Exploring the Role of Materiality in Physical Activity

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Figure 1: Some of the 3D printed objects based on the heartbeat data of different physical activity.

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Abstract
Providing visual feedback plays an important role in motivating users towards physical activity. Supporting this trend, previous works in the field of HCI has concentrated on virtual representations of physical activity. However, with recent advancements in digital fabrication, I see an opportunity to consider the role of materiality in representing physical activity. I advocate a novel approach of representing physical activity data in the form of material artifacts. By crafting material artifacts that represent one's exertion over time, my aim is to harness the opportunities provided by materiality to enrich the experience of being physically active. As a starting point of this investigation, I have created a system called SweatAtoms that builds material artifacts using the measured heartbeat data of an individual during physical activity.

Author Keywords
Physical Activity; Materiality; Autotopography.

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

General Terms
Design; Human Factors.

Introduction

With rapid advancements in sensing technologies, we are witnessing a growing interest in using technology to foster a healthy lifestyle [2, 17, 18]. Recent studies have pointed out that a lack of awareness about physical activity may lead to a sedentary lifestyle [17, 26]. In response, there has been an increase in technology that aims to make people aware how much – and how little – they engage in physical activity: for example, many personal informatics tools exist that measure bodily movements and bodily responses that occur during physical activity for the purpose of self-monitoring and reflection on the activity [17, 18]. Another example are devices like heart rate monitors that inform users about their exercise intensity by measuring the changes in heartbeats during a physical activity session. Studies have shown that regular use of these tools can increase physical activity [1, 26]. However, the data measured through personal informatics tools is often very abstract in nature: in particular biofeedback data such as heart rate and breathing rate "has no natural counterpart that can be graphically reproduced" as pointed out by Vande Moere [28]. Therefore, it seems it is imperative to create meaningful metaphors and mappings to communicate this data to the user.

Over the last decade, the field of Human Computer Interaction (HCI) has seen various attempts at creating novel information visualizations of physical activity data [5,6,8,13,19] mainly focusing on virtual representations and accurate portrayal of the physical activities. For example, Lin et al. [19] have used virtual metaphor of a fish to represent physical activity data while Fan et al. [8] have used abstract art for representing physical activity. Most of the commercial personal informatics tools use numbers and graphs to show the recent and past activities of the users on screens. However, I argue that as personal informatics tools are becoming increasingly pervasive in our daily lives, what we design for them does not need to be limited to making users aware of their activity and to prompt users for the next achievable health goal. I believe there is an opportunity for complementary design strategies surrounding physical activity and its representation, specifically thinking beyond the virtual experience.

This work presents a novel approach of representing physical activity data in the form of material artifacts (refer Figure 1). By material artifacts, I refer to physical objects that are constructed from digital designs using a digital fabrication process [22]. By incorporating a digital fabrication process of constructing material artifacts, the proposed research aims to explore a "*physical – digital – physical*" mode of interaction. In this interaction, physical energy is first invested in creating a digital output, which is later converted back into physical form, re-entering the physical world.

Approach: Material representations

Recent advancements in digital fabrication have made the task of fabricating personalized material artifacts easier, accessible and affordable with devices like 3D printers and laser cutters [20, 22]. Gershenfeld [9] envisions that 3D printers and scanners will soon be found in every home and people will regularly use them to make, copy, and share their custom made designs and material artifacts. As a result, design and HCI researchers are now considering the role of digital fabrication and materiality in HCI [20, 22]. As a result, I got interested in investigating this domain further by

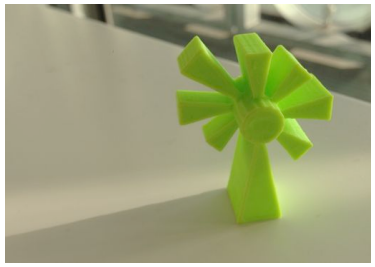

Figure 2: A material artifact put on a public display can become an external representation of the self [10].

identifying its significance for enriching the physical activity experience. After studying the related literature on materiality, I believe that material artifacts can offer the following opportunities to enrich the experience of being physically active.

Material artifacts for an autotopography
Miller [21] argued that individuals like to express themselves with material artifacts that embody their lives, personalities, emotions and achievements. For example, results of one's crafts and achievements are often displayed on fridge doors, walls and shelves. Photographs of trips and events, even though they can be viewed on digital screens, still often get printed in order so that they can be framed and hung on a wall [16]. Such an arrangement of material artifacts as physical signs spatially representing identity of an individual is called 'Autotopography' [12]. This autotopographical collection of material artifacts can also serve as a memory landscape to the owner triggering reminiscence [24, 27]. Moreover, any material artifact, if put on display, can become the public representation of the self [10]. Additionally, the material properties such as shape, form, texture and color may also provide opportunities to support self-expression and possibly creativity [25]. Furthermore, I also believe that the opportunity to create a physical world (an autotopography) of material artifacts that represent one's exertion over time could inspire users to become more physically active. For example, a user might become creative with their exercise pattern rather than simply mimicking any steps being instructed, which according to Candy and Hori is how users exhibit physical skills and agility [4]. As a result I envision that it could lead to more engaging experiences, possibly even altering the monotonous nature of many physical activities.

Material artifacts as rewards
The affordability of digital fabrication [20] has prompted me to consider fabricating personalized material artifacts that can provide an alternate testimony to the invested efforts in performing physical activity. Previous research on archiving and souvenirs support this argument that material artifacts can be more cherishable and meaningful than virtual objects because of their higher visibility in the surrounding and low replication possibility [11, 27]. However, one could argue that with the rise of personal fabrication, the uniqueness property of the material artifacts can be lost as one can now easily make many replicas of the same object. I address this concern by fabricating material artifacts based on the physical activity data of the users during physical activity. I draw on the fact that the bodily response to physical activity is different for every individual and varies with each physical activity. Therefore, when utilized in the design process of material artifacts, chances are high that resultant material artifacts will bear a unique pattern. Therefore, I argue that these material artifacts will hold more meaning due to their distinctive quality and design for every individual and activity.

Challenges

Although material representations might offer opportunities as listed above to enrich the physical activity experience, there is a lack of understanding on how to design such representations for physical activity. In particular, I identify three key challenges in designing material representations, which could affect the user experience of engaging with material

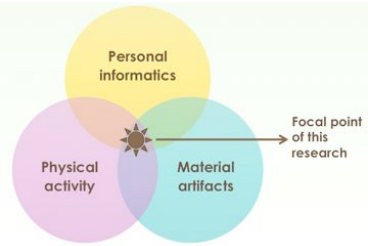

Figure 3: The focal point of this research lies at the intersection of physical activity, personal informatics and material artifacts.

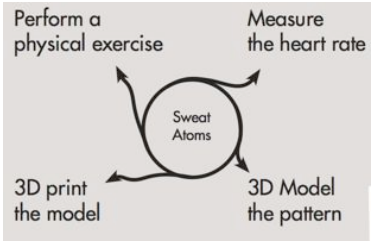

Figure 4: The SweatAtoms loop in action: 1) Perform a physical exercise 2) Measure the heart rate 3) 3D model the heartbeat pattern 4) 3D print the model.

representations of physical activity. **1) Representation challenge:** Which physical activity data should be represented and in what form? For example, should we consider accurate or metaphorical representations of physical activity data in designing material artifacts? **2) Feedback challenge:** When should we present the material artifact to the user? For example, should the digital fabrication run in parallel with a physical activity or should it also be delayed until the user finishes her physical activity? **3) Implementation challenge:** When and how often should the material artifacts be printed? For example, should every physical activity be converted into material artifacts? **4) Engagement challenge:** What are the potential ways of using or engaging with the material artifacts? What should people do with these artifacts once printed? Should they serve utility purposes or aesthetic purposes?

I believe exploring these challenges can help gaining an understanding of the interrelationship between physical activity and material representation. By contributing to this understanding, my aim is to help to situate material outcomes of physical activity within the context of interaction design.

Thesis statement

This thesis explores material representations of physical activity. It involves investigations of the design space surrounding physical activity, personal informatics and material representations as shown in Figure 3. The main research question explored in this thesis is:

"*How does the design of a material artifact – representing one's physical exertion – influence a person's relationship with physical activity?*"

I will utilize research through design and mixed method research practices to answer the research question of the thesis. I will explore physical activity data such as invested time and bodily responses to exertion as central design elements to develop two prototypes around physical activity representation. Firstly, I have designed a system called SweatAtoms that constructs static 3D printed objects using the heartbeat pattern of the individuals engaged in physical activity. Secondly, I seek to develop a system that makes such outcomes interactive. Finally, I will use my investigations of these to build a theoretical design framework for the design of material representations of physical activity.

Work done so far

The starting point of this investigation is a design prototype called SweatAtoms that utilizes measured heart rate data during physical activity to create digitally fabricated material artifacts. I have built a system that generates and then fabricates 3D models using the heart rate data of the user, engaged in physical activity [14] (refer Figure 4). This system has been demoed at the Interactivity venue at CHI 2013 [15].

Contribution

This research contributes to knowledge about understanding material representations of physical activity both in practice as well as theory. This research makes the following contributions. 1) This research contributes to practice by providing implementation details and insights gained from the design and evaluation of a prototype that demonstrates how material representations can facilitate engaging physical activity experiences. 2) This work contributes to the understanding of the interrelationship between

representations and physical activity. 3) This work expands the view of personal informatics tools and physical activity representation beyond efficiency and performance goals, by focusing on the quality of the physical activity experience. 4) By drawing on key principles from materiality and HCI to support the physical activity experience, this work serves as a theoretical bridge that offers a language mediating between the two. It thus aims to situate the role of materiality in interaction design.

Brief biography

I am Rohit Ashok Khot, first year PhD student in the Exertion Games Lab at RMIT University, Australia. My advisors are Dr. Florian 'Floyd' Mueller and Dr. Larissa Hjorth. I started the PhD in September 2012 and I am expected to finish it by July 2015.

Benefits of attending Doctoral school

The values of attending the Doctoral school (DS) at a prestigious conference like UbiComp are significant: 1) I have been working in HCI over the last four years and have been active in the HCI community both as an author and reviewer at conferences like CHI and OZCHI. Venues like DS provide a great opportunity to the emerging researcher like me to interact with noble researchers in the field of HCI and gain initial feedback on my work. The gained knowledge will help me to improve my work and grow as a researcher. 2) DS will also help me to connect with other doctoral scholars working in related areas and to incorporate their thinking and research methodologies into my work. I consider such an interaction as a perfect blend of different cultures and backgrounds, which I believe is essential for HCI researchers to get a wider perspective on their work. 3) Finally, I also think I am capable to add diversity to the venue and positively contribute to the understanding of the role of materiality in the field of HCI with my work.

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