Personal-Public Displays: Motivating Behavior Change through Ambient Information and Social Pressure

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Abstract
Our research investigates how public displays of personal information can be used to motivate behavior change. We describe six characteristics that are important for such information displays to embody. These build on two well-established methods for motivating behavior: presenting pertinent information at the point-of-decision and leveraging social pressure. To investigate how these personal-public displays can be used to motivate behavior change we developed Pediluma, a wearable device with sensing and dynamic lighting capabilities. In particular, it tracks and visualizes the wearer's physical activity by changing the brightness of its display. We hypothesize that the public display of behavior and subsequent social pressures will motivate people to increase their physical activity as well as their awareness of it. We describe our current user study design, and discuss possible generalizations of the work.

Keywords
Wearable, visualization, ambient information, behavior change, motivation, point-of-decision, physical activity, captology, ubiquitous computing, persuasion, health, social impact.

ACM Classification Keywords
H5.m. Information interfaces and presentation: Miscellaneous. H.5.2.i Information Technology and Systems: Interaction styles. C.3.h Computer Systems Organization: Ubiquitous computing.

Introduction
Motivating behavior change is an enormous challenge. People find comfort in familiar routines and attitudes, and naturally resist change, even if to their benefit. Technology is increasingly being applied in persuasive ways in order to promote behavioral change [8, 14]. Previous efforts have primarily relied on two methods to motivate users: displaying timely and relevant information, and leveraging social pressure.

Targeting behavior change at the point-of-decision has been shown to be highly effective. This is the moment when people consult their memories to make an informed choice about how to proceed. Any pertinent information injected into the environment at this moment will be at the forefront of the decision-making process. This strategy has been leveraged in numerous domains, including physical activity [1, 7, 22], diet [12], energy conservation [10], recycling [11], and water usage [4].

Aside from personal decision-making, people place great emphasis on how others perceive them. The goal to produce a positive perception is often the root of behavioral changes [5]. Technology can leverage and amplify this effect by enhancing the communication and interaction between users and their social circle. For example, social networks can be used to stimulate competition or create support groups, both of which motivate behavior change (e.g., [1, 14, 23, 25]).

Additionally, social exposure can lead to public commitment which has been shown to significantly improve the likelihood that the associated behavior change will be achieved [13, 17].

Design Characteristics
We attempt to capitalize on the aforementioned effects by creating a category of devices we call Personal-Public Displays, which embody six characteristics:

Personal
The information that is displayed should be relevant to the user. Specifically, the information should reflect a particular dimension of the user's state, such as his or her grade point average, number of calories consumed, time spend indoors, or number of steps walked.

Public
To best leverage social pressures, the information should not only be displayed to the user, but also publicly, for example, to the user's family, friends, peers, and even strangers.

Persistent
Previous research has shown the effectiveness of presenting information at the point-of-decision [4, 12, 22]. Traditionally, this is achieved by collocating the information necessary to affect a behavior with the target action (e.g., a sign promoting physical activity next to a staircase [2]). Unfortunately, sensing context, such as social interaction, location and time, continues to be a challenge for mobile devices. By persistently displaying the information, users are free to consult the information when they deem necessary.

Peripheral
Although the information display will be persistently active, it should not be distracting when the user is engaged in other tasks. Therefore, to accommodate other priorities it should be an ambient display, providing information peripherally to viewers.

Present
The information should reflect the user's present state. By placing an emphasis on the present moment, users can make an informed decision regarding an immediate choice.

Positively Reinforcing
People are more likely to repeat an action with positive reinforcement [21], so the device should provide immediate positive feedback after a favorable action to further encourage it. Additionally the information should be presented in a positive context such as "calories burned" or "total savings."

Demonstration domain: Physical Activity

To investigate how a Personal-Public Display can support behavior change, we have selected the physical health domain. The lack of physical activity is regarded as a "public health crisis," leading to a wide range of health problems, including coronary heart disease, type 2 diabetes, and cancer of the colon [16]. Established recommendations call for at least 30 minutes of moderate physical intensity on most days of the week – an intensity that has been shown to provide substantial health benefits [16, 20]. In particular, we target walking, a convenient form of physical activity, which can be easily incorporated into everyday life and sustained into old age [19]. Moreover, it is widely regarded as one of the best opportunities for impacting personal health [15].

Pediluma Prototype

We have developed Pediluma, a wearable shoe accessory, to encourage walking through the public display of recent physical activity.

Design
Pediluma follows two of Consolvo et al.'s design requirements [7]: (i) providing *personal* awareness by associating the device's luminescence (i.e., intensity of a light) with recent physical activity, and (ii) supporting social pressure by *publicly* displaying recent walking behavior through the light.

Similar to UFOS [6], Pediluma will provide a light source on the shoe, but for the purpose of motivating walking, rather than expressing gait articulation. The shoe is the most relevant piece of clothing associated with walking, so wearers and onlookers can easily and persistently associate the device with walking. The feet are also typically located in the periphery of one's view, affording a convenient placement for an ambient display.

Pediluma allows the user to note his present state of walking by having a light that changes brightness depending on the wearer's current or recent walking activity. To support positive reinforcement, the light grows brighter the more the wearer walks. This would attract the positive (or curious) attention of onlookers who see the bright light, and could stimulate the wearer to walk more. We avoid the practice of including goal-setting towards step count targets to avoid confounding additional positive effects.

figure 1. The covered Omron HJ-112 pedometer that all participants would wear to log their step counts.

figure 2. Pediluma strapped to a shoe and fully lit.

Implementation

The prototype uses a light to indicate the wearer's current and recent walking activity. If the wearer has remained stationary for some time, the light will be off. As the wearer begins to walk, the light will quickly brighten to indicate increasing levels of activity. When the wearer stops walking, the light will slowly decay in brightness until it returns to being off. The rate of brightness change will be calibrated such that walking will be quickly rewarded. However, brightness decay will be slow such that there is a lingering reward.

To detect walking, we use a ball-bearing tilt sensor to detect steps, which is less expensive and easier to interface with than shoe-based commercialized pedometers, such as the Nike + iPod Sport Kit [18]. An ultra-bright LED is used for the activity display. Device logic is controlled by a PIC processor, and the device is powered by three AAA batteries, allowing it to be run optimally under typical conditions over two weeks. As ground truth, the Omron HJ-112 pedometer is used to track steps accumulated each day for a week. The pedometer's display will be covered (see figure 1) to hide the step count accumulation from the wearers so as not to confound our results (for example, users might begin to set daily goals if there step counts are visible). Several design iterations of Pediluma have culminated in the prototype shown in figure 2. Earlier prototypes had included a compound LED showing progress towards a daily goal. However, we decided to forego this progress meter to simplify the device and to focus on investigating the effect of real-time positive reinforcement. This also allowed the prototype to have a smaller housing and blend better with the shoe.

Study Design

We will investigate the personal and social changes due to the public display and real-time positive reinforcement of physical activity.

Objectives

We expect to see behavioral change through an increase in physical activity measured by an increase in average step count per day. We also expect to see changes in awareness (i.e. wearers more conscious of their walking behavior), motivation (i.e. wearers inspired to walk more in response to the positive reinforcement), identity (i.e. wearers themselves as being more physically active), and perception of social influence (i.e., wearers perceiving increased influence from others regarding their physical activity).

Design

We will recruit participants who are interested in increasing their physical activity. All participants will carry a pedometer for the first week as a baseline. To explore the main cause for change, participants will subsequently be separated into four groups, each subjected to different conditions:

CONTROL

Participants will continue wearing just the pedometers. This will control for novelty effects of carrying a pedometer, and possible Hawthorne effects as a result of participating in the study.

CONTEXTUAL LIGHT

Participants will wear the full-featured Pediluma with step sensing and a light that brightens in accordance with their walking.

NON-CONTEXTUAL LIGHT
Participants will wear a version of Pediluma with no step sensor. The light will brighten and dim independently of the wearers' walking. It is visually identical to that of the full-featured Pediluma. The frequency and rate of change of the light will be set to mimic a full-featured Pediluma on an average user. This will help determine if any measured changes are merely due to the presence of a light. For example, wearers might become more conscious of their shoes and walking even if the light is independent of his walking.

NO LIGHT
Participants will wear a version of Pediluma that is filled with non-functional electronics (i.e., no step sensor, no lights). This will allow us to gauge the novelty effects of simply wearing a shoe-mounted device.

Throughout the study we will conduct periodic ethnographic observations of the participants in their public environments and record externally observable social effects of the device. At the end of the study, we will conduct exit interviews about the social experience of wearing the device. We will determine the wearer's awareness, motivation, and identity. Additionally, we will also attempt to ascertain the how others influence the wearer, and vice versa.

Discussion

Our study will contribute to the existing body of wearable technology, ambient display, and persuasive technology research by blending the effects of point-of-decision information and social pressure. Our research advocates a model for behavior change that is personal, public, peripheral, present, persistent, and positively reinforcing. Our goal is to support the personal goals of the user unobtrusively in their daily routines with current and actionable information, while simultaneously reinforcing desired behavior with positive feedback. The public display of this feedback allows for the interaction to be socially supported, and potentially more likely to be maintained and incorporated into the user's identity. While this has been employed on a limited level in the virtual world [24, 25], we believe that the pervasive nature of our work will be more compelling to participants and yield a more tangible impact.

We believe the public display of personal state could be successfully applied in many other domains to support behavior change. For example, the diet and environmental domains are well suited for socially supported decision-making and behavior change. These applications could range from the number of calories burned in a day, to amount of carbon offset over the course of the week.

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