# EdiPulse: Supporting Physical Activity with Chocolate Printed Messages

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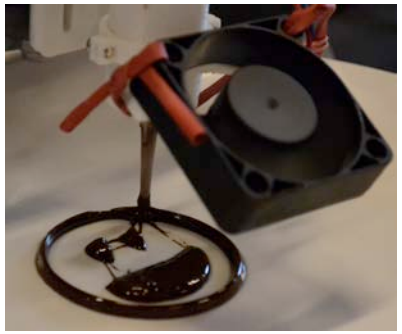

**Figure 1:** EdiPulse turns heart rate data into a chocolate using a chocolate printer.


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## Abstract
Designing to support physical activity is a growing field of interest in interaction design. However, existing explorations in this area have mostly focused on using screens to graphically report physical activity data such as heart rate. The use of edible mediums such as 3D printed food for representing such data opens up new possibilities and challenges to push the field forward. Supporting this, we present EdiPulse that 3D prints in chocolates, personalized cheerful messages and emoticons, displaying heart rate data from physical activity session. By varying the thickness of the printed letters and emoticons, the system also supports abstract visualization of the heart rate data, while the printed chocolate incentivizes participation in physical activity. Ultimately, with this work, we aim to inspire and guide design thinking on food printing and edible quantified self representations, which we believe opens up new interaction possibilities to support the physical activity experience.

## Author Keywords
Physical activity; edible representations; food HCI; food printing; 3D printing; quantified self.

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

## Introduction

Wearable devices such as heart rate monitors and pedometers are becoming increasingly popular in the consumer market to support self-monitoring and reflection on physical activity [22]. By capturing previously invisible data such as heart rate, these devices enable a better understanding of individual's physical activity levels, which in turn can prompt actions towards health and fitness related aims [13, 24]. For example, heart rate monitors inform users about their exercise intensity by measuring the heart rate during physical activities while pedometers capture individual's movements such as numbers of steps taken in a day, to inform about active lifestyle. Earlier studies have found that the regular use of such devices motivates participants to be physically active [24].

However, most of the data measured by these devices is abstract in nature and does not hold any one-to-one relationship with real world objects. As a result, in order to make sense of this data, creating an appropriate visual mapping of the activity becomes important. Addressing this, previous works in the field of HCI have concentrated primarily on interactive digital medium to communicate this data using a variety of different visualization techniques [4,5,14]. However, the emphasis of these works has been on quantification in order to increase awareness of and participation in physical activity. However, for a person, with limited experience in data visualizations and statistical reasoning, such visualized data may not be of a value if it is not accessible, understandable and interpretable to gather new insights and actionable knowledge as argued by Huang et al. [9]. Additionally, the use of screens to visualize this data offers limited interaction capabilities catering only to our visual senses but ignoring the abundance of other senses that are available to us [10, 25]. We therefore believe that there is a need and an opportunity to explore alternative design strategies looking beyond quantification goals and making use of mediums other than screen to represent physical activity data.

In this work, we explore this opportunity through the use of 3D printed food in particular chocolates to represent physical activity data. We present a system called EdiPulse that transforms the measured physical activity data into cheerful messages and emoticons, which are later 3D printed as chocolates. These messages and emoticons also provide abstract visualization of the physical activity by varying the thickness and portrayed emotions in accordance with the physical activity levels. For example, the system will print thick letters when user has an active day whereas on a sedentary day, the system will print thin letters. This work extends our earlier work [11, 12], where we explored non-virtual representations of physical activity data using 3D printed material artifacts and personalized sport drinks. We believe using food such as chocolates to represent physical activity data can offer a multisensory experience combining vision, touch, smell and taste, which in turn could support new ways of engaging with physical activity.

## Existing works on visualizing physical activity

Most commercial systems offer visualizations of physical activity data through an accompanying website or a mobile app. Predominantly, these systems use numbers, graphs and charts for the visualization. However, research suggests that people have low graph literacy skill and inferring personally relevant

information from graphs is often difficult [8]. Addressing this, previous work in HCI has looked at other ways of representing physical activity data. For example, Consolvo et al. [4] have used the metaphor of a virtual garden where on screen flowers grow when user does different physical activities. Similarly, Lin et al. [14] created a system that maps individual's physical activity levels to a virtual fish whose growth and activity is decided based on how physically active user has been in a day. Fan et al. [5] explored abstract visualization methods using informative art to represent physical activity data. In most of the existing works, the screen is primarily used for displaying physical activity data. However, recently other mediums such as 3D printed plastics and fluids have been explored as representation mediums [11, 12, 21]. Accompanying studies of these works show that physical mediums can positively influence the user relationship with physical activity. Taking inspirations from these works, we explore another physical medium: food in particular chocolate.

## Opportunity with edible mediums

Human Food Interaction (HFI) [2, 3] is an emerging research community within HCI, which explores different food practices (such as how we grow, shop, cook, eat and dispose food) and how such practices are related to physical health. However, the use of food as a medium to represent physical activity data does not appear to be widely explored because of the scarcity of resources. However with recent advancements in digital fabrication technologies and the availability of food printers and laser cutters that can create digitally enhanced food, the interest in this area is growing [19, 20]. For example, Fukuchi et al. [7] invented laser cooking that uses a laser cutter and image processing techniques to cook food according to the shape and composition of ingredients, allowing for new tastes and textures to emerge. Artists like Tisha Cherry [23] experiments with innovative food arts by presenting food in unique design. Qkies [17] is another system that embeds QR codes on cookies, while Wei et al. [26] created a system that supports food-based messaging between friends and loved ones. Taking inspiration from these works, this work extends the idea of creating digitally enhanced food to support physical activity and quantified self practices.

## Blending quantified self practices with food printing

We find quantified self technologies and food printing as an intriguing combination where the first provides information about how much energy has been expended in a physical activity, while the later focuses on the novel ways of producing food (energy). We believe that this is an exciting premise for supporting physical activity experience. As a starting point, we choose to create edible representations of personal data using chocolate. We choose chocolate because it is "culturally understood as the symbol of love, packaged with high emotions to inspire feeling of self indulgence and hedonistic ecstasy" [15]. Owing to its high calorie and sugar content, some may argue against using chocolates in relation with physical activity, however, we feel that this fact makes this research more intriguing in understanding how users will react to such representations, e.g., will participants eat such chocolate or throw it away? Will they give it to someone as a token of their heart? Intrigued by such questions, we put forward a system called EdiPulse, which we explain below.

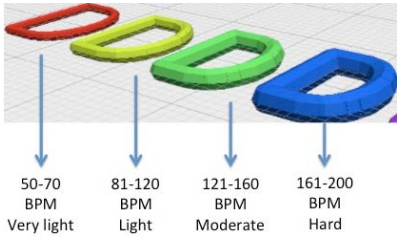


**Figure 2:** Each zone maps to a different thickness value for the printed letter.


**Figure 3:** EdiPulse prints cheerful message such as 'U rock!'

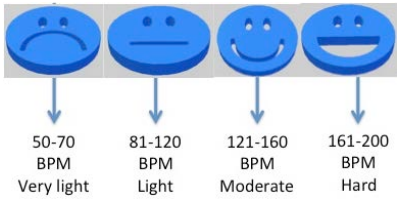


**Figure 4:** Each zone maps to a different emoticon.

## EdiPulse

EdiPulse is a 3D modeling system that transforms heart rate data of a physical activity into cheerful messages and emoticons, which are later 3D printed in chocolate. The working of the system is as follows.

*1) Extracting physical activity data (heart rate)*
We record the heart rate data of physical activity using Polar heart rate monitor and its accompanying mobile app. This app records heart rate data and saves it to the Polar website. When the physical activity is over, we download the data from the website in XML format. The EdiPulse application (written in JavaScript) then parses this XML data to calculate the duration and intensity of the physical activity by identifying heart rate zones within the recorded data.

We use four heart rate zones, each corresponding to a different level of exercise intensity using Fletcher's classification of exercise intensities []. These zones are: 1) very light activity zone with heart rate value in the range 50-70 beats per minute (bpm), 2) light activity zone (71-110 bpm), 3) moderate activity zone (111-140 bpm), and 4) hard activity zone (141-180 bpm). We discard the heart rate values below 50 bpm and above 180 bpm as they rarely occur.

*2a) Printing of cheerful message*
We maintain a database of cheerful messages such as "U Rock! ", "Well done, Mate! ", from which we select one message at random for printing. We then divide the activity duration in the interval of 5 minutes, to select the desired length for the message. For example, an activity of duration 15 minutes will result into printing of first three characters of the selected message. Our intention behind printing incomplete messages was to incentivize user in continuing physical activity for longer duration by which they can then see the complete message.

We then utilize the intensity of the physical activity to select the desired thickness of the letters in the printed message. The intensity is calculated based on the most frequently occurring heart rate zone within the recorded activity. Corresponding to each heart rate zone, we have mapped a thickness layer as shown in Figure 2. The thickness layer describes the amount (layers) of chocolate to be added while 3D printing a letter on the print bed. For example, zone 1 (light activity zone) having a thickness value 1 will add one layer of chocolate, whereas zone 2, 3 and 4 will respectively add 2,3 and 4 layers of chocolate.

Finally, the prepared 3D model of the message of chosen length and thickness is 3D printed using a Chocolate Printer as shown in Figure 3.

*2b) Printing of an emoticon*
EdiPulse system also allows printing of emoticon. In order to print an emoticon, we first map the four heart rate zones to four different emoticons as shown in Figure 4. We then identify the most occurring heart rate zone within the recorded activity and choose its corresponding emoticon for printing. For example, if the user has spent most of her time in hard activity zone (141-180 bpm), then the system will print the smiling emoticon representing hard activity zone. Similar to the printed letters, the thickness of the emoticon is based on the identified heart rate zone.

The user is free to taste or share the printed chocolate (Figure 5) with someone else. Additionally, by looking


**Figure 5:** EdiPulse prints cheerful messages to positively enforce participation in physical activity.

at the thickness of printed letters or the emoticon, user gets an abstract idea of how active she has been during the day. As a result, the printed chocolate becomes a form of abstract visualization informing users about their physical activity levels for a given day.

In our system, the user receives a 3D printed chocolate in the form of a cheerful message or an emoticon irrespective of whether or not she has performed significant amount of physical activity. However, as user performs various physical activities, the heart rate will vary and which would result into increasing the quantity of the printed chocolate. Therefore, in order to get a rich amount of chocolate, the user might get inspired to exercise differently and to try out new forms of exercise. For example, the user might be interested in figuring out how the pushup exercise would reflect in the design in comparison to jogging? What message or which emoticon would I get in the end? We believe such questions would inspire the user to exercise more and be creative with her exercise. As a result, we envision that it would lead to an engaging experience.

## Proposed study

We are planning to conduct an "in the wild" [18] study practice to collect the subjective data about the experiences of participants with the proposed systems. We will install the system in different homes across a metropolitan city for a period of 3 weeks. Participants will record their heart rate data while performing various physical activities on their daily basis. Heart rate data of their workout will be fed into the system through EdiPulse application, which will then create cheerful messages and emoticons for the user. At the end of the study, we will conduct semi structured interviews with the participants to reflect upon their experiences with the system, which will guide us towards understanding the design of edible representations to support physical activity experience.

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