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Digital and Physical Materiality of Information Technologies: The Case of Fitbit Activity Tracking Devices

Mohammad Hossein Jarrahi
School of Information and Library Science
University of North Carolina, Chapel Hill
jarrahi@unc.edu

Abstract

This paper explores the role of digital and physical materiality in relation to the use of Fitbit activity tracking devices. Materiality concerns properties of a technology that transcend space, time, and particularities of the contexts. Our objective, in particular, is to examine how digital and physical properties may play a role in shaping user's perception and actions around the use of Fitbit devices. The primary findings are (1) both digital and physical material properties of the device together provide a material framework, which constrains and enables users' activities, and (2) both forms of materiality are contingent upon the design/form of the device. As a result the materiality of digital information cannot be studied without examining its entwining with the information technology that records, processes, shares, and represents it.

1. Introduction

The use of information technologies plays an important role in the reconfiguration of social practices and the way we make sense of the world. From a sociotechnical perspective, on the one hand, the effects of information technologies on social practices are mediated by a variety of social processes [1]. On the other hand, technological properties serve as tangible material resources that provide social actors with the new abilities (e.g., to do old activities in new ways or to do new activities that they were not able to do) [2]. As a result, most contemporary sociotechnical scholars recognize both human agency and technological agency (what is implied by the concept of technology materiality) as well as the way both "enable," or "afford," the social context [3]. Therefore, while humans and material technologies are entangled, materiality of technology is the set of specific effects affiliated with the material properties of technology that transcend the interpretation and experience of individuals in particular settings. These properties of technology are inscribed into technological artifact, as the reification of the assumption and knowledge of technology developers about the world [4, 5].

Over the past few years, the concept of materiality has gained considerable currency in a variety of academic communities, directing attention to how technology's materiality is implicated in social practices. Despite this pervasive "turn to materiality" in social sciences [6, p. 2], the empirical and conceptual framing of the concept is still in developing stages and remains largely evasive [3]. Particularly, while physical materiality has been the explicit object of academic attention [7], there is a lack of conceptual clarity about digital materiality and the ways information technologies handle digital information. Most social scientists seem to inquire into the concept of materiality from the narrow lens of physical properties and forms, as Dourish and Mazmanian [8, p. 94] state: "Coming from various disciplinary backgrounds such scholars argue that the social world manifests itself in the configuration and use of physical objects and that the properties of those physical objects and the materials from which they are made – properties like durability, density, bulk, and scarcity – condition the forms of social action that arise around them."

What's more, when one moves from the world of the physical to the digital, it becomes more difficult to delineate the materiality of technology, as things are less tangible. However, the role of these conceptual properties cannot be reduced to human intention or action, so the adjective "material" does not only apply to physical aspects of technology, but also embraces these non-physical, conceptual features that offer capabilities to constrain or enable action. Materiality should not consequently be taken as tantamount to physicality or tangibility [9, 10].

We know that how many technologies play out in our life is not only a function of their physical properties but also derive from their conceptual ability to complement the way we think or make sense of the world. For example, historians argue that how the mechanical clock conceptually represented information changed how human thought about the concept of time since the 14th century [11]. Before the advent of mechanical clock, people would think about time in a more natural way which focused on a natural sensory appreciation of time. The novel ways the mechanical clock presented time was contingent upon a concrete set of information and involved a series of mathematically measurable units (hours, minutes, and seconds), creating a frame of reference for both action and thought [11].

Just like the mechanical clock, most information technologies can be considered “intellectual technologies” [12], which are primarily developed to extend our mental and cognitive rather than our physical capacities. To this end, in addition to their physical forms and matters [13], the digital (conceptual) materiality of information technologies are consequential in shaping the way we think or act. Digital materiality concerns conceptual properties such as the logical or ontological constitution of a technology. While the two aspects of materiality (physical and digital) are interrelated, they are phenomena of different orders: the physical material properties can be touched while the digital properties cannot be sensed through the same means [14].

This paper seeks to advance the concept of materiality by exploring the distinction and interrelation between digital and physical materiality. Drawing on an empirical study of the use of Fitbit tracking devices, this paper investigates both physical and digital compositions of Fitbit devices, ascertaining how they are brought to bear in users’ perception and activities formed around these devices. The paper further discusses how the two types of materiality may vary across different Fitbit devices and how they are interlaced with distinctive form and design of each device.

2. The technological focus: Fitbit

Fitbits are activity tracking device that use a three-dimensional accelerometer to sense user movement. The device focuses on steps taken, and by combining that with user data, it calculates basic measures such as distance walked, calories burned, floors climbed, and duration and intensity of activity. Fitbit tracking devices continuously sync information with the computer and smartphone through a wireless technology. Hence, the user information can be viewed on Fitbit mobile app, Fitbit website or the device itself. The website allows users to log their food, weight, blood pressure, heart rate, and glucose levels to track them over time. All of the participants of this study had used one or both of the following types of Fitbit trackers.

2.1. Fitbit Flex (wrist wearable)

This is a wearable model and is worn like a watch on the wrist (See Figure 1). It has a simple display of 5 LED lights which represents the number of steps taken in a day, and it vibrates to indicate that the personal goal has been reached. So, for example, if the activity level is low, only one or two LED lights will be on. The device is water-resistant and can be worn all day and night, even in the shower.

Figure 1. Wearable Fitbit

2.2. Fitbit One (clip-on)

Fitbit One is clipped to one’s clothing or can be put in a pocket (See Figure 2). As opposed to Fitbit Flex, this version of the device offers a digital display that shows the numbers of steps and other types of information. It also has a feature that is missing in Fitbit Flex: an altimeter that measures elevation gain in terms of floors.

Figure 2. Clip-on Fitbit

2.3. Why Fitbit

This study focuses on the Fitbit for both intellectual and pragmatic reasons. The device embodies both important digital and physical material properties that manifest themselves in the user-device interaction. This enabled us to capture the way these properties were arranged into the device and played a role in shaping activities that were enabled or constrained by the tool. The two Fitbit devices we placed our focus on were adequately different in terms of both digital (e.g., information representation) and physical material properties (e.g., wearable vs. clip-on), providing us with a basis for comparing the significance of both types of materiality (physical vs. digital). It's important to note that some participants had experienced both devices, so they were able to draw meaningful comparison between their functionalities. As a pragmatic consideration: we also had access to a critical mass of participants who had used the device for some time, and were willing to reflect upon their experience with it.

3. Methods

The empirical basis of this work included semi-structured interviews with 15 research participants who were selected based on the adoption of Fitbit devices and their willingness to share their experiences and thoughts about it. All the participants worked in the same academic institution and had used Fitbit in the past year, so were able to provide their perspective on a recent use of the tracking device. Out of 15 participants (11 females and 4 males), 6 had used the clip-on Fitbit, 6 had used the wearable Fitbit, and 3 had used both. The third group could therefore provide feedback comparing the functionality of the two different forms of Fitbit.

All the participants were interviewed face-to-face, and interviews lasted between 45 and 60 minutes. The interview protocol included questions about: (1) their primary motivations for adopting Fitbit, (2) the general ways the participants used the device, (3) the type of information they obtained from the device and how they made sense of it, and (4) potential changes in their behavior or perception as a result of using the device. All the interviews were audiotaped and transcribed verbatim. A few still photographs were also taken to complement the interviews with visual demonstrations of the device, as participants were elaborating on their use behavior.

Data analysis was inductive as what was being sought were emergent ideas, leads, and issues about material properties of Fitbit devices and their contribution to the user's conduct. This iterative process enabled the generation of emerging themes about different dimensions of materiality, their distinction and interdependency.

4. Findings

Findings underscore two types of materiality affiliated with the wearable devices: physical and digital. The former focuses on the physical forms (i.e., tangibility) and its consequence for the user's actions and perception while the latter concerns the nature of affordances of non-physical properties of the device that remain relatively constant in differing contexts.

4.1. Digital materiality

Digital materiality is largely conceptual and embraces those properties of the tool that enable or constrain actions, and are not necessarily attributable to a fixed set of physical aspects of the tool. Digital materiality in the case of Fitbit devices reflects the internal logic of the device and has two interrelated dimensions: informational and motivational.

4.1.1. Informational features. Informational features (constructs) of a technology or medium undergird the materiality of information representation, and shape how we engage with, experience, and make sense of information [8]. Despite many arguments to the contrary [15], the materiality of information is still dependent on the carrier (technology) [16]. For example, if the number of steps was written in a physical journal, the materially of information would be different than the number of steps appearing on a digital readout of a digital screen. In this respect, information materiality embodies the distinctive and unchanging ways a device registers and presents information across contexts and individuals. Fitbit devices automatically register several forms of physical activities and present this set of information via various methods (e.g., immediate feedback on the device or detailed analysis of activity on the Website). These particular forms that information takes have consequences for how users encounter, use, and interpret them. As such, digital features provide informational affordances, informing users about details of their activities.

The device collects information automatically, hence serving as material extension of individual's cognitive capacity. Several of the participants had to keep journals about their activities before adopting Fitbit; however, they commonly found it cumbersome and inconsistent. With the Fitbit device, users can collect information about physical activities without interfering with their daily life activities. The user can therefore have their activities recorded without the need to remember and manually journal them. Participant 12 signified the potential brought about by this digital feature: *"I wanted an easy way to get in better shape that didn't require a lot of my time and a lot of tracking which is the value of having something else do the tracking for you…. To me this alleviates some stress because I feel like I'm letting somebody else monitor for me."*

The device poses certain material constraints when it comes to monitoring and recording of physical activities. For example, it does not register upper body activities even though several participants found these important types of physical activities commonly performed when they exercised. The focus of information collection is largely on step-based activities (e.g. walking and running). So the device does not provide an accurate representation of other types of exercise (e.g., weight lifting, cycling, and rowing.). Participant 9 voiced her dismay with this material limitation: *"One of the things I do is calisthenics, so I do a lot of body weight exercises; well it doesn't measure that at all. So I might tap it and say; ugh that's not counting any of that. "*

Perhaps the most important informational affordance of the devices can be attributed to its representational resources. The device offers representations of activities that may specifically enable users to form a more accurate awareness about their activities. This has salient consequences for most users in terms of their perception of their daily life and associated activities even though they may use the device based on dissimilar motives.

For individuals who are inactive and are not seeking to change their inactive lifestyle, the device still generates a sensible estimate of their routine activities. While conceiving herself as inactive and sedentary, participant 8 still found the informational aspect of the device useful : *"I wore it everywhere; I'd just put it on the morning when I got up. It was interesting just to see like how many steps I took. Because in the morning, I have a child, and so you get up in the morning and you go in the kitchen and you make coffee and you go back to the bedroom and you get your kid, it was interesting to see how many steps I had taken."* This representational feature often led to a better understanding of one's activities and oftentimes could be a source of surprise: "*Well, it actually did show that I was getting more steps than I thought that I was getting since I was at a desk job*." (Participant 13).

It should, however, be noted that the materiality of the device may not translate into a long-term informational affordance for the above group of users. Because of their motivation (or probably lack of motivation to be more active), the novelty of information representation may wear off over time as the user learns about routine patterns of activities that do not necessarily change into a more active lifestyle. Participant 2 noted: "*Earlier on, I was paying more attention to the compilation, but now because it's become this routine thing and the novelty is wearing off, it's kind of like oh well yeah I forgot it."*

For those participants who believed they were already physically active, Fitbit's informational properties similarly generated more awareness about their activities. They used the device to learn about their activity patterns and especially distances they walked on a regular basis. As an active person, Participant 2 remarked: "*Now if I look at it, it's almost 5,000 steps and it's 1.99 miles. I don't think that I would have appreciated it that I had walked almost 2 miles just going from home, taking the dog on a short loop, and walking to the bus stop. I wouldn't have known it was that much in terms of distance that I had walked."* At times, the devices can also provide surprising information for more active individuals, as participant 6 highlighted: "*It's kind of amazing when I go to my part time job and it's really interesting how much increase in activity level I have just being a cashier… I didn't realize it was that much activity."*

4.1.2. Motivational features. In addition, to informational properties, Fitbit features conceptual properties and mechanisms that enable setting and reinforcing personal goals for physical activities. The device leverages information about activities and shows the progress towards the goal. It also provides various forms of gratification, encouraging goal achievement. The default goal is 10,000 steps a day while the user is then able to adjust the default goal. Several of the participants were going beyond the informational affordance of the tool, drawing upon the motivational materiality of it. The motivational features in combination with the informational features allowed them to pursue distinct objectives such as personal accountability (that were presumably not as easy to purse in the absence of the device), and to adopt a more active lifestyle. Participant 11 highlighted this dimension: "*I do think it's important to have that accountability to be able to have the number in your face because if you walk around the block and you don't know that block is 1,000 steps then you think you've done something, but if you have your Fitbit and you walk around the block and that block is a half mile and your goal is one mile then you know you need to walk around it again. So it keeps you focused on what you're doing and you know the numbers don't lie.*"

Through a more coherent representation of daily activity levels and the progress against the personal goal, the device has helped several participants develop a more active behavior. For example, participant 15 stated: "*It motivated me because if I needed like, 900 more steps to get to 10,000, I might go out at 10:30 at night; I literally did that a couple times and walked.*"

One of the ways that Fitbit trackers reinforce goal achievement is by offering gratifying representations. On the Fitbit website, badges and signs are presented if the user reaches certain activity levels. In addition, each type of Fitbit devices has its own means of gratification. The clip-on Fitbit shows a flower that adds pedals if the user engages in more physical activities. The wearable Fitbit vibrates if the user reaches the daily personal goal. One user underscored the value of these little representations aimed at gratification: "*I love recognition for accomplishments because health and exercise have never been a priority for me, so acknowledgements that [say]: yes you're making this change, yes, you've met this goal, are excellent. You got a little flower that would grow, I loved it.*"

Embodied mechanisms in devices such as gratifying representations tended to provide extrinsic motivation that supplemented the preexisting intrinsic motivation of several of the users. We found that individuals with preconditions (e.g., recent surgery or obesity) that were urged to embark on more health-aware behaviors were more willing to take advantage of the motivational features of the device (as extrinsic motivators) to become more physically active.

In short, the use of Fitbit devices offers an information ecosystem which involves more effective recordings, processing, analyzing and representing information pertaining to one's activities. In absence of these enabling digital material resources, the participants had to resort to assortments of mostly non-digital approaches in order to create the same informational or motivational affordances. These approaches were often not adequately simple and precise. Participant 15 described the approach she had employed to create awareness and a plan to become more physically active prior the use of Fitbit: "*I simply defined a walking route for myself and I said I'm going to walk this area and then I got in my car and drove it so I would have an approximate mileage, so I knew it was approximately 2.3 miles, if I walked it twice I was doing 4.6. Then I went on the Prevention Magazine website which has an exercise calculator and it would say if you weigh this amount and you do this amount of exercise you are burning this many calories. So I did some extrapolations and it was very low tech.*"

4.1.3. Divergent digital materialities based on different designs. Material properties can be different from one device to another, creating often divergent platforms for recording, and representing users' information. Findings from this work demonstrate that the materiality of digital information representation is entwined with its carrier: the specific information technology that affords the representation. Goody [17] long ago contended that different technologies provide distinct representational forms that serve as frameworks for engaging with, organizing, and knowing the world. Wearable Fitbit therefore offers a distinct form of information representation that is at variance with that of the clip-on Fitbit. In what follows, we will discuss these differences and how they may lead to differing digital affordances.

The wearable Fitbit features 5 dots to indicate the daily activity level and the progress against the personal goal. Users can tap on the device and the number of glowing dots shows how close to the daily goal they are. For some participants, this simple representation mode seems to have been effective as it provided quick feedback about their activity level, while it concomitantly motivated further activities. Participant 13 noted: "*I knew that the more dots that lit up the more steps I had had, and I would look at the dots and if I only had two dots I would be 'oh I need to do some more walking today', so I might have gone to the mailbox a couple extra times or something like that.*" In addition, these dots could serve as a modest form of acknowledgement for some: "*Surprisingly [I tap on it] a lot; I enjoy getting that little affirmation*" (Participant 15).

On the flip side, the wearable device lacks a numerical display, and the information representation it offers does not involve numerical details such as exact number of steps. To this end, most participants had to complement it with the more complete information provided on the Fitbit website. Participant 11 described a situation in which the specific information representation afforded by wearable Fitbits proved insufficient: "*The problem with the Fitbit Flex was let's say your goal was 5 miles and you tap and you have one blinking dots, you know that you are within the first mile but you don't know how far. You don't know if it's a tenth of the first mile or three quarters of the first mile. So if you're trying to get to a certain place before a certain part of the day to reach the rest of your goal the latter part of the day; that's why you're in front of the computer or at the phone trying to sync up to see your actual measures.*"

Furthermore, several participants found it frustrating that the exact digits are not presented. Nevertheless, the most important digital material constraints of the wearable Fitbit has to do with its limitation in capturing flights of stairs. This constraint was evident in the ways participant 15 performed his exercise: "*For one thing I stopped doing the elliptical, which had been very successful for me but I found that [Fitbit] did not track elliptical movement the way I wanted it and I wanted credit for all my activity. So I found that it changed the type of exercise I did.*"

As another digital constraint, several participants believed the wearable device registered some hand motions as steps, and the motions were not normally considered physical activities. That urged some participants to take it off, for example, when they were driving long distances or during physical intimacy.

The limitation of the wearable Fitbit in providing precise numbers (e.g., steps and active minutes) is considered a non-trivial advantage of the digital representation offered by clip-on Fibits. Clip-on Fitbits provide a more precise representation of physical activities and may diminish the need for visiting the website or using the app on mobile devices. In this regard, participant 6 asserted: "*the things I liked about the clip-on is you could sit there, anywhere you were; you could push a button and see how many steps you had reached and you could read what your success was at that point in time. You didn't have to log onto the phone or to the computer and look.*" And likewise, participant 4 commented: "*I see 6,429 which seems to me a more useful number than three or two dots.*"

As opposed to the wearable Fitbit, the clip-on version registers and reflects flights of stairs. As such, this difference in digital materiality of the two devices may have consequences for the way users conceive and execute physical activities. Participant 5 had been already active before adopting Fitbit, but he saw changes in his exercise pattern after he began to use it as a result of this feature: "*The major difference is I'm much more interested in climbing hills now, so I'm to a point now where I've run up every hill around my house. Before there were lots of places I wouldn't go because I'd have to climb a hill.*" However, as an outdoors runner, he highlighted one of the constraints of the display on the clip-on Fitbit: "*In bright sunlight you can't see anything. If I went outdoors into the bright sun and clipped this you wouldn't be able to read it.*"

The above delineation of differences between the two Fitbit devices reveals how digital materiality and its contribution to the user's conduct may vary based on the specific design/form of the device. The ways the representation of digital information comes to play are therefore closely tied to the nature and form of the technology that enables it.

4.2. Physical materiality

Beside the digital materiality, which is tightly coupled with informational properties of the device, the physical properties of Fitbit devices play a key role in the way users adopt and take advantage of the device. The physical materiality of Fitbit devices altered the ways some users thought about their bodies in space. For example, the visibility and physical presence of the device served as a reminder for more physical activity and exercise.

Just like digital materiality of each device, its physical materiality is unique and may lead to distinct set of affordances in the daily life of the user. In the following, the physical materiality of the two models of Fitbit and their respective consequences are discussed.

4.2.1. Physical materiality of the wearable Fitbit.

Most users of the wearable Fitbit appreciated that they could wear it on their wrist and it attached to their body. This physical aspect of wearable Fitbits created a key basis for a series of affordances. First, it is easier to carry it around and less likely to lose it. Participant 1 noted: "*I like that it's on my wrist, and I don't have to worry about taking it out of a pocket and into the next pocket... I only take it off to take a* *shower. I wouldn't want the one that I clip on; I would never remember to put it on in the morning.*"

Second, an important consequence of its physicality has to do with the visibility of the wearable Fitbit. Since other individuals can see the device, it can become a subject of interesting conversations. Participant 6 mentioned: "*When somebody makes a notice it on my arm, I'll start talking about it and showing it.*" The visibility of the device on one's wrist may further serve a symbolic purpose for users themselves. Participant 11 viewed it as "*a constant reminder that she was actively doing something for her health.*" Furthermore, visibility of tracking devices to others may create a sense of community that could result in conformity. Participant 12 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.*"

The physical aspect of wearable Fitbit can concurrently be constraining for some users. A few participants found it intrusive (e.g., participant 10) as they were often not used to wearing things like a watch on their wrist. And because the device is often visible, it involves a fashion-related dimension. For example, participant 11 discussed the downside of the visible tracker and how she overcame it: "*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. But what I learned to do is: I had some chunky bangles and I would slide it over it, and then you couldn't see it.*" Along the same line, participant 13 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.*"

4.2.2. Physical materiality of the clip-on Fitbit. Because the clip-on Fitbit can be attached to clothing or carried in pockets, it can be easily concealed. In the interview, participant 11 indicated: "*Right now I have one in an inconspicuous place because you can clip it anywhere without it being so close to your skin all the time... I can just put it in my pocket.*" For the same reason, the clip-on Fitbit is considered less obtrusive than the wrist wearable version, as it does not interfere with the way the user dresses or wears jewelry. Participant 7 made this clear by drawing a comparison between the two versions: "*It's just simpler and easier and it's unobtrusive. I wear jewelry and I don't want the band on with my diamond bracelet or a gold watch. If I'm going to wear it all the time, it's kind of in the way for me if I was dressing up.*"

Unsurprisingly, some upsides of the wearable Fitbit is taken by some users as downsides of the clip-on version. A few participants complained about the possibility of forgetting to pick the device before leaving the house or to transfer it between different clothing. They also found it somehow easy to lose the device. Participant 2 compared this physical aspect of the clip-on Fitbit with that of the wearable one: "*Sometimes I do forget it, so I can imagine the band being better in terms of always having it on.*" In like manner, participant 12 contended that carrying the device became a responsibility for her because it kept falling off, and she had to search for it in a couple of instances.

To overcome this physical limitation of the clip-on Fitbit, few participants came up with improvisational solutions. In effect, they extended the physical materiality of the tool, and supplemented it with other objects. For example, participants 3, 4, and 5 attached the device to a chain or a necklace around their neck to which other objects such as dog tags and the office key were also attached (See Figure 3)

Figure 3. Extending the physical materiality of clip-on Fitbits

5. Discussion

Different information technologies embody varying designs as a set of physical and digital properties, and it is through this design that materiality and affordance of the tool are made to bear upon one another.

As Kallinikos [13] suggets, matters can assume various physical forms and designs, serving different functions. A vast majority of technology reseachers define materiality based solely on physical forms of technological artifacts as objects, and hence dwell primarily on the physical aspects of them, which can be sensed through tactile experience. In fact, most conceptualizations of materiality still equate it with physicality of technology [10]. For example Kallinikos [13, p. 68] notes: "I take the concept of materiality to literally signify the material or physical constitution of technological objects (or lack of it) and the implications (social and technical) such a constitution has for the design, making, and use of such objects."

Findings from this research suggest digital materiality of Fitbit devices is equally important because it affords and constrains actions of the user. Digital materiality interweaves with digital information and the processes by which it is generated, collected, processed, and represented. These features shape how we engage with and make sense of digital information. Even though we may be able to physically touch the technology, we cannot interact with its digital features in the same manner we feel and experience physical properties of the technology. As the example of Fitbit indicates, the data collection mechanism of the device cannot be touched, but it has a bearing on how users perceive and arrange their physical activities. Therefore, digital properties, too, provide observable constraints and affordances in not exactly the same way as physical properties do, and physicality is not a necessary component of materiality. For certain types of information technologies that are more loosely coupled with the hardware or physical components, (e.g., software packages) the digital dimensions come to occupy a more central role.

Whilst physical materiality is closely related to the hardware and physical component of technologies, digital materiality focuses on features such as inner logic of how it captures and visually represents information. Digital and physical materiality correspond to the three critical levels of system structure as presented by Wand and Weber [18]: Surface (the interface of the tool); Deep (inner logic) and physical (hardware component).

Research findings further demonstrate that digital and physical materialities are interconnected and both are grounded in the design and form of technology. For example, vibration of the wearable Fitbit involves both aspects of materiality; it serves as a representation of the attainment of the daily goal (which is a conceptual matter) and at the same time it takes a physical form as a direct bodily sensation.

Blanchette recently [16, p. 1043] highlighted "the trope of immateriality," indicating both public press and scholarly work tend to consider digital information primarily a mere collection of 0s and 1s, and independent of the technology that handles it. Our discussion of digital materiality of Fitbit devices exposes a drawback of this view by making it clear that the nature of digital information representation and the affordance arising from it is largely dependent on the specific design of the technology that undergirds it. In spite of the argument that digital information is undergoing a process of liberation from matter and the medium [e.g., 15], digital technologies (particularly information technologies) continue to exert their agency in how we engage with digital information through their digital materiality, which does not have to take a physical form.

Physical and digital properties define a range of materially-supported activities that are enabled via the use of a technology. For example, the wearable Fitbit does not register flights of stairs no matter the user's interpretation of the device. Any technology hence imposes material boundaries that demarcate a range of possible actions around it. The material boundaries do not only constrain actions but also enable new forms of awareness and behavior. While material boundaries determine a range of possible adoption behaviors, users can engage with technologies within those boundaries in infinite and often unpredictable ways, enacting disparate technological affordances based on their context, individual preferences, motivations, and the like.

It is important to note that materiality of technology should not be treated as the sole determinant of technological affordances. Affordance of technologies is achieved through the interplay of human agency (e.g., user interpretations of the tool) and technological materiality (e.g., physical and digital dimensions). In this light, a physical property of a technology (that is common to each person who encounters it) may be a problem for some users while others may find it an enabling factor. For example, several of the participants considered the wearability of Flex Fitbit beneficial to their lifestyle, whereas a few others found it intrusive. The wearability of the device as a physical feature is fixed and does not change based on the user's subjective interpretation, yet the meaning that each user assigns to it can vary, shaping how the affordance of the device is enacted in practice. Affordance is a therefore occasioned based on both material properties and the way the user makes sense of them.

As such, while material features influence the way people make sense of them and put them into use [2], technological affordances are subject to human interpretation and contextual influences. Moreover, the materiality of the device does not normally change over time, but its affordances can evolve. For example, several inactive users found the informational aspect of the device useful for representing their daily activities. However, the usefulness of the feature diminished over time as the represented information centered on the same daily routines and did not lead to any meaningful behavior change, partly because these users were not intrinsically motivated to take on extra physical activities.

As noted, technological affordances remain highly connected to the materiality of the technology and are mostly an outcome of experiential use rather than deliberate design [13]. Affordances of the Fitbit device for some users may not fit with the designer's intentions and rationales, which are reflected in its material properties. Although the properties formulate the material boundaries, the user may not perceive them in the same way the designer has intended them. For example, participant 13 was not aware that the wearable Fitbit would vibrate once she reached her goals: "*The first time it scared me because I was out walking with my husband. It was really crazy because I had the Fitbit on and I was really close to my steps but I didn't realize I was that close, and there was this bee that was circling me and he was buzzing by my ear and I finally like swatted and this thing started vibrating and I did jump.*

Over time, the two divergent understandings (designers' vs. users') may converge as users interact more closely with the technology and gain more opportunities to discover the material features and the rationality behind them.

6. Conclusion

The empirical work presented here casts a spotlight on the two salient dimensions of materiality: physical and digital materiality. This work theorizes on the more sophisticated materiality of many technologies that play out in our daily lives through not only their physical enabling and constraining roles but also their digital and conceptual logic which goes beyond physical resources and constraints, and includes such technological layers as applications or infrastructure software [16].

The paper suggests both types of materiality hinge upon the form and design of the technology. In relation to many information technologies around us (e.g., software-based information technologies), isolating materiality is a challenging undertaking, since how these technological artifacts play out in our life is grounded more deeply in their conceptual and digital nature rather than their physical composition. In particular, informational materiality is entwined with the technologies that collect and represent digital information. It is therefore theoretically shortsighted to advance the concepts of digital information and digital materiality without attending to the materiality of digital technologies that are increasingly implicated in the capture, transfer, and representation of digital information. Finally, it is crucial to note that intrinsic functional properties of technologies (both digital and physical) matter only if the *materialization* process proceeds. That is, if the user does not engage with material properties and does not enact the affordance, these properties do not lead to any meaningful changes. As a result, the material properties of artifact begin to matter, only as the user leverages them to meet particular goals. That is, materiality and materialization matter only if the engagement with the information or technology produces measureable change.

It is important to note a limitation of our findings which are derived from the particular context of Fitbit activity tracking devices. As a conceptualization about digital materiality of information technologies more generally, along with the expanding contexts that are technology-mediated (e.g., entertainment, work, and online communities), the assumption of goal-driven motivations may not hold so strongly, and the connection between motivational features and intrinsic motivation of users to use the technology may not generalize to the use of other information technologies. For example, the connection between Fitbit devices' motivational features and the strong intrinsic motivations of some participants of this study may not be as evident in the use of other digital technological artifacts, and therefore requires further verification.

7. References

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