Watch your Steps: Designing a Semi-Public Display to Promote Physical Activity

Robert Cercos
Exertion Games Lab
RMIT University
Melbourne, Australia
robert@exertiongameslab.org

Florian 'Floyd' Mueller
Exertion Games Lab
RMIT University
Melbourne, Australia
floyd@exertiongameslab.org

ABSTRACT
Sedentary time is considered a health risk factor, even when it is compensated with some exercise. Frequent activities of minimal physical exertion throughout the day like walking or climbing stairs are therefore recommended. To promote these activities through social play and collective awareness, we designed a semi-public display that shows the step count of a group of players in near real-time, using a wearable self-monitoring device that senses their physical activity. We included a fictional player that walked at constant speed during the whole day to promote a shared goal. Our preliminary findings suggest that the display motivated players to use a self-monitoring device everyday and enabled new conversations among players without producing privacy issues. Emotional connections with non-collocated participants and creative ways of cheating were also observed. We believe our work highlights the opportunities to extend the potential of self-monitoring devices, which require little effort and resources to be implemented.

Categories and Subject Descriptors
H.5.2. [Information Interfaces and Presentation]: User Interfaces - Miscellaneous.

General Terms
Design, Human Factors

Keywords
Persuasive technology, persuasive games, serious games, behavior change, behavior change technologies, self-monitoring devices, physical activity displays

1. INTRODUCTION
Sedentary behavior is related to an increased risk of having some health conditions, like cardiovascular diseases and type-2 diabetes [3,10]. Preliminary evidence also shows that the practice of some exercise cannot compensate these negatives effects; frequent physical activities of minimal exertion (e.g. walking, climbing stairs) throughout the day are therefore recommended [3].

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A growing area of interest in HCI has been the use of technology in helping people to change their sedentary behavior. Also a community around the concept of the 'quantified self' has emerged, exploring the possibilities of internet devices (e.g. smartphones) and wearable self-monitoring technologies (e.g. digital pedometers, heart rate monitors) to track wearers' health.

We think there is an opportunity in using self-monitoring technologies in social settings, particularly those associated with shared spaces (e.g. office shared by co-workers, home shared by a family) to encourage physical activity throughout the day. In this paper we explore the social dimension of using these technologies through the design of a semi-public display showing physical activity. To achieve this, we designed Watch your Steps, a semi-public display of collocated players' step count.

This paper is structured as follows: Firstly, in Section 2 we present some of the most used behavior change theories in the field of HCI, explaining how semi-public displays could be suitable for addressing them. In Section 3 we provide an overview of some existing research studies that explore the use of displays in increasing physical activity levels of users. In Section 4 we describe the design of Watch your Steps, showing its technical components and game elements. In Section 5 we present our findings from the design process and preliminary observations. In Section 6 we discuss our findings and limitations of the study. Finally, we present the conclusions of our work in Section 7.

2. BACKGROUND
2.1 Behavior Change Theories
Behavior change has been increasingly explored in HCI research [5]. Some theories of behavior change that have been commonly used in this field are the self-determination theory, social cognitive theory, and the transtheoretical model.

Self-determination theory [11] focuses mainly on explaining the mechanisms of intrinsic motivation, suggesting three main drivers: competence (e.g. skills, ability), autonomy (e.g. level of control and agency, freedom of choice) and relatedness (e.g. connecting with others, meaningful causes that benefit others). It also describes a spectrum of forms of motivation that goes from complete amotivation to fully intrinsic motivation, passing through different categories of extrinsic motivation.

On the other hand, social cognitive theory introduces the concept of self-efficacy [1]. It refers to the assessment that a person has about his/her own ability to perform a task or achieve a goal, which can play a crucial role in succeeding in changing behavior. This theory also suggests that self-efficacy is based in four information sources: performance outcomes (one's past success or failure in facing a challenge), vicarious experiences (success or failure of others in facing a challenge), verbal persuasion (what others tell about one's future performance) and physiological feedback (how one's body responses are interpreted when facing a challenge).

Finally, the transtheoretical model [9] describes a general process of modifying problematic behaviors by condensing several fragmented theories. In this model, the 5 sequential states of change are: precontemplation, contemplation, preparation, action and maintenance.

These three theories can be used in different ways in interventions that aim to change a sedentary behavior using technology. While self-determination theory highlights the relevance of perceived agency, user's skills and social context while using an interactive technology to increase extrinsic motivation, social cognitive theory could be used to enhance self-efficacy, highlighting own and other's successful experiences using technological tools. Finally, the transtheoretical model can be used to evaluate the effectiveness of an intervention, by measuring in which stage is the user before and after the use of a certain technology.

2.2 Semi-Public Displays

Semi-public displays are public displays in which the shown information and the interaction "is only available to members of a co-located group" [6]. One of the key advantages of using semi-public displays is the possibility of sharing rich visual content (text, videos, images, graphs) within a shared space without the need of having any specific device, connectivity or technology in order to access it. In addition, it can be a non-invasive method to quickly distribute information to a group (i.e. only to those who are interested in receiving the content and interact with the device). Finally, its semi-public nature provides a convenient way (i.e. low cost or effort) to generate and support interaction within the members of the collocated workgroup.

In the context of sedentary behavior change, semi-public displays could enable interactions of social support and distributing information that could lead to an increased self-efficacy. Semi-public displays also provide a convenient way of supporting social play and collective awareness; both can be explored as ways of increasing physical activity of collocated groups.

3. RELATED WORK

In this work, we are interested in understanding how displays of physical activity captured by a self-monitoring device can be used in changing users' sedentary behavior. Some examples of behavior change interventions that use displays of physical activity data can be found in HCI literature, using both personal and semi-public displays.

Using a simple phone screen, UbiFit Garden [2] focused on users that already recognize the relevance of introducing more physical activity into their lives. Accordingly, they targeted only the 3 first stages of the transtheoretical model. The system consists in what the authors called a 'glanceable display' (i.e. that could be interpreted 'at a glance'). A cellphone background image shows weekly progress on achieving a physical activity goal using the metaphor of a garden with flowers and butterflies; the diversity and amount of flowers depend on the amount and variety of physical activity, the goals are represented by butterflies. Interestingly, users were allowed to manually introduce their own modifications to sensed data when they felt the step count did not match their perceived amount of activity, increasing their sense of autonomy.

In Fish 'n' Steps [7] a metaphor for physical activity of a co-located group of users was used: physical activity was linked to the growth and activity of virtual fish. The authors used both public and private displays that innominate the data in order to hide from the players the information about the 'owner' of each fish. The authors used the same model as Ubifit's garden to analyze the impact of the intervention, measuring the progress of users in the stages of the transtheoretical model.

Another workspace intervention using pedometers is StepMatron [4], a Facebook application to collect and share step activity. In this study, two conditions were compared: a socially-enabled version in which users were able to see their friends' step count, and a non-social version in which users could only see their own data, showing that the first one had a significantly higher step activity.

Based on these experiences, we think there is an unexplored opportunity in using the context of a shared space with co-located people to encourage physical activity through social play using semi-public displays, without hiding the identity of the players and, also, providing a more informative (i.e. less metaphorical) representation of their activity. Our aim is to understand how to promote physical activity between a group of co-located people using wearable self-monitoring devices and semi-public displays.

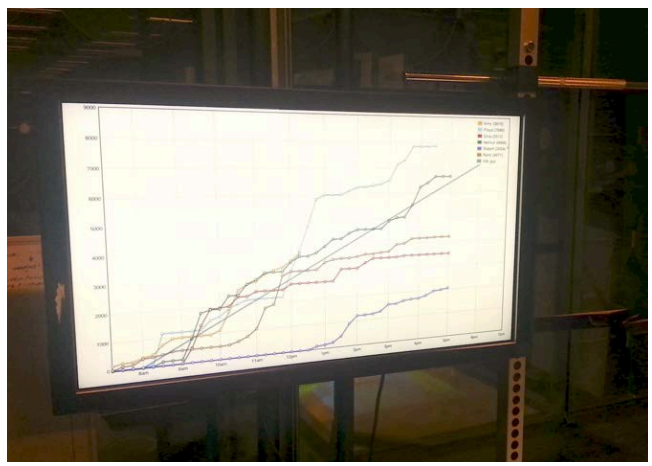

Figure 1. Watch your Steps display

4. WATCH YOUR STEPS

To gain a better understanding of the social dimension of using a wearable self-monitoring device, we designed Watch your Steps: a shared semi-public display of physical activity data within a group of players that share a workspace (Figure 1).

With Watch your Steps, our approach was to utilize the power of social relationships in changing people's behavior, enabling new forms of play and increasing the collective awareness about how different contexts, attitudes and activities foster physical activity. We did not set any rules in order to achieve a higher perceived user agency. Our aim was to create a system that promotes a shared and reflective view of players' recent activities as the base of a new space for social play.

In our case, players were students and researchers that work in a research lab, forming a community. The system consists of a 46-inch display placed in a visible place of an open workspace, that shows a graphical representation of the accumulated amount of steps of each player throughout the day, being updated every 15 minutes. It only reflects one day of activity; the step count starts with the player's first synchronization of the day and it resets to zero at the end of the day. A fictional player called "10k guy" was also included to promote a shared goal of 10.000 steps (standard goal for daily steps) uniformly distributed from 8am to 10pm (Figure 2).

4.1 Data Collection

To capture and count players' steps, we used Fitbit (www.fitbit.com), a wearable self-monitoring device that is commercially available. It uses a 3D accelerometer to register the steps that the user has made throughout the day. The device also has an altimeter that enables to count the floors climbed without taking into account when the user is descending the stairs. Nevertheless, for simplicity, we are only collecting step count in our design.

Using a low-energy Bluetooth pairing, the device is able to wirelessly synchronize the data with an online database through players' personal computers. To trigger that process, the user has to be near to one of the USB dock stations, not necessarily the one that was originally associated with the device. This means in our case that a player usually synchronizes his/her device immediately after arriving at the workspace, several times every hour thanks to the proximity to other players' docks. This particular feature has some advantages for displays that are made for co-located groups of people, but it also limits players' agency over the synchronizing process with some potential privacy downsides, as we are going to discuss later (see 5.2.2 in Findings section). Once the users have authorized to share their data with our system following a 3-legged Oauth process, we are able to pull the users' data through the API provided by Fitbit. The extraction process runs every 15 minutes, because of the limitations of Fitbit's API (see 5.1.1 in Findings section). After the extraction process is finished, the pulled data is interpreted in order to obtain the step count of each user for the last 15-minute interval from an XML structure. Finally, the accumulated number of steps is calculated for each interval.

4.2 Data Visualization

We chose a web-based visualization for the data, using an open-source JavaScript plotting library for jQuery called Flot (flotcharts.org). This allowed us to quickly build a 2D line graph that is refreshed every 15 minutes (Figure 2).

4.3 Daily Operation

When a day starts, the graph will show the step count for the "10k guy" but no players' data until the first player synchronizes his/her device. Other players' data will be shown on the display as they arrive near to a USB dock, in our case, that place is usually the research lab. Thereby, every 15 minutes each player's data will be updated only if a new synchronization event occurred in that lapse. At the end of the day, the graph will return to its original state and another day of play will start.

4.4 Alternative Design Elements

Our design emerged from a multiplicity of alternatives for each of its constructs. In that process, we analyzed advantages and disadvantages for the main alternatives for sensing technology, privacy level, data representation and display type (Table 1).

Regarding the sensing technology used, we chose Fitbit instead of other self-monitoring devices available because of its wireless operation, battery life of more than 8 days, and availability of an API to access the data.

We chose an informative representation instead of an abstract representation because we wanted to increase the awareness of physical activity levels, providing also normative information that lead users to gain more knowledge about their (and others') current physical activity, enhancing the drivers of self-efficacy and relatedness. It is arguable that both can be addressed using an abstract representation of physical activity data, like in [2] and [7], but we think an informative representation facilitates a more direct assessment of the impact of each activity.

Table 1. Alternative Design Elements

Aspect	Alternatives	Pros	Cons
Sensing technology	Fitbit	Wireless sync, API, good battery life	Clip shape, need charger
	Nike Fuelband	API, wireless sync, wristband, no charger	Lack of accuracy
	Smartphone	No additional device needed	Battery life decreases
Privacy level	Aggregated group data	High collaboration, high privacy	Less personal awareness
	Shared but innominate	High privacy, allows comparison	Less social involvement
	Shared and nominate	High social interaction and learning	Less privacy
	Non-shared	High privacy and personalization	Less social interaction, comparison is difficult
Data representation	Informative	Easy to understand, high awareness	Low privacy, less playfulness
	Abstract	More privacy, playfulness, aesthetics	Comparison with others and understanding feedback are more difficult
Display type	Public	More exposure, no additional device is needed	No control over the context, low user agency
	Semi-public	Exposure in a controlled context, no additional device is needed	Low user agency
	Personal	High privacy, high user agency	Less social involvement

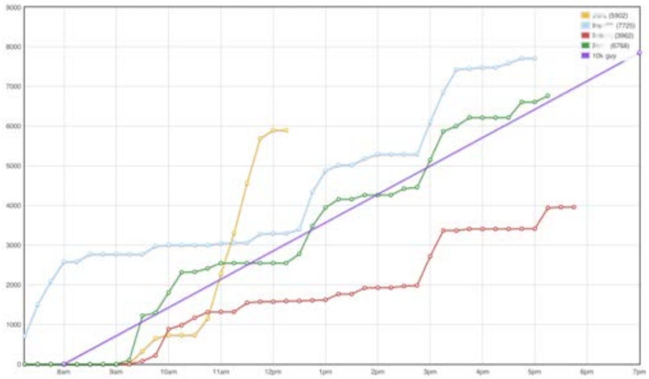

Figure 2. 2D graph with players' activity (names were omitted)

We decided to use a web-based visualization because this provides flexibility and scalability; we only need computers connected to the same network located near a display in order to be able to show the visualization in different spaces of the workspace by using a web browser.

Regarding the privacy level, we chose a shared and nominate view in which it is clear for all the players which is the step count of the others. Through this we tried to achieve more interaction among players in order to explore the social dimension of using a wearable self-monitoring device, in comparison with an innominate view (used in [7]), in which players can compare themselves with others but without knowing their identity. With the same purpose of highlighting social interaction, we opted for a semi-public display that lead to a new shared space of conversation without showing the data in a completely public setting (e.g. situated display) or keeping it exclusively for personal access (e.g. smartphone display). Similarly to the informative visualization, by choosing a semi-public nominated setup we aim to increase the drivers of self-efficacy and competence (by facilitating new knowledge), and also relatedness (by facilitating social support and collective awareness of the importance of physical activity).

4.5 The System as a Game

Even when our approach in Watch your Steps can be considered mostly informative based on the use of elements like graphs and numbers, it is important to observe and analyze the different game perspectives explored as part of the system's design and operation. These perspectives (taken from [12]) can be explored further and expanded considering our aim of supporting social interactions among players.

4.5.1 Games as Systems of Conflict

Even when there is no defined rules or a formal competition, it is likely that by displaying the amount of steps of each player in a semi-public screen it could generate an informal contest for the 'pride' of being (one of) the most active player(s). The way the data is represented (graph shows amount of steps in time) also suggests that players are somehow participating in a competitive race, creating an artificial conflict. As shown by Vorderer et al. [13] this game element could boost engagement and enjoyment, but also could negatively affect motivation in players that are not competitive.

In regards to competitive tactics, there is no possible attack or defense between players in the digital space of this game. This matches with the concept of 'parallel game', where "the player has no direct influence upon the difficulty of the task faced by the opponent" [8]. In contrast, tactics like stealing the device or preventing others to gain more steps are possible in the physical space, creating a non-parallel game space outside the digital parallel game.

Finally, we reflected a target number of steps for the group (10.000 in this case) using an additional virtual player that walks at a constant speed throughout the day. This is similar to the way digital games use fictional characters as opponents and allies; in this case, the fictional player is the way used by the system to show that it is possible to achieve the goal of 10.000 steps by consistently doing some few steps throughout the day. The fictional player can also introduce elements of conflict, related to the distance between the goal he represents and the relative position of each player at that time.

4.5.2 Games as Narrative Systems

Our system design enables a reflective view of the past trajectory of players throughout the day showing the time of each data point, in order to increase the awareness about the activities that can be associated with steps. We consider this possibility as an analogue of the replay feature widely used in digital games; players can watch and reflect about their activities from another angle (steps made) after having finished them, and through this, adding a narrative layer to the system.

4.5.3 Games as the Play of Experience

Digital games "offer real-time game play that shifts and reacts dynamically to player decisions" [12, p. 87]. Similarly, Watch your Steps displays the amount of activity in near real-time (15 minutes of delay), enabling players' immediate action, which, in turn, will be reflected in the next 15 minutes of the display content. This near-real-time experience affects how players interact with our system.

On the other hand, Watch your Steps data is displayed in a 2D space, with time and number of steps the two dimensions. Players have limited agency over the display's content because they can only influence their position in the step count dimension. This limitation evokes a game-like experience as it can be also observed in some digital games where players cannot move freely in the 2D space (e.g. games that allowed to move only in one direction).

4.5.4 Games as the Play of Meaning

Related to the chosen 2D representation, in our design a particular position in the space can have different meanings depending on the time of observation. The limited time exerts a sustained pressure over the players because what is a relatively good amount of steps at one time (e.g. 3000 steps at 9am) can be bad afterwards (e.g. 3000 steps at 7pm), so even when a player is in a "good zone" of the 2D space at some point of the day, she/he has to keep walking in order to avoid falling into a "bad zone" when time moves forward.

4.5.5 Games as Social Play

The performance of each player is visible to the other players and outsiders at any time in the shared digital space. As the system was designed for people that also share a physical space, this enables multiple social interactions throughout the day based on the data displayed.

Figure 3. Players watching group's performance

5. FINDINGS

After conducting a preliminary study for 8 weeks with 15 players, we can report some initial findings from our work with Watch your Steps.

5.1 Design findings

5.1.1 Impacts of API Limitations

Besides the benefits of using an established API like having easy, secure access to player's data, there are also limitations. In the case of Fitbit's API it has a limit of 150 calls per hour per application, and each player requires one separated call to pull his/her data each time. This limitation establishes some design challenges related to how near to real-time the system provides feedback to the players, because a real-time display would require several calls per player per minute, exceeding the API limits. This trade-off between real-time operation and efficient access to the data through limited API resources constitutes a relevant dimension within the design process of this kind of display.

5.1.2 Displaying Data for the Whole Group with Players' Name

In order to increase social interaction, we chose to display players' name in a shared display. We analyzed possible privacy issues but after exploratory conversations with potential players, we realized that all the members of the research lab were not having privacy concerns.

5.2 Preliminary findings from observation

5.2.1 Motivation for Enrollment

Initially, we offered each member of the lab a Fitbit device, without mentioning the display. Even when some of the members liked the idea, when the display started working we perceived more motivation in joining and sustained usage of the device.

5.2.2 High Frequency of Synchronization

We found a higher synchronization frequency than expected, mainly because each Fitbit pairs with any USB dock that is nearby. This can be explained because of the co-location of players, which resulted in a space with several USB docks; it is very difficult to be inside the shared space without passing a nearby USB dock and, subsequently, wirelessly synchronizing.

5.2.3 Non-Co-located Data Synchronization

Synchronization events can also occur outside the display's location (e.g. players that are near to an USB dock that is placed in their homes), but usually they are triggered in the shared workspace because that is where most of the USB docks are installed. Nevertheless, non-co-located synchronizations allowed a virtual connection between non-collocated players and people within the premises of the lab, enabling speculative conversations and remembrance between the latters. This was particularly evident when players travelled or did not come to the lab for a long period.

5.2.4 New Conversation Space

As the day moves on, some of the shared activities that involve walking will be reflected in the display (e.g. two players went out for a coffee). Also, some data outliers will catch viewers' attention (e.g. a player went jogging and made 6.000 steps in 30 minutes). All of those 'abnormalities' enabled new conversations after the data was reflected in the display.

5.2.5 Other Findings

As we expected from the design process, privacy and data interpretation was not an issue for players while using the display. None of the players expressed any concern related to privacy. Similarly, the graph did not require any explanation in order to be interpreted. None of the players expressed confusion or doubts about the displayed data while watching the display.

Another finding is related to the space of the non-displayed data. Players tended to talk about the days that were not displayed (e.g. weekends) saying things like "I made 17.000 steps on Sunday". Conversations about the final amount of steps of the day before were also observed.

Finally, some cheating —understood as increasing the sensed amount of steps with activities that do not involve steps— was observed among players. For instance, one player put his Fitbit in the wheel of his bike, getting an additional amount of steps.

6. DISCUSSION

The display was effective in creating a new space of social interaction among players, increasing motivation and providing new ways of emotional connection with non-co-located members of a group. Even when previous work (like StepMatron in [4]) has shown a positive influence of socially enabled interventions using private displays, further study is required in order to understand the impact of the semi-public display in engagement and physical activity levels.

We think that a good way of evaluating the impact of a project like Watch your Steps is measuring the change in the stages of the transtheoretical model, as shown in UbiFit Garden [2] and Fish 'n' Steps [7]. Thereby, the impact could be measured as the progress of the players towards active and maintenance stages. The increase of both motivation and awareness of players' physical activity lead us to believe that Watch your Steps could have a positive impact in this regard.

Interestingly, in our preliminary observations privacy was not an issue, even when it was considered as a relevant topic in other related projects like Fish 'n' Steps. We think this could be explained in part because of the context in which our work was conducted: a small group of young people that work together on a daily basis within a research lab. It would be interesting to test this same setting (semi-public, nominated data) in different kind of spaces (e.g. offices, more players, bigger space).

In regards to the risk of cheating, we think it may be an additional source of physical activity and richer interactions. It is likely that a player will need some kind of physical activity in order to increase the step count with activities different than walking. Furthermore, in our findings cheating was associated to cycling, an activity that Fitbit has some problems to track. Based on that, we suggest that the design could use these problems as opportunities to create engaging interactions that could have an impact on players' levels of physical activity and, in addition, foster creativity in players.

Another point of interest is the type of visualization that should be used in a project of shared display of physical activity. Unsurprisingly, we found that players quickly understood a graphical representation without any instructions. Nonetheless, the power of metaphors (as shown in [2], [7]) in our view resides in providing a more playful representation of the activity, and may be included in new versions of our system.

Finally, we see an opportunity in including elements like conversations, speculations and comments as part of the display. Similarly to UbiFit Garden, where users were able to add comments about daily activity, we think including players' opinions, thoughts or comments on the display could increase their sense of autonomy and boost social support in changing sedentary behavior.

6.1 Limitations

The limitations of this study are mainly related to the particular context in which it was tested, so its results require further studies in order to be confirmed and generalized. Moreover, the small numbers of participants in the study could affect the richness of the observations. Finally, the absence of conclusive evidence about the effectiveness in changing players' behavior of a system like Watch your Steps is still a challenge to be addressed.

7. CONCLUSION

In this paper we presented Watch your Steps, a semi-public display of physical activity data within a group of co-located players. We believe there is an opportunity to use this kind of display in supporting groups in increasing their physically activity, enabling social support and creating new ways of interaction between the members of a community based on their number of steps.

Through this project, we have gained a better understanding of the interactions between users of wearable self-monitoring devices that share a physical space. We expect to obtain further evidence in further iterations in order to contribute to the way technology supports both, social play and a less sedentary lifestyle. We think our work highlights the opportunities to extend the potential of self-monitoring devices that require little effort and resources to be implemented. In conclusion, with our work we hope we can aid researchers and designers in understanding the design of interactive social systems that aim to promote a less sedentary behavior.

8. ACKNOWLEDGMENTS

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