Counterfunctional Things: Exploring Possibilities in Designing Digital Limitations

James Pierce[1,2], Eric Paulos[2]

[1] Carnegie Mellon University
Human-Computer Interaction Institute
Pittsburgh, Pennsylvania, USA
jjpierce@cs.cmu.edu

[2] University of California Berkeley
Berkeley Center for New Media
Berkeley, California, USA
eric@paulos.net

ABSTRACT
This paper presents a set of design studies and discussions investigating new possibilities in designing digital limitations. Focusing on digital photography as a medium, we present design prototypes and experiments including Ultra-Low Resolution Displays, Inaccessible Cameras, and a set of point-and-shoot digital camera variants. Our design work is based on the concept of a counterfunctional thing—a thing that figuratively counters some of its own functionality. We present the concept of counterfunctionality as a way of approaching the design of interactive technology. In conclusion we connect our work with critical discourses surrounding technology and the value of designing limitations.

Author Keywords
Limitations; counterfunctionality; photography; digital cameras; critical design; interaction design; design

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

INTRODUCTION

Digital technologies offer increasingly more diverse and numerous functional capabilities. While limitations often carry normatively negative connotations, there are many familiar counterexamples: a limited shopping selection makes it easier to decide on a choice while possibly enhancing the exclusivity of the options, Twitter's 140 character limit enables consistently clear and simple messages, less email and Facebook make it easier to focus on work, retreating to a remote location without Internet makes it possible to stop working altogether.

Figure 1. Several counterfunctional camera prototypes, here displayed as we presented them to participants in our study.

Given the vast possibilities afforded by digital technologies, we present a set of design studies and discussions based on a seemingly counterintuitive notion: Designing digital technologies around extreme functional limitations can be a valuable source of new positive possibilities. In doing so, we aim to contribute to the formation of an emerging research agenda around designing digital limitations. One of our goals is to help demonstrate that designing digital limitations is not limited to addressing criticisms or shortcomings of technology. If digital technologies are at times characterized by seemingly limitless capabilities, then we see ample opportunity in designing new forms of digital limitations.

To help focus this agenda we present the concept of a counterfunctional thing— a thing that figuratively counters some of its own "essential functionality". Using digital photographic technologies as medium for our exploration, we present several design studies investigating counterfunctionality, including Ultra-Low Resolution Displays, Inaccessible Digital Cameras and a set of point-and-shoot digital camera variants[1] (e.g., Figure 1). These

[1] A selection of counterfunctional digital camera variants are also the focus of a separate piece published in the DIS '14 Pictorials track (see [25]). Although these publications can be read separately we encourage reading them together as companion pieces.

studies investigate questions such as: In an age of faster, smarter and more numerous multi-functional technologies, what value can emerge based on technological absence, inability and inhibition? How might the removal of familiar features serve as a methodological basis for designing new technologies and experiences? Applied to digital photography, what specific design forms and functions emerge from this approach? How do research participants react to our counterfunctional cameras and the underlying themes of digital limitations and feature removal?

Reflecting on our design studies and related work, we discuss counterfunctionality as a way of approaching interactive design. While our design studies avoid adopting an initial and specific critical stance, we conclude by connecting our work explicitly to various critical discourses concerning technology and design. We begin by situating our design studies and approach amidst prior design work exhibiting "functional oppositions".

EMPLOYING FUNCTIONAL OPPOSITIONS IN DESIGN

General strategies of opposing familiar functional features of technology can be identified in a variety of experimental and avant-garde art and design works. Within the HCI and DIS communities, design approaches such as ludic design [12] and slow design [15,23] can be seen as generally opposing mainstream goal-driven, feature-laden, and productivity-enhancing digital technologies. Instead these designers and researchers explore technologies that enable playfulness, surprise, ambiguity, pause and reflection—often by disabling functionality that might otherwise be expected or desired. Functional oppositions are also employed in many examples of critical design [9], reflective design [29] and adversarial design [7].

One way functional opposition has been formalized in art practice and theory is in the technique of defamiliarization, which has more recently been discussed in HCI [4]. Another way this has been formalized is Gaver, Beaver and Martin's use of ambiguity as a resource for design. As one tactic, the authors propose that designers "block expected functionality to comment on familiar products" [13, p. 239]. To help contextualize our work, we present three interpretations of how the design of functional oppositions can function to make familiar things strange and novel.

Strangely bizarre

Functional opposition can to work to make what is familiar bizarre, surprising and amusing. Convenient examples can be found in the edited collection *Strangely Familiar: Design and Everyday Life* [5]. An example is Paolo Ulian's Greediness Meter, a chocolate bar molded in the form of a ruler to gauge how much has been eaten. The Greediness meter employs a "conflation of forms: the seductive lure of chocolate in a shape that inhibits its intake" (ibid, p. 132).

Strangely problematic

Functional opposition can also work to make what is familiar problematic. Works of critical design [9], reflective design [29] and adversarial design [7] share a similar aim of prompting people to question and reflect on familiar technologies, practices and values. Bizarreness can thus serve as a prompt or point of entry for critique and reflection. For example, Carl DiSalvo interprets artist Mark Shepard's CCD-Me Not Umbrella through the lens of "adversarial design" [7]. CCD-Me Not Umbrella is an ordinary umbrella that has been modified with infrared LED lights to distort its appearance in images taken by digital cameras that utilize charge-coupled device (CCD) technology. DiSalvo interprets the CCD-Me Not Umbrella as an example of a "countercollective" which "operates in a manner contrary to another collective": "[It] can be taken as an attempt to address and counter pervasive video surveillance and the use of computational vision systems as part of that surveillance" (ibid, p. 106).

Strangely useful

What is strange can nonetheless exhibit familiarity. One way this can occur is when the initial novelty of a technology wears off. Gaver et al. have discussed a trajectory of appreciation [11] they have observed during field studies of technologies such as the Drift Table, a coffee table that displays slow moving aerial photography. For example, in a field study of the Drift Table a participant describes new domestic routines of "post-pub, pre-bed table-time" around the table. Another participant, however, was unconvinced by her housemates to engage with the table, seeing it as "a mere demonstration of technical possibility" [12, p. 897]. The Drift Table suggests how an artifact that is initially seen as bizarre can over time become integrated in useful ways within everyday contexts and routines; otherwise, engagement can fade over time or a device can be outright rejected.

Things such as the Greediness Meter, CCD-Me Not Umbrella and the Drift Table are of course open to different interpretations. Indeed each of these things lends itself to an interpretation as strangely bizarre, strangely problematic or strangely useful. Nonetheless, bizarreness, problematization, and usefulness represent three distinct intended and observable outcomes of the strangeness created by employing functional opposition in design.

DESIGNING COUNTERFUNCTIONAL THINGS

With ideas of functional opposition in mind, we initially set out in an open-ended manner to explore the redesign of everyday technologies based upon removing, inhibiting or otherwise countering familiar features. We specifically wanted to experiment with new possibilities from designing digital limitations but without initially limiting our explorations within a particular orientation such as critical, ludic, slow or adversarial design [7,9,12,15]. We further wanted to avoid constraining our work to the realms of the

strangely bizarre, problematic or useful. Instead we implicitly explored potentials across these areas.

Retrospectively we describe our approach as aiming to design counterfunctional things. We propose the concept of a *counterfunctional thing* as a thing that exhibits features that counter some of its own "essential functionality" while nonetheless retaining familiarity as "essentially that thing". In terms of actual material artifacts, our use of the concept of counterfunctionality is not intended to describe an intrinsic property or quality. Rather we propose counterfunctionality as a way of both interpreting existing artifacts and approaching the design of new things. In the concluding sections of this paper we further discuss counterfunctionality as a way of approaching design.

Schematized Design Process

While we wish to avoid formalizing our process into a prescriptive method, there is a simple underlying scheme to our process that is useful for conveying our design intent and approach. This involved identifying familiar functional features of digital devices and then redesigning around the removal or inhibition of these features. Schematically this process can be outlined as follows:

> Normally one *can* ____ [a "positive function"].
>
> Now one *can not* ____ [a "countered positive function"].
>
> But now one might (not) ____ [a new (counter)function].

To illustrate this approach, consider a set of examples from our design explorations: The 1-Pixel, 4-Pixel, 16-Pixel and 256-Pixel Camera, collectively referred to as the Ultra-Low Resolution Cameras. Within our overly schematized design process, the Ultra-Low Resolution Cameras can be outlined as follows:

> Normally one can capture and view high-res images.
>
> Now one cannot capture and view high-res images, but instead can only capture and view very low-res images.
>
> But now one might capture and view images as placeholders or abstract representations rather than photorealistic depictions. These low-res images might take on significance in a world populated by increasingly high-res images.

As preliminary interpretations, we can view the Ultra-Low Resolution Cameras as a playful and amusing take on current digital cameras. Alternatively we can position them as a critique of the overabundance of high-resolution images in a digital era. We may also envision these cameras as useful things that give rise to new photographic practices and experiences, such as capturing and possessing special images that are distinguished from high-resolution images.

Focusing on digital photography

Initially we conducted concept exploration in several areas including digital recorded music, telecommunication and photography. However we decided to focus our later studies on digital photography and cameras. Given our design aims, photographic technology proved to be particularly appropriate and fruitful area to explore for several reasons. Photography allows for accessible everyday modes of authorship and creation, whereas most everyday technologies related to recorded music are more limited in this regard. Photographic technologies also have both playful and serious uses, and people continue to use a range of old and new photographic technologies. For these reasons and others, photography was especially well suited for exploring bizarre, problematic and useful counterfunctional things.

Digital cameras further lent themselves to our goal of exploring possibilities in limitations but without overly focusing on addressing "bad" aspects of technology. In contrast to things like Facebook, Wifi, email and smart phones, digital cameras do not appear to be as widely criticized on moral grounds such as overwork and communication overload (e.g. [3,17,18,21]). With digital cameras we found it easier to avoid a strong critical or problemitizing stance as compared with designing counterfunctional email or wireless routers.

COUNTERFUNCTIONAL CAMERAS: DESIGN STUDIES

We now turn to present two interrelated sets of studies in designing counterfunctional digital photo technologies. The first study focuses on experimenting with new material and interactive forms. The second study focuses on a winder range of camera prototypes involving participants. Although presented sequentially, the reader should note that historically these studies have progressed in tandem and mutually informed one another.

Design Study 1: Material Form Experiments

Here we present two sets of experiments in designing counterfunctional photographic forms. We refer to these as experiments for two reasons. First, our intention was to explore new forms and functions in a provisional manner without overly focusing on specific applications or finished, usable artifacts (although in the end, this was arguably achieved). Second, the outcomes depicted can be viewed as designs with incomplete narratives surrounding their use. Instead we present the outcomes of our experiments as encapsulating new and unique types of interactive forms. This approach has similarities to prior design approaches within the HCI community (e.g., [8,15, 24,31]).

Ultra-Low Resolution Digital Displays

Related to the previously discussed concepts for the Ultra-Low-Res Cameras, we conducted a focused set of experiments in Ultra-Low Resolution Digital Displays. The underlying idea was to design in the opposing direction of the trend toward higher-resolution displays. Our aim was to explore interesting and possibly useful forms that might emerge based on this opposition.

Several of these experiments are depicted in Figures 2-3. One interesting result of these experiments was the

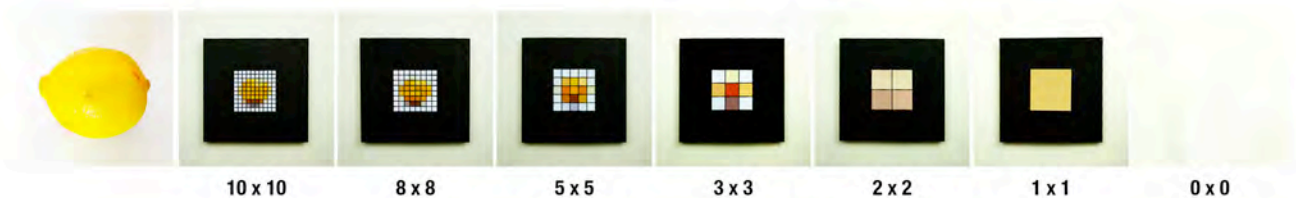

Figure 2. A high-resolution image of a lemon presented on several Ultra-low Resolution LCD Displays

observation that an outline of face could begin to be made out at around the 10x10 resolution of our experiments (see Figure 3), and specific faces could be made out at around our 30x30 resolution. Our lowest resolution experiments (1x1, 2x3, 4x4) obviously appeared abstract and unable to communicate basic shapes and familiar things without prior knowledge of what was depicted. One application concept that emerged with these experiments was a series of "Pixelated Telepresence" devices that could preserve privacy while providing a playful and provocative portal into another location.

Our Ultra-Low Resolution experiments share similarities with prior experimental art and design works such as Jim Campbell's low resolution photographic work, David Chatting's Reflections in Cider, and Daniel Rozin's Wooden Mirror. Our 1-Pixel Display also shares similarities to HCI design examplars such as Kaye et al's 1-bit communication device [18] and Gaver et al's Light Collector [10].

A primary theme that we discern across these works and our own experiments are new forms of expressivity that are counterintuitively based on lower resolution displays. By setting themselves in opposition to high-resolution digital images, things like Campbell's low resolution images and the Wooden Mirror stand out as differentiated against the new norm of high-resolution digital imagery. In the case of things like the Light Collector, 1-bit communication devices and our Ultra-Low Resolution Cameras, the "counterforms" of the ultra-low resolution displays communicate and offer new types of functionality. Seen in the light of these various low-resolution works, our experiments conceptually and materially depict a trajectory of counterfunctional displays culminating in the ultimate case of the 0x0 Pixel Display.

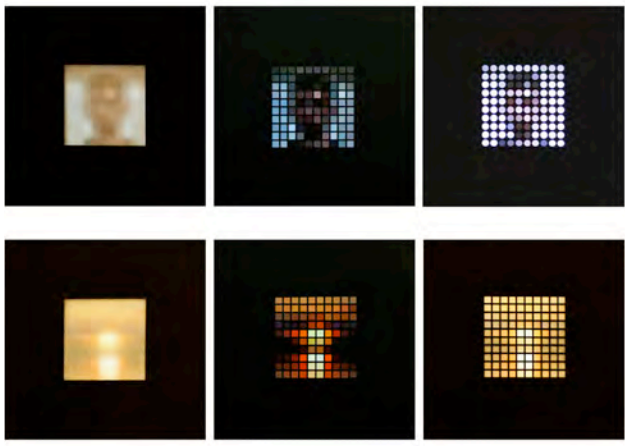

Figure 3. Ultra-low Resolution displays, 10x10 variations displaying an image of a face and a sunset over water. Different forms of light diffusion and tangible grid overlays are employed.

Inaccessible Digital Camera Enclosures

A second set of design experiments we conducted was based on the idea of inhibiting access to digital images. Digital cameras allow for instantaneous capturing and viewing of images. We wanted to explore cameras that allow for capturing digital images instantaneously but inhibit viewing images immediately (thus sharing similarities with older film cameras). The ultimate form of this concept is the Unviewable Image Camera: Images can be instantly stored as digital data on the camera, but there is no feature that allows for viewing the images. Perhaps the only hope of accessing the images is to perform a skilled technical act of reverse engineering (see also [25] for additional discussion of unviewable images).

Several more conceptually and materially accessible versions of the camera were then designed around the idea of requiring the user to physically break apart the camera in order to gain physical access to the digitally stored images. A selection of experiments designing Inaccessible Digital Cameras with different materials is depicted in Figures 4-5. The images depict ways of interacting with the cameras in order to access the images, for example, cutting open the enclosure with a saw or smashing it apart. Destructive interactions of this sort with electronic products are atypical, and these exaggerated interactions are likely to evoke elements of surprise, even absurdity. However these experiments also share similarities with more familiar things such as disposable film cameras, time capsules and ceramic piggy banks. In the following sections we present versions of a related design concept, the Capsule Camera.

Figure 4. An Inaccessible Digital Camera with a concrete enclosure.

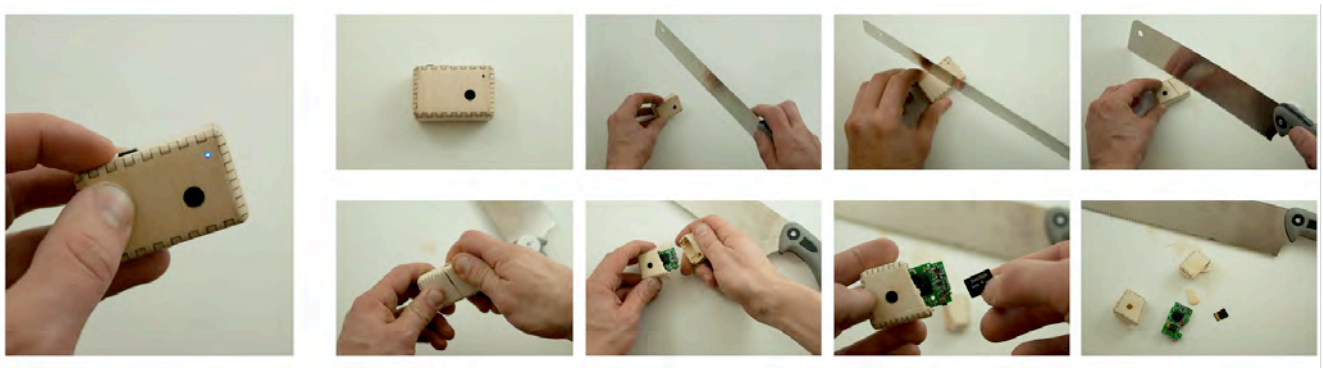

Figure 5. An Inaccessible Digital Camera. The SD card with stored images is accessed by sawing and breaking apart the basswood enclosure.

This camera builds on these experiments and seeks to more clearly recall elements of film cameras, time capsules and piggy banks and the related experiences of patience, anticipation, delayed gratification and surprise.

Design Study 2: Camera Variants Study

Our second design study aims to explore a greater breadth of counterfunctional camera concepts, and solicit feedback and discussion with participants. The goal of the empirical portion of this study was to investigate participants' initial reactions to our camera prototypes and the underlying, implicit themes of counterfunctionality and new possibilities based on technological limitations.

We eventually settled on 10 concepts that we refined and presented to participants as prompts for conversation. (We describe the details of our prototypes in the following sections.) Drawings were created for each camera concept variant. For 5 of these concepts we produced physical prototypes. The operational function of these prototypes varied. The Cabinet Camera (Figure 7) allowed for capturing and viewing images. The Capsule Camera (Figure 6) and Non-Stop Camera (Figure 7) could not take photos but had working digital display elements. The Single-Shot Cameras (Figures 1,7) were non-digital form prototypes.

This approach allowed us to present more polished forms alongside more open-ended visual ones. It also lowered the production costs of time and resources compared to developing 10 fully formed and functional prototypes. This strategy was especially well suited given we expected some cameras were unlikely to be "interesting to actually use" but would nonetheless prompt useful discussions regarding functional opposition and limiting features of technology.

Involving participants with camera variants

The use of "user studies" to validate design prototypes may be considered a norm within HCI. While we do not believe that a user study is necessary to communicate the main ideas in this paper, we found it valuable to be able to ground our own conceptual studies by soliciting reactions from outside participants. Our hope was that a study involving participants would both lend some empirical support to our conceptual explorations while also surfacing new issues, criticisms and design inspiration.

We deployed our prototypes as prompts for conversation rather than products to evaluate. 8 participants were recruited through San Francisco Bay Area Craigslist. Participants were selected based on diversity in age (19-56), gender, race and occupation. 4 were college students. The other 4 were working professionals. Each interview session lasted approximately an hour and was conducted in a comfortably furnished area of our lab. The structure of these sessions is outlined as follows: *(1) Study Introduction.* During this time we asked about participants' use of various photo technologies. *(2) Prototype introduction and discussion.* We introduced each of the form prototypes and then discussed each. We then did the same for the visual paper prototypes. We initially presented a well-defined variation of each camera, but later offered and encouraged participants to consider slightly different variations. *(3) Card sorting*. We created cards with images of each of the 10 prototypes and had participants sort them into semantically opposed categories, e.g., "useful vs. useless", "conventional vs. unconventional". Participants were asked to say the reasoning behind each categorization. *(5) Camera app vs. stand-alone camera comparison*. We described versions of our prototypes that were smart phone apps instead of stand-alone devices, and then discussed. *(6) "Limitations"*. We revealed and asked participants to reflect on the theme of "limitations" as product features, which we had not previously made explicit. *(7) Keep a camera?* We concluded by asking which, if any, camera they would want to keep and why. After each interview, notes were reviewed and reflective notes added. We selectively transcribed audio recordings of each interview guided by timestamps from interview notes.

In one sense it is a limitation of our work that we present participants with "partially functional" prototypes in a laboratory setting. A corresponding benefit, however, is that this approach allows us to gauge open-ended initial reactions across a breadth of design concepts. Given the incomplete aesthetic of our designs, we anticipated that participants would be more open to criticizing the design concepts, including openly expressing confusion or distaste.

The empirical question we investigate, then, is not: How are these products experienced within use or practice? (which participants can of course only speculate on.) Rather the questions are: What are participants' initial thoughts about these things? How do they envision using or not using these things? Would they consider adopting such things? What similarities and differences are noted across these things?

Prototypes and Participant Reactions

We present findings organized around a selection of counterfunctional camera prototypes. Two straightforward observations are worth mentioning at this point. First, the 5 younger participants (19-23) in our study tended to view the cameras more favorably than the 3 older participants (35, 43,56). Second, there was a great deal of variation within and across participants in terms of camera preferences. Yet two cameras stood out as the most and least favored. The Capsule Camera was the favorite of 4 participants, while no participant wanted to use the Reverse Polaroid Camera.

Each of the following camera subsections begins with a verbal description similar to that given to participants. The naming and descriptions of these cameras was intended to initially constrain the space of discussion. For example, we clearly presented each prototype as a "camera", thus constraining its intended functionality. Although in each case our descriptions were only starting points. We offered and encouraged participants to consider variations on each prototype throughout our discussions. We devote greater space to the Capsule Camera and Reverse Polaroid, the most and least popular cameras respectively. We offer shorter discussions of a selection of the remaining cameras.

The Capsule Camera

The Capsule Camera (Figure 6) was introduced as follows:

> This is the Capsule Camera. You can take lots of pictures with it, like this. The numerical display always shows the total number of images that have been taken. But you *can't* view the images right away. If you want to access the digital images stored in memory, you'd have to literally break the porcelain camera open…

Our intention behind the Capsule Camera was to create a digital camera experience based on patience, suspense and surprise. We also wanted to explore the idea of meaningfully possessing images that cannot yet been seen. This led us to create an atypical digital camera display in which the total number of pictures taken was displayed rather than the images themselves. The origins of the Capsule Camera can be traced to one of our more extremely counterfunctional concepts, The Unviewable Image Camera. With this camera you can take pictures, but they can never be viewed (unless, perhaps, you take it apart and reverse engineer it). The design of the Capsule Camera further builds on our Inaccessible Camera experiments (e.g., Figures 4-5).

Figure 6. The Capsule Camera prototype as presented to participants.

Participants tended to be very drawn to the Capsule Camera. 5 participants expressed a strong desire to use it, and it was the favorite choice of 4 participants. The initial variation we presented could store up to 9999 images. However, one could break apart the camera to view the images at any point. We had envisioned that people might take photos of mundane events as well as special ones, similar to placing mundane objects in a time capsule anticipating that they might take on significance when encountered in the future. However, these participants all envisioned using the Capsule Camera only for special events such as trips, weddings, and family gatherings.

As with all of the prototypes, we prompted participants to consider different variations on the camera. Variations on the number of images yielded particularly interesting discussions. We asked participants: What if it could only hold 10 images? 100 images? 1000? Participants tended to settle on about 100 images as optimal, rather than 10 or 1000 or more. It was interesting to us that participants *wanted a limit*, and this limit was less than we originally suggested. There were two main reasons stated for this preference. The first was a desire to avoid being overwhelmed by having to look through 1000s of images upon breaking open the camera. The second was a desire to be more thoughtful and judicious in the process of capturing photos. Participants wanted to be able to reserve these images for special moments; they wanted to *not* be able squander them on unimportant moments. As one participant puts it, "I'll [currently] snap a thousand photos in 3 days [when I use my camera phone]… taking less photos would make them more meaningful" (Scott, age 20).

We had expected that at least some participants would want to use the Capsule Camera and would appreciate it for what it can and does *not* do. It was encouraging to find out that these expectations held true. However, these initial findings raise many empirical questions that can only be answered through a longer-term field study of a more developed prototype: Is 100 the "right" number? Would 1000 images be overwhelming? In practice, would the Capsule Camera counterfunction as well as participants envision against camera phones, digital SLRs and Instagram?

The Reverse Polaroid Camera

We introduced the Reverse Polaroid Camera as follows:

> This is the Reverse Polaroid Camera [showing the visual prototype]. You can take pictures with it, and similar to your camera phone it stores the pictures in a gallery mode. You can

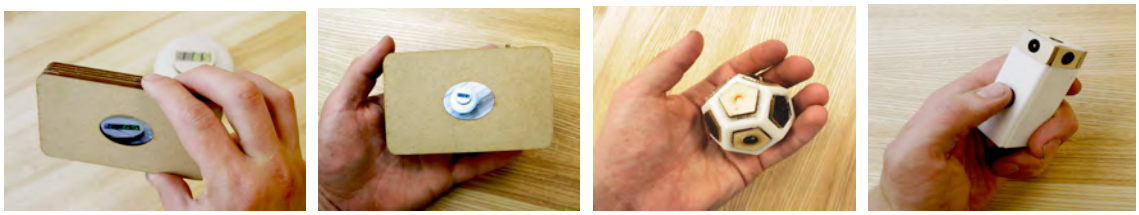

Figure 7. Prototypes presented to participants (left to right): Cabinet Camera, Non-Stop Camera, Single-Shot Camera (Multi-Angle version).

> tap on the image to see it in picture mode. However, for each second that you view the image in picture mode, it begins to pixelate and degrade. If you view it for too long, it degrades to the point where it is just a solid color—1 pixel. But when you are not viewing the image in picture mode, the image stays as it is and doesn't degrade. So: you can't see the image unless you destroy it a little bit, and you can't keep the image safe unless you don't see it.

Our intention here was to create a tension between viewing an image that you cannot maintain and maintaining an image that you cannot view. We wanted to explore appreciation for a photograph as either fleeting or else permanent but unviewable. We also wanted to play with a photographic possibility that appeared uniquely digital: precise control of the destruction of a photograph.

While 5 of the participants wanted to use the Capsule Camera, no participant wanted to use the Reverse Polaroid Camera. The Reverse Polaroid was unanimously suggested as "useless". This was not altogether surprising to us. We had in fact included the Reverse Polaroid in our selection because it struck us as interesting conceptually but perhaps less likely to be used and appreciated in (imagined) practice. Yet what appealed to us conceptually as design researchers did not resonate with our participants: "But we take pictures so we can keep them!" (Scott, age 20); "That makes me really sad" (Jen, age 23); I don't want to lose my pictures!"(Lea, age19).

Why were the limitations of the Reverse Polaroid seen as useless, whereas the limitations of the Capsule Camera and other counterfunctional cameras were appreciated and embraced? We consider a few explanations, setting aside the non-trivial issue that our presentation of this camera was limited to a set of visual depictions and verbal descriptions.

The Reverse Polaroid seems to counter what lies at the essence of photography: visually capturing something so it can remain to be seen. The Reverse Polaroid offers itself as a camera for capturing, keeping and viewing images. However, viewing the images slowly destroys them. What is the purpose of keeping a photo you cannot see, or seeing a photo that will not keep?

Compared to other counterfunctional cameras, the Reverse Polaroid also does not counter functionality so as to readily recall older photographic technologies and experiences. Destroying an image appears antithetical to every preceding photographic technology. Instead this counterfunctionality has similarities with naked visual perception of our environment: We can try to fix our field of vision, but we cannot fix what occurs within it. Photographs allow us to approximate completely capturing and fixing in space and time what we see before us in an instant.

However the Reverse Polaroid is reminiscent of the recent and popular app Snapchat, as two of our participants noted. Snapchat allows you to send photos to your friends using your smart phone. Upon receiving a photo you can choose to open and view it. But once you open the image it disappears permanently after 1-10 seconds. According to one participant, "[The Reverse Polaroid Camera] reminds me of Snapchat, but pointless" (Paul, age 20).

Interestingly, this participant describes Snapchat as less of a photo app and more of a chat app. While the Reverse Polaroid was apparently seen as a device for destroying photos, Snapchat was described as an app for chatting with photos. The inability to keep an image with Snapchat is a "negative affordance" that enables one to treat images less as photographic objects and more as spoken words. You can send risky, inappropriate, silly, unsophisticated and what might otherwise be uninteresting images precisely because you *can not* send images that are easily kept.

While our 8 participants unanimously determined that the Reverse Polaroid design concept was very unlikely to be interesting to actually use, or even to think about using, it is interesting to think about why this was the case. In this way designing and making things that are likely to be "useless to use" can nonetheless have practical and theoretical value.

The Cabinet Camera

> This is the Cabinet Camera [Figure 7]. You can take pictures and view the pictures whenever you want, like this. However you can never transfer the pictures off of the camera; they "live" on this camera display forever. So you can't put them on your computer, or edit them, or post them to Facebook…

4 participants were very drawn to the Cabinet Camera and wanted to use it. It was likened to both a traditional photo album and a digital photo frame. Similar to the Capsule Camera, it tended to be envisioned for special pictures: "I'd take pictures of things I'd wanna keep… weddings, family gathering..." (Scott, age 20); "It'd be convenient as a safe…for precious memories… like an album" (Laura, age 21); "I would have to really think about the pictures [I take]" (Tanya, age 22). Others saw little value in it: "The only bad part is that [the images] can't be pulled off… I can't see using it as a better option… there's no benefit." (Tom, preage 43).

The Non-Stop Camera

> This is the Non-Stop Camera [Figure 7]. You can set it down so the lens is aiming in the direction you want, but you cannot control when it takes a photo. It randomly takes photos and it lights up to show you when it is taking a photo. In fact, you can never turn it off. It recharges itself with these solar panels…

As expected, many were drawn to its unique form and the functionality of the solar panels, rather than its intended negative function of not being able to turn it off or control when it snaps photos. Most participants were not particularly drawn to this camera. However, we were surprised that this was the only camera that one participant wanted to use. For this participant, "The randomness is a positive… I wouldn't perceive it as a limit" (Tom, age 43). This example highlights the diversity in participants' thoughts and preferences for the cameras.

The Single-Shot Cameras (Single-angle and Multi-angle)

> These are the Single-Shot Cameras [Figures 1, 7]. You can only take one shot at a time with these cameras. The single-angle version has just one lens; the multi-angle version takes pictures in 5 different directions. Let's start by imagining you can only take one picture per month with these cameras…

All but one participant did not find much or any value in limiting the number of photos that could be taken. But this one participant expressed substantial interest in using the counterfunctionality of Multi-Angle Single Shot Camera: "It'd be like an experience… With only 1-shot, I would not feel pressure to take pictures…I'd take casual shots and see how things have changed" (Shen, age 19).

The Prompt Camera

> This is the Prompt Camera. You cannot take pictures whenever you want with it. You can only take pictures when it lights up, prompting you to take a picture…

While it was no participant's favorite, preferences were somewhat varied on this camera. One participant liked "the idea" but didn't know "where to use it":

> I do like ***the idea*** [emphasis added] of taking pictures when you're not ready. Because, you know, for every single picture we do try to dress up, do our hair, do our makeup, make a pretty face [laughs]. I *do* like the idea, ***I just don't know where to use it, where to put it*** [emphasis added]. Maybe at the workplace, to take a picture with coworkers at random moments? (Shen, age 19).

DISCUSSION AND IMPLICATIONS

In this final section, we discuss counterfunctionality as a methodological and conceptual route to approaching interactive design. We conclude by connecting our work to various critical discourses around technology and design.

Counterfunction as a way of approaching design

As a way of approaching design, we have used the concept of counterfunctionality in two ways. At a more general level, counterfunctionality encapsulates the notion that functional oppositions can create new types of useful and desirable functionality. In a more specific manner, we have employed counterfunctionality to focus on designing digital limitations as a valuable source of new positive possibilities.

We have articulated this general and specific focus through a series of design studies using digital photography as a medium. Schematically our process involved identifying positive features of technology and redesigning around the removal and absence of these features. Reflecting upon our studies, we draw out 3 key dimensions to consider with respect to designing counterfunctional things and functional oppositions more generally.

Interesting to actually use vs. interesting to think about using

The first dimension differentiates counterfunctional designs that are only "interesting to think about (using)" versus ones that may be "interesting to actually use". In our studies several participants were drawn to the Capsule Camera and Cabinet Camera as things they would want to adopt, use and potentially incorporate within their everyday lives. In other cases participants found the prototypes interesting conceptually but difficult to imagine using in practice. For example, one participant liked "the idea of taking pictures when you're not ready. Because…for every single picture we do try to dress up…make a pretty face." But in practice, the Prompt Camera did not appear useful to her: "I do like the idea, I just don't know where to use it, where to put it." And still other concepts were thought to be interesting and useful to us as designers and researchers but did not resonate in these ways with participants. The key example of this we discussed is the Reverse Polaroid camera, which appealed to us conceptually but seemed confusing and absurd to our participants as we presented it to them.

This distinction between "interesting to actually use" and "interesting to think about using" complicates more traditional notions of usefulness and usability. And it represents an issue that demands stronger consideration in future work, particularly as it relates to notions of critical design and the functions of design research artifacts (c.f. [1,7,9,24]).

Adding new features along with removing existing ones

The second dimension is the extent to which a counterfunctional redesign introduces new positive forms and functions along with the removal of desired and familiar ones. Each of the designs we have presented is based on the absence of familiar technological features. To varying degrees, many of our designs also introduce some novel forms (e.g., a concrete enclosure, a physical grid overlay that defines the "ultra-low resolution", the multiple angles and smaller form factors of the Single-Shot Cameras). Adding new features can serve to counterbalance an introduced absence by drawing attention away from it. If too pronounced though, new forms can overshadow or obscure the new counterfeatures. For example, many participants focused on the new and unconventional

features of our concepts such as the solar powered elements of the Non-Stop Camera rather than the counterfeature of not being able to control when it is powered on and taking images. Conversely, adding new forms along with removing existing ones can also serve to support and amplify the newly intended counterfunction. For example, the Capsule Camera seemed to succeed in part because the new form factor and materials helped communicate that the inability to immediately view images was a defining positive feature of the device.

Recalling older technologies

The last dimension we consider is the extent to which a counterfunctional redesign recalls features of older technologies. Many of our designs recalled elements of preceding camera technologies. For example, participants described the Cabinet Camera as similar to a photo album. On the other hand, a design concept like the Reverse Polaroid appears to break more radically with both new and old camera technologies. Instead it opposes a long held tradition in photography: the desire to permanently fix an image. The extent to which a counterfunctional thing recalls earlier technologies appears to be a crucial part of how it is experienced. As one participant remarked when asked about whether she perceived the cameras as limited: "Maybe I'm more okay with [the limitation of the Cabinet Camera] because that was what it was like before [with photo albums]. And you know, like, breaking this [Capsule Camera], is like breaking a piggy bank" (Jen, age 23). Our studies strongly suggest that recalling older technologies is a critical design dimension to consider and a conceptual thread worthy of continued investigation.

Connecting counterfunctionality to critical discourses

We have a tendency to think of limitations as bad and possibilities as good or neutral. Yet technological possibilities can be limiting, just as technological limitations can open up new possibilities. Currently we are witnessing technology countertrends across areas of Europe, the U.S., Australia and Japan around "slow", "local" and "do-it-yourself", which respectively oppose the speed, globalization and automation afforded by new technologies. Paralleling these countertrends are recent HCI concerns with busyness [20], simple living [14,28], conflicting cultural discourse surrounding the smart phone [17] and voluntary non-use and removal of technologies such as email [21] and Facebook [3]. These grounded studies highlight both negative limitations of digital technologies while suggesting positive opportunities derived from creating and offering new limitations.

Recent critical essays from areas adjacent to HCI similarly discuss the value of technological limitations, including the value of simple communication tools in an age of communication overload [18], the benefits of deleting and forgetting digital content in an age where Facebook and Google remember everything [22], and the literal and metaphorical lack of sleep amidst a 24/7 culture [6].

Another recent cluster of writings discuss the methodological value of limits, absence and negation for HCI. Satchell and Dourish argue for the value of studying non-uses of technology [27]. Tatar et al. point out that features that are not included can be just as important as those that are, a perspective they refer to as zensign [30]. Adopting a more critical oppositional stance, Baumer and Silberman propose that HCI consider the implications to not design technology [1] while Pierce argues that the HCI community should consider undesigning technologies [26].

The notion of counterfunctionality draws from the perspectives and insights mentioned above. But as a design approach it is distinguished in important regards. First, counterfunctionality encapsulates a basic strategy of employing functional opposition. It further highlights how the removal, inhibition and inversion of functional features can form the very basis for new interactions and experiences. Second, counterfunctionality foregrounds the concept of "enabling limitations". It points to the ways in which a thing can function by virtue of the functionality it omits or opposes. Extending beyond the observation that decisions to omit features are important in the design process (c.f. [30]), counterfunctionality brings into focus how omission and opposition can be salient features in one's use and interaction with a technology. That is, counterfunction can be a defining aspect of the experience of use, rather than simply a decision in the design process.

All new technologies are met with some degree of criticism and resistance, and digital technologies are certainly no exception. What is perhaps unique at this moment in time is that there are signs that designers and researchers of technology are becoming more interested in discussing and identifying limitations of digital possibilities. While never naively rejecting technology, all of the above-mentioned works give attention to under-examined "limiting" rather than "empowering" aspects of technology. Connecting our work with critical discourses, we further draw attention to underserved needs and design opportunities related to digital limitations. However we also see opportunity for design that works across the rigid dichotomy of "addressing bad" and "offering new good".

Our work thus reflects a double-desire. On the one hand we wish to help dissolve a divisive split between negatively critiquing technology and affirmatively designing it. At the same time, we want to help establish the design of limitations as a clustering of methods, approaches and concepts that are both highly applicable but not limited to addressing what is deemed to be bad, wrong or problematic with technology in either its particular or general manifestations.

CONCLUSION

At some level every good designer understands the value of absence and limitations. Twitter, Snapchat and the Drift Table evidence this, as do the well-known design concepts of negative space, minimalism, and feature creep. Building

on prior design research, we have proposed the concept of counterfunctionality as a way of approaching the design of new technologies. We have also touched on the concepts potential as a lens for interpreting existing technologies. Through our design studies and discussions of counterfunctional photo technologies, we have given focus to a research agenda of designing digital limitations. If digital technologies are currently limited by their possibilities, we see great possibility in designing new forms and functions of digital limitations.

ACKNOWLEDGMENTS

We thank the participants in our study. Financial support for this work was provided in part by National Science Foundation Grant #IIS- 1018340. Photos © James Pierce.

REFERENCES

1. Bardzell, J. and Bardzell, S. 2013. What is "critical" about critical design? Proc. CHI ’13.
2. Baumer, E. & Silberman, S. 2011. When the implication is not to design (technology). Proc. CHI ’11.
3. Baumer, E., Adams, P., Khovanskaya, V., Liao, T., Smith, M., Sosik, V. & Williams, K. 2013. Limiting, leaving, and (re)lapsing: an exploration of facebook non-use practices and experiences. Proc. CHI '13.
4. Bell, G., Blythe, M. and Sengers, P. 2005. Making by making strange: Defamiliarization and the design of domestic technologies. ACM Trans. Comput.-Hum. Interact. 12, 2 (June 2005), 149-173.
5. Blauvelt, Andrew, Walker Art Center, Carnegie Museum of Art, and Musée de l’Hospice Comtesse. Strangely Familiar: Design and Everyday Life. Minneapolis, Minn.: Walker Art Center, 2003.
6. Crary, J. 2013. 24/7: Late Capitalisms and the Ends of Sleep. Verso.
7. DiSalvo, C. 2012. Adversarial Design. MIT Press.
8. Djajadiningrat, Tom, Stephan Wensveen, Joep Frens, and Kees Overbeeke. “Tangible Products: Redressing the Balance Between Appearance and Action.” Personal Ubiquitous Comput. 8, no. 5 (September 2004): 294–309.
9. Dunne, A., & Raby, F. 2001. Design noir: The secret life of electronic objects. August Media, Boston.
10. Gaver,W., Bowers, J., Boehner, B., Boucher, A., Cameron, D., Hauenstein, M., Jarvis, N. & Pennington, S. 2013. Indoor Weather Stations: Investigating a Ludic Approach to Environmental HCI Through Batch Prototyping. Proc. CHI ’13.
11. Gaver, W., Sengers, P., Kerridge, T., Kaye, J. & Bowers, J. 2007. Enhancing ubiquitous computing with user interpretation: field testing the home health horoscope. Proc. CHI ’07.
12. Gaver, W., Bowers, J., Boucher, A., Gellerson, H., Pennington, S., Schmidt, S., Steed, A., Villars, N. & Walker, B. 2004. The drift table: designing for ludic engagement. CHI EA ’04.
13. Gaver, W., Beaver,J. and Benford,S. 2003. Ambiguity as a resource for design. Proc. CHI '03.
14. Håkansson, M. & Sengers, P. 2013. Beyond being green: simple living families and ICT. Proc. CHI '13.
15. Hallnas, L., Redstrom, J. 2001. Slow Technology: Designing for Reflection. P. Ubi. Comp. 5(3): 201-212.
16. Hallnäs, Lars, and Johan Redström. “From Use to Presence: On the Expressions and Aesthetics of Everyday Computational Things.” ACM Trans. Comput.-Hum. Interact. 9(2):106–124.
17. Harmon, E. and Mazmanian, M. 2013. Stories of the Smartphone in everyday discourse: conflict, tension and instability. Proc. CHI ’13.
18. Harper, R.. 2012. Texture: Human Expression in the Age of Communications Overload. MIT Press.
19. Kaye, J., Levitt, M., Nevins, J., Golden, J. & Schmidt, V. 2005. Communicating intimacy one bit at a time. CHI EA '05.
20. Leshed, G. & Sengers, P. 2011. "I lie to myself that I have freedom in my own schedule": productivity tools and experiences of busyness. Proc. CHI ’11.
21. Mark, G., Voida, S. & Cardello, A. 2012. "A pace not dictated by electrons": an empirical study of work without email. Proc CHI '12.
22. Mayer-Schönberger, Viktor. Delete the Virtue of Forgetting in the Digital Age. Princeton [N.J.]: Princeton University Press, 2009.
23. Odom, W., Selby, M., Sellen, A., Kirk, D., Banks, R. & Regan, T. 2012. Photobox: on the design of a slow technology. Proc. DIS ’12.
24. Pierce, J. 2014. On the presentation and production of design research artifacts in HCI research. Proc. DIS ’14.
25. Pierce, J. & Paulos, E. 2014. Some variations on a counterfunctional digital camera. Proc. DIS
26. Pierce, J. 2012. Undesigning technology: considering the negation of design by design. Proc. CHI ’12.
27. Satchell, C. & Dourish, P. 2009. Beyond the user: use and non-use in HCI. Proc. OZCHI ’09.
28. Sengers, P. 2011. What I learned on Change Islands: reflections on IT and pace of life. interactions, 18(2).
29. Sengers, P., Boehner, K., David, S., & Kaye, J. 2005. Reflective design. Proc. Critical Computing '05.
30. Tatar, D., Lee, J.-S., Alaloula, N. 2008. Playground games. Proc.DIS ’08.
31. Vallgaarda, A. 2008. PLANKS: A Computational Composite. Proc. NordiCHI ’08.