contained an even mix of male/female, a spread of age and a range of professions. This was done to account for the richness of varying individual experiences rather than attempt to produce generalisable theory, much like Denegri-Knott, Watkins and Wood [2012]. Sessions took place in either the participant’s home or a private space near their workplace. All participants were recruited from the broader social networks of the researchers and came from a diverse range of professional fields such as engineering, education, IT, accounting and healthcare. As reward for their participation, a small donation of five dollars (AUD) was made to a charity of their choice.

#### 3.2 Procedure

We conducted semi-structured interviews and two prompting activities we describe as *association cards* and *meaningfulness ratings* that divide and compare the perceptions and value ascribed to physical and digital components of participants’ technological possessions. Participants were instructed to select their three most important technological possessions (e.g. phone, laptop, tablet, game console, e-book reader or camera) and if possible, bring them to the session. We asked participants to select possessions that were important rather than meaningful to allow for richer comparisons of product significance. These instructions were also deemed

more likely to include possessions used in a workplace that may also extend one's sense of self but are not often perceived as archetypal examples of meaningful possessions [Tian and Belk 2005]. Completion of the study, including prompting activities and interviews took between 30-60 minutes per participant.

### **3.2.1 Association Cards.**

The first prompting activity involved a series of *association cards* shown in Figure 1 that asked participants to list all associations that come to mind when engaging with one of three components (object, collection, item) of their selected technological possessions. We first deployed *association cards* in a study of physical objects [Orth et al. 2018] and have since iterated the cards to suit the comparative objectives of the reported study. This iteration process involved a piloting session in which eight individuals were asked to complete an object, collection and item association card by following the instructions written on each card. Amendments were then made to the design and phrasing of each card based on the feedback provided.

Associations are often discussed in attachment literature as a determinant of attachment and a key source of a possession's emotional value [Battarbee and Mattelmäki 2004; Kujala and Nurkka 2012; Mugge, Schoormans and Schifferstein 2008]. This includes ties to memories, loved ones, material and experiential qualities, usage scenarios and facets of self-identity. Associations can also arise from reflective thoughts and feelings or imagined futures derived from memories [Zijlema et al. 2016]. By asking participants to list associations, we intended to reveal differences in the ways in which each aspect of the possession is perceived and how these differences in perception translate to their assigned value. Participants were first asked to list associations related to the physical *object*. Second, they were asked to list associations related to a selected digital *collection* contained within the possession such as a library of music, photos, videos, games, podcasts, apps, programs, emails, messages, contacts or working files. Finally, they were asked to list associations related to a single digital *item* within the selected digital collection such as an individual song, photo, video, game, podcast, app, program, email, message, contact or working file. A complete overview of the activity, including descriptions of objects, collections and items was provided prior to completing any lists of associations. Participants were informed that associations may include memories, experiences, events, places, time periods, people, things, emotions, values, personality traits or qualities. Our instructions promoted the inclusion of responses ranging from specific to vague and from meaningful to mundane. These instructions remain open to a broad scope of associations beyond meaningful relationships as we were also interested in the perception of a possession in the absence of meaning to aid our comparative analysis.



<h2>Object Associations</h2> <p>Object description <u>iPhone</u></p> <p>List all of the associations that come to mind when engaging with this object. This can include memories, experiences, time periods, events, places, people, things, emotions, values, activities, personality traits or qualities.</p> <ul style="list-style-type: none"> <li>• Sleek</li> <li>• Polished</li> <li>• Overpriced</li> <li>• Fun</li> <li>• Entertaining</li> <li>• Communication</li> <li>• Fragile</li> <li>• Educational</li> </ul>	<h2>Collection Associations</h2> <p>Collection description <u>Podcasts</u></p> <p>List all of the associations that come to mind when engaging with this collection. This can include memories, experiences, time periods, events, places, people, things, emotions, values, activities, personality traits or qualities.</p> <ul style="list-style-type: none"> <li>• Travel</li> <li>• Entertaining</li> <li>• Insightful</li> <li>• Humorous</li> <li>• Educational</li> <li>• Road Trips</li> <li>• Motorway</li> <li>• Exercise</li> <li>• Internet</li> <li>• Reddit</li> <li>• Calm</li> <li>• Relaxing</li> </ul>	<h2>Item Associations</h2> <p>Item description <u>Myths + Legends</u></p> <p>List all of the associations that come to mind when engaging with this item. This can include memories, experiences, time periods, events, places, people, things, emotions, values, activities, personality traits or qualities.</p> <ul style="list-style-type: none"> <li>• Epic</li> <li>• Heroic</li> <li>• Humorous</li> <li>• Narrative</li> <li>• Travel</li> <li>• Exercise</li> <li>• Film/TV</li> <li>• Calming</li> <li>• Unique</li> <li>• Work</li> <li>• Fantasy</li> <li>• Educational</li> </ul>
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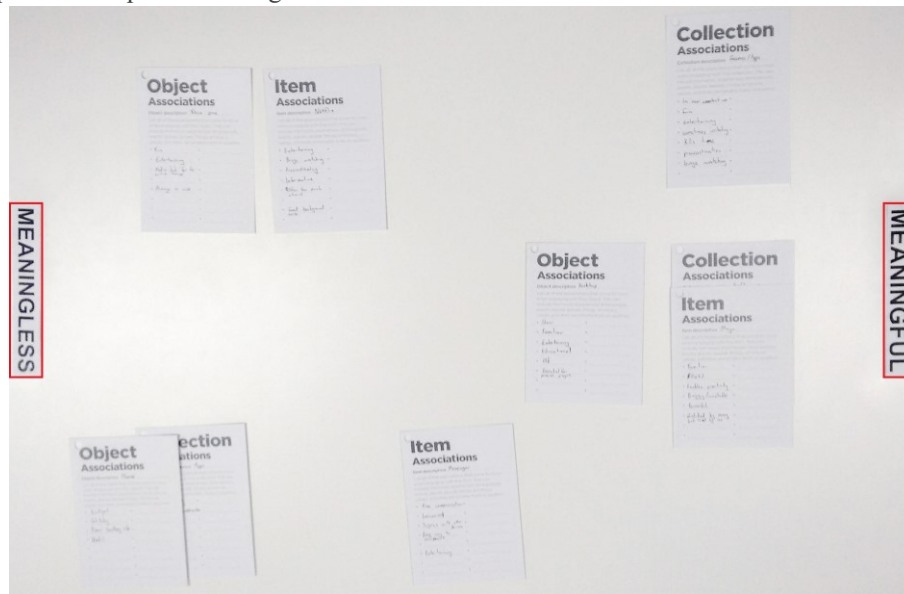
**Figure 1. An example of a participant's (P12) object, collection and item association cards describing the associations evoked by their smartphone.**

We distinguish between the physical and digital by referring to each as an *object* or *item* respectively. We found this phrasing to minimise confusion while piloting study activities as many people did not think of digital media as objects. Previous studies that intended participants to openly select physical and digital possessions have used inclusive phrasing by requesting *special things* [Petrelli and Whittaker 2010] which they suggest may have led to the inclusion of few physical photos and few digital collections of media. We also believed it was important to distinguish between digital contents as either collective or singular to better address our goal to understand the level of abstraction of attachment in physical and digital contexts. Digital collections and items are often studied separately or comparatively in the HCI community [Belk 2013; Feinberg, Geisler, Whitworth and Clark 2012; Petrelli and Whittaker 2010]. Due to the often-blurred boundaries between a digital collection and item we remained open in allowing participants to determine what they considered to be collective or singular. For example, a social media app may be considered a collection of conversations with friends or a single piece of software that belongs to a broader collection of apps used on the device.

### 3.2.2 Meaningfulness Ratings.

The second prompting activity asked participants to rate each of their object, collection and item association cards on a scale from *meaningless* to *meaningful*. We use these terms as an abstract measure of attachment that is consistent with the methodology of previous studies analysing people's relationship with technological possessions in an exploratory manner [see Blevis and Stolterman 2007; Denegri-Knott, Watkins and Wood 2012; Gegenbauer and Huang 2012; Odom, Pierce, Stolterman and Blevis 2009]. Studies aiming to quantify product-related attachments have traditionally assessed responses in relation to the criteria of *irreplaceability* [Kleine, Kleine and Allen 1995; Schifferstein and Zwartkruis-Pelgrim 2008; Schultz, Kleine and Kernan 1989]. This can be problematic when comparing the personal significance of physical and digital belongings as the irreplaceability of a digital possession can be difficult to conceptualise [Feinberg 2013] and may unduly influence participant responses. The concept of meaningfulness was seen to provide an even field of measure across physical and digital forms and to also provide an indication of emotional significance, a characteristic that is strongly correlated with measures of attachment [Ball and Tasaki 1992]. Participants were asked to discuss their interpretation of meaningfulness while completing their ratings to ensure there was consistency across responses. They were also instructed to rate the specific thing described in their card, for example, to rate the meaningfulness of their specific phone rather than phones in general. We adopted the usage of a spatial scale over the more commonly used Likert scale to offer participants a more intuitive approach to

comparatively consider each aspect of their technological possessions. Each card was plotted along a shared axis to emphasise comparative ratings.



**Figure 2. An example of a participant's (P15) spatial ratings from meaningless (left label) to meaningful (right label) for association cards relating to their smartphone, desktop computer and game console.**

### 3.2.3 Interviews.

We concluded by conducting semi-structured interviews with each participant to discuss their completed responses to the two prompting activities. Participants were asked to further explain each of the associations listed within their object, collection and item association cards. This was done to clarify the thought process that led to their inclusion, whether the association was personal or objective in nature and to determine its level of specificity such as whether it relates to a single or recurring experience. Finally, participants were asked to provide reasoning for the meaningfulness ratings given to each of the association cards. This included prompts to compare the ratings assigned to the object, collection and item associations of the same possession and ratings across all three selected technological possessions.

## 3.3 Data Collection and Analysis

Collected data included completed *association cards*, photos of each participant's *meaningfulness ratings* (as shown in Figures 1 and 2 respectively) and audio recordings captured during the interview sessions. All interviews were transcribed to provide further context in the coding of listed associations and analysis of self-reported reasoning for the value ascribed to product components in participants' *meaningfulness ratings*. Each listed association was coded by the first author using seven association categories derived from the meaning categories developed by Csikszentmihalyi and Rochberg-Halton [1981] and possession value categories developed by Richins [1994] respectively (see Table 1). Similar categories included in both aforementioned studies were merged to accommodate the broad scope of associations listed. The categories developed from these two seminal studies act as foundational theories of attachment literature and allow us to frame participant responses in relation to the meanings often assigned to non-digital possessions. We are then able to compare the types of associations evoked by the physical and digital components of technological possessions and determine whether these associations reflect variances in their assigned emotional value.

**Table 1. Association categories coding scheme derived from Csikszentmihalyi and Rochberg-Halton’s [1981] meaning categories and Richins’ [1994] possession value categories.**

<b>Association Category</b>	<b>Meaning Category</b> [Csikszentmihalyi and Rochberg-Halton 1981]	<b>Possession Value Category</b> [Richins 1994]
Utilitarian	Utilitarian	Utilitarian
Materiality	Style	Appearance-related
Literal	Intrinsic Qualities of Object	Financial Aspects
Symbolic	Associations   Personal Values	Identity
Memories	Memories	Personal History
People	Immediate Family   Kin   Nonfamily	Interpersonal Ties
Experiences	Experience	Enjoyment

Each category was further defined and supplemented with model examples to create clear distinctions between related categories (see Table 2). Transcripts from each of the conducted semi-structured interviews were referred to throughout the coding process to verify the nature of each association. This was a necessary step as the word or phrase included in association cards were often ambiguous when considered without context. For example, *holiday* could be a symbolic association to leisurely travel or refer directly to memories from a specific trip.

**Table 2. Descriptions and examples of coded responses for the seven association categories.**

<b>Category</b>	<b>Description</b>	<b>Examples</b>
Utilitarian	What it provides (efficiency, performance, features)	powerful, water-resistant, reliable <i>“it’s quite slow and annoying”</i> [P2, tablet]
Materiality	What it is (appearance, style)	sleek, colourful, thin <i>“it’s a minimalist design”</i> [P9, smartphone]
Literal	What it consists of (description, factual)	email, movies, camera <i>“I have all my lesson plans on it”</i> [P18, USB drive]
Symbolic	What it represents (abstract concepts, values)	career, travel, knowledge <i>“this movie came from my childhood”</i> [P2, movie]
Memories	What memories it triggers	wedding, Japan, birthday

Category	Description	Examples
	(events, time periods, experiences)	<i>“we were in a small town that sold pottery”</i> [P17, photo]
People	Who it brings to mind (family, friends)	family, friends, mentor <i>“my fiancée bought it for me”</i> [P11, laptop]
Experiences	What is done / how it feels (activity, emotions)	communicating, fun, relaxing <i>“the music can calm me down”</i> [P6, music library]

## 4 FINDINGS

In this section we present our findings that resulted from the prompting activities and interviews conducted with our 20 participants. We provide an overview of the types of devices and digital media (both digital collections and digital items) selected and the respective associations listed. We then provide a summary of participants’ spatial ratings for possessions that were considered highly meaningless or meaningful and compare the rationales provided in relation to the meaningfulness of a possession’s physical and digital components.

**Table 3. Most frequently selected categories of devices and media in absolute number and percentage.**

Physical Devices (n=54)		Digital Media (n=108)	
Phone	20 (37%)	App/s	32 (30%)
Laptop	15 (28%)	Program/s	25 (23%)
Desktop	5 (9%)	Photo/s	17 (16%)
Tablet	3 (6%)	Working file/s	11 (10%)
Camera	2 (4%)	Video/s	7 (6%)

A total of 54 technological possessions were discussed in the study. In some cases, participants were only able to select two possessions of which they could complete an object, collection and item association card. Participants primarily selected their most prevalent and frequently used possessions. The five most commonly selected devices and media are outlined in Table 3. All participants selected their phone as their primary device. Other possessions selected included game consoles, smart TVs, GPS units, hard drives and e-book readers. Other digital collections or items contained within these possessions that were selected included games, music, podcasts and e-books.

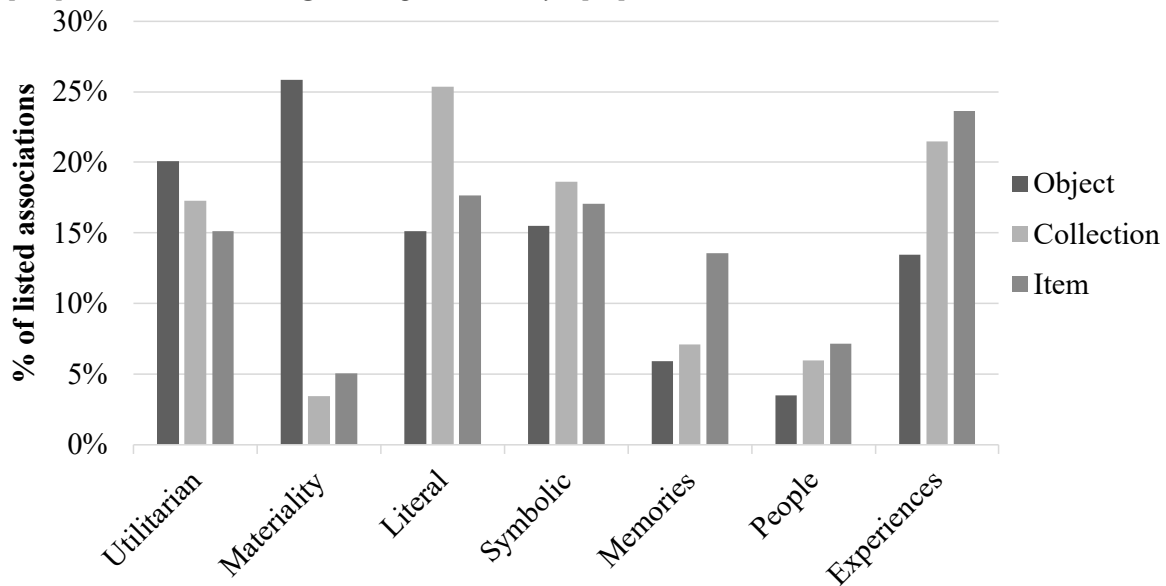
### 4.1 Association Cards

Each of the 54 technological possessions were reported on through the completion of an object, collection and item association card. A total of 1579 associations were listed within the 162 completed association cards, an average of nine associations per card. Each of the three components of the technological possessions addressed received a similar number of listed associations (542 object, 521 collection and 516 item associations). Out of the 1579 associations, 11 were omitted as they did not fit within any of the seven

association categories. These omitted associations consisted of thoughts loosely related to the possession in question and were deemed irrelevant to the objectives of the study.

#### 4.1.1 Object, Collection and Item Associations.

The types of associations listed within the three product components: the physical object, digital collection and digital item were relatively consistent, as seen in Figure 3. Notable differences in the frequency of associations within each category relate most to the *materiality*, *memories* and *experiences* that come to mind when engaging with either the physical, collective digital or singular digital. Associations relating to *materiality* were frequently mentioned in relation to the physical form of the device such as its size, colour, texture, weight or form. In our coding process, *materiality* included all references to sensory properties, allowing for equal representation among the three components. For example, a digital photo could be *colourful*, a song could be *upbeat*, or an app could be *sleek*. Despite this, digital collections and items were often not described in this way. Digital components were associated with both *memories* and *experiences* more frequently than the physical device, a finding that contrasts previous studies comparing peoples’ use of physical and digital possessions as mementos [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Petrelli and Whittaker 2010]. In particular, digital photos frequently evoked vivid recollections of personal history: “it captures a moment in time and a specific event, our friend’s wedding, and I can remember where it was [and] what we were wearing on that particular day” [P4].



**Figure 3. Percentages of listed associations coded in each category for physical objects, digital collections and digital items.**

In our analysis of the 1579 associations listed by our participants we did not encounter specific references to the self, which was surprising given its prevalence as a signifier of meaning found in previous studies of attachment [Csikszentmihalyi and Rochberg-Halton 1981; Golsteijn, van den Hoven, Frohlich and Sellen 2012; Richins 1994]. This was likely due to the nature of the *association cards* task, asking for a broad range of thoughts brought to mind by possessions rather than prompting participants to more directly reflect on their possessory relationships. Interviews conducted with participants to discuss and elaborate upon the listed associations revealed several ways in which their possessions held significant ties to aspects of their self-identity that are not conveyed in the adopted coding scheme. Both physical and digital components were associated with characterising a participant’s identity: “those photos are a part of the meaning of who I am. They help define me” [P16, photos] and expressing a sense of self: “it’s like a bit of you imparted on to it because you picked out everything and you assembled it” [P14, desktop computer]. Connections to significant aspects of a person’s identity were also found to provide unifying associations to the physical and

digital components of a possession, for example P12's game console and games collection similarly representing an aspect of his identity: "I've kind of always personally identified as a gamer".

#### **4.1.2 Physical and Digital Associations.**

In most instances, the associations reported for the physicality of a possession had little to no relation to the digital contents they expose. For example, P7's laptop was described as *lightweight*, *sleek* and *silver* while the music library stored on its hard drive was associated with *university*, *friendship* and *gossip*. Similarly, P1's camera was described as *robust*, *water-resistant* and *expensive* while the photos stored within were associated with *Chinese New Year*, *hard work* and *Sydney harbour*. This separation of associations may be less prevalent in other forms of technological possessions that were not reported such as wearable devices that more directly pair physical interactions with digital information. The few examples we found of physical devices with associations relating to their digital contents were often nonspecific such as a phone being *convenient* (P16) or *entertaining* (P12). This inconsistency in the ways in which the physical and digital components of a technological possession are perceived has not yet been addressed by the HCI community. Efforts to understand differences in object form have predominantly explored differences between possessions that are purely physical or digital [Atasoy and Morewedge 2017; Belk 2013; Denegri-Knott and Molesworth 2010; Gruning 2018; Odom, Zimmerman and Forlizzi 2014; Petrelli and Whittaker 2010]. Those that do consider technological products often frame them as singular possessions akin to physical products [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom and Pierce 2009; Turner and Turner 2013]. We elaborate further upon differences in the perception of physical and digital components of possessions in section 6.1 to outline a number of unique characteristics of attachments to technological possessions.

## **4.2 Meaningfulness Ratings**

All participants were able to interpret and complete the task of rating the meaningfulness of physical and digital components of their possessions. In most instances, participants positioned their association cards throughout the full spectrum of the spatial scale. As these ratings are subjective in nature, we avoid making claims of the broader significance of these possessions and instead focus on the comparative value participants ascribe to the physical and digital components in relation to one another. Broadly speaking, the reported meaningfulness of a physical or digital component was not found to correlate with differences in the types of associations it brought to mind. The exception to this is seen with digital items rated highly *meaningful* containing associations to *memories* four times more frequently than digital items rated highly *meaningless*. This aligns with previous findings that memories are often a key determinant of attachment [Csikszentmihalyi and Rochberg-Halton 1981; Page 2014]. While participants were instructed to rate the meaningfulness of their specific object, collection or item, this was found to be difficult to do in isolation from its broader value. In many cases, participants described the value of the product category or brand of their specific device: "all of the other products I have are Mac so there's just a general trust with that product" [P2, phone]. This issue of singularity was particularly difficult to define in the context of digital media with participants often valuing a song or movie highly whilst seeing their specific copy as replaceable.

#### **4.2.1 Physical and Digital Meaning.**

Digital contents were generally considered to be more meaningful than the material device. The physical object was rated less meaningful than both its collective and singular digital contents in 33 instances (61%). The majority of these physical devices contained a broad scope of digital functionality and media that extended beyond the specificity of the digital contents addressed in our study, for example a phone containing collections of apps, music, photos and videos. However rather than being assigned greater significance for their broader value and prevalent usage in daily life, the physicality of these possessions was often considered to be meaningless and replaceable. In contrast to this, both collective and singular digital contents were considered highly meaningful for their associations to memories, experiences, emotions, goals, values and aspects of identity. This finding addresses gaps in our understanding of attachment in the context of technological possessions. Several prior studies concluded that people do not value their digital possessions as highly as their physical possessions [Atasoy and Morewedge 2017; Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom and Pierce 2009; Odom, Pierce, Stolterman and Blevins 2009; Petrelli and Whittaker

2010]. While these studies provide a comparative analysis of the different categories of possessions, they do not delve into the complex and unique nature of attachment when both physical and digital forms are integrated within a single possession.

When discussing why they assigned little value to the materiality of their technological possessions, many participants described their devices as interchangeable or replaceable: “*you can just go get another one so they’re totally meaningless [...] it’s just a point-in-time object*” [P16, phone]. This finding aligns with the conclusions of previous studies that describe people’s perception of technological possessions as important but highly replaceable [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom and Pierce 2009]. Our results do however convey a more nuanced view of this category of products in which we place greater emphasis on their physical (carrier) and digital (content) duality. This may be due to increases in the usage and prevalence of digital services and technologies since these studies were conducted. Participant responses revealed that technological possessions do hold personal meaning, but this meaning is ascribed at a level of abstraction beyond the singular physical object.

#### **4.2.2 Meaninglessness and Meaningfulness.**

Participant’s rationale for rating a product component either meaningless or meaningful varied across the object, collection and item categories. As mentioned in the previous section, the physical object was often rated meaningless when it was seen to be interchangeable or replaceable. Other examples include devices that were rated poorly due to their functional decline. Digital collections and items were both similarly considered meaningless when they related to an aspect of life that was not perceived as significant for the individual such as TV shows and movies watched for entertainment (P10) or programs and working files used in a professional role (P9).

Objects were considered highly meaningful for a variety of reasons. This included the importance of how it was acquired such as memories associated with receiving it as a gift or the monetary expense involved in its purchase. In other instances, devices empowered participants through their functionality: “*it’s a multi-task object that allows me to do so much that does add meaning to my life*” [P18, laptop]. The materiality of a device was rarely mentioned as a source of meaning. An exception to this was seen in P14’s relationship with his custom-built desktop computer: “*there’s a connection because I built it and because I put the effort in and I selected the parts*”. Digital collections differed in value depending on their nature as either engaging or reflective media. Engaging media such as programs or games were considered highly meaningful for what they enable: “*without that, we can’t run our business*” [P4, IBM programs] and the investment made by the individual: “*a lot of time and effort has gone into those*” [P15 – games library]. Reflective media such as photo albums were valued highly for the memories they represented and the personal history they record. Highly meaningful digital items were often described as irreplaceable: “*you can’t replace a wedding photo. If you lost it, you can’t recreate the moment*” [P1, photo]. This included media that contained records of a personal history and social ties such as messages and conversations with close friends and family.

In the few cases of the physical and digital components of a possession being rated similarly meaningful, consistent associations were found to relate to the symbolic and experiential value of the possession. For example, a phone used to stay in touch with friends being associated with *connectedness* or a personal laptop used to unwind after a day’s work being associated with *relaxing*. The most notable example of this is seen with P7’s phone in which both the device and the digital contents were associated with *family, friends, travelling* and *photos*. These symbolic associations created a unified sense of meaningfulness, blurring boundaries between the physical and the digital.

## **5 DISCUSSION**

Our primary research goal within this project was to address the question of why people do not develop attachments to technological possessions in the same way they do to purely physical possessions. To do so, we built upon the work of Feinberg [2013] to explore the ways in which people perceive and value their technological possessions, comparing both physical and digital components of the possession. This was done to better understand where the attachment lies within these possessions to provide insights on how designers can create technological products with lasting meaning. In this section, we reflect on our use of prompting

activities to generate rich data and propose several approaches for designers to create lasting devices within this increasingly prevalent design space.

## 5.1 Reflections on our Prompting Methodology

We employed two prompting activities, *association cards* and *meaningfulness ratings* to accompany our interview sessions that explored differences and similarities in the ways in which people think about and value the physical and digital components of their technological possessions. These prompting activities were developed to uncover insights that may be overlooked in solely conversational methods of inquiry. Previous studies that discuss the meanings of digital possessions have found participants to be initially dismissive of their meaning [Petrelli and Whittaker 2010] and reluctant to admit they hold personal significance [Orth and van den Hoven 2016]. The idiosyncratic complexities of attachment experiences can also be difficult for people to describe [Richins 1994]. Prompting activities can provide participants with a less formal method of communicating their thoughts and feelings to bring forth insights that might otherwise remain unsaid [Wallace et al. 2013]. Our research sessions conducted with participants began with the association cards activity openly inquiring about the thoughts evoked by technological possessions without assessing the personal significance of these thoughts. More narrowly framing our association cards on the meanings of participant's possessory relationships with their technological belongings—a category of products that has been found to often hold little personal significance [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Odom and Pierce 2009]—may have filtered out data that would otherwise provide insights relevant to our research objectives.

Several limitations to the prompting activities we developed were brought to light through reflecting on our findings. While participants were instructed to repeatedly report associations that come to mind at both the physical and digital level in completing Object, Collection and Item association cards, the free listing component of this activity predominantly emphasises variance in responses [Quinlan 2017] and may have led to fewer instances of repeated associations. We also found our analysis of data generated by the two prompting activities relied heavily on the proceeding discussions held with participants to further clarify, rationalise and articulate their responses. As an example, responses listed within our association cards did not provide clear ties to identity-based motivations such as characterising, expressing or developing a sense of self, despite the centrality of these behaviours in attachment literature [Belk 1988; Csikszentmihalyi and Rochberg-Halton 1981; Kleine, Kleine and Allen 1995; Richins 1994; Schultz, Kleine and Kernan 1989; Zimmerman 2009]. Explicit ties between reported possessions and aspects of a participant's self-identity were only revealed through elaborating on listed association and meaningfulness ratings in proceeding interview sessions. This suggests our prompting activities were susceptible to providing misrepresentative data if used as standalone methods for acquiring either information or inspiration for design processes and should instead be seen as supplementary tools to conversational methods of inquiry.

This does not necessarily detract from the potential worth of exploring new uses for prompting activities in data collection processes. The spatial layout of association cards conducted in our meaningfulness ratings activity often acted as a prop to our conversations with participants, allowing us as researchers to identify patterns for further inquiry and allowing participants to reflect upon, compare and adjust their responses in real time. The positioning of ratings spatially within a shared scale emphasised comparing and weighing responses against one another. By providing physical points of comparison, we found participants were motivated to identify underlying reasons for personal significance, enhancing the clarity and certainty of their judgements. Through completing our prompting activities, participants were guided through a process of conceptually distinguishing between physical and digital components of their belongings. They were then able to clearly articulate these distinctions, providing rich accounts of the thoughts and meanings evoked by their technological possessions. We advocate the merit of further exploring the use of prompting activities to sensitise participants to complex concepts related to personal human experiences and enrich researcher-participant dialogue.

## 5.2 Designing Technological Products with Lasting Meaning



Our findings suggest that the physicality of technological products is often perceived to be meaningless and highly replaceable despite their importance and prevalence in the daily lives of users. This echoes a broader concern for the rate of consumption and disposal of technological products within the HCI community [Gegenbauer and Huang 2012; Huang and Truong 2008; Odom and Pierce 2009]. Addressing concerns related to the longevity of a product produces additional requirements to the goal of creating meaningful products. Meaningful possessions are not inherently perceived as irreplaceable [Grayson and Shulman 2000]. To become an irreplaceable possession, the meaning and the specific object must be inseparable, otherwise the possession can be replaced by another that conveys the same meaning [Mugge, Schoormans and Schifferstein 2008]. To create lasting technological products, designers must ensure a product is perceived to be meaningful and for this meaning to be assigned to the specific object.

### **5.2.1 Lasting Symbolic Associations.**

Many of the possessions discussed in our study were predominantly valued for their functionality or digital contents. Previous studies have emphasised that for a physical possession to be considered irreplaceable, it must be valued for its material qualities as opposed to its functionality or symbolic meaning [Mugge, Schoormans and Schifferstein 2008; Odom, Pierce, Stolterman and Blevis 2009; Verbeek and Kockelkoren 1998]. Functional and symbolic qualities are argued to be vulnerable to replacement by new products that can perform similar functions or express similar characteristics of the user. While our findings support this conclusion of the replaceable nature of a possession's functional value, our in-depth analysis of the associations surrounding technological possessions suggests a more nuanced and optimistic stance on lasting symbolic value.

The symbolic associations reported by our participants related to either the present or their past and anticipated future. Symbolic associations linked with the present encompass the lifestyle and day-to-day activities performed by the user, such as a laptop used for keeping in touch with friends or while working in a corporate environment. We argue that this type of symbolic meaning is vulnerable to replacement as it relates purely to on-going aspects of the user's identity that can be characterised by any product that is used for the same goal-oriented purpose or reflects the same role. In contrast to this, symbolic associations linked to a user's past or future such as their personal history, experiences, memories or hopes for the future are much more difficult to replace as they relate to unique, specific aspects of identity such as the user's childhood or a trip taken overseas.

While symbolic associations often develop from the proximity of a possession to a source of meaning [Belk 1988], such as a pair of gloves worn whilst gardening or a photo taken at a friend's wedding, they can also arise from product properties that are a direct result of design decisions. Perceptions of a product's aesthetic properties such as form, colour, texture and size or the experience of use both produce an array of associations that vary from indistinct values to specific memories [Allen 2002]. Designers can create products that develop personal symbolic associations by employing an empathic approach to tap into the meaningful imagery already in the minds of intended users [Orth, Thurgood and van den Hoven 2018].

### **5.2.2 Meaningful Integration of the Physical and Digital.**

In this section, we aim to expand on Golsteijn et al.'s [2012] discussion of the value of meaningful integration of physical and digital product components. We found distinct differences in the ways in which people describe and value the physical and digital components of their possessions. Both the physical object and digital contents stand to benefit from being more cohesively perceived and valued. Within our study, digital contents were at times seen to be irreplaceable and a rich source of meaning. Music libraries and photo albums reflected a rich personal history that continued to evolve with each new experience. This meaning however was disconnected from the value assigned to the physical device that enabled these experiences. In their exploration of ownership experiences of consumers and their digital virtual goods, Denegri-Knott, Watkins and Wood [2012] found the meaning assigned to personal data to be seamlessly transferable from one device to another. They argue that this leads to a significant amount of the meaning assigned to a technological product to be independent from any given device.

Many researchers within the HCI community have explored ways to more closely integrate the physical and digital components of a technological product [Dourish 2004; Fitzmaurice 1996; Golsteijn, van den

Hoven, Frohlich and Sellen 2014; Hornecker 2015; Ishii and Ullmer 1997; Kirk and Sellen 2010; van den Hoven and Eggen 2004; van den Hoven et al. 2007; West et al. 2007]. While this was initially done with the intention of improving the usability of the system [Fitzmaurice 1996; Ishii and Ullmer 1997], it may also improve the emotional value of the device itself. By more closely linking the physical device with its digital contents, the meaning assigned to these contents will be more likely to be associated to the specific object, potentially delaying its replacement. Conversely, materialising the meanings assigned to digital contents would provide additional properties that allow for a richer attachment experience. Our findings from coding participant's listed associations revealed that digital collections and items were rarely thought of in relation to their aesthetic and sensory properties. Materialising digital media brings forth temporal elements such as ageing with the passage of time and containing traces of usage as well as a stronger sense of ownership from its singular form [Odom, Zimmerman and Forlizzi 2014]. It also allows for greater presence in the day-to-day lives of users [Kirk and Sellen 2010] and the opportunity for public display that can evoke feelings of pride [Brown and Sellen 2006]. While photos are easily displayed and shared with others via social media, other digital media such as meaningful programs, games, working files or music remain hidden on personal devices.

## 6 FUTURE IMPLICATIONS

In this section, we use complimentary findings from each of our study activities to outline several unique characteristics of attachment in the context of technological possessions and propose a number of design themes for materialising the meaningful associations that people ascribe to their digital media. These characteristics and design themes are intended to further inform HCI and design practitioners seeking to address unsustainable consumption behaviours by creating technological products that have value assigned to their singular physicality.

### 6.1 Characteristics of Attachment to Technological Possessions.

Our study encouraged participants to isolate and compare the physical and digital components of their technological possessions to better understand their relative significance. We found the digital components of these possessions to be rated more meaningful than the physical components in most instances. We also found associations evoked by the physical and digital components of a possession to often be unrelated. Similarly, technological possessions were found to evoke highly diverse ranges of associations. We build upon these three key findings to argue that the duality of technological products creates a number of fundamental differences to purely physical or digital products that in turn influences the ways in which people ascribe emotional value. These differences bring into question the transferability of findings from the study of purely physical or digital possessions in aiding designers seeking to create technological products with lasting meaning. The characteristics of attachment to technological possessions detailed in this section aim to highlight the opportunities, challenges and expected outcomes for designers seeking to promote attachment in the growing technological sector.

#### 6.1.1 From Singular Devices to Systems of Products.

There were often distinct divisions between the associations and meaningfulness of a possession's physical and digital components. A laptop may be described as *powerful*, *sleek* and *expensive* while the music library stored on its hard drive may be associated with *cooking*, *motivation* and *travel*. The responses provided by our participants often suggested a conceptual separation between the device itself and its contents, both in the thoughts they brought to mind and the value they were assigned. P1 conceptualised his devices as *tools*, his digital collections as *gateways* and his digital items as "*what you're trying to get to*". P19 drew distinctions within his phone in a similar light to the human mind and body, describing the device itself as the *mechanical level* and digital contents as the *spiritual level*. This suggests that technological possessions are in many cases perceived as a *system* of products rather than as a singular device. In this way, we see technological possessions to be more akin to the product-system existing within a wardrobe rather than the singularity of a car assembled from many parts. A wardrobe may contain a wide range of clothes that come together to form an array of outfits. These items of clothing and the outfits they form can hold singular or

collective meanings that are entirely devoid of reference to the wardrobe in which they are stored and accessed from. Similarly, the meaning assigned to a phone for its role in facilitating social connections may not be tied to the phone itself as a specific object, but rather to the apps and chat history stored within it and the empowering functionality of phones in general, as was found by Vincent [2006] and Meschtscherjakov, Wilfinger and Tscheligi [2014]. Conceptual distinctions between physical and digital product components may alter the level of abstraction of a possession's meaning to its user. Existing conceptual barriers from studies of physical objects distinguish between meanings assigned to the specific object, the product brand, the product category and to objects in general. HCI research has recently explored distinctions between attachment to a digital possession, a digital collection and the *intellectual work* [Feinberg 2013]. Our findings suggest there is a need for distinctions between the hardware and software of technological possessions in studies that report on their assigned meaning as these components were perceived as separate entities within a system. Our object, collection and item association cards provided initial traces of the assignment of meaning within the physical-digital product system. Establishing clear divisions between the various levels of abstraction in which meaning may have been assigned remains a difficult task, especially for devices that make use of ubiquitous technologies such as cloud-based storage or online streaming services. Our findings showed that in most instances, greater emotional significance was assigned at the digital levels of abstraction. We do not see this as a limitation for designers seeking to create meaningful technological products, however it does place much greater emphasis on the question, at what level of abstraction will meaning be assigned?

### **6.1.2 Diverse Meanings.**

Technological products are used for a vast array of purposes that relate to personal, social and professional goals. They have become central to the ways in which people communicate with others, conduct business and spend their leisure time by containing and providing access to a vast range of digital functions and media. The breadth of usage of these devices extends further than any non-digital product. The results obtained through our use of *association cards* highlight the broad prevalence of the technological possessions selected by our participants. The distribution of listed associations across meaning categories derived from prior studies of attachment [Csikszentmihalyi and Rochberg-Halton 1981; Richins 1994] showed a high level of diversity in the thoughts brought to mind by the selected technological possessions. One hundred and forty (85%) of the completed association cards included associations that spanned across at least three of our seven association categories (Utilitarian, Materiality, Literal, Symbolic, Memories, People and Experiences). These ties often included references to unexpected and seemingly unrelated aspects of the user's life. For example, P19 associated a navigational app on his phone with *family* due to its usage in trips taken to visit extended family members. The lists of associations generated by our participants reflect the ways in which technological possessions develop a diverse array of meanings for their owner. These possessions were found to no longer fit traditional object categories proposed in early attachment studies that distinguish between sentimental, utilitarian, aesthetic, social and monetarily valued objects [Richins 1994]. Possessions were valued for their pleasing aesthetics, empowering functionality and links to emotive experiences, engaging activities and relationships with loved ones. These divergent meanings vary in significance but ultimately contribute to the overall perceived value of the possession [Orth and van den Hoven 2016].

We found the widespread usage of many technological possessions led their value to be associated with several facets of a user's identity such as a laptop used for both professional work and personal entertainment: "*you can put podcasts on it, movies on it, make games on it, communicate...*" [P12, laptop]. Many possessions were associated with several facets of life, including personal (e.g. *entertainment, relaxation*), social (e.g. *communication, gift*) and professional (e.g. *work, study, job-seeking*) activities. In contrast to this, possessions are often used to help define and in turn create distinctions between identity roles that may contrast with one another, for example being both an *aggressive* financial trader and a *compassionate* father [Reed et al. 2012]. While the diversity of meanings we observed add richness to the emotional value of these possessions, they may also diminish the clarity of their role in the characterisation and development of a sense of self for the user [Tian and Belk 2005]. Defining and segregating personas and identity roles through the use and ownership of objects has been argued to be increasingly difficult in digital contexts [Belk 2013]. Our findings suggest this may be a consequence of the diverse thoughts, memories, emotions, people and

activities that become associated to technological possessions through their rich involvement and prevalence in personal, social and professional experiences.

### 6.1.3 Dematerialising and Dispossessing Meaning.

Our study was inspired by Feinberg's [2013] questioning of the abstraction of people's attachments to technological possessions. We found varying levels of abstraction of attachment at both the material and digital level. This consequently leads to changes in the experience of attachment to a possession and the outcomes that can be expected from designing meaningful technological products. Past studies of physical products have concluded that attachment often develops over time through the on-going presence and usage of a product in meaningful scenarios [Mugge, Schifferstein and Schoormans 2005]. This would suggest that the ubiquity and physical intimacy of devices such as phones should lead to strong feelings of attachment as they are centrally involved in many significant aspects of a person's life such as staying connected with friends and family [Golsteijn, van den Hoven, Frohlich and Sellen 2012; Meschtscherjakov, Wilfinger and Tscheligi 2014]. In contrast to this, we found many participants to consider their selected devices to be highly replaceable.

While we believe technological products can hold strong emotional value to users, this value appears to often be assigned at a level of abstraction beyond the specific, owned object. We found participants to often value a device for *what it provides* rather than *what it is*, a distinction that has been presented as a key factor in the rate of technological product consumption [Borgmann 1984; Odom and Pierce 2009; Verbeek 2005]. Several participants discussed differences in the value they assigned their specific device and the broader product category it belongs to. P2 had developed an attachment to her phone's brand rather than the phone itself: "*I'm not loyal to this phone in particular [but] I would always want to go back to a Mac phone [...] there's just a general trust with that product*" [P2]. P6 recalled a rich history of moments shared with his phone, but held no attachment to it as he felt the memories it cued could also be evoked by a replacement. The meaning assigned to the physicality of these possessions is therefore *dematerialised*. It does not relate to the product's materiality but rather its functionality or brand, which can be replaced by any other similar product. We do not see the dematerialising of meaning to *diminish* its worth, however it does raise issues in addressing sustainability challenges such as the rate of product consumption [Huang and Truong 2008]. Many researchers within HCI have explored design strategies for promoting attachment primarily for its potential to address sustainability concerns [Gegenbauer and Huang 2012; Odom and Pierce 2009], yet the sustainable value of attachment arises predominantly when meaning is assigned to the singularity of the device.

Digital photos, songs, videos, working files, apps, programs and games were highly valued by participants, however the singularity and sense of ownership attributed to these digital items was often blurred. Participants often had copies of these possessions either backed up on a separate hard drive, stored in a cloud-based platform or readily available to stream online. With the transition to cloud-based storage, online streaming services and collaborative consumption practices, the value of digital items has been argued to have less to do with *ownership* and more to do with *accessibility* [Belk 2014; Odom, Zimmerman and Forlizzi 2014]. The owned mp3 copy of a song may be no more meaningful than any other digital instantiation of the same song. In this way, the meaning assigned to the digital nature of these products is often *dispossessed*. We found evidence to support this in participants' frequent referral to meaningful *experiences* rather than meaningful *possessions*: "*whenever I listen to this song, it empowers me*" [P6], "*I really enjoy the feeling of playing it. I get really immersed in it*" [P12, role-play game]. Digital media was often valued for enabling users to communicate, listen, create, curate, read, learn, play and reminisce.

## 6.2 Design Themes for Materialising Digital Meaning

Designers seeking to create lasting technological products must consider both its meaningfulness and irreplaceability in the eyes of the user. We propose that designers can materialise the meaningful associations ascribed to digital media as a strategy for both integrating physical and digital components and creating a source of value for the physical device that is long-lasting. Instead of designing new meanings, this strategy aims to strengthen the linkage between the physical object and the personal meanings already tied to its digital contents. Meaningful associations facilitate the formation of emotional value in a possession through

its ability to characterise and communicate significant memories, experiences and values held by the user. The results of our study suggest that designers seeking to create technological products with unified meaning must evoke associations that are specific enough to hold personal meaning for the individual, yet abstract enough to be homogeneously tied to physical and digital elements of the possession. This balance can be achieved through ties to the product's experiential value, such as the relaxing act of listening to music with an mp3 player, or symbolic value, such as a camera used and resulting photos taken whilst travelling.

Technological products are a diverse category of objects that is continually expanding in both form and digital functionality [Vallgård and Redström 2007]. This diversity requires designers to adopt a flexible design approach that considers the most appropriate means for meaningful integration of physical and digital components. We conclude by providing six design themes to illustrate several ways in which designers can materialise the meaningful associations ascribed to digital contents within this diverse category of products.

### **6.2.1 Design Theme: Meaningful Containers**

Many of the widely adopted technological products currently available are centred on their digital functions. This theme is motivated by our results in which a possession was largely valued for the meaningful contents within such as photos, music or apps. There is opportunity for designers to explore the quality of *containing* as a means for materialising meaningful digital associations. We return to our example of the container-contents product system seen in a personal wardrobe. The clothes stored within a wardrobe can hold collective meanings such as an assembled outfit worn in a work environment to express professionalism or singular meanings such as a sweater received as a gift from a loved one. While it may contain meaningful contents, the wardrobe itself may be considered a meaningless storage commodity. Designers should therefore seek to create cohesive value within the entire product-system by designing *meaningful containers* that become deeply connected with their meaningful contents. The design of technological products that are primarily used as containers of digital media such as external hard drives or USB flash drives can take inspiration from the emotional value of one of their predecessors, the family photo album. As a product category, family photo albums have been known to hold significant sentimental value. The photos contained within these family photo albums may be considered precious and irreplaceable. The album itself is imbued with these attributes by serving as a protective shell, with certain material qualities such as a leather-bound exterior further reinforcing its authenticity as a container of cherished memories. Designers of technological products can similarly explore the relationship between container and contents to create meaningful physical containers that are imbued with the personal meanings of their digital contents.

### **6.2.2 Design Theme: Meaningful Enablers**

Digital media is often accessible across multiple devices via the usage of cloud-based storage and online streaming services. The transient nature of the digital contents accessed from a device can undermine its singularity as a meaningful container. This theme is motivated by numerous descriptions of digital media being valued for the actions they facilitate. In these cases, the primary value of the physical device is *enabling* users to view, listen, read, play, communicate, create, curate, explore, learn and reminisce. This enabling functionality allows users to engage in meaningful actions. Devices could be designed to associate more directly with these meaningful digital actions, for example designing an e-book reader to embody the *learning* and *self-improvement* experienced by P11 whilst reading one of her e-books. A user's collection of digital media is also continuously evolving over time, as existing media is altered, or new media is acquired. Designers seeking to materialise the meaningful associations assigned to the digital contents of a product should therefore adopt a dynamic (rather than static) approach. This can be achieved by capturing the broader significance of digital collections rather than specific temporal experiences. These broader meanings allow for evolving ties to the digital contents meaning that avoid becoming outdated over time. For example, designing a music player to associate with the *motivation* and *inspiration* that P14 experiences whilst listening to his personal music collection. These meanings are not tied to a specific digital item, but rather the continuously evolving meaning of the collection as a whole.

### **6.2.3 Design Theme: Temporal Form**

A key characteristic of technological products that influences their perceived unification is the *singularity* of their material form and *multiplicity* of their digital information. This theme is motivated by the lack of meaning that participants assigned to devices that contain and enable access to a vast array of meaningful digital contents. Interactive devices often make strong use of *temporal form* to move between different sensorial expressions of their contents, such as the pixels on the screen of a digital photo frame that change to display each of the contained photos. This allows the material form of a device to alternatively represent singular digital items. The temporal form of many interactive devices allows for richer experiences than static objects [Vallgård et al. 2015], however their universal and transient nature may hinder the process of acquiring meaningful ties to the digital items they reveal. Temporal form can be used to construct unifying links between collections of digital media, such as a digital photo frame that transitions between photos in a way that communicates a story beyond the individual captured moments. This could be in the form of a chronological retelling of a person's life or the sequencing of a particular event such as a wedding. More novel technological products may utilize technologies to create three-dimensional temporal forms that unify physical and digital components. Vallgård, Winther, Mørch and Vizer [2015] explored the use of a shape-memory alloy and several servomotors to create boxes that transition between abstract forms in a way that evoked viewers to perceive the order of movements as telling a story. The development of such shape-changing interfaces has become an ongoing research interest within the HCI community [Rasmussen et al. 2012].

### **6.2.4 Design Theme: Physical-Digital Collections**

Materialising collections of digital media in a meaningful way could be achieved by dividing the singular device into a collection of physical objects [van den Hoven and Eggen 2004]. This theme is motivated by the frequency of multi-functional devices such as mobile phones containing a diverse range of meaningful digital media but ultimately being perceived by participants as generic possessions. By dividing the materiality of a device into a collection of objects, each object can be designed to more directly embody a specific digital collection. For example, digital photo albums could be divided and stored on a range of unique physical tokens that each relate to the event or time period at which they were taken such as unique souvenirs from various holidays. This allows the physical device to more clearly materialise specific experiences within a broader collection of personal history. Several existing research projects have explored this type of system, such as the *Chameleon Table* by van den Hoven and Eggen [2004] that allows physical souvenirs to be placed on a table to interact with digital photo albums. Similar projects have explored the merit of re-materialising digital music libraries, such as the *Tangible Jukebox* [Gallardo and Jordà 2010] that uses paper cards to represent playlists and operate controls on a multi-touch surface.

### **6.2.5 Design Theme: Embodying Aspects of Identity**

This theme is motivated by the numerous descriptions of media containing meaningful ties to a particular aspect of the participant's identity, such as their profession or role as a parent. The material properties of a device could be designed to encompass abstract, open-ended associations to the personal history and identity of the user enacted through their engagement with the digital contents. This could be achieved through data materialisation methods such as creating a patina from a cyclist's journey data [Lee et al. 2016] or smart textiles that contain digital story recordings [ten Bhomer 2016]. Significant aspects of a user's identity can also bring unified meaning to a technological possession much like P12's game console and games library similarly characterising a gamer identity. Products with more ubiquitous functions could be designed to more clearly associate with a specific aspect of the user's identity by specialising their functionality to the activities conducted in a particular role. This can be seen in BlackBerry mobile phones that are often associated with a businessperson identity as they contain work-specific features such as a full QWERTY keyboard and push email.

### **6.2.6 Design Theme: Materialising Experiences**

Many digital items were considered meaningful for the experiences they enabled such as communicating, reading, listening, playing, creating, curating or reminiscing. This theme is motivated by the vivid recounts

by several participants of the emotive rituals they adopted when engaging with certain digital possessions. For example, P6 would listen to a particular song on his phone before every job interview he attends as a way to gain confidence and calm his nerves. These meaningful experiences and the emotions they conjure were less likely to be associated with the physical device. There is opportunity for designers to encourage users to associate these experiences with the physical by materialising these interaction rituals through the use of tangible [van den Hoven, Frens, Aliakseyeu, Martens, Overbeeke and Peters 2007], embodied [Dourish 2004] or hybrid [Gullick and Coulton 2016] interactions. Examples of this include the *Materialise* kit by Golsteijn, van den Hoven, Frohlich and Sellen [2014] and the *Marble Answering Machine* conceptualised by Bishop [1992]. The *Materialise* kit contains physical, Lego-like building blocks with various interchangeable digital components such as a touch screen display or speaker that can be configured and assembled into novel forms. The *Marble Answering Machine* allows the user to grasp and place marbles as a means of interacting with their digital message inbox. Materialising experiences could also be envisioned in a music player by requiring the user to momentarily play the beat of a song as a means of selection control.

## 7 CONCLUSION

This article has presented a study investigating the ways in which people perceive and value their technological possessions with distinctions made between physical and digital components. The self-reported associations and meaningfulness of these components were used to provide insights related to understanding the nature and source of attachment within the increasingly prevalent category of technological products. The study revealed that the digital contents of these possessions were often the most meaningful component and that the material device was important but replaceable. These findings were used to discuss the ways in which attachment to technological possessions differs to traditional material possessions. Technological possessions are more akin to systems of products than singular devices, causing a shift towards dematerialising and dispossessing meaning. From a sustainability perspective, there is value in creating products with meaning directly associated with their materiality to delay disposal and reduce the rate of resource consumption. It is proposed that designers can create lasting technological products by adopting various methods of materialising the meaningful associations ascribed to the product's digital contents.

### ACKNOWLEDGMENTS

We would like to thank all participants for their time and contributions. This study was approved by the UTS Ethics Committee (#2015000289) and supported by STW VIDI grant number 016.128.303 of The Netherlands Organisation for Scientific Research (NWO), awarded to Elise van den Hoven and an Australian Government Research Training Program Scholarship awarded to Daniel Orth.

### REFERENCES

- [1] Michael W Allen 2002. Human values and product symbolism: Do consumers form product preference by comparing the human values symbolized by a product to the human values that they endorse? *Journal of Applied Social Psychology*, 32(12), 2475–2501.
- [2] Consumer Technology Association. 2014. Consumer Electronic Product Life Cycle.
- [3] Ozgun Atasoy and Carey K Morewedge 2017. Digital goods are valued less than physical goods. *Journal of consumer research*, 44(6), 1343–1357.
- [4] A Dwayne Ball and Lori H Tasaki 1992. The role and measurement of attachment in consumer behavior. *Journal of Consumer Psychology*, 1(2), 155–172.
- [5] Katja Battarbee and Tuuli Mattelmäki 2004. Meaningful product relationships. In D. McDonagh, P. Hekkert, J. van Erp, & D. Gyi (Eds.), *Design and Emotion: The experience of everyday things* (pp. 337–344). London, UK: Taylor & Francis.
- [6] Mehmet Aydin Baytas, Aykut Coskun, Asim Evren Yantac and Morten Fjeld 2018. Towards materials for computational heirlooms: Blockchains and wristwatches. In *Proceedings of the Designing Interactive Systems Conference*, Hong Kong, China.
- [7] Russell W Belk 1988. Possessions and the extended self. *Journal of consumer research*, 15(2), 139–168.
- [8] Russell W Belk 1991. The ineluctable mysteries of possessions. *Journal of Social Behavior and Personality*, 6(6), 17.
- [9] Russell W Belk 2013. Extended self in a digital world. *Journal of consumer research*, 40(3), 477–500.

- [10] Russell W Belk 2014. You are what you can access: Sharing and collaborative consumption online. *Journal of business research*, 67(8), 1595-1600.
- [11] Russell W Belk, Melanie Wallendorf, John F Sherry and Morris B Holbrook 1991. Collecting in a consumer culture. In *Highways and buyways: Naturalistic research from the consumer behavior odyssey*, Russell Belk Ed. Association for Consumer Research, Provo, UT, 178-215.
- [12] Durrell Bishop 1992. *Marble answering machine* [Product concept]. Royal College of Art. Retrieved from <http://dataphys.org/list/durrell-bishops-marble-answering-machine>.
- [13] Eli Blevis 2007. Sustainable interaction design: Invention & disposal, renewal & reuse. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, San Jose, California, USA.
- [14] Eli Blevis and Erik Stolterman 2007. Ensoulment and sustainable interaction design. In *Proceedings of the International Association of Societies of Design Research Conference*, Hong Kong.
- [15] Susanne Bødker and Clemens Nylandsted Klokmoose 2012. Dynamics in artifact ecologies. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, ACM, 448-457.
- [16] Kirsten Boehner, Janet Vertesi, Phoebe Sengers and Paul Dourish 2007. How HCI interprets the probes. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 1077-1086.
- [17] Albert Borgmann 1984. *Technology and the character of contemporary life: A philosophical inquiry*. University of Chicago Press.
- [18] John Bowlby 1977. The making and breaking of affectional bonds: I. Aetiology and psychopathology in the light of attachment theory. *The British Journal of Psychiatry*.
- [19] Christina Brodersen, Susanne Bødker and Clemens Nylandsted Klokmoose 2007. Ubiquitous substitution. In *IFIP Conference on Human-Computer Interaction* Springer, 179-192.
- [20] Barry Brown and Abigail Sellen 2006. Sharing and listening to music. In *Consuming music together* Springer, 37-56.
- [21] J Allison Bryant and Anna Akerman 2009. Finding mii: Virtual social identity and the young consumer. *Virtual social identity and consumer behavior*, 127-140.
- [22] Jonathan Chapman 2009. Design for (emotional) durability. *Design Issues*, 25, 29-35.
- [23] Carolyn L Costley 1988. Meta analysis of involvement research. *NA - Advances in Consumer Research*, 15, 554-562.
- [24] Andy Crabtree, Terry Hemmings, Tom Rodden, Keith Cheverst, Karen Clarke, Guy Dewsbury, John Hughes and Mark Rouncefield 2003. Designing with care: Adapting cultural probes to inform design in sensitive settings. In *Proceedings of the Australasian Conference on Computer-Human Interaction*, 4-13.
- [25] Mihaly Csikszentmihalyi and Eugene Rochberg-Halton 1981. *The meaning of things: Domestic symbols and the self*. Cambridge University Press.
- [26] Amber L Cushing 2013. "It's stuff that speaks to me": Exploring the characteristics of digital possessions. *Journal of the Association for Information Science and Technology*, 64, 1723-1734.
- [27] Janice Denegri-Knott, Rebecca Watkins and Joseph Wood 2012. Transforming digital virtual goods into meaningful possessions. *Digital virtual consumption*, 23, 76.
- [28] Janice Denegri-Knott and Mike Molesworth 2010. Concepts and practices of digital virtual consumption. *Consumption, Markets and Culture*, 13, 109-132.
- [29] Wen-Jing Deng, John P Giesy, Cs So and Hai-Long Zheng 2017. End-of-life (eol) mobile phone management in hong kong households. *Journal of Environmental Management*, 200, 22-28.
- [30] Paul Dourish 2004. *Where the action is: The foundations of embodied interaction*. MIT press.
- [31] Melanie Feinberg 2013. Beyond digital and physical objects: The intellectual work as a concept of interest for hci. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 3317-3326.
- [32] Melanie Feinberg, Gary Geisler, Eryn Whitworth and Emily Clark 2012. Understanding personal digital collections: An interdisciplinary exploration. In *Proceedings of the Designing Interactive Systems Conference*, ACM, 200-209.
- [33] George W Fitzmaurice 1996. *Graspable user interfaces*, University of Toronto.
- [34] Susan Fournier 1998. Consumers and their brands: Developing relationship theory in consumer research. *Journal of consumer research*, 24, 343-373.
- [35] Daniel Gallardo and Sergi Jordà 2010. Tangible jukebox: Back to palpable music. In *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction*, Cambridge, Massachusetts, USA, ACM, 199-202.



- [36] Bill Gaver, Tony Dunne and Elena Pacenti 1999. Design: Cultural probes. *interactions*, 6, 21–29.
- [37] Silke Gegenbauer and Elaine M Huang 2012. Inspiring the design of longer-lived electronics through an understanding of personal attachment. In *Proceedings of the Conference on Designing Interactive Systems*, ACM, 635–644.
- [38] David B. Gerritsen, Dan Tasse, Jennifer K. Olsen, Tatiana A. Vlahovic, Rebecca Gulotta, William Odom, Jason Wiese and John Zimmerman 2016. Mailing archived emails as postcards: Probing the value of virtual collections. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, San Jose, California, USA, ACM, 1187-1199.
- [39] Connie Golsteijn, Elise Van Den Hoven, David Frohlich and Abigail Sellen 2012. Towards a more cherishable digital object. In *Proceedings of the Conference on Designing Interactive Systems*, ACM, 655–664.
- [40] Connie Golsteijn, Elise Van Den Hoven, David Frohlich and Abigail Sellen 2014. Hybrid crafting: Towards an integrated practice of crafting with physical and digital components. *Personal and Ubiquitous Computing*, 18, 593–611.
- [41] Kent Grayson and David Shulman 2000. Indexicality and the verification function of irreplaceable possessions: A semiotic analysis. *Journal of consumer research*, 27, 17–30.
- [42] Jane Gruning 2018. Displaying invisible objects: Why people rarely re-read e-books. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Montreal QC, Canada, ACM, 1–12.
- [43] David Gullick and Paul Coulton 2016. Designing information feedback within hybrid physical/digital interactions. In *Proceedings of the Design Research Society Conference*, Brighton, UK.
- [44] Terry Hemmings, Karen Clarke, Mark Rouncefield, Andy Crabtree and Tom Rodden 2002. Probing the probes. In *Proceedings of the Participatory Design Conference*, Malmö, Sweden, 42–50.
- [45] Eva Hornecker 2015. Tangible interaction. *The Glossary of Human Computer Interaction*.
- [46] Elaine M Huang and Khai N Truong 2008. Breaking the disposable technology paradigm: Opportunities for sustainable interaction design for mobile phones. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 323–332.
- [47] Hiroshi Ishii and Brygg Ullmer 1997. Tangible bits: Towards seamless interfaces between people, bits and atoms. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Atlanta, Georgia, USA, ACM, 234–241.
- [48] Fernando R Jiménez and Kevin E Voss 2015. An alternative scale of emotional attachment. In *Proceedings of the 2010 Academy of Marketing Science (AMS) Annual Conference*, Springer, 18–18.
- [49] Heekyoung Jung and Erik Stolterman 2012. Digital form and materiality: Propositions for a new approach to interaction design research. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*. ACM, 645–654.
- [50] David S Kirk and Richard Banks 2008. On the design of technology heirlooms. In *Proceedings of the International Workshop on Social Interaction and Mundane Technologies*, Cambridge, UK.
- [51] David S Kirk and Abigail Sellen 2010. On human remains: Values and practice in the home archiving of cherished objects. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 17, 10.
- [52] Susan Schultz Kleine, Robert E Kleine and Chris T Allen 1995. How is a possession “me” or “not me”? Characterizing types and an antecedent of material possession attachment. *Journal of consumer research*, 22, 327–343.
- [53] Sari Kujala and Piia Nurkka 2012. Sentence completion for evaluating symbolic meaning. *International Journal of Design*, 6.
- [54] Moon-Hwan Lee, Oosung Son and Tek-Jin Nam 2016. Patina-inspired personalization: Personalizing products with traces of daily use. In *Proceedings of the Conference on Designing Interactive Systems*, ACM, 251–263.
- [55] Paul M Leonardi 2010. Digital materiality? How artifacts without matter, matter. *First monday*, 15.
- [56] Paolo Magaudda 2011. When materiality ‘bites back’: Digital music consumption practices in the age of dematerialization. *Journal of Consumer Culture*, 11, 15-36.
- [57] Rebecca Mardon and Russell Belk 2018. Materializing digital collecting: An extended view of digital materiality. *Marketing Theory*, 1470593118767725.
- [58] Catherine C Marshall 2007. How people manage personal information over a lifetime. *Personal information management*, 57–75.
- [59] Jennifer Martin 2008. Consuming code: Use-value, exchange-value, and the role of virtual goods in second life. *Journal of Virtual Worlds Research*, 1.

- [60] Tuuli Mattelmäki 2005. Applying probes—from inspirational notes to collaborative insights. *CoDesign*, 1, 83–102.
- [61] Alexander Meschtscherjakov, David Wilfinger and Manfred Tscheligi 2014. Mobile attachment causes and consequences for emotional bonding with mobile phones. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 2317–2326.
- [62] Mike Molesworth, Rebecca Watkins and Janice Denegri-Knott 2016. Possession work on hosted digital consumption objects as consumer ensnarement. *Journal of the Association for Consumer Research*, 1, 246–261.
- [63] Ruth Mugge, Hendrik Nj Schifferstein and Jan Pl Schoormans 2005. Product attachment and product lifetime: The role of personality congruity and fashion. In K. M. Ekström, & H. Brembeck (Eds.), *European Advances in Consumer Research* (pp. 460–467). Vol 7. Goteborg, Sweden: Association for Consumer Research.
- [64] Ruth Mugge, Jan Pl Schoormans and Hendrik Nj Schifferstein 2008. Product attachment: Design strategies to stimulate the emotional bonding to products. In H. Schifferstein, & P. Hekkert (Eds.), *Product experience* (pp. 425–440). Elsevier.
- [65] William Odom and James Pierce 2009. Improving with age: Designing enduring interactive products. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 3793–3798.
- [66] William Odom, James Pierce, Erik Stolterman and Eli Blevis 2009. Understanding why we preserve some things and discard others in the context of interaction design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 1053–1062.
- [67] William Odom, John Zimmerman and Jodi Forlizzi 2014. Placelessness, spacelessness, and formlessness: Experiential qualities of virtual possessions. In *Proceedings of the Conference on Designing Interactive Systems*, ACM, 985–994.
- [68] Daniel Orth, Clementine Thurgood and Elise Van Den Hoven 2018. Designing objects with meaningful associations. *International Journal of Design*, 12, 91–104.
- [69] Daniel Orth and Elise Van Den Hoven 2016. "I wouldn't choose that key ring; it's not me": A design study of cherished possessions and the self. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction*, ACM, 316–325.
- [70] Tom Page 2014. Product attachment and replacement: Implications for sustainable design. *International Journal of Sustainable Design*, 2, 265–282.
- [71] Daniela Petrelli and Steve Whittaker 2010. Family memories in the home: Contrasting physical and digital mementos. *Personal and Ubiquitous Computing*, 14, 153–169.
- [72] Marsha B Quinlan 2017. The freelisting method. In *Handbook of research methods in health social sciences* Springer, 1-16.
- [73] Majken K. Rasmussen, Esben W. Pedersen, Marianne G. Petersen and Kasper Hornbæk 2012. Shape-changing interfaces: A review of the design space and open research questions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Austin, Texas, USA, ACM, 735-744.
- [74] Rose Read 2015. *10 years of Mobile Phone Recycling Insights*. Global Product Stewardship Council.
- [75] Americus Reed, Mark R Forehand, Stefano Puntoni and Luk Warlop 2012. Identity-based consumer behavior. *International Journal of Research in Marketing*, 29, 310–321.
- [76] Marsha L Richins 1994. Valuing things: The public and private meanings of possessions. *Journal of consumer research*, 21, 504–521.
- [77] Hendrik Nj Schifferstein and Elly Ph Zwartkruis-Pelgrim 2008. Consumer-product attachment: Measurement and design implications. *International Journal of Design*, 2.
- [78] Susan E Schultz, Robert E Kleine and Jerome B Kernan 1989. "These are a few of my favorite things"; toward an explication of attachment as a consumer behavior construct. *Advances in Consumer Research Volume 16*.
- [79] Martijn ten Bhomer 2016. *Designing embodied smart textile services: The role of prototypes for project, community and stakeholders*. Eindhoven University of Technology.
- [80] Kelly Tian and Russell W Belk 2005. Extended self and possessions in the workplace. *Journal of consumer research*, 32, 297–310.
- [81] Phil Turner and Susan Turner 2013. Emotional and aesthetic attachment to digital artefacts. *Cognition, technology & work*, 15, 403–414.
- [82] Anna Vallgård and Johan Redström 2007. Computational composites. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 513–522.

- [83] Anna Vallgård, Morten Winther, Nina Mørch and Edit E Vizer 2015. Temporal form in interaction design. *International Journal of Design*, 9.
- [84] Elise Van Den Hoven and Berry Eggen 2004. Tangible computing in everyday life: Extending current frameworks for tangible user interfaces with personal objects. *Ambient Intelligence*, 230–242.
- [85] Elise Van Den Hoven, Joep Frens, Dima Aliakseyeu, Jean-Bernard Martens, Kees Overbeeke and Peter Peters 2007. Design research & tangible interaction. In *Proceedings of the 1st international conference on Tangible and embedded interaction*, Baton Rouge, Louisiana, ACM, 109–115.
- [86] Nancy A Van House 2011. Personal photography, digital technologies and the uses of the visual. *Visual Studies*, 26, 125–134.
- [87] Peter-Paul Verbeek 2005. *What things do: Philosophical reflections on technology, agency, and design*. Penn State Press.
- [88] Peter-Paul Verbeek and Petran Kockelkoren 1998. The things that matter. *Design Issues*, 14, 28–42.
- [89] Jane Vincent 2006. Emotional attachment and mobile phones. *Knowledge, Technology & Policy*, 19, 39–44.
- [90] Jayne Wallace, John Mccarthy, Peter C Wright and Patrick Olivier 2013. Making design probes work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 3441–3450.
- [91] Rebecca D Watkins, Janice Denegri-Knott and Mike Molesworth 2016. The relationship between ownership and possession: Observations from the context of digital virtual goods. *Journal of Marketing Management*, 32, 44–70.
- [92] Rebecca D. Watkins, Abigail Sellen and Siân E. Lindley 2015. Digital collections and digital collecting practices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Seoul, Republic of Korea, ACM, 2702380, 3423–3432.
- [93] Rebecca Watkins and Mike Molesworth 2012. Attachment to digital virtual possessions in videogames. In *Research in consumer behavior*, Emerald Group Publishing Limited, 153–170.
- [94] David West, Aaron Quigley and Judy Kay 2007. Memento: A digital-physical scrapbook for memory sharing. *Personal and Ubiquitous Computing*, 11, 313–328.
- [95] Sophie Woodward and Alinka Greasley 2017. Personal collections as material assemblages: A comparison of wardrobes and music collections. *Journal of Consumer Culture*, 17, 659–676.
- [96] Annemarie Zijlema, Elise Van Den Hoven and Berry Eggen 2017. A qualitative exploration of memory cuing by personal items in the home. *Memory Studies*, 1-21.
- [97] John Zimmerman 2009. Designing for the self: Making products that help people become the person they desire to be. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 395–404.