Personal Informatics as an Information Ecology: Activity Trackers and Relational Affordances

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ABSTRACT

With the proliferation of activity-tracking devices and other smart tools, more users leverage these personal informatics technologies to track their physical and fitness-related activities. The research on the benefits (and limitations) of these devices tends to focus on the use of a single tool, leaving out the interactions among multiple technologies, and how these interactions influence the way users perceive their affordances. Building from an ecological perspective, I extend this research by providing insight into the competitive and complementary relationships among activity tracking devices and other fitness-related and personal informatics technologies within the device ecology of technologies around the user. The affordances of these devices are therefore not enacted in isolation but are relational to understanding of other technological options and differing personal preferences and goals of the user.

1. Introduction

Personal informatics concerns activities and systems that enable collecting personally relevant information and better understanding of "self" (Murnane et al., 2018; Rapp & Tirassa, 2017). People for years have used both digital and non-digital artifacts (paper, websites, devices, etc.) to facilitate self-refection (Li et al., 2013). However, with the advent of smart tools and fitness technologies, more users leverage these technologies to track and quantify their physical and fitness-relat ed activities. As such, the information-rich environment that defines personal informatics today is increasingly characterized by the use of a large number of devices, technologies and applications.

Wearable activity trackers are considered the primary tools for collecting and analyzing personal information, and therefore scaffolding personal informatics (Brickwood et al., 2019; Rooksby et al., 2014). In recent years, we have witnessed a proliferation of wearable fitness or activity tracking devices such as Fitbit, Jawbone, Garmin Vivoactive, Samsung Gear Fit or Apple Watches, as more curious users adopt them to track and monitor their fitness-related activities (Dominick et al., 2016; Shin et al., 2019). As a subset of consumer wearable devices, "activity trackers" or "fitness trackers" are used for monitoring physical activity and fitness-related metrics. Unlike smartphone embedded

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functionality or applications, activity tracking devices are mostly wearable and primarily serve a fitness monitoring purpose (Nelson, Verhagen & Noordzij, 2016). Their popularity has risen, as they have become more affordable, unobtrusive, and useful in their application.

With the rising popularity in the consumer market, several research studies of personal informatics have drawn attention to the benefits of these trackers for self-monitoring, reinforcement, personal goal setting, and behavior change (e.g., Ashur et al., 2021; Brickwood et al., 2019; Lazar et al., 2015; Shih et al., 2015). This research provides insight into the reflective and persuasive nature of fitness trackers and other personal informatics tools but tends to study the effects of these devices in isolation from other devices and technological options available to the user (Shin et al., 2019). In this paper, by adopting an ecological perspective, we provide a richer characterization of how the use of these devices may fit into a larger device ecology of fitness-related technologies surrounding the user. In doing so, we highlight the interactions of the devices within the device ecology, that manifest themselves as both competitive and complementary relationships.

2. Related Research

In line with the proliferation of various consumer-wearable personal informatics technologies, the medical or health informatics research focusing on the adoption and behavioral consequences of personal informatics technologies has risen sharply in recent years. This stream of research suggests that activity tracking devices, by offering mechanisms such as goals reinforcement, gamification, and possibilities for social competition generate greater awareness about one's activity and motivate engagement in specific fitness-related activities and behaviors (Cadmus-Bertram et al., 2015; Ridgers, McNarry and Mackintosh, 2016; Shih et al., 2015). Several studies in the past years (e.g., Ashur et al., 2021; Fritz et al., 2014; Harrison et al., 2014; Harrison et al., 2015; Lazar et al., 2015) have focused on how different groups of users perceive and interact with the affordances of activity tracking devices. For example, recent studies have explored older adults' acceptance of and experiences with activity trackers (McMahon et al., 2016; Mercer et al., 2016). Fritz et al. (2014) studied how users' practices surrounding an activity tracker evolve over long periods of use. Harrison et al. (2014) focused on the long-term use of Fitbit activity trackers and corresponding behavior changes in users. Nelson, Verhagen and Noordzij (2016) investigated the health empowerment of Fitbit or Jawbone trackers by conducting quantitative surveys of 210 users; similarly, Meyer et al. (2015) shed light on the usability of activity trackers in daily life by considering how users perceived and made sense of feedback mechanisms and the way personal information was presented.

Despite the insight offered by this set of research studies, the analysis approach used is predominantly geared towards the study of a single activity tracking devices. Even though these studies may include multiple trackers, the analytical focus still rests upon how various users engage with a single device, be a Fitbit or a Jawbone tracker. So the diversity of users and their perception (not the technologies) shapes the focus of these studies, and as a result, they may lose sight of the bigger picture or what the recent HCI conceptualizations (Bødker & Klokmose, 2012; Stolterman, Jung & Will, 2013; Vasiliou, Ioannou & Zaphiris, 2015) have begun to presents as a device ecology (of fitness-related

technology), within which users interact with a multiplicity of technologies and digital representations of personal activities. The concept of artifact or device ecology suggests that artifacts and their affordances cannot be understood separately. Rather, these are meaningful only in relation to one another and the ecology itself (Dearman & Pierce, 2008; Houben, Tell & Bardram, 2014).

3. Methods

The primary empirical basis of this research includes semi-structured interviews with 29 research participants (19 females and 10 males), who have used a Fitbit device. Even though the participants all used Fitbit devices, they employed a wide range of other technologies and applications. In the interview participants reflected on the concurrent use of these devices and applications. All participants worked in the same academic institution; all had adopted Fitbit of their own volition and had used them for between 2 weeks and 35 months. Overall, our sample embraced a diversity of perspectives about the benefits of activity trackers, including the 6 participants who had stopped using the device by the time of interview.

All the participants were interviewed in person, for between 45 and 65 minutes. The interview protocol included questions about: (1) their primary motivations for adopting fitness technologies, (2) the general ways participants used Fitbit and other technologies (3) the type of information they obtained from them, and how they made sense of it, and (4) potential changes in their behavior or self-perception as a result of using these technologies. The interview protocol explored the role of Fitbit but enabled the participants to compare and contrast the use of Fitbit trackers with other technologies. The interviews were audiotaped and transcribed verbatim.

Data analysis was inductive, as what was being sought were ideas, leads, and issues about affordances of Fitbit devices and other technologies, and their contribution to the user's fitness-related information practices. This iterative process enabled the generation of emergent themes about important utilities and limitations of technologies, and specific ways through which, participants interacted with them.

4. Findings

A majority of our participants used or had used other forms of fitness technologies in addition to Fitbit devices. These included other technologies such as heart rate monitors, simple pedometers, a wide variety of tracking mobile applications (e.g., MapMyRun and RunKeeper), online diet or fitness communities (e.g., SparkPeople), and food tracking systems (e.g., Weight Watchers).

While describing the affordance of activity tracking devices for their fitness-related information practices (recording, analyzing, visualizing and interpreting personal information), the participants made frequent connections to other technologies that directly or indirectly supported these information practices. These connections between personal informatics technologies and other technologies and devices are manifest in two forms: 1) competition, and 2) synergy.

Because of continuous evaluation and comparison, our participants decided what technology to

choose over others (when one technology wins the competition), or how to connect and pair multiple technologies for fitness-related purposes (when multiple technologies form a synergetic alliance). A salient and common activity among most participants was comparing or even trying the functionality of various mobile applications, devices and even non-digital means such as paper-based diaries. Some of our participants (e.g., P10, P16, and P24) wore another wearable device (in addition to Fitbit) to examine and compare the precision of data collection and representation offered by these technologies. P24 noted: *"for several months I used the Fitbit, the NikeFuel and MapMyRide in order to try and judge accuracy, and actually for a while, I was keeping track of each of the readings for the exact same walk."* His conclusion was that Fitbit used a more effective formula than Nike Fuel Bands for calculating calorie counts.

4.1 Competitive relationships

Various technologies "compete" with one another for the attention of the user. That is, the user constantly compares the functional capabilities of available technologies and consider some more effective than the others in supporting their fitness-related information practices. So, Fitbit and other trackers "wins" the competition (is used) only if their material properties prove more supportive in relation to certain information practices. Fitbit needs to present and reinforce a competitive edge over other technologies. P10 stopped using his Fitbit after finding and acquiring another tracker (Basis): *"Fitbit does some of it, but it doesn't work from a habit perspective; it just says okay here's how many steps and so forth, and it has these badges that it gives you. But this is really sort of a minimal interface for it, the "Basis" interface is a lot more powerful with regard to getting you to do something."*

A few other participants did not consider the physical appearance of Fitbit particularly consistent with their personal style and preference. Some preferred to use mobile applications as they found wearing a device on their wrist to be cumbersome and intrusive. In addition, because the device is often visible, it involves a fashion-related dimension. For example, P11 discussed the downside of the visible tracker: *"I'm part of a group of women that really like to do the make-up, the hair, and the formal gowns. So you're all dressed up and you have this slate blue thing on your wrist that goes with nothing."* Along the same line, P13 considered the wearable Fitbit unfashionable and somewhat bulky: *"It literally looks like the tracking devices that they put on people who are under home arrest; that's almost what it felt like to me."* As a result, two participants started using Nike Fuel Band because they considered it a little more fashionable than Fitbit.

The same physical and digital features have proved beneficial for some other participants. P12 tested S-Health App on her Samsung phone, but still viewed Fitbit as a more pragmatic choice, since she did not carry her cell phone around, particularly in her workplace. The constraints of other options contribute to the competitiveness and appeal of Fitbit trackers. P3 used a mobile application that reflected various modes of movement (e.g., walking, running, and riding buses), something not offered by his Fitbit device; nevertheless, he resorted to Fitbit because the mobile application did not look viable due to its battery usage. Finally, Fitbit (and other wearable devices) have a physical and symbolic affordance, missing in a mobile application: As a visible device,

it serves as *"a constant reminder that I am actively doing something for my health."* (P11), and it may create a sense of community that could result in conformity. P12 emphasized this: *"From a social aspect, if you look around and everybody is wearing something, and if you look around and see people doing the same thing it makes it seem like it's the thing do to."*

4.2 Complementary relationships

For some, even though Fitbit still played a key role, it lacked critical functions. Some of the participants complemented affordances of their Fitbit trackers with the use of other technologies to support a full range of information practices. Several participants voiced concern over the precision and comprehensiveness of data collected and represented by Fitbit devices. These concerns were driven by personal experiences about the inconsistency of data collection about certain physical activities. To overcome these perceived deterrents, participants may have paired the use of Fitbit with those of other technologies. For example, several participants saw Fitbit as a useful mechanism for daily walking activities captured in number of steps taken, but less precise or completely incapable of registering other physical or exercise activities. P10 used a mobile application called Moves, to record cycling (that Fitbit does not register) and running. P24 leveraged MapMyRide app to specifically track his cycling workouts. P5, P16, and P20 used Fitbit to account for their daily number of steps, (for example, in their office) but also took advantage of Garmin watches when running to gain more precise and detailed information about their exercise activities based on GPS and heart rate data; the two devices together provided them with a more holistic picture of their weekly physical activities.

In addition, even though the Fitbit ecosystem (i.e., the device, mobile application, and Website) offers a relatively effective way of recording and presenting activities (calorie consumption) for many users, some of our participants considered other systems more useful when it came to registering and analyzing calorie intake. A couple of participants used applications such as WeightWatchers and MyFitnessPal in conjunction with Fitbit. These ecosystems alone were not deemed sufficient for accounting for both calorie intake and consumption, but they together could create a richer understanding of one's personal health activities. P11 provided an example: *"I was using the app called C25K (Couch to 5K) where it took you through about three weeks of walk-run intervals to help you build up to straight running versus walk run, and I used it in conjunction with my Fitbit so the Fitbit could track the actual activity and the Couch to 5K app could be my personal trainer cause it would ding when you were supposed to walk and ding when you were supposed to run."*

These synergetic uses of fitness technologies allow users to bring together multiple technologies (to form a device ecology), and to create a broader set of affordances, overcoming the material constraints of single devices.

5. Discussion

Users do not use personal informatics technologies in a vacuum, and they do not engage with them in isolation from other technologies. To them, the affordance of these tools depends on their personal goals as well as the affordances offered by other tools at their disposal. Relational affordances of each technology are decided upon and brought to bear at the intersection of the distinct material properties of the technology (e.g., unique technological features and physical appearance) and the personal context of each user (perception, assumption, situations and personal needs). For example, most users were not particularly concerned about the accuracy of data collection insofar as Fitbit provided a consistent baseline for comparing activity level over time. However, as noted, a few participants paired the use of Fitbit with other devices to make sure that they obtained precise data about their activities.

Relational affordances also emerged from the synergetic or competitive relationships among multiple tools within the device ecology. Our participants tended to view Fitbit and other technologies as part of a bigger ecology of fitness-related digital technologies that collectively record, process, quantify and represent personal health information. The positions of any technology in this device ecology is determined by its utility toward personal goals and preferences that vary across individuals. For some Fitbit occupies a central role while others may prefer other digital or non-digital options (Cheon, Jarrahi and Su 2016). For example, a group of our participants enjoyed self-sustained motivation structures (e.g., running routines), and as self-motivated, active runners, cyclists, or racquetball players, Fitbit or other activity trackers aimed at registering and motivating daily activities provided no perceived value for this group of users (occupying often a marginal position in the device ecology around them). These users already benefited from other more concrete and persistent intrinsic motivation al mechanisms and took advantage of other technologies customized for athletic and heavy exercise uses.

The holistic perspective on technological affordances of personal informatics technologies offered in this article can supplement the previous studies of these technologies. With the proliferation of ubiquitous and personal tools, technologies increasingly operate concurrently, so accounts of isolated effects can gloss over the heterogeneous nature of the computational environment wherein users interact with multiple devices and interfaces. For example, previous research indicates that a large number of users abandon wearable activity trackers after a short period of time (e.g., Clawson et al., 2015; Gulotta et al., 2016; Lazar et al., 2015; Yang et al., 2015); this type of analysis may not necessarily consider the ecology of fitness tools that the user puts together and draws upon; abandoning a wearable tracker does not necessarily imply that these users lose interest in using digital tools for tracking fitness and physical activities; several of our participants stopped using an activity tracker once they found a more effective alternative (e.g., mobile application). P27 found Fitbit irrelevant since he had very structured exercise routines, and he did not pay much attention to Fitbit's frequent goal notifications (as one of its primary gratification mechanism): *"I decided I wanted to be in shape and so I run at least like three times a week. And when I run it's like 8 miles, so breaking the whole 10,000 steps (default daily goal of Fitbit), the days that I run I break them, the days that I don't, I don't. And I'm fine with that. I don't feel guilty at*

the end of the day because I didn't break the 10,000." Instead, he considered himself an avid user of "MapMyRun," a GPS-enabled mobile app, for tracking his running routines.

What can also be ignored in the research focusing on the use of a single activity tracker in isolation is the crucial roles played in the ecology by those technologies that are not considered smart wearables or mobile. P22 drew upon and closely paid attention to the FitLinxx system that tracked her weight lifting activity in the gym; which are not registered by her Fitbit, as one of the major limitations of the device is recording upper body movement. Other participants (P7, P15, P18, P22, and P27) often combined data about calories burned on treadmills and ellipticals with numbers of daily steps walked provided by Fitbit (most versions of Fitbit trackers do not precisely track elliptical workout).

Adopting an ecological perspective can have implication for the design of future personal informatics technologies. As our findings suggest, fitness technologies can play a more synergetic role where their design enables interoperability with other technologies and ecosystems, and sharing of personal data across them, creating a more cohesive device ecology for the user. Activity trackers or fitness mobile applications do not need to offer a full range of functionalities as long as they provide the user with the opportunity to connect with already available technologies that may present a superior affordance relative to certain fitness-related activities (e.g., tracking physical activities or counting calorie intake). This comes with the recognition that each ecosystem organized by an independent technology vendor is unlikely to provide the capabilities that cater to the personal needs of various user groups, and users must be provided with the flexibility to choose and bring together various ubiquitous devices, apps, and technologies to construct their own individualized device ecologies. For example, some of the diet tracker systems such as MyFitnessPal or Weight Watchers offer automatic ways of importing and integrating Fitbit data. However, this interoperability is not always granted by other technologies. In these cases, our participants used either manual approaches or gateway technologies to integrate personal data from different sources. For example, as a Quantified-Selfer, P16 resorted to a spreadsheet to manually incorporate personal activity data from various devices he used. P23 used IFTTT app ("if this, then that"), as a gateway technology that connected multiple application, to export his Fitbit data into other mobile applications.

6. Conclussion

The research presented here advocates an ecological perspective in personal informatics, examining relational affordances of personal informatics technologies as a part of a larger ecology of technologies, tools, and applications. A primary contribution of this work to personal informatics is, therefore, presenting the use of activity trackers and other fitness-related technologies as a holistic information ecology, within which, multiple technologies or ecosystems facilitate collection and analysis of different forms of information, and may compete with one another to become a part of fitness-related information practices of users. While a single technology is useful but ill-fitting to support various practices performed by the users, multiple technologies based on their unique affordances may be leveraged and paired, creating complementary relationships within the device ecology. This ecological

perspective draws attention to the interactions among multiple technologies and helps us contextualize the use of wearable activity trackers in a broader context of alternative technologies.

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