

Breaking the Disposable Technology Paradigm: Opportunities for Sustainable Interaction Design for Mobile Phones

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ABSTRACT

We present a qualitative study of mobile phone ownership, replacement and disposal practices geared towards identifying design opportunities towards sustainable mobile phone interfaces. Our work investigates how people understand the lifespan of their phones, what factors, such as style, service contracts, and functionality, affect how they attribute value to their phones, and their awareness and actions regarding mobile phone sustainability. Our findings reveal the complexity of the actions and decision-making processes involved in phone ownership and replacement. We use these findings to present open areas for sustainable interaction design and generate seed ideas for designs and services to provoke thought and further exploration towards more sustainable mobile phone interfaces and practices.

Author Keywords

Sustainability, mobile phones, qualitative studies, design, e-waste

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI):
Miscellaneous.

INTRODUCTION

Advances in computing combined with an increasing dependence on technology in everyday activities have yielded continual increases in the consumption of computational devices. While such devices offer many communication, productivity, entertainment, and safety benefits among others, their increased consumption has also resulted in problems of sustainability and disposal. For example, a 2006 report by the Environmental Literacy Council showed that consumer electronics comprise between .8% and 4% of the municipal waste stream in Europe and the United States, but are responsible for 40% of the lead in the stream [19].

Sustainability is a particular challenge for handheld devices, which are proliferating at a rapid rate. Although the small size of a handheld device means that its disposal yields less waste than that of a traditional desktop computer, its size also makes it more likely to be thrown away [12]. Along with this increase in devices, we witness the emerging “disposable technology paradigm” – characterized by technology that comes with the expectation of a short *usage* lifetime, despite the potential for a longer *functional* lifetime. In comparison to older, conventional counterparts, such as landline phones and stereos, consumers now purchase devices such as mobile phones and mp3 players with the expectation that they will be replaced within a period of a few years.

According to a 2007 study, American consumers use their mobile phones on average for only 17.5 months [16]. The problem of mobile phone proliferation and e-waste has been addressed in other fields from a materials science perspective, economic perspective, and policy perspective. However, from an interaction design standpoint and human-centered perspective, the sustainability of cell phones is largely unaddressed. As Blevins points out, sustainability challenges must also be considered as a first-class issue in interaction design [3]. While policy reform, incentive reform on the part of service providers, improvements in battery life and efficiency, the development and use of more sustainable materials, and other innovations are all crucial to achieve mobile phone sustainability, we also believe that HCI will play a necessary, complementary, and parallel role in reaching this goal. Designing phone interfaces and services that help users to engage in sustainable practices with low effort and make informed decisions are clear avenues for which user research and experience design knowledge are critical. HCI expertise and design can be leveraged to find ways to encourage longer use, less frequent replacement, responsible disposal, and novel repurposing to extend lifetime and value thus reducing the need for the production of new devices.

As a first step towards this goal, we undertook a qualitative survey- and interview-based study of mobile phone ownership, specifically investigating the reasons people choose to acquire, discard, or replace their mobile phones and what they do with them after they stop using them. In this work, we present

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findings about people's awareness and concern about sustainability problems surrounding mobile phones, the role that contracts, style, and functionality play in how people attribute value to their phones, the complexity of the decision-making process for users, and how this affects their actions in acquiring and replacing phones.

As an additional contribution and challenge to the HCI community, we present lessons and design opportunities based on the findings of our study. These opportunities are open areas of research in which we believe concrete design will be beneficial to achieving cell phone sustainability. For each design opportunity that we offer, we present individual design ideas. These ideas are presented *not* as fully developed designs or as complete and comprehensive solutions that address the entire area for design; the ideas themselves are concepts that vary in the extent to which they are currently feasible. These seed designs are instead intended to prompt further thinking and creativity in the area towards more complete solutions. Currently, the findings of our study are based on practices in the US and Canada, but we believe the design areas could yield designs that would have sustainability benefits on a far broader scale.

RELATED WORK AND BACKGROUND

Sustainability is an emerging area in HCI, and several works have recently served to introduce the value of considering it in design. For example, work introducing Value Sensitive Design [5] and Sustainable Interaction Design [3] has served as motivating visions for sustainability research in HCI. The CHI 2007 SIG on sustainability brought the issue closer to the forefront of attention [10]. Thus far, little has been done in research to examine mobile phone sustainability from a human interaction perspective. A recent study by Hanks *et al.* considers similar issues of consumption and technology replacement, questioning undergraduate students about their technology ownership and practices, including high-level inquiry into mobile phone ownership [7].

Mobile device sustainability and impact has been studied from perspectives other than experience design. For example, work by Jain and Wullert looks at how to design mobile devices to be more sustainable from a software perspective, considering how software can use less energy and minimize unnecessary data storage [8]. Companies have also developed phones made of biodegradable materials [21, 22], one type of which grows into a sunflower when planted in the ground [22]. Waste issues surrounding phones have also been studied from materials science and economics perspectives, considering the toxicity of their components and the challenges and benefits of remanufacturing and refurbishing [4, 14]. From ecological and policy standpoints, the benefits and drawbacks of practices such as recycling [2, 12], donation [12], and take-back programs [11] have been considered. It should be noted that such practices, while ultimately more sustainable than discarding phones, are themselves imperfect solutions. For example, while refurbishing and resale of donated phones can extend their life spans and additionally fund charities, the phones are often sent to areas such as Latin America for resale,

where they may eventually be thrown in the trash, thus shifting the location of the waste problem [12].

Several government studies and organizations have examined cell phone waste from a more general standpoint, considering the cell phone components and waste and pollution that they generate, as well as providing statistics about phone consumption and resulting waste production [17, 18, 19]. Additionally, a report from the US Environmental Protection Agency reports on technologies currently in development that could be beneficial in extending the functional lifetime of mobile phones in the future, including solar powered batteries, hydrogen fuel cells, and, and alternative power sources such as a hand-held generator that is squeezed to produce energy [17].

STUDY DESIGN AND DATA COLLECTION

The data collection for this study consisted of two components: a 34-question web survey (n=79), and a series of in-depth, semi-structured phone interviews with participants selected based on survey responses (n=10).

Web survey

Participants were recruited using snowball sampling; the survey was distributed via SurveyMonkey.com and was open to adult participants in the United States and Canada. It was designed to collect a broad set of data regarding people's mobile phone ownership, replacement, and disposal practices, as well as reasons and motivations behind their actions. The survey was designed to be brief and simple, requiring 10-15 minutes to complete. The questions were largely short answer (*e.g.* "Have you ever sold a phone, and if so, how and to whom?"), and multiple choice questions (*e.g.* "I had: a) a service plan for this phone b) pre-paid/pay as you go service for this phone") with the exception of an open-ended optional question that asked participants to recount experiences in acquiring, getting rid of, or replacing a mobile phone.

The survey was written and portrayed as an inquiry into general phone ownership and replacement experiences, rather than presenting people with an explicitly sustainability-oriented survey that might bias responses. The lens of sustainability was then applied during our data analysis.

The survey was comprised of two parts and focused on real experience and practice; no speculative, hypothetical, or opinion-oriented questions were asked. To prompt grounded and contextualized responses and obtain concrete experiential data, the first part of the survey asked specific questions about the participant's current phone, the participant's most recent previous phone, and any other phone that the participant had owned. These questions focused on the duration of ownership and use, how and why the phone was acquired, and why or how it had been replaced or disposed of. The second part asked general questions about the participants' overall phone ownership history, such as whether they had ever had a phone repaired, given a phone away, recycled a phone or parts of a phone, and how many old phones they still kept.

Interviews

Based on the survey responses, we conducted a series of semi-structured interviews to probe for people's personal stories regarding phone ownership and phone replacement experiences. The interview guide included a set of core questions inspired by the survey responses. Each interview also included individual "probe questions" based specifically on that participant's survey responses.

In choosing participants, we looked for those whose survey responses suggested an interesting history or experience, such as one participant who routinely donated phones through her synagogue, a participant who had disposed of multiple phones by throwing them in the kitchen trashcan, and a participant who reported loving her phone so much that she repaired it with duct tape when it broke, even though she was eligible for a free upgrade. These participants cannot be assumed to be a cross-section of the general population in terms of practices; instead, they provided a wide variety of perceptions, practices, and experiences. One interview participant was recruited outside of the survey process, a mobile phone enthusiast who represents yet another wide-ranging perspective. We recruited P79 because only one other survey participant could be classified as a phone enthusiast, replacing her smart phone yearly to have the newest model, and she was unavailable for interview but we wanted to have an enthusiast's point of view. P79 was a consultant who replaced his smart phone yearly after extensive research, and required advanced functionality such as billing software on his phone for his job.

Interviews were conducted over the telephone and audio recorded; they lasted between 30 and 45 minutes each, beginning approximately 6 weeks after we deployed the web survey. Although we again grounded our inquiry in concrete practices by inquiring primarily about specific experiences, we encouraged participants to share opinions and reflections.



Fig. 1. Affinity diagram with 700+ interview and survey quotes.

We analyzed our survey data and interview data in stages as we received it, using a grounded theory affinity analysis [1, 6]. In the first phase, we transcribed over 700 items from the data in the form of direct quotes, and in the second phase created a bottom-up affinity diagram by identifying and clustering similar or related items (Fig. 1). Simultaneously one researcher took the items from the first phase analysis and used open-ended inductive coding to identify potential design opportunities and brainstorm design ideas. The design opportunities and ideas

were subsequently filtered by comparing them to the high-level findings of the affinity analysis; we selected those most deeply tied to the findings. We chose this two-pronged approach so as not to limit creativity early on, but also to ensure the design opportunities and ideas were ultimately relevant and grounded.

RESULTS OVERVIEW

We received 79 survey responses from people ranging from 20 to 69 years of age, representing a wide variety of occupations, including journalists, attorneys, graduate students, CEOs, software developers, homemakers, educators, administrative assistants, and chefs. Our survey population was 62.5% female and 37.5% male, and the two age groups with the most representation were ages 20-29 with 35 participants, and 30-39 with 22 participants.

Why do people replace their phones?

As we expected, a common reason to replace a phone was because a service provider offered a free or discounted incentive phone with a contract. Thirty-seven of the 79 participants stated this as a primary or secondary reason for getting their current phone. Comments from participants also supported our idea that the perceived lifetime of the phone was greatly influenced by the contract length:

"The only time I replace a mobile phone is when the contract is up. I find no need to replace it otherwise. Every phone I purchase and enjoy its use until the contract on it is up."

This comment suggests that the user perceives her usage pattern to be one that maximizes the duration of phone use and entails no more replacement than necessary, although it has little to do with the functional life of the phone.

Other common reasons for replacing their previous phone were because it lacked desired features or functionality (19 participants) and because users preferred how another phone looked (three participants). These numbers may be somewhat misleading, however. As we found out during our interviews, participants who cited functionality and style as primary reasons for replacing the phone often actually replaced the phone only when they received an incentive replacement with a new contract; the functionality or design was often the primary reason they selected the phone from those available, but not the main motivation for deciding to replace the old one. Thirteen participants replaced their phones because their previous phone broke or had diminished battery life. Eighteen reported that they had repaired one of the phones that they had owned in the past, and 17 had replaced a battery at some point, while others told us that it was often cheaper to wait out the contract and get a new phone than pay for a new battery. No participants cited poor ease of use or software interfaces as a reason for replacing a phone.

What do people do with their old phones?

Among the people surveyed, 17 of the participants reported disposing of at least one phone by throwing it in the trash. Sixteen participants said they had donated phones to various charities. Twenty-six participants had given phones away, usually to partners or family members. Smaller numbers had recycled (10 participants) or sold previous phones (7).

The most common practice, however, was retaining old phones. Forty-one participants owned at least one phone that they were not currently using, with participants stating that they had as many as five old phones still in their possession. As one participant stated, “We usually hold on to the phones until they are ridiculously outdated.” Participants offered brief and straightforward explanations for keeping their phones, such as, “backup,” “emergency spare,” “pack rat. I should probably throw it out,” “lazy,” “don’t know,” and “no reason.” In our interviews, people reported keeping phones knowing they could not use them as backup because they were broken or not compatible with their service plans.

A few instances of phones being creatively repurposed were reported. One participant mentioned keeping several old GSM phones explaining, “When friends and family from out of the country visit they use an older phone with a pre-paid SIM card so they are connected for coordination and emergencies.” Another participant stated that she used her former phone as her current alarm clock, commenting, “[I] like it because I can set it and throw it across the room. That forces me to get out of bed to turn it off in the morning.” Such examples, though few, were encouraging in their suggestion that people might attempt to extend the value of their old phones. Also encouraging was the fact that some users who had not yet found uses for their old phones expressed a desire to do so. For example, one stated that she kept her old phones because “I’m thinking that I might be able to still use them one way or another.”

AWARENESS AND ACTION REGARDING SUSTAINABILITY

In this and the following sections, we present in-depth findings regarding the complexity of people’s motivations, actions, and attitudes towards phones, and present opportunities for which design could yield more satisfying and sustainable user experiences with mobile phones.

Attributing Value to Actions

Nine of the ten interviewed participants expressed an awareness that certain courses of action with their old mobile phones were problematic from a sustainability standpoint, even ones in which they themselves had engaged. In response to a survey question about whether they had ever discarded a mobile phone and if so, how, some responses were “I’m ashamed to admit that I think I’ve just thrown some out” and “yes, i think i threw one away a long time ago before i understood the environmental repercussions.” Our follow-up interviews indicated as well that most participants attached “right/wrong” or “good/bad” values to actions they could take with their old phones, and that these values were strongly tied to perceptions of sustainability. A small number of participants had stated in the survey that they had discarded phones in the trash in the past without qualifying that they had any sense of regret; we interviewed two of these, who both indicated during the interviews without prompting that they would likely not take that action now because they are more aware of environmental repercussions. One participant who had given some phones to an electronics

recycling service along with old computing equipment explained his actions:

“There was a bunch of old computer junk lying around and we just wanted to get rid of the stuff because it was taking up space, and I think someone had mentioned recycling computer stuff so I thought it would be like the right thing to do.” (P7, student in his 20s)

Another participant who regularly donated phones to her synagogue’s collection service reasoned:

“I would never just throw it out not knowing exactly, you know, with the battery, all of that, what that would do to the environment. So I would always dispose of it properly through some kind of organization.” (P4, educator in her 50s)

Even some participants who had kept all of their previous phones and never donated or recycled them explained their reasons for retaining them and not throwing them out from a sustainability standpoint:

“Well there are certain places where they allow you to dispose of your cell phones, I don’t know exactly where they do that. It’s like a service that’s run over here some places. Because it’s just like disposing of a computer. They’re just filled with some nasty stuff. So you just don’t throw them out in the garbage.” (P28, student in his 20s)

“I didn’t really know what to do with it. Like I haven’t found a convenient recycling thing and I know it’s a bad idea to just throw it away because the battery can leech lithium and nasty chemicals into landfills... you don’t throw cell phones into the regular trash.” (P13, student and artist in her 20s)

We did not find any evidence in our interviews of anyone being entirely ignorant of the sustainability repercussions of throwing away cell phones in the trash. Even those who had thrown phones away expressed some attachment of “right” and “wrong” values to the actions. One participant who had never recycled a phone and generally threw away his old phones and the broken phones of his employees said:

“I don’t really know what to do with [my employees’ old phones.] I guess I could take them to the cell phone store and try to recycle them but I figure at some point I’ll go through a temporary insanity and clean my office, throw everything out in a big pile [in the trash.] No... I’ll probably try to be a good Earth person and recycle the phones.” (P18, engineering firm CEO in his 20s)

The Interplay of Convenience and Awareness

Despite the fact that nearly all participants revealed some awareness of the environmental repercussions of discarding a phone in the trash, those who had engaged in practices that they believed to be more sustainable generally did so in part because the option was available to them at very low effort or cost. Two participants who had donated old phones described how the practice fit into their routine:

“[Donating my phone to my synagogue] was just like kind of almost a no-brainer... I didn’t have to go out of my way to

donate it, and we got money for it, so, you know, why not.” (P4, educator in her 50s)

“I walk past [The Body Shop, which has a donation bin for phones] almost every day to catch the train, so it’s on my way. It wouldn’t be a trip out of my way to do it.” (P41, journalist in her 30s)

On the other hand, some participants who had kept their phones and stated that they would ideally donate or recycle them explained that they had not done so because they had were not aware of such services, had not yet bothered to locate a service, or did not want to go out of their way to get to one:

“I don’t really want to go out of my way to find a recycling deposit... I’ve seen them in places like out of the corner of my eye... But it has yet to be a priority for me to like dig the phone out... and bring it with me with the intention of dropping it in the recycling receptacle.” (P13, student and artist in her 20s)

“I didn’t know what to do with it. I looked into donation/recycling but seemed difficult because I don’t have easy access to packing materials or post office” (P66S)

Others expressed similar difficulties with the effort necessary to become informed about sustainable practices. Even though the last question in the survey asked the participants tell us about an experience they had had in acquiring, replacing, or discarding a phone, two participants answered as follows:

“seems it’s hard to find a company/organization that would recycle phones in a hassle-free way” (P44S)

“i would like to know about convenient ways of getting rid of phones in a responsible manner.” (P66S)

Lessons and Design Opportunities: Awareness and Action

These findings have some positive implications for sustainability. It is clear that people are largely aware that cell phones pose environmental problems and that many are willing to take actions that they believe are sustainable if they can do so at reasonably low cost and effort, especially if the responsible method of disposal is integrated into their everyday lives. It is also clear that people often learn about disposal methods through word-of-mouth and chance happenings, while others wish that it were easier to obtain this information. The current overhead for obtaining information or practicing responsible disposal also leads people to retain their old phones after they have stopped using them.

These findings suggest several opportunities for sustainable interaction design, including interfaces to make information about responsible disposal more readily available through the phone itself or the user’s environment, and design to make the disposal itself better integrated with everyday life. As a possible design idea to ease the overhead of sustainable disposal, a phone could be designed to be aware of when the user’s contract is running out, and take advantage of its knowledge of its own location and leverage that to obtain information about options available to the owner. It could

then inform the user of local resources or options for sustainable disposal, donation, or reuse.

RESISTANCE AND APATHY TOWARDS REPLACEMENT

Given that the vast majority of mobile phones in the United States and Canada are locked to a particular service provider, it is unsurprising that our survey and interview participants replaced their phones primarily when changing service providers or renewing a contract with their existing service providers. Only two of the interview participants had ever purchased a phone that was not free or discounted by a service provider. Because most service providers offer substantial discounts on a regular basis as incentives, it is only to be expected that people rarely purchase phones in the middle of a contract. All participants with the exception of one always exercised the option of receiving a free or discounted phone when it was offered, regardless of whether their existing mobile phone was still functional.

While it is unsurprising that people do not refuse an expensive new piece of technology for free or at a bargain as a replacement for an old one, deeper examination of the practice of replacement reveals that it is more complex than mere joy at getting something cheap or for free. Some participants clearly welcomed any opportunity to have a new gadget, stating, “I’m always ready to go, ready for a new one. They’re like shoes!” but most of our participants did not express particular enthusiasm for getting a new phone, and some even seemed to replace the phone when offered a free or discounted phone because they felt they were supposed to.

P13 spoke of having to sign a new contract following the merger of two wireless providers. At this time, a salesperson informed her that as part of her new contract, she would receive a new phone that would be technically compatible with the new network. P13 was resistant to an upgrade, because her existing phone still worked and she understood very well how to use it, protesting, “I don’t want to buy a new phone. I don’t want a new phone... This isn’t my decision to do this.” Eventually the store located a compatible version of the same model of phone that she already had and offered it to her at no cost, which she reluctantly accepted. Although she explained that this solution was preferable to getting a different new phone because she was already familiar with it, she also expressed dissatisfaction, saying, “I don’t know what of the inner workings is different, but it seems a little wasteful to me to have to get an entirely new device that is identical to the one I had before, to my eyes.”

Another participant told a similar story of preferring to keep an existing phone rather than getting a new one. P38 spoke of having a phone that was 3-4 years old (“People were like, ‘Whoa your phone is really old.’ But I didn’t care”) and then moving to a new city. After the move, she considered purchasing a new phone, but opted instead to keep the old phone and get a new number. She was told, however, that it was not possible to give her a new number and allow her to continue using the same phone. Instead she received a

voucher toward a new phone, which she took, and stated, “The [old] phone was looking pretty dated anyway, so I figured it was probably a good time to get a new phone.” She added though “I really don’t care if it looks technologically current. As long as it works sufficiently. I mean, that’s enough for me... if they’d been able to switch the number, I would have just kept that [old] phone.” Ironically, the fact that she was prohibited from taking the sustainable course of action led to an unsustainable one – P38 threw her old phone away in the trash because she reasoned, “I knew it wasn’t usable because of this thing with this number...I knew that it couldn’t accept a new number, so I figured [nobody else could use it either].”

P7’s comments in an interview indicate how his perceptions of mobile phone lifespan are greatly influenced by contract and policy, even when prefers his old phone to a new one. P7 renews his contract yearly, at which time he selects a phone from the models that his service provider offers him for free as an upgrade. During a recent upgrade, P7 found that the phone models available at no cost with his renewal were less desirable to him than his existing phone. The phone he had gotten with his previous renewal had Bluetooth and a camera, whereas the new options did not. Rather than foregoing the incentive, he selected one, but then found that he did not want to switch to using it. Finally after some months, one of the keys on the phone he was using broke, and he switched to using the one he had acquired in the latest contract renewal. While this set of actions is unsurprising, his description of the switch belies an interesting assumption regarding the lifespan of the phone: “It was just a free phone and there happened to be another free phone sitting next to it. You know, which I guess I was supposed to [switch] to anyway.”

Lessons and Design Opportunities: Reducing Replacement

These findings and anecdotes are encouraging for sustainable design because they challenge the assumption that people are always enthusiastic to receive a new device when it is offered. Only two of our interview participants stated that they always liked receiving a new incentive phone, with the remainder expressing some type of reluctance or apathy in some situations, as evidenced by these stories. The findings also illustrated how a phone’s perceived life cycle is decoupled from the actual functional lifetime of the phone, and strongly influenced by contract length, incentive schedules, and network compatibility. While reforming contract structure, incentive programs, and cellular network architecture would help address these issues, the fact that people may be open to the idea of keeping their phones longer than a contract length also suggests room for design to encourage such practices.

This knowledge presents opportunities if we consider how to use design to influence the perceived lifetime of the phone such that it is closer to the functional lifetime and less dependent on factors such as contract length. For example, a phone might make a user more conscious of the functional lifetime; it could display a simple progress bar that shows how long the user has had the phone in comparison to the

projected functional lifetime of that particular model. Having such information as a reference might even have the side benefit of influencing people to choose phones that will last longer and perceive them as less temporary, or promoting a sense of pride in long ownership of a single device.

OLD PHONES AND THE ASYMMETRY OF VALUE

People ascribed some measure of value to their old phones in different ways, even though they rarely actually found need to return to a backup phone. In addition to the phone’s value as a personal backup, people often attributed value to the form in regards to the phone’s *potential* value to someone else. Many participants, especially those who had switched service providers, mentioned keeping their old phones in the event that someone else needed a phone:

“If... someone I know wanted to get an account with Telus, I could just give them that phone.” (P28, student in his 20s)

“It’s in perfect condition... my daughter who has Verizon, should she lose her phone... I would much prefer that she use this phone for whatever it would cost just to switch it over than to have to spend \$100, \$200 to purchase a new phone.” (P4 educator in her 50s)

Interestingly, however, there is an asymmetric quality to this attribution of value. Both of these participants, as well as several others had tried to give phones away in the past only to find that others did not want them, even when they were in need of a phone:

“I have a friend, her daughter even though she’s 14 has never had a cell phone. And they were also just looking for a really minimal [phone and service]... but I guess they opted out because I never heard from her” (P4, educator in her 50s)

“So my sister, she wanted a cell phone about maybe a year ago, a little bit over a year ago... and I just offered her mine, but she wasn’t really particularly interested in that because it wasn’t what she wanted in a cell phone. Like I think the reason she wanted a cell phone is because it’s trendy or whatever as well to have a nice cool phone... we’re sitting at the table and she’s complaining about wanting a cell phone and I said you can have my old phone and she said, ‘oh, I don’t want that piece of crap.’” (P28, student in his 20s)

Offering old phones to friends and family who were on the market for a new one and having it refused turned out to be a common occurrence among our interview participants; P28 was particularly aware of how little interest others had in taking his phones, even when they were fully functional, and offered at no cost to someone seeking a phone, stating, “no one wants my old phones.” In regards to a phone he is currently trying to give away, he expressed little optimism, “I mean, they expressed a mild interest. It tends not to work out.”

The asymmetry between the potential value for others that people ascribe to their old phones and the appeal they hold for others was also mirrored in the fact that using someone else’s old phone in a situation of need was generally viewed as a very temporary solution. Two of the participants reported

borrowing family members' old phones until they were able to obtain new phones, one by switching service providers and the other by using her daughter's contract renewal upgrade because she was not due for an discounted upgrade for a while. Two of the participants had given phones away, but these phones were returned to them within a few weeks because the recipients purchased new phones:

"She used it for a month or two and then gave it back to me... [I gave it to her because] she liked it, but she ended up not using it for too long. I have it in a box now somewhere." (P18, engineering firm CEO in his 20s)

The exception to this trend was P79, the phone enthusiast consultant whom we recruited to interview. P79 often sent his old phones to his cousin in Egypt who would either keep them for personal use or sell them within Egypt. Because P79 nearly always purchases sophisticated smart phones as soon as they are released in the US, or even before they are released in the US if he can order them from them from outside, and because he usually keeps them for less than a year, it is likely that his phones are perceived as more valuable than those of our other participants. Even so, P79 had three old smart phones for whom he has not yet found recipients at the time of interviewing.

Perhaps because of the ample opportunities to obtain a new phone at low or no cost, people often view taking someone's old phone as an unappealing option or a temporary solution. At the same time, people often hold onto their old mobile phones because they attribute value to them themselves. This paradox is further supported by the fact that several survey participants said they kept their old phones in case someone else wanted it, but not a single participant was currently using a phone that they had received used from someone else.

Lessons and Design Opportunities: Increasing Value

From these findings, we can surmise that people often attach value to their phones, even when they themselves are no longer using them, and that there is a desire for someone else to benefit from them. People who want to give their phones away often have difficulty finding recipients for them, finding leads by chance and often never completing the gifting.

These findings present the opportunity to use design to make it easier for people to find recipients for old phones, or make used phones more appealing. For example, a phone could take advantage of a person's social network to foster distribution. The phone's contact list could be used to try to find someone who is looking for a phone automatically through SMS and/or email to those friends who have opted to receive such messages. This idea mimics the current practice of using informal communication with members of one's social circle to try to redistribute old phones. Similar models of free distribution of previously owned items advertised through community email have already proven successful as web services [25]. Another idea is to make an old phone more appealing to a potential recipient through interfaces for novel repurposing that can benefit others. Phones could be designed to be repurposed easily as a personalized gift, such as a photo

collection, a mix "tape", or video collection to be passed around and added to among a circle of friends.

THE ROLE OF STYLE AND DESIGN IN VALUE

In examining people's motivations for acquiring new mobile phones and replacing old ones, we were interested in the role that style plays in how people ascribe value to their phones. Given the emphasis on visual design in iconic products such as the Motorola RAZR phone and the Apple iPod¹, we sought to understand the influence that the physical design of the object had on phone replacement.

In our survey, while 21 participants stated that they "preferred how the new phone looked" as a secondary reason for why they had replaced a phone in the past, only three cited that as the primary reason. One participant who cited aesthetics as the primary reason for her most recent phone replacement explained that she had seen her friend's RAZR and coveted it, and then purchased one at a discount after waiting until her contract renewal. She said that although she loved the design of the phone as soon as she saw it, she would not have purchased the phone without receiving the incentive from her service provider, and that she would have gotten a new phone with her renewal contract even if there had not been one about which she was excited. Therefore, while in her opinion, the appearance of the phone was the most important factor in her acquiring it, the actual replacement was prompted primarily by a contract renewal.

Interestingly, in our interviews, most other participants seemed to take a pragmatic view of design and aesthetics. Sleekness and beauty were rarely mentioned as important in the decision to acquire a phone. Participants were more likely to cite specific physical design aspects or size as what attracted them to a phone. The preference for small phones or flip phones seemed also to be driven by practical reasons:

"I want smallest on top of all... Because I don't carry a purse... I always have to carry a cell phone in my pocket, So the smaller the size, the easier it is to carry in my pocket."(P41, journalist in her 30s)

Although P41 repeatedly mentioned size as the factor of overwhelming importance in her phone selection, she also explained that diminutiveness alone was not enough to motivate her to purchase a phone; she only purchased new smaller phones through her service plan upgrade options in the event that her current phone broke. Others in our interviews took a similar practical perspective on design:

"I like that it is a flip phone. I don't like having the buttons exposed because I carry it in my pocket all the time." (P7, student in his 20s)

¹ Our study took place shortly after the release of the iPhone and none of our participants owned one, though one mentioned being somewhat interested in it, and two interview participants had other smart phones. The Motorola RAZR gets frequent mention in this section because five of the ten interviewed participants referred to during the interview, although we did not specifically query about it.

“I like that I can put it in my purse and it won’t dial itself... and since the first [phone that I owned], they’ve all been flip.” (P24, marketing professional in her 60s)

Aesthetic and design preferences generally played a role in how users selected a phone during a scheduled replacement, but we saw no evidence of anyone making the decision to replace a phone primarily because they were dissatisfied with the design or because they liked the design of another phone on the market. In our interviews, we encountered only one other person who talked about the importance of design in her phone choice outside of practical considerations:

“When [the salesperson] showed me the phone... at that point I did like the fact that it was a white phone, it was a little bit different than anything that I had. It reminded me of a time many many years ago, I used to play tennis and I saw the movie ‘The Witches of Eastwick’ ...I had to go out and get a white tennis racket, because I think that’s what Jack Nicholson used. So it kind of just reminded me of a simple change but a big change.” (P4, educator in her 50s)

What is interesting about this reasoning is that the phone appeals to her because it is unlike her other phones, but also that the attraction to the phone is less about it looking new, impressive, or cutting edge, and more because it reminds her of an event in the past. Again, she took design into consideration when choosing the phone, but it was not the main motivation for replacing her existing phone, as she got it with a new contract.

Style plays an interesting role in how people attribute value to their phones as well. When asked if she had had a favorite among all of the phones she’d owned, P58, who had coveted her friend’s RAZR and then gotten her own, answered that she had no real preference for any of them, including her RAZR. Although the RAZR was the only phone she ever had selected primarily for aesthetics, it did not make it more valuable to her than any of her previous phones:

“I bought it because I thought it was really cool-looking, but like, you know, everybody’s got a RAZR now so the novelty’s kind of worn off. So now it just seems like, you know, another phone.” (P58)

However, style did play an important role in the potential value for others that people ascribed to their phones. While we were initially curious to see whether style led to more frequent replacement of phones, we found that style prompted people to keep (though not use) their phones longer than they ordinarily would have. Two participants who own RAZRs and habitually donate their old phones to charity said that they have kept or would more likely keep their RAZRs after replacing them rather than donating them because they think they are more desirable to others than their previous phones:

“Because it’s a RAZR, I may try to give it away... because it’s a more modern and a more popular design than previous phones [I’ve had].” (P41, journalist in her 30s)

Lessons and Design Opportunities: Style and Design

Based on these findings, it seems that style generally plays an important but secondary role in phone selection and is not a primary motivation for phone replacement. Indeed, studies of teenagers’ cell phone perceptions in 2001 and 2007 suggest that the importance of phone aesthetics may be decreasing as phones become more ubiquitous [9, 23]. Perhaps because of the regular opportunities to obtain new phones at low or no cost with contract renewals, new styles, colors, or particular physical design were not things that people expected to pay for significantly in our study. From this we can surmise then that style and physical design generally does not warrant the full cost of a new phone to most people.

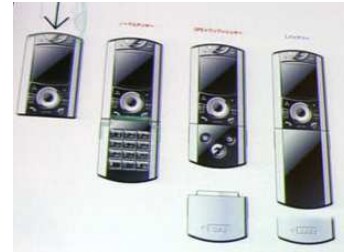


Fig. 2. The Will COM WP004 that allows both physical reconfiguration and snap-on modular functionality.

Thus, with cell phones at least, design may not be driving waste and replacement to the extent to which it is popularly perceived and may be a secondary factor in the problem of cell phone sustainability. Even so, the fact that our findings indicate that style is often something for which people are not willing to pay a significant amount in the context of cell phones suggests some potentially beneficial design opportunities. As a first step, we can consider ways in which upgrading the aesthetics or physical design of the phone would not necessitate replacing the entire phone. Interchangeable faceplates and skins are an existing solution within this space, but there is room for additional design. For example, phones could offer modular designs that allow people to reconfigure the physical form between a flip style, candy bar style, or slide style without replacing the central hardware. Such upgrades could be offered with contract renewal as cheaper options than a new phone. This type of modifiable design is currently being explored commercially [24] (Fig 2.) Given our findings that people have concern about the sustainability issues of mobile phone replacement, and that some people replace phones when they do not necessarily want to, such an option may be desirable, especially if the environmental benefit is made explicit as a “feature” of the design.

TECHNICAL FEATURES, FUNCTIONALITY, AND VALUE

Functionality plays a surprisingly similar role to style and physical design in how people attribute value to their phones. Although functionality was cited more frequently (23 out of 79 participants) as the primary reason for having replaced a mobile phone (not necessarily their previous one), this figure is once again ambiguous, as our interviews indicate that people were more likely to choose a new phone based on functionality, but were unlikely to make the decision to replace their existing phone out of a desire for a specific technology.

Functionality plays an interesting and complex role in how people attribute value to phones; our interviews revealed that people generally considered all but the basic capabilities of the phone (voice calling, SMS, contact list) unnecessary:

“I really appreciate having a very very simple phone. You know, I don’t want a picture phone. I don’t want a video phone. I just want a phone that, you know, I use it to talk, I use it to send text messages, and I use it as an alarm and a reminder device. But really, the first two functions, that’s all I need my phone to do.” (P13, student and artist in her 20s)

Another participant explained why she chose her phone:

“Because it was basic. It didn’t really do a whole lot of extras. It just did everything I needed because I’m pretty basic.” (P24, marketing professional in her 60s)

Even those who appreciated the features of a more advanced phone expressed some sense that many of the less-often-used features were unnecessary:

“It’s got the camera, it’s got the Bluetooth, which is kind of fun. You know, I like gadgets, functionality... The reality is I just use my cell phone to chat. 99.99% of the time, that’s what I’m doing. You know, the extra stuff, if it’s there, I’ll play with it. [But] it’s not the end of the world if it doesn’t have a camera or Bluetooth.” (P7, student in his 20s)

Only two participants expressed strong enthusiasm for technical features of their current phones, including P24 who appreciated voice dialing and the speakerphone, which she and her husband used while videoconferencing with their children and grandchildren because they found that the computer’s microphone did not work well. P79 (consultant in his 30’s), the phone enthusiast, appreciated features of his smart phone that allowed him to email and to take care of records and billing while at a client site without having to pull out his laptop.

With the exception of P79, however, the phone functionality that people appreciated or desired did not motivate the acquisition of the phone, but rather only the selection of the phone, even in the case of P24 who picked her phone from among those in a special offer that allowed her and her husband to purchase two phones for \$20. Further statements indicate that functionality is only worth having if it comes at low or no cost:

“Just recently within the last couple of months I’ve thought, ‘hmm. I wish I had a picture phone!’ But I haven’t looked into the plan or purchasing, because I don’t want to pay extra money. I’m very thrifty.” (P13)

“I mean, I got this phone because it was the cheapest one available when I really needed a phone. But it doesn’t really have the feature set that I like, other than battery life.” (P28)

Lessons and Design Opportunities: Technical Features

Much as with style and design, technical features and functionality of a phone play an important role in the selection of a phone, but a relatively minor one in whether people replace their phones. This is again a positive finding in terms of sustainability, as it suggests that the development

of new cell phone features is generally not contributing to waste and replacement as much as service provider contract incentives.

These findings also suggest opportunities for design that can help alleviate waste and foster a longer perceived lifecycle for phones by finding ways to allow people to have functionality that they require and add functionality as necessary by extending rather than replacing. Given that people appreciate functionality when choosing a phone but do not expect to have to pay much for it, modular technology design can also be beneficial here. For example, a possible idea for hardware extensions such as speaker phone, camera, or Bluetooth might lead to a “Lego-style” design that would allow owners to snap new functionality in to fit their existing phones. Modular functionality is currently being explored in industry as well [24]. Once again, given our findings regarding people’s concern and knowledge regarding the environmental repercussions of phone disposal, this type of design might be especially appealing to phone owners if the green benefits are made explicit.

ADDITIONAL OPPORTUNITIES FOR DESIGN

There are other avenues for mobile phone experience design that could also yield sustainability benefits, such as opportunities for design posed in Weiser’s vision of “tabs” [15] – small, ubiquitous palm-sized devices that are appropriated and left behind in an environment on an ad-hoc basis. Today’s mobile phones embody far more computing power than a standard desktop machine at the time of Weiser’s publication; the glut of unused phones presents an opportunity to repurpose these devices and integrate them into the ubiquitous computing future, and reduce the need for the production of new devices. While mobile phones are often used for prototyping such devices, further benefit can be gained by considering how used phones can be repurposed for the final product, as suggested by Paulos *et al.* [13]. The fact that used phones are plentiful and powerful but often unwanted makes them fitting as devices that serve a purpose in an environment but have a loose sense of ownership.

One such design idea is the repurposing of old phones as entertainment devices for patients in a hospital or a waiting room. In talking about his previous phones, P18 mentioned that he missed the games on his old phone that he could play to pass time while waiting. This idea is appealing in conjunction with the idea of modularly designed phones that would enable easy modification of the physical form and software to reinvent it explicitly as a gaming device. Finding new audiences for such devices and ways to reuse and redistribute them could extend the use of the phone beyond its life as a personal communication device, as well as reduce the need for the production of new devices. Other ideas include devices for giving presentations, leaving notes, museum guides - functions that have previously been implemented on proprietary devices.

CONCLUSIONS AND FUTURE WORK

Through an investigation into people’s practices regarding mobile phone acquisition, ownership, disposal, and replacement, we have uncovered complex perspectives and experiences that indicate several broad, mostly unexplored

areas for design that can help break the *disposable technology paradigm* in the context of cell phones. People are often ambivalent about getting a new phone and aware of the environmental problems that phone disposal presents, underlining the need for and potential value of sustainable interaction and experience design for mobile phones. We also propose opportunities for applying design as a way to close the gap between the *functional* lifetime and the *perceived* lifetime of mobile phones. Based on our findings regarding the role of style and functionality in phone selection and replacement, we have identified the opportunity for design that permits upgrades to both while eliminating or reducing the waste caused by unnecessary disposal and replacement. We present seed ideas for these opportunities to spark further creativity towards realizing solutions to these open problems.

There are several directions for extending this work. Participatory design with phone owners may yield further ideas about to make better use of old phones, and what would foster novel repurposing. Comparative studies of phone ownership practices in other countries will yield more generally applicable ideas for sustainable design and help us to understand the problem from a global perspective and effects of technology, policy, and culture on the attribution of value. For example, phones in Europe are generally not locked to a service provider, and customers are often offered cash in lieu of a phone with a contract, yet the average replacement time is still fairly short at two years [20]. Finally, we aim to examine the disposable technology paradigm in the context of other devices for which value may be determined differently such as iPods and laptops to generate more universal ideas and implications for sustainable interaction design.

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