Supporting Autonomy in Physical Activity through Material Artifacts

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Figure 1: A material artifact put on a public display can become an external representation of the self [7].

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Abstract
Autonomy is one of the crucial psychological needs and should be satisfied in order to sustain the interest of people in physical activities. This work explores a way to support autonomy through 3D printed artifacts that are material representations of physical activity. We describe a system called SweatAtoms that creates material representations of physical activity based upon the measured heart rate during physical activity. We discuss its potential implications to physical activity experience.

Author Keywords
Autonomy; physical activity; physical creativity; self-expression; 3D printing.

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

Introduction
Autonomy refers to the innate desire to take actions out of personal volition and not under external influence or control [17]. According to the Self Determination Theory, autonomy is experienced when a user is given the freedom and scope to vary the activity within its set boundary [3]. Unfortunately, physical exercise often does not give us the true sense of

Figure 2: In Dance Dance Revolution game, there is a predefined mapping between bodily movements and actions. If the user does not make the correct body movement at the correct time, there is no defined action within the system.

Figure 3: In Farmville, game players use their virtual farms as a canvas to create pixel-based art.

autonomy. For example, in order to achieve the desired health benefits, an individual should not only exercise regularly but also at the appropriate level of intensity [20]. This would involve setting up an exercise routine (which also means repeating similarly structured exercise everyday) and obeying the rules instructed by the physician, coach or fitness DVD program (which also means having an external control over our actions). This repetitive nature of exercise activities coupled with the perceived control of external factors on our actions makes physical exercise a boring and non-engaging experience [6, 10].

We believe that in order to make the exercise experience engaging, the exercise routine should facilitate autonomy by providing users with options to innovate through exertion. Sheridan calls innovation through exertion as physical creativity [18] and recommends that rather than asking users to simply memorize and mimic the exercise pattern, users should be given freedom to experiment and improvise with their exercise routine within the set boundary. Candy and Hori stated [1] that people exhibit physical skills and agility by breaking the simple routine and reconfiguring and extending the patterns of movements.

However, in reality, the designer of exertion-based systems often pre-tailors the exercise experience and rewards user only when she follows the exercise instructions correctly and in order. For example, in most physical activity based interactive systems, there is a predefined mapping between bodily movements and actions. If the user does not make the correct body movement at the correct time, there is no defined action within the system [19]. As a result, many unmapped bodily movements go unnoticed. Similarly, many other exertion-based systems model a real world scenario by creating a virtual instructor [15] or by accompanying the exercise with the stepwise video recording of an expert trainer. Most of the times, the user has to simply mimic the steps being instructed (refer Figure 2) [2]. Sheridan [18] argued that this instilled vicarious nature of exercise experience limits autonomy and fails to provide users with options for self-expression and creativity within physical exercise.

Interestingly, it has also been observed that when an activity does not provide users with any option for creativity and self-expression, they often alter their due courses of actions to make themselves feel autonomous and creative. For example, many runners in the UK tried to be creative with their running patterns, tracked by a mobile phone app on a virtual map by deliberately running in a pattern that resulted in a running route representation in the shape of a penis [16]. Another example is of Farmville based pixel art where the game players use their virtual farms as a canvas to create pixel-based art as seen in Figure 3, with no particular advantage in the game except using it as a tool for self-expression. There are also people who instill self-expression in physical sports, body sculpting and performance-based arts such as dance. Drawing inspiration from the performance-based arts, where creativity and physical activities are interlinked, I ask the following research question:

"Could self expression and creativity be a way to support autonomy within all form of physical activity? If so, would it alter the way people do the physical activity afterwards?"

Figure 4: As Miller argued, individual like to express themselves in the form of readily displayed material artifacts.

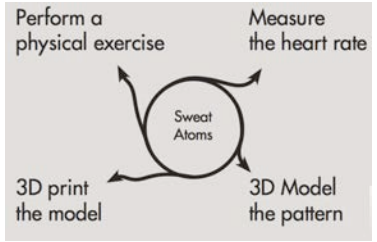

Figure 5: Different action phases of SweatAtoms system: 1) Perform a physical exercise 2) Measure the heart rate 3) 3D model the heartbeat pattern 4) 3D print the model.

Approach: Material representations

To address the research questions sketched above, the initial research direction taken is in terms creating material representations of physical activities. Our idea is to harness (utilize) the measured biofeedback data during exercise activities to create a personalized collection of digitally fabricated physical objects. We have built a system called SweatAtoms that generates and prints 3D designs using the heartbeat data of an individual engaged in a physical activity [11, 12]. The working of the system is briefly explained in Figure 5. We next discuss its potential advantages.

Miller [13] argued that individuals like to express themselves with material artifacts that embody their lives, personalities, emotions and achievements. When material artifacts are put on display, they not only become the public representation of the self and craftsmanship [7] but also serve as a memory landscape to the owner triggering reminiscence [8]. Currently, the digital fabrication of physical objects (for example, using a 3D printer) requires considerable time and so is the process of achieving health goals. Therefore, the final constructed physical output appears as a good match for the temporal and longitudinal nature of health outcomes of regular physical activity. To understand, how physical objects and physical activity relate to each other, let us elaborate on the synergy between energy expenditure in physical activity and additive manufacturing process of fabricating physical objects.

Energy expenditure vs. additive manufacturing

Any physical exercise done in order to achieve a certain health outcome involves stepwise investment (subtraction) of energy. On the other hand, in additive manufacturing, a 3D model is constructed (printed) by adding materials on a flat surface layer by layer. I see a synergy between the two activities. For example, the continuous subtraction of energy while performing a physical exercise is analogous to the continuous addition of materials to print a 3D model. This synergy between the two activities inspired us to think about interlinking them together. For example, what if the obtained patterns of the exercise activities are fed into additive manufacturing process; can it result into interesting abstract designs?

We also noticed that there exists subtle difference in terms of the biofeedback pattern among people despite their physical activity being the same (jogging, walking). We draw on this fact each person brings her own unique flavor to exercise, in particular how the body responds to the activity over time. However, these nuances within the exercise activities are not easily noticeable. Fortunately, the sensing technology can now measure these nuances, and we see this as an opportunity to support our endeavor.

Moreover, we also believe that crafting or designing objects according to our choices is one supreme example of an autonomous activity where actions are often guided with self-interested (motivated) outputs. Moreover, physical crafted objects also provide (or can be molded in) variety of different ways of altering the design, shape, material and even the intended purpose. Therefore, in order to craft different physical objects, the user might feel inspired to try out new forms of physical activity to express her self. For example, users might be interested in figuring out how a push-up exercise would be reflected in the design. I believe

Figure 6: Newer, fancier shapes and artifacts might prompt the user to innovate through exertion.

physical crafting of objects could inspire users to be more physically active and also to be creative with their exercise pattern rather than simply mimicking the steps being instructed (refer Figure 6). As a result, we envision that it could lead to an engaging experience, possibly even changing the monotonous nature of physical activity.

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