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Radhika Garg

School of Information Studies, Syracuse University

Jenna Kim

School of Information Studies, Syracuse University

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Description/Abstract

The potential of things or objects generating and processing data about day-to-day activities of its users has given a new level of popularity to Internet of Things (IoT) among its consumers. Even though the popularity has seen a steady increase, the use of IoT devices has been slow and abandonment rapid. To build on the existing literature and advance our understanding of the sociological processes of use and non-use of these devices, this paper presents results from the survey of 489 IoT users. Our qualitative analysis of open ended questions revealed that the motives for use include multi-functionality of devices that provide control over daily activities, social competitive edge, economic advantage, and habit. The justifications for limiting or stopping the use include privacy concerns, information overload and inaccuracy, demotivation because of the reminders about pending or failed goals, no excitement after satisfying initial curiosity, and maintenance becoming unmanageable in terms of effort, time, and money.

Keywords

Use and Non-use of Technology, Internet of Things, Mixed-Method Study

Disciplines

Library and Information Science

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An Exploratory Study for Understanding Reasons of (Not-)Using Internet of Things

Radhika Garg

Syracuse University
Syracuse, NY 13244, USA
rgarg01@syr.edu

Jenna Kim

Syracuse University
Syracuse, NY 13244, USA
jkim141@syr.edu

Abstract

The potential of things or objects generating and processing data about day-to-day activities of its users has given a new level of popularity to Internet of Things (IoT) among its consumers. Even though the popularity has seen a steady increase, the use of IoT devices has been slow and abandonment rapid. To build on the existing literature and advance our understanding of the sociological processes of use and non-use of these devices, this paper presents results from the survey of 489 IoT users. Our qualitative analysis of open ended questions revealed that the motives for use include multi-functionality of devices that provide control over daily activities, social competitive edge, economic advantage, and habit. The justifications for limiting or stopping the use include privacy concerns, information overload and inaccuracy, demotivation because of the reminders about pending or failed goals, no excitement after satisfying initial curiosity, and maintenance becoming unmanageable in terms of effort, time, and money.

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ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]:
Miscellaneous

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Excerpts from Scenarios'**Pool:**

1. Have you used a device that **automatically** keeps track of what is consumed at your house (e.g., power usage) so that you remotely control things and manage the consumption by switching off connected devices?
2. Have you used a device for self-**security** purpose that collects your personal data (e.g., location) to be shared with trusted friends and family in case of emergency?
3. Have you used a device (e.g., fitness tracker) during workout to collect your personal data (e.g., heart rate) to keep track of or improve your **health and wellbeing**?
4. Have you used a device (e.g., smart watch) to collect data for personal **informatics/logging** purposes?
5. Have you used a device (e.g., smart locks, security systems) in your **connected home** for being notified about conditions of the thing that the device is installed on (e.g., opening of garage or main doors of your house)?

Introduction

Even though the Internet of Things (IoT) is considered to be still in its infancy, today a consumer IoT can range from a simple personal fitness device to a high-end smart home application. These multiple connected devices are capable of automation, monitoring users, and collecting data from the moment they are installed. Ericsson mobility report of 2017¹ predicted 18 billion connected IoT devices by 2022. Although the number of commercially available devices is on a steep rise, the uptake of these devices has been slow, and the abandonment rapid. In fact, according to a recent study 40% of U.S. activity tracker (most popular IoT device today [8]) owners stop using these devices within the first six months of ownership [9]. This means that IoT devices may be are not able to meet needs of the users in full. Recent studies have started to show that Internet users form a heterogeneous group based on their activities [13]. The users of IoT will comprise of a even more heterogeneous group that will not only be based on their activities but will also be dependent on multiple other factors like availability of resources, demographics of users, and users' past experience and understanding of technology. This raises following relevant, but yet unanswered, questions: What sort of factors influence the decision of using and/or abandoning the devices? Can users be grouped based on their preferences and decisions?

Recent scholarship in HCI and UbiComp has started exploring technology use or non-use. In the context of social media, [2] illustrates that the motivations for not using Facebook include concerns for privacy, data misuse, and addiction. In the domain of activity trackers, [4] and [9] have argued that short term use can be an effective use of these devices when users are able to alter habits and routines. All

¹<https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-november-2017.pdf>

these studies discuss technical, design, or device-related issues that influence (non-)use, but fail to investigate the comparison between current users and abandoners. Also, little is known about how individual characteristics and contexts might affect the practice of (non-)use of IoT. Therefore, the aim of this paper is to identify the reasons behind the continued use or abandonment of the IoT devices that users voluntarily adopted.

Background and Related Work

Motivated by the definition provided in [9], we are using the term IoT in this paper to refer to *devices that automatically sense data about users or their environment, assist them in automating their spaces or activities, or help the users in gaining knowledge about themselves.*

Researchers in the past have explored the use and abandonment of smart devices, specifically for wearables and activity trackers. [12] provided Fitbit activity trackers to college students over six weeks to understand their practice of (non-)use. 65% of these students stopped using Fitbit, within two weeks, because they felt device was very obtrusive, it did not become part of their routine, or it was too difficult to manage and integrate data across multiple devices. [9] and [3] indicated that users may stop using their devices as soon as they gain sufficient information about their activities, fulfill their goals, or satisfy their initial curiosity of using such devices. However, these findings are based on the devices that were provided to the participants after their recruitment to the study. This must have affected their choices, preferences, and (non-)use of these devices. More recent studies (e.g., [4]-[6], [8]) explored reasons for abandoning activity trackers in more naturalistic settings. [5] observed that older adults stopped using their activity monitors when the device was uncomfortable or the data it collected was inaccurate. [8] argued that for long-term use

Category	Value
Age (Average)	36.47 (min. 18, max. 74)
Gender (in %)	Male: 43 Female: 56.4 No Answer: 0.6
Education Level (in %)	No High School: 0.4 High School: 6.1 Some College: 20.7 Associates: 17 Bachelors: 42.1 Masters: 11.9 Others: 1.8
Annual Income (in %)	<\$10k: 2.7 \$10k - \$34k: 25.8 \$34k - \$74k: 41.3 \$74k - \$149k: 24.5 \$149k - \$199k: 3.7 >\$199k: 0.4 No answer: 1.6

Table 1: Participants' Demographic Information

motivational affordances are required, otherwise informational affordances of such activity trackers diminish over time. Other set of studies have examined use of smart devices with health associated goals such as that of physical therapy (e.g., [1]), or fitness maintenance (e.g., [7]). Such studies discuss design-based challenges users face, but they fail to identify the reasons of using or not-using these devices. Researchers (e.g., [11]) have pointed out that behavior change is not just a possible outcome of using an individual technology, but is something that is achieved by people, potentially across various technologies that they interweave. Therefore, the studies examining the use of one specific category of devices (e.g., activity trackers) are insufficient, as the results obtained cannot be generalized. To address these gaps this study purposes the following questions: **RQ1:** Why do some users continue to use their IoT devices in the long term while others stop using them? **RQ2:** How can users be differentiated based on their preferences and practices of using or abandoning IoT?

Method

Survey Design, Participants, and Data Collection

We conducted an online survey using Amazon Mechanical Turk (AMT) with people from the United States who had completed at-least 1,000 HITs with a 95% acceptance rate. This research was approved by the Syracuse University IRB office. To identify people who had previously used IoT devices and the kind of devices they had used, participants completed a 1-minute screener survey. Selecting participants who had adopted the device voluntarily helped us identify the exact reasons for continued use or the benefits that faded away with time. Each of the participants was shown scenario(s), from the pool of five scenarios (excerpts shown above), corresponding to the device(s) they had past experience with. Five scenarios were purposefully selected (purposeful sampling [10]) to reveal variations and patterns

in challenges and dynamics of using IoT in day-to-day living. This also increases the probability of generalizability of our results to other devices. For each of the displayed scenarios, participants were then asked to answer multiple choice questions regarding their past experience with IoT devices, and open-ended questions to list their reasons of (not-)using the device. The survey ended by asking participants their demographic information (age, gender, annual income, education level), as shown in Table 1. We received 555 responses to our survey, of which 489 were valid.

Content Analysis

We qualitatively analyzed participants' responses to open-ended questions to understand their reasons of (not-)using these devices. In the first phase, open coding was performed by both authors individually. Each response was reviewed and given a tentative code for any apparent reason mentioned, coded at the sentence level; sometimes multiple codes were applied to a single sentence and response. In the second phase, both authors worked together discussing and refining codes to reach high agreement (Cohen's Kappa 0.87). The final round of analysis proceeded into an axial coding process for identifying relationships in the open codes. A total of 9 reoccurring codes/broad themes emerged describing reasons of (not-)using devices. The number of responses and some of the most representative responses per theme are shown in next sections.

Preliminary Results and Findings

Our analysis revealed overlaps in devices and reasons of (not-)using those device across multiple scenarios from our scenarios' pool. As shown in Table 2, highest number of current users and non-users (people who have stopped using the devices they own) existed for the scenarios of health and wellbeing and informatics. This is logical as activity trackers have the largest share in the current IoT market.

Devices used by participants per scenario:

Automation: Voice assistants, smart blinds, smart plugs, smart thermostats, home energy monitors

Security: Security camera, smart watches, smart locks

Health and wellbeing, informatics/logging: Activity trackers, smart watches, heart rate monitors, smart weighing scales, phone applications

Connected home: Smart doorbells, smart locks, smart garage door openers, door sensors, smart light sensing systems, smoke alarm detectors

Scenario	(Non-)Users
Automation	(12)45
Security	(17)59
Health and Wellbeing	(108)254
Personal Informatics	(85)213
Connected Home	(16)82

Table 2: Number of (Non-)Users per Scenario

Why Did Participants Stop Using Devices?

(De)motivation, 43: Negative notifications due to incomplete goals lead participants to perceive these devices as a source of demotivation. Such notifications reminded them about their failures and disappointed them (P11, P435), or distracted them from other important things of life (P352). Other studies (e.g., [9]) have concluded that the novelty of a device affects its use. In this study, we found that once this curiosity and excitement faded or the initial goal was achieved, participants found no further motivation to continue to use the device (P317). This even led them to forget using these devices as part of their daily routine (P182). However, this tendency was only observed in scenario 3 and 4, otherwise participants pointed that "device is easy to use and convenient as the device functioned by default after installing it once" (P143).

Affordability, 57: The time, effort, and money needed to use and maintain a device also play a role in its long-term use. P450 said "my long-term savings (e.g., energy savings) vs. actual cost of maintaining the device did not make sense and hence I stopped using and upgrading it". Other participants found replacing broken devices economically unreasonable (P23, P115). Finally, the effort and time needed to upgrade and charge these devices (specifically the wearables) also tipped users to abandonment (P294, P410).

Device Issues, 72: In addition to issues of device aesthetics and comfort, as found by other studies (e.g., [9], [12]), this study revealed that participants also stopped using a device when it is too complicated to use due to the overload of features (P246, P375). However, if device(s) helped participants in achieving their goal(s), majority of them ignored such issues (e.g., In Scenario 3, 71.02% of participants who rated goal fulfillment and device issues on the higher end are still continuing to use their devices).

Information Overload, 34: Some participants stopped using devices when too much information coming from too many devices - sometimes uninteresting (P22), inaccurate (P130), conflicting (P161), and insufficient (P450) - became difficult to handle. P125 nicely summarized "...It was too distracting specifically because the information (sometimes incorrect) it provided was not needed, and it only conveyed the current condition of my devices and health but not the actions needed to improve it"

Privacy Concerns, 32: Few participants mentioned privacy as a reason of concern. However, this always occurred in conjunction with one of the other four reasons of non-use. 76.9% of non-users in scenario 3 said privacy concerns did not or only slightly impacted their decision to stop using these devices (similar patterns emerged in all scenarios). For example, P271 mentioned "It always seemed clunky and obtrusive on my wrist. I prefer to use a fitness tracking device that is less obvious and obtrusive. It also recommended wearing it 24 hours a day to track activity and sleep habits, and I found that intrusive to my privacy."

Why Did Participants Use Devices?

Control in Daily Activities, 307: A subset of the participants enjoyed having the capability to control daily activities (e.g., health related) or things (e.g., temperature, house, doors, lights) in their lives. P349 said "During my initial use of the device I lost 30 lbs.. because I was able to control my activity levels and also logged my food intake via the Fit-bit app.... I can see the difference in my lifestyle when I do not use it, so I will continue to do so until I reach my goal, and then after to maintain my healthy lifestyle." P447 said "...Nest is helping with the security for my house and regulating my house temperature... I can also monitor my house from work and I can see when the kids are in the house or not".

Limitations

We acknowledge that practices of (not-)using these devices can also be dependent on the former experience of technology, demographics, and other personal contexts. This paper, however, primarily presented the qualitative analysis of the explicitly mentioned reasons by the participants. Therefore, while this qualitative analysis partially addressed RQ2, a quantitative approach may provide richer insights to further explain the themes that emerged in this paper.

Future Work

This study only looked at the self reported user preference data through AMT, further work may expand on finding hidden motivations by evaluating actual usage patterns of different type of IoT within diverse populations. Subsequent research may also investigate how abandonment of IoT by resource (technical, economic, or social) constrained population can lead to another wave of digital divide.

Competitive Edge, 144: Another frequently cited reason for use was fitness and technology oriented competitive edge among peers that IoT devices provided. For instance, P135 said "If I sit around too much, the device buzzes lightly and reminds me that I have not been active....I can know how much my friends are working, the competition makes me workout even more". P463 conveyed "Being able to ask my assistant by just interacting with it via voice, leave my friends awestruck. They feel I am rich, and I like that"

Economic Advantage, 132: Several participants continue to use their devices because of the associated economic benefit. For example, (P325) said "...my Nest saves energy when i am not home, saving me lot of money..." and P54 used his activity tracker as his insurance provides incentives based on steps taken. Also, some tried to intentionally utilize their device because they felt "...once money is invested it is better to use it than to throw it away" (P247).

Habit Formation, 70: Habit formation seemed to be more consistent in users of installable stationary devices (such as smart locks, blinds, thermostats etc.) that are not necessarily worn or carried on body (P7, P149, P403). Wearables became part of routine only when they saw a high possibility of achieving their goals (P264) or the device was unobtrusive (P271).

Discussion and Conclusion

Based on participants' preferences and past experiences our analysis also points to four distinct groups of IoT (non-)users: *Curious Fun Seekers* only have a primitive understanding of the technology, but they use these devices due to the associated competitive edge. Designing more transparent devices to reduce the unfamiliarity, unpredictability, and privacy concerns can ensure users' long-term commitment. *Cautious Starters* appreciate IoT devices only when

continuous investment of time, money, and effort is not required. These concerns call for designing hassle-free and simple devices (without any feature overload) that will require least possible maintenance. *Goal-chasers* are primarily short-term users. They use devices for long-term only when new goals (e.g., economic, social, or personal health related targets) continuously emerge and the devices consistently aid them in achieving these goals. Similar reasons are supported by [8] from the perspective of motivation affordance in activity trackers. Therefore, devices should be designed to instill sense of agency by providing context aware notifications or reminders, and accurate and relevant information about things and activities. Finally, people who manage to use their devices for long term (more than 6 months) become *Persistent Loyalist* due to the convenience and multiple functionalities that these devices provide.

In this study, we analyzed 489 survey responses to better understand why people (not-)use their IoT devices. Based on our initial analysis it can be concluded: *These devices work differently for different people*. Therefore, it is critical to be attentive of this differentiation and allow for personalization in the way these devices are used.

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