No Longer Wearing: Investigating the Abandonment of Personal Health-Tracking Technologies on Craigslist

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ABSTRACT

Personal health-tracking technologies have become a part of mainstream culture. Their growing popularity and widespread adoption present an opportunity for the design of new interventions to improve wellness and health. However, there is an increasing concern that these technologies are failing to inspire long-term adoption. In order to understand why users abandon personal health-tracking technologies, we analyzed advertisements of secondary sales of such technologies on Craigslist. We conducted iterative inductive and deductive analyses of approximately 1600 advertisements of personal health-tracking technologies posted over the course of one month across the US. We identify health motivations and rationales for abandonment and present a set of design implications. We call for improved theories that help translate between existing theories designed to explain psychological effects of health behavior change and the technologies that help people make those changes.

Author Keywords

technology abandonment; health-tracking; self-monitoring

ACM Classification Keywords

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INTRODUCTION

New advances in sensing technologies have exponentially increased their availability for individuals of all walks of life. As a result, individuals are capable of tracking and monitoring a variety of activities and generate volumes of self-monitoring data. Self-monitoring enthusiasts, like quantified selfers [25], advocate the multiple benefits of self-monitoring technologies and their ability to lead to insight and increased self-knowledge.

One area where wearable self-monitoring technologies receive particular attention is in the domain of health and wellness. Physical-activity trackers (e.g., Fitbit), digital scales, bluetooth-equipped heart-rate monitors, and other emerging sensors give rise to mobile health (mHealth) applications to collect data about users' activities and states with minimal burden, easing the process of self-monitoring [22]. Marketing research shows that these technologies have reached a wide level of adoption among American customers: as a product sector, predictions indicate that wearable personal-tracking technologies will eclipse $70 Billion by 2024 [20]. HCI research on self-tracking has made great strides towards understanding the motivations that lead individuals to adopt novel sensing technologies into their daily lives [6, 38].

However, together with this enthusiasm, there exists considerable and growing skepticism regarding these technologies and their ability to inspire and sustain individuals' ongoing engagement with their everyday health and wellness [17]. A recent study suggests that one third of all Americans who purchased a wearable self-monitoring product abandoned it after only 6 months of use [23]. Many interpret these findings as indicative of the failure of wearable health technologies to inspire continuous engagement and interest from their users, and question the benefits and even the survival of these technologies [15, 19]. However, an in-depth account of the reasons why individuals abandon their wearable self-monitoring devices is lacking. This scholarship is important as it could enrich the existing knowledge on how individuals engage or fail to engage with self-monitoring technologies and suggest directions for future designs and research.

In this paper we examine why users abandon self-monitoring technologies. This problem is challenging to study with traditional qualitative methods, such as interviews or focus groups, because of the potential bias in the sampling of participants. To address this limitation, we examined a less traditional but potentially rich destination for 'abandoned' fitness technologies: secondary sales in online marketplaces. Specifically, we focused on posts from the classified ad site Craigslist, collecting advertisements for sales of common consumer fitness trackers that took place over the course of one month across the US. We analyzed and iteratively coded the approximately 1600 posts that matched our criteria to understand sellers' point of abandonment, motivation for discarding the technology, and any additional comments or stories included in the posts. Throughout the analysis of our data, we adopted the assumption that, while there are definite outliers that are abandoning their technologies based on "positive" rationales, most abandoning of health-tracking technologies are ultimately a "negative" activity because the owner has not fully exploited the benefits of using that technology.

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The results of our study suggest a more optimistic view of the adoption potential of wearable self-monitoring technologies than recent studies and media reports may suggest. While the rate of abandonment may indeed be high, our analysis reveals that not all acts of technology abandonment are motivated by a perceived lack of utility or borne out of frustration with the device. We discovered abandonment happening due to a host of unassociated reasons. These include productive rationales for abandonment (goals obtained, technological upgrades), rationales associated with one's social environment or physical abilities (social connections, health conditions, changes in activities associated with device), and a mismatch between users' expectations and the capabilities of the device - the most common rationale for abandonment in our dataset. This suggests that personal health-tracking technologies are used in complex dynamic social environments and need to fit within individuals existing, messy practices [2]. Based on our analysis, we propose enriching the contemporary theoretical landscape with theories of sense-making, problem-solving, and experiential learning that can provide more direct guidance to the design of self-monitoring technologies and expand capacity for users to gain deeper insight and discovery into their everyday health. Finally, we present a set of design recommendations to assist designers in creating technologies that inspire sustained evolving adoption. As such, our work makes the following contributions to HCI research:

- We present the first investigation into the abandonment of wearable health-tracking technologies outside of a particular intervention or technology.
- We analyze people's own accounts of personal-tracking technology abandonment through an exploration of secondary sales on Craigslist.
- We identify health motivations and rationales for abandonment and connect these actions to current theories in health behavior change.
- We describe implications for designing health-tracking technologies that, in the future, will not be so easily abandoned.

RELATED WORK

Health trackers and quantified self

In recent years, the increasing availability of commercial activity monitoring devices has inspired interest from the research community regarding their ability to inspire self-reflection and positive behavior change. Even at this early stage, studies of activity-tracking technologies (e.g. pedometers) prove effective at improving individuals' physical activity [7, 27, 32]. In addition to studying these technologies from the perspective of health and wellness [22, 28, 34], HCI researchers also study their potential for improving self-knowledge (personal informatics) [25, 26], augmenting memory [18], and reducing environmental impact [10].

More recently, wide adoption of such devices from Jawbone, FitBit and Nike created opportunities for interactive applications that target a range of individuals' behavioral goals and activities. These platforms allow for custom application development with a more sophisticated set of features through their coupling with smartphone applications and the fact they have open APIs. There is ongoing research focused on the accuracy of these devices [14, 43]. In addition, there are also early efforts to utilize these devices for delivery of behavior change interventions from increases in physical activity [24, 44] to improvement in quality of sleep [4, 5, 21, 39] to playful interaction through personal data [30]. The quantified self movement garnered attention in the research literature as well, as they represent early adopters of these behavior-tracking technologies [6, 25, 38, 42].

Abandoning technology

The abandonment of health technology is not a new phenomenon. However, few systematic studies exist of why people stop using health technologies. While the assistive technology community looks at adoption and abandonment of clinician-provided personal health technologies, their findings do not fully capture today's consumer-led health tracker market. For example, in a 1993 study of assistive technology abandonment, Phillips & Zhao describe four factors: 1) lack of consideration of user opinion in selecting the devices; 2) poor device performance; 3) the ease of procuring the devices; and 4) change in user needs or priorities [35]. The first two factors are less applicable in today's consumer-focused health tracker industry: consumers often buy health trackers directly, and the devices themselves (particularly movement trackers) have become more robust and accurate over the last several years. However, the last two are still relevant today. Phillips & Zhao found that the easier it was for users to acquire a device, the quicker they were to abandon it. These days, a decent health-tracking device can be found for relatively little money at any number of stores or online retailers.

More recently, the researchers within the CHI and Ubiquitous Computing communities have also started to explore abandonment. For example, Cordeiro et al. surveyed food journalers and examined forum posts to identify reasons people stop using food diaries [8] and Schwanda et al. explored reasons individuals abandon using the Wii Fit as health technology while advocating that researchers and designers consider the role that persuasive technologies play in encouraging healthy habits [40].

However, to date, there has been little work directly examining the adoption and abandonment of *wearable* self-monitoring technologies [23]. While Fritz et al. explored the adoption of wearable health trackers [9], only an Internet study conducted by Endeavour Partners has investigated the abandonment of these technologies [23]. They report that one in ten Americans over 18 owned an activity tracker, such as Jawbone or Fitbit, suggesting that wearable devices are finally achieving mass market penetration. On the other hand, the study reports that a third of U.S. consumers who have owned one of these devices stopped using it within six months of receiving it. These numbers certainly inspire concern; however, while the report suggested many directions for improving adoption, it did not explicitly addressed the reasons why these devices are abandoned. The goal of our study focused on examining these reasons and drawing conclusions for the design of future wearable health-technologies.

Health behavior change theory

When considering issues of technology adoption and abandonment, it is important to reflect on the driving forces behind these technologies as well as the theoretical foundations that ground them. Many contemporary technologies for health self-monitoring and self-management are inspired by theories of health behavior change. For example, in Social Cognitive Theory, a health tracker can enable interpersonal interactions to facilitate observational learning [1]. Similarly, in individual models such as the Theory of Planned Behavior, health trackers may succeed or fail an individual to the extent that they enable or inhibit a person's perceived behavioral control [11]. Goal Setting Theory predicts that an appropriately-targeted specific goal is more likely achievable than not [41].

At both the interpersonal and individual level, health behavior change theories themselves give little advice to developers and researchers of health trackers on exactly *how* the technologies can best take advantage of theory [37]. HCI researchers have begun to address this issue through empirical study (such as Munson & Consolvo's research on goal-setting for physical activity [33]). Others have called for technologists and health researchers to work closer together [16].

METHODOLOGY

The goal of this project is to better understand the rationale behind why people abandon technology, more specifically health-tracking technologies. Even though people will certainly complain online through reviews and customer service platforms, those who abandon technology do not typically discuss their abandonment decisions online in any centralized forum. To that end, we chose to investigate abandonment in the public marketplace. The marketplace chosen for this study is Craigslist. We posit that when an individual sells a health-tracking technology, they are actively abandoning said technology. To achieve our research objective exploring why people choose to abandon technologies, we first selected a set of popular health-monitoring technologies, collected sales posts associated with the selected technologies, and conducted a content analysis of the sales posts.

Technology selection

To begin, we researched the pervasiveness and popularity of health trackers. Based on their sales rankings on Amazon, we selected personal health-monitoring technologies as the basis for data collection in this study. These technology brands included Fitbit, Jawbone, iHealth, Polar, Omron, Withings, Fuelband, and Eatsmart. We did not discriminate between specific technologies within these brands during the data collection instead choosing to be inclusive of all tracking technologies within those brands. In total, we collected data on 21 individual technologies (see Table 1).

Brand	Technologies
Eatsmart	Scale
Fitbit	Aria, Flex, Force, One, Ultra, Zip, unclassified
iHealth	Scale
Jawbone	UP, UP24, unclassified
Nike	Fuelband
Omron	blood pressure, nebulizer, pedometer, scale
Polar	heart rate monitor, watch
Withings	blood pressure, scale

Table 1. Selected Technologies

Data Collection

We used the technology brands identified through Amazon as the seed terms to search Craigslist postings. We collected posts from July 1 to July 31, 2014 from all 416 U.S. Craigslist city directories. For each Craigslist posting added to our dataset, we collected information regarding the search term used to find the advertisement, the state and city from which the post originated, the text of the post, the post ID, and the hyperlink to the post. When we purged duplicate posts from the data, we were left with a total of 1561 results.

The majority of the posts in our initial dataset represented traditional sales advertisements in that they provided no insight into why an individual would be selling/abandoning the health-tracking technology. The quote below is an example of a traditional advertisement.

> "I am selling my Nike Fuelband, its medium/large size and black. It comes with the box and all accessories. Can meet up around the metrotown area."

We found that traditional advertisements did little to help us understand abandonment and as such decided to remove these types of posts from our data. We refined our dataset to only include posts that contained some sort of personal story attached to the advertisement. Posts with personal stories related to the technology had the potential to provide information about why the individual was choosing to abandon their technology. We coded the dataset for personal stories resulting in a dataset containing 462 posts.

Code Book

We used an inductive approach to analyzing the 462 posts that included a personal story. A team of three researchers independently open coded a randomized sample (10.0%) of the personal story posts. We coded for general themes in the data. Next, we met as a group to discuss themes and further refine the coding taxonomy. Technology use, rationale for sale, the time of ownership, and motivation for health use were the general themes that emerged.

We developed a list of themes for our initial codebook (see Table 2 for the list of high-level themes).and each coder resampled another 10% of the data. The coding had an inter-rater reliability of 92.0%. The team met to discuss what types of categories were present in each of the themes and further refined and expanded the codebook. A third and final coding exercise took place with a randomized 10.0% sample of the data. An inter-rater reliability of 96.0% was achieved between the three researchers.

Two researchers independently coded the reduced dataset using the refined codebook developed by the team. During this process, an additional 24 records were flagged by the researchers as not having a personal story attached to the record. The team met, discussed each of these records, and agreed to take them out of the dataset. They also chose to

Category	Number of Codes
Technology	23
Technology Acquisition	6
Condition	5
Technology Count	4
Abandonment Point: Time	7
Abandonment Point: Use	7
Abandonment Rationale	15
Health Motivations	17

Table 2. The categories that organized our codes

remove all posts where a fitness tracker was part of a bulk sale/yard sale because in these posts the seller typically lists a large number of items and the personal story relates to the sale of all items, not just the fitness tracker. Finally, the team chose to remove all posts in which the seller was simply discussing spare parts (wristbands, extra straps, or power chords for example). This process generated the final dataset which contained 427 advertisements.

In total, we found 1561 Craiglist posts met our criteria during the month of July 2014. Sampling that dataset to remove all posts that did not contain personal stories, resulted in a set of 462 advertisements. Further sampling of the data to remove advertisements for parts and all posts where a fitness tracker was part of a bulk/yard sale resulted in a final dataset composed of 427 records.

RESULTS

We begin by describing the technologies present in the posts and then move on to discuss the acquisition of the technology, the condition of the technology, the abandonment point, the rationale behind the abandonment, and conclude with health motivations related to the abandonment of the technology.

Health-tracking technologies for sale

The final dataset consisted of 427 Craigslists posts that contained advertisements for 470 health-tracking technologies. Several posts (3.6% of total posts) in our dataset were selling multiples of the same item or selling trackers in tandem, for example selling a smart scale and a fitness tracker in the same advertisement. Taken together, the Fitbit (180), Nike Fuelband (130) and Jawbone (111) technologies accounted for the vast majority of the technologies in the dataset (38.3%, 29.3% and 22.3% respectively). Wearables (436 items) accounted for 92.8% of all the advertisements in the dataset, while scales (18 items) comprised 3.8% of the data and blood pressure monitors (16 items) accounted for the remaining 3.4%. Table 3 highlights the breakdown of these technologies.

Initial Technology Acquisition

We coded each advertisement to note if there was a description regarding how the individual seller had acquired their technology, as we were interested in the relationship between ownership, adoption, and abandonment. Roughly half of our posts (50.3%) described the method by which the seller came to own their technology. Table 4 reflects the breakdown of the posts in our dataset as it relates to the specific acquisition method.

Technology	Number of Items for Sale	% of total items
Eatsmart scale	1	0.2%
Fitbit (unclassified)	51	10.9%
Fitbit aria	14	3.0%
Fitbit flex	75	16.0%
Fitbit force	1	0.2%
Fitbit one	22	4.7%
Fitbit ultra	4	0.9%
Fitbit zip	13	2.8%
iHealth	1	0.2%
Jawbone (unclassified)	23	4.9%
Jawbone UP	60	12.8%
Jawbone UP 24	28	6.0%
Nike fuelband	130	27.7%
Omron blood pressure	14	3.0%
Omron pedometer	2	0.4%
Omron scale	2	0.4%
Polar heartrate monitor	14	3.0%
Polar watch	13	2.8%
Withing blood pressure	2	0.4%
Total	**470**	**100%**

Table 3. Technology distributions across the craigslist posts

Acquisition method	Technology count	Technology %
Found	3	0.6%
Gift	88	18.6%
Purchased	123	26.0%
Won	18	3.8%
Employment/School program	3	0.6%
Not reported	238	50.3%

Table 4. Technology acquisition method

Acquisition method turns out to be an interesting component of the advertisements when observed through an abandonment lens. Individuals who purchased their technology typically had a greater sense of ownership over their device(s) than those who won or were given the technology. For example, a person who won a health-tracking technology was much more likely to abandon the technology immediately, sell it new in box, and explicitly abandon the technology for monetary reasons. Below is a typical advertisement for a health-tracking technology that someone won:

> "I just won a fitbit flex valued at $99.99 but I know I won't use it and hope to make a fair deal with someone who would. Brand new not even opened"

Compare that to a typical example of an advertisement in which the seller had purchased her technology.

> "Hi, I'm selling my Jawbone UP 24. Purchased brand new...No defects, works great...I am not using it like I thought I would so I figured I would re-sell and get some of my money back since I cannot return it."

In the case of the individual who purchased the technology, they were at some point interested in using a personal health-tracking technology to collect health information. Though they did not sustain their initial interest in fitness-tracking, they at least tried out the technology and owned the device for a period of time before deciding to abandon it. In contrast, the individual who won the technology had no interest in using the device at all: they simply won a new fitness tracker and are taking advantage of that opportunity to make some money.

Condition	Technology count	Technology %
New	97	20.6%
Opened	32	6.8%
Used	301	64.0%
Damaged	3	0.6%
Not reported	37	7.9%

Table 5. Technology condition

Our data indicates that giving someone a health-tracking technology as a gift can be a risky endeavor as there is a high probability of a mismatch between the giver's idea of what a good health-monitoring technology is and receiver's own idea. Given the multitude of available technologies, finding the right match is not always easy. We labeled advertisements as gifts if the individual selling the health tracker was either the recipient or the giver of a gift. The gift category is particularly illuminating when considered in conjunction with Abandonment Rationale category (discussed in detail below). For example, 20.5% of people who received a health activity tracker as a present already owned a similar device (18 of 88). Similarly, in 18.2% of the posts containing gifts (16 of 88) there was an expectation mismatch between the giver and the receiver.

When there was an expectation mismatch between the giver and the receiver, the advertisements were much more similar to posts in which the seller had won the technology than posts where they had purchased the technology. In both of these cases, the device was never really adopted by owner and the device was quickly abandoned.

Technology Condition

On the secondary market, health-tracking technologies are sold in various conditions ranging from unopened to well used and even occasionally broken. Table 5 shows the distribution of products organized by their condition.

Items were only labeled "new" if they were still in the original packaging. Posts were labeled as "used" if the advertisement said it was used or if the seller had discussed the use of the technology. Labeling posts as new and used was relatively straightforward, however, we did encounter an interesting edge case that we termed "Opened." A device was labeled as "opened" if the technology was no longer contained within the original packaging and yet the seller had not actually used the device. Here is an example of such a post:

> "Nike fuel band here, was bought as a gift but it's too small, still brand new only opened to try on was never turned on or synced to a computer asking $120"

These are interesting posts from an abandonment perspective. The seller is abandoning the technology without having used it but, in most cases, the seller was interested in at least trying on the wearable. Below we discuss in detail various rationales for selling health-tracking devices on Craigslist. One of the rationales frequently mentioned is that the device in question did not fit or that it was the wrong size. Of the 32 devices that were labeled as "opened," 11 of the advertisements (34.4%) described sizing/fit as the reason that the technology is for sale. Though "opened" is a small category, it contains the largest number of posts where the rationale for selling the technology is because it did not fit.

Abandonment point

"Abandonment point" is the term we coined to capture both the amount of time the individual had owned the device as well as the amount of use the device had seen while in possession of the owner. Essentially, we wanted to know when the individual decided to abandon the technology.

Duration of time before abandonment

Determining how long a piece of technology was owned prior to it being posted on Craigslist was challenging. Unfortunately, the majority of the posts (60.0%) did not contain time-related information. From the posts where we were able to ascertain this information, 29.4% of the items had been owned for weeks, months, or even years (see Table 6). On the surface, this observation appears to be an encouraging finding. However, just because someone owns something for a long period of time doesn't correlate to that individual using the technology to maximize the health utility afforded by its functions or designs. By design, most wearable health fitness trackers are worn daily - not worn a few times and then, literally, put on the shelf for a later date. For example:

> "Got this a year ago for Mother's Day (I'd asked for it) but I've only used it for about 3 weeks - a year ago! Thus it is in mint condition, still in box with all the accessories (charging cable and an extra bit to change the size). It's looking for someone who will treat it better - likely someone more determined to get fit!?"

When examining posts in which it was clear that the individual was immediately abandoning the health technology, it was likely that the individual did not purchase the technology (only 5 of 23), that it was either new or opened but not used (20 of 23), and that the seller was abandoning the technology without using it (20 of 23).

Abandonment point	Technology Count	Technology %
Immediate	23	4.9%
Day(s)	13	2.8%
Week(s)	51	10.9%
Month(s)	77	16.4%
Year(s)	10	2.1%
Vague	17	3.6%
Not reported	282	60.0%
Total	470	100%

Table 6. The amount of time people report owning and using their devices before selling them.

Frequency of use before abandonment

In addition to tracking the amount of time an individual owned a health-tracking technology, we were also interested in determining the amount of use the technology had experienced prior to abandonment.A quarter (23.4%) of the technologies in our dataset were either completely unused or had been used only once. Here is an example of a post in which the seller is abandoning the technology immediately having never used it ("unused').

Abandonment Rationale	Technology Count	Technology %
Activity change	21	4.5%
Change in health status	5	1.1%
Expectation mismatch	119	25.3%
Experimentation	7	1.5%
Goal met	5	1.1%
Monetary	30	6.4%
Owns a similar device	44	9.4%
Peer influence	12	2.6%
Purchased/received wrong item	10	2.1%
Sizing/fit	27	5.7%
Technical complexity	10	2.1%
Technology failure	5	1.1%
Upgrade	48	10.2%
Not reported	61	13.0%
Vague	66	14.0%
Total	470	100%

Table 7. What motivated individuals to sell their activity tracker on Craigslist

> "I have two brand new Fitbit Flex activity monitors. These are unopened, brand new, unused... How clear can I be about it. They are NEW... I got these through my employers health plan so they are legitimate."'

Contrast that with a post in which the individual describes their investment in tracking their behavior and are abandoning their current technology for a technology that better matches their current needs.

> "Am selling both of the following Polar Heart Rate monitors along with the data transfer unit with which you can upload your workouts to Polar's free weblog...The watches are 3 years old and we used them for 2 years. We really liked them while we used them, with just enough features to be neither too complicated nor too simple. They still work perfectly well, and we are selling them as we decided to get GPS + HR watche."

Surprisingly, only 1.3% of the technology being abandoned had received moderate usage. Perhaps it is the nature of collecting abandonment data through an examination of second hand sales that we did not find usage to be more evenly distributed. Certainly individuals interested in selling a technology will attempt to cast it in the best possible light and downplaying the amount of use is an easy way to do so.

Abandonment Rationale

Understanding the rationale behind abandoning these health behavior-tracking technologies is one of the primary goals of our work. We ended our inductive coding with 13 different rationale categories (15 in total including "Not reported" and "Vague"). See Table 7 for a list of all the categories as well as the distribution of technology advertisements amongst the categories.

Posts were labeled as containing "activity change" when the seller indicates that something about his/her life or goals have changed such that the health behavior tracker is no longer tracking behaviors of interest.

> "I am selling a like-new Jawbone Up 24 is in perfect condition and works just like the day I bought it. ... There is nothing wrong with it, I am selling it so that I can purchase a waterproof fitness tracker. I do a lot of swimming and scuba, and the Up isn't waterproof..."

Activity change however does not always mean that the seller is further engaging in tracking activity. Sometimes the activity change relates to decreasing tracking activity.

> "Both of these [fitbits] work great. My wife and I used them a year ago, but now we have a little one and have no need to know how much activity we are getting. We already know we are getting plenty."

We labeled posts with the "change in health status" category when individuals posted ads selling their technology because they could no longer use it due to a change in their health.

> "I am selling my UP24 Jawbone. It is a black medium band that is only a month old. I had shoulder surgery recently and anything on my wrist whether it be a watch or this aggravates my shoulder. Therefore I am selling it because I can't wear it without being in pain..."

Posts were labeled with "Expectation mismatch" when the seller is abandoning a technology because either the technology did not do what was expected or, much more common in the dataset, the individual is no longer using the device in the way that they anticipated when they first acquired the technology.

> "Not using it like I thought I would...lazy people shouldn't have these gadgets. Excellent condition..."

The "Experimentation" category was an unexpected find. In each of the of these posts, the seller describes acquiring several different fitness trackers in an effort to determine which tracker they will choose to keep and integrate into their lives.

> "I have both a brand new fitbit flex that was used for a month, and a jawbone up that was only opened to see how it would fit and feel when worn. Both of them I am selling because I found a different fitness band that will suit me better."

There were several straightforward categories such as "goal met" - the individual lost the weight they wanted to lose or achieved their desired number of steps and decided to sell the technology since they had accomplished their goal. The "Monetary," "Owns a similar device," "Purchased/received wrong item," "Sizing/fit," and "Upgrade" categories are self-explanatory. The two technology categories "Technical complexity" and "Technology failure" are similar in that in both cases individuals are selling their technology due to their challenges interacting with the technology (either due to failure on the part of the technology or failure on the part of the user to be able to comfortably interact with the technology). In both cases, the individuals are selling the technology out of frustration, the frustration comes from different places depending on where the fault lies.

> "Brand New fitbit with rubber case!!! I dont have the charger with it though. I cant find it so Id rather just sell it rather than going through the process of buying another charger."

> "...Like New Jawbone UP for sale...i Couldn't figure out how to use it...I'm still old school and have trouble with my intelligent fhone."

The final category worth detailing is "Peer influence." There are clear implications for the design of personal fitness-tracking technology contained in these posts. For an advertisement to be labeled "peer influence" there needed to be evidence that the seller was abandoning their current technology because it did not support their desire to compete with their friends who happen to be using a different platform.

> "Like new fit bit flex. had no issues with it, buddy had up24 and we wanted to compete so I switched over. but still great piece I have everything it comes with. also the large band still has original plastic over it."

Excluding posts in which the reason for abandoning the technology was either "not reported" or was "vague" (accounting for 27.0% of the advertisements) "expectation mismatch" was the most popular reason for selling a health tracking technology on Craigslist (24.4%). The next most popular reasons for individuals to abandon technology was to "upgrade" their activity tracker (9.8%) or because they had received a new activity tracker but "already owned a similar device (9.1%).

Assessing Health Motivation

In our analysis, we tried to understand whether or not there was a health motivation behind the sale of a particular device. In some cases, the sale of a device seemed to be associated with a decrease in health motivation. Yet in others, sellers appeared to be discarding a particular device because the scaffolding afforded through the device was no longer necessary: they had either achieved their goal or needed a more sophisticated device to support changes associated with the increasing the level of activity in their lifestyle. We were interested in understanding if the motivation behind abandoning the technology was internal (self driven) or external (influenced by others). Further, we were wanted to determine if the motivation was increasing, decreasing or unchanged. Table 8 shows a complete breakdown of the health motivations coded in the dataset.

Health Motivation	Technology Count	Technology %
Internal decrease	123	26.2%
Unchanged	85	18.1%
Internal increase	11	2.3%
External decrease	13	2.8%
External increase	6	1.3%
Internal change in goal	3	0.6%
Not reported	229	48.7%
Total	470	100%

Table 8. A breakdown of the health motivations found in the dataset..

Of the 470 technologies for sale in our dataset, almost half (48.7%) reported no health motivation for abandoning their technology. Furthermore, an additional 18.1% of the records showed an unchanged health motivation. An example of posts in this category:

> "Selling my nike fuelband. It's the clear band. Just received one as a gift and don't need two...I've only had it for 3 months."

Looking at the remaining posts, 33.2% discuss an explicit change in health motivation underlying the abandonment of their technology. These can be divided into four distinct categories: personal (internal) changes in health goals; personal (internal) changes in physical activity or capability; beginning a new fitness program or gym membership and tracking health with that institution instead of individually (external); or changing jobs/schools and being barred from using the technology in the new facility (external).

Though often not specified in detail, many of the posts contain unique glimpses of sellers' health motivation. Many sellers reported a decrease in health motivation over time. This finding is unsurprising given that many individuals initially adopt health-tracking technologies so that they can set and make progress towards goals that improve their health. However, improving one's health in this manner can be challenging. Below is a typical post in this category.

> "Great Fuelband bought it about a month ago I just don't use it enough..."

Posts like this are open to many possible interpretations. It is possible the seller lost motivation to work out, or the seller may have lost interest in the device as a motivational tool for his or her workouts, or the seller may simply not be gaining enough benefit for the cost of the device.

However, a sale does not necessarily imply the failure of a particular device to motivate a change in health behavior. In some cases, the seller was 'abandoning' a device but continuing to track their health status through another device. A common abandonment rationale in this category is "upgrade" or "owns similar device." In both of these instances, the seller is abandoning one health-tracking technology but intends to use a second health tracker to continue tracking her health. For example:

> "I am selling this because I had the first generation model, and it was broken. After it broke I went and bought a new one from the store. Then realized my broken one was still under warranty. Nike sent me a new one to replace my broken one, so now I have 2..."

Though posts exhibiting an internal increase in health motivation were relatively rare, these posts are of particular interest to the designers of mobile health technologies. In the case of an internal increasing health motivation, typically the individual has experienced some degree of success with setting and maintaining goals in the past.

> "I've had this Fuelband for 4 months... I'm selling because I need something more suited to triathalon training."

The externally motivated examples almost entirely are tied to either an individuals work/school needs or are linked to a users gym or workout center.

> "Fitbit zip.Got it as a gift, but just got a gym membership, so that's what I'm tracking..."

The final code in this category pertains to the attainment of goals. Though this code is similar to the "goal met" code

in the Abandonment Rationale category, here, we are specifically interested in the health motivation associated with accomplishing or abandoning a health goal.

> "This fitbit is in perfect condition...I am no longer counting my steps and actually trying to gain weight so I do not have use for this anymore."

Methodological Limitations and Affordances of Craigslist

Gathering data related to the abandonment of personal-tracking technology proved to be a challenge. Selling a technology online is a public and visible presentation of abandoning a technology. People also abandon mHealth applications and personal behavior trackers by simply choosing not to use those devices over the course of time, however long that may be. The return on investment of the time and attention required to create and manage an advertisement on Craigslist might not be motivation enough to cause an individual to abandon the technology in the marketplace: it's quite possible forgetting the technology is the more attractive decision. Passive abandonment is certainly simpler than making the effort to actively actively sell a piece of technology online. On the other hand, one of the attractions to studying advertisements on Craigslist is that we know these individuals were intentionally abandoning their health trackers.

With that said, there are definitely limitations to using Craigslist as a data source for abandonment. We assume that there is a bias towards describing positive aspects of the technology and minimizing negative details since the user posting an advertisement is obviously motivated to maximize profits. For example, people most likely downplay the amount of wear and tear the device has received. We definitely see that bias in our data with the only 2.1% of the posts reporting that they had owned the technology for a year or more and only 1.3% of the posts describing moderate usage. Another major disadvantage of using Craigslist is the inability to follow up with sellers to learn more about what they were selling and why. Without this context to ground the Craigslist advertisements, the analysis of the data was open to interpretation of the research team. We found ambiguity in a considerable number of posts which made reconstructing individuals' intentions and motivations challenging to say the least. We were often left without the ability to figure out what statements like "it's not for me" means due to limitations in our methods. Hence the large number of posts labeled as "Vague" or "Not Reported" in the abandonment point, abandonment rationale, and health motivation sections.

However, using Craigslist is not without its methodological advantages. Using Craigslist afforded us wide geographic coverage and enabled us to avoid self-selection bias and other limitations of using more traditional qualitative methods to investigate abandonment. Additionally, the nature of examining advertisements illuminated certain aspects of the technology which we might have not observed otherwise. For example, Technology Condition had the lowest number of "not reported" values. Describing the condition of the item for sale on Craigslist is part of the advertising culture on the site and it often was the catalyst for individuals sharing their personal stories online. Learning about the condition of a device (i.e. new vs. opened vs. used) often provided insight into the motivation behind the technology acquisition which in turn taught us things about abandonment that we might not otherwise have been able to observe.

Finally, both an affordance and a limitation of using Craigslist is that the data is temporally bound and only represents a brief snapshot of abandonment practices. For example,Fitbit, Nike Fuelband, and Jawbone technologies comprise the majority of technologies in the dataset (89.9%). As such, most of the reasons we report for abandoning health tracking technologies refer particularly to these devices. If the data had been collected at a different time, i.e. two to three years earlier, perhaps other technologies would be better represented (such as Omron pedometers, Omron scales, or Polar heart rate monitors). Though the temporal nature of using Craigslist places limits on the generalizability of our findings,(it is entirely possible that a different set of reasons would be highlighted had we collected data five years ago or five years from now), it affords a viewpoint into current abandonment practices and sheds light on societal perceptions towards wearable health tracking technology. While abandonment practices are constantly changing, our research captures a snapshot of the current societal perceptions towards the adoption, use, and abandonment of wearable health tracking technology.

DISCUSSION

Recent publications and media reports paint a rather grim picture regarding wearable technologies and their ability to help users achieve meaningful goals or enact long-term changes in their health behaviors [17, 19, 23]. The natural consequence of the recently published studies documenting the high rate of abandonment of wearable health technologies by their users is to question the core functionality of these technologies and to conclude that either the overall vision for these technologies is misplaced, their design is deeply flawed, or both. However, our study shows that reality is more complex than these initial conclusions imply and that there exist many reasons for abandoning wearable health technologies that do not immediately reflect negatively on their design or their raison d'être.

Successful Abandonment

In our data, we uncovered multiple dimensions of technology abandonment. Certainly there are instances where individuals abandoned their wearable health-tracking technology because it was too complicated to use, too complex to learn, or because it failed to help them achieve their goals. However, not all abandonment was a result of failure in design. Rather, we uncovered many instances where individuals abandoned their technology after experiencing success using the technology.

Celebrating "Happy" Abandonment

When examining issues of adoption and abandonment, it is easy to take a stance that all abandonment signals a failure of technology. Our study suggests, however, that, at times, abandonment may indicate that technology has successfully served its intended purpose and achieved the point of retirement. For example, the desire to upgrade devices to newer models accounted for about 10% of the abandonment cases

in our dataset. In a world of rapidly changing technologies, this observation should not be surprising and should signal a continued, rather than waning interest in self-monitoring. Schwanda et al. observed instances of "happy" abandonment when they argue that "The idea that abandonment can be a marker of success also implies that persuasive systems can be explicitly designed for this gateway' effect, planning for the day when the system will no longer be needed to support new behaviors. Instead of seeing persuasive tools as persistent, permanent companions, persuasive systems designers should consider whether the systems might play a critical but temporary role in a gradual change, much as nicotine patches are not designed for indefinite use." [40]. Another example of how technology serves its purpose prior to being abandoned arises in the cases where individuals achieve their goals. In these cases, individuals no longer have reasons for self-monitoring and thus abandon their technology. While this scenario may be problematic from the perspective of device manufacturers, it may not be so for the customers as they have already benefited from utilizing these products to achieve their goals. In both of these abandonment cases, individuals are happily abandoning their self-monitoring technology as they accomplish goals and move on to other activities or devices.

Exploring Social Switching

Another example of successful abandonment is a class of individuals we termed social switchers. The examples of "social switching" in the study – cases when individuals decided to switch to a different device because it was preferred by their friends, family, or colleagues – suggest that health-monitoring practices often exist within individuals' social networks. Understanding an individual's social environment and designing software to take advantage of a social network are relatively new challenges for the designers of wearable health-tracking technology. We have already seen several examples where peer influence played a role in the decision to abandon a wearable health-tracking technology. While these instances were rare in our dataset, the importance of social network effects – particularly peer influence on adoption and abandonment – is only beginning to be felt in the wearable health-tracking domain. Designing compelling social experiences for health-tracking is certainly a health-tracking challenge today and will continue to be a health-tracking challenge moving forward.

Designing for Messy Practices

Yet another instance where abandonment of technology may not signify its failure is when the circumstances dictating its use and the context of individuals' lives change. Many of the Craigslist posts referred to important changes in individuals' circumstances and the resulting changes in their priorities. New situations a new baby, a new health condition, or resolution of a previously identified concern can significantly reduce individuals' commitment to self-monitoring despite their initial or ongoing interest. This finding is consistent with previous accounts of real-world practices and adoption of ubiquitous computing technologies. For example, Bell and Dourish pointed out that the human practices that surround contemporary ubiquitous technologies are infinitely messier, more dynamic, and less predictable, than the visions of ubiquitous computing generated within research labs [2]. Similarly, Grudin points out the importance of understanding how technology use in context evolves over time. Specifically, a deep understanding of the context associated with the technology use is essential if we hope to maximize the potential of the technology [13].

Our study supports these ideas and suggests that self-monitoring health technologies need to exist within the ever changing dynamics of individuals' lives. Health-tracking is not limited to a specific subset of users and our findings highlight the need to design solutions that embrace a diversity of users and have the ability to support these users over time. Our findings highlights the importance of taking a longitudinal approach to the study of ubiquitous technologies.

Understanding Evolving Use

To further expand on the argument regarding the changing and dynamic nature of human practices, our data suggest a complex interplay between these changes and evolution in the self-monitoring technologies themselves. Previous analysis of the complex historical trajectories of contemporary technologies hinted that their development is shaped through the adoption and use by consumers [3]. Often these trajectories of use and appropriation unfold in ways unexpected by both the designers and consumers of technology.

Our study identified a number of scenarios in which individuals' understanding of their own needs evolved through their use of technologies. For example, some of those who started with FitBit as their first choice of self-monitoring technology, realized they needed a device that was more resistant to water (since many of their fitness practices were related to water sports and activities). Similarly, a person who decided to train for a triathlon after purchasing their first tracking device may choose to switch to a new device that supports logging cycling activity. One post shared that the individual was upgrading from the Jawbone Up to the Nike Fuelband because the seller did not want to wear multiple technologies (watch and fitness tracker). These examples do not necessarily suggest failures of technology, but rather the continuous evolution of how the self-monitoring technology is perceived by the consumers and how their evolving needs suggest opportunities for new design solutions.

Enriching the Theoretical Landscape

Overall, the results of the study identified a host of reasons why individuals abandon their self-monitoring technologies, which suggests that human practices related to self-monitoring are rich, complex, and highly dynamic. As we argued above, as circumstances of individuals' lives change, so do their needs and expectations for self-monitoring. In our study, mismatch in expectations was identified as the most common reason for abandonment. This points to a possible disconnect between the human practices that emerge around wearable self-tracking technologies and theories of behavior change that often provide theoretical foundations for the design of technologies for health and wellness. Many of these theories focus on such issues as motivation to engage in self-management [12], readiness to change one's health behaviors

[36], and individuals' perceptions regarding their ability to succeed in this challenging undertaking [1]. Yet few of these theories account for the continuous and increasing influx of data available to individuals with new self-monitoring technologies. Moreover, these theories take a static view of the individual, and usually do not account for changes in either an individual's own internal state, or in their life circumstances [37]. Our study suggests a need for more flexible technologies that could adapt to the changing goals and priorities of their users. This calls for new ways to conceptualize and theorize about individuals' health behaviors that take into account new streams of information, dynamically changing contexts of use, and rich messy practices that emerge around technologies for health. For example, Riley et al. suggested incorporating a dynamic systems modeling approach to flexibly adjust the content and dose of health interventions based on the changing context (individual and environmental). Similarly, Mamykina et al. proposed sensemaking as a way of conceptualizing individuals' engagement with information in the context of health and health management [29].

Designing for Evolving Adoption and Continuous Use

In this study our goal was to explore the issues of technology adoption and abandonment in all their richness and complexity, without reducing them to a small list of design recommendations. There are, however, a number of lessons we learned that suggest more tangible opportunities for new design solutions that can help to support the evolving adoption and continuous use of wearable health-tracking technologies. Below we discuss several concrete design opportunities we identified during the study; we hope our findings will inspire a continuing discussion within the HCI and UbiComp communities as to the future trajectory of wearable self-monitoring technologies.

1. **Self-monitoring as a means to an end** - Many of the original self-monitoring technologies focused on data collection, leaving it up to their users to utilize the data in any way they saw fit. New applications, however, are beginning to view self-monitoring not as a goal in itself, but rather as a means to some end, a way to achieve a certain goal. Our study suggested, however, that these goals vary greatly between individuals. Some of these are concerned with eating habits, some with weight loss, some with increased physical fitness. Moreover, these goals are likely to change and evolve as individuals make (or fail to make) progress towards them. We propose that new self-monitoring technologies further embrace goals as a motivator to engage in data collection; however, we suggest that the applications should support a wide variety of these goals, and help their users to re-assess and re-evaluate them when necessary.
2. **From self-monitoring to personal analytics** - Further, we propose that self-monitoring technologies increase their focus on the analysis of data they collect and provide more extensive personal analytics features. Most of the technologies available today focus on data collection, and usually present their users with a historical log of captured data. However, many previous studies of individuals' learning in health and wellness suggest that dependencies and correlations in the data are more important and more difficult to identify than simple historical records [28, 31]. Moreover, the focus of such analytics could be not only on the patterns of dependencies in the captured data, but also on the evolving patterns of the technology use. We propose that personal self-monitoring technologies incorporate more robust analytical engines that can help individuals notice and test these dependencies.
3. **Beyond individual** - Our study suggested that self-monitoring technologies often exist within individuals' social networks and as part of individuals' social practices. Yet many of these devices provide only a limited set of features for individuals to share their data with others and to subscribe to other individuals' records. These new abilities, however, could help to promote such important phenomena as social and observational learning and allow individuals to provide encouragement and motivation, thus contributing to continuous and sustained engagement.

CONCLUSION

Personal health-tracking technologies have been rapidly adopted into mainstream culture and have sparked an explosion of interest in self-monitoring. While there has been a lot of recent research investigating the use of these self-monitoring technologies for health and behavior change interventions, the adoption, use, and particularly abandonment of these technologies in everyday life is relatively unexplored. We conducted an investigation into the abandonment of personal health-tracking technologies collecting almost 1600 online classified advertisements. We conducted iterative inductive and deductive analyses of these advertisements, and uncovered a set of themes around the acquisition, usage, and abandonment of personal health-tracking technologies.

Our study uncovered that in many cases, abandonment does not necessarily reflect individuals' dissatisfaction with technology. Many individuals were selling their old devices because they achieved their goals or were upgrading to newer models, scenarios that indicate success, rather than failure of technologies. Others were selling devices because of unanticipated changes in their life circumstances that led to changes in their priorities and abilities, for example a surgery, or the birth of a child. These cases, while difficult to predict, suggest that self-monitoring technologies are often integrated within complex, messy, and dynamically changing human practices. Understanding the context of their use can help designers identify potential use trajectories and design for evolving adoption. However, over a quarter of all devices in the study were abandoned due to a mismatch between users' hopes and expectations and device capabilities. This suggests a need for new theoretically-grounded approaches for engaging individuals in the analysis of data collected through self-monitoring that can lead to discovery, insight, and, as a result, improved health.

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