ActivMON: Encouraging Physical Activity Through Ambient Social Awareness

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Abstract
In this paper we discuss the use of low-complexity interfaces to encourage users to increase their level of physical activity. We present ActivMON – a wearable device capable of representing a user's individual activity level, and that of a group, using an ambient display. We discuss the results of a preliminary usability evaluation of ActivMON.

Keywords
Physical activity; ambient display; wearable computing

ACM Classification Keywords
H.5.2 [Information Interfaces And Presentation]: User Interfaces – Interaction styles;

Introduction
According to the World Health Organisation over 1.6 billion adults globally are overweight or obese. This figure is projected to climb to 2.3 billion by 2015 [8]. This increase is attributable to higher intake of energy-dense foods and a trend towards more sedentary lifestyles.

There are two broad approaches to using technology to promote physical activity. One is to provide the user with an activity, such as an exertion game. Another is to provide the user with information on their level of physical activity in order to motivate them to do more.

In terms of the latter approach, Lin et al. found that the likelihood of users changing their attitude and behaviour to physical activity depends on users' current attitudes and behaviours [7]. A person who has no intention of doing physical activity is unlikely to be motivated by technology to do so. A person who is already doing a significant amount of physical activity is unlikely to need to be motivated by technology, and may use it more in a supporting role (to track and record their activity). A person who is moderately motivated to change their behaviour, however, may use technology as a source of additional motivation.

Different styles of interaction are appropriate for these different roles. Most existing activity monitoring devices (Garmin Forerunner, Nike+iPod, FitBit etc.) and smart phone apps present a large amount of information to the user (time, distance, calories burned) mostly in numerical form. The user must be willing to commit time to regularly monitor and understand this information. This is desirable for motivated users who wish to monitor their physical activity in detail. However less motivated users might be satisfied with less complex interfaces that are simpler to engage with, such as ambient displays.

In this paper we discuss the use of low-complexity low-engagement interfaces to motivate physical activity – specifically wearable ambient displays. We present a preliminary usability evaluation of such a technology, and show that issues such as size, form factor, accuracy, privacy and battery life are important for user acceptance. We argue that the success of future, larger studies is dependent upon these issues being addressed.

Previous Work

Several previous works use technology to motivate physical activity. Lin et al. developed a physical activity game called "Fish'n'Steps" [7]. Each user in the game was represented by a virtual fish in a fish bowl. The fish would change its size, appearance and facial expression depending on the user's level of physical activity.

Consolvo et al. developed a mobile phone-based display called "UbiFit Garden" [4]. The user's phone received data from a sensor worn on the waist to determine physical activities performed. These activities were then shown on the phone's screen saver using a garden visualisation, with flowers representing different types of activity and butterflies showing goals achieved.

Both of these technologies use a low-complexity low-engagement interface – an ambient display. However they are contingent upon the user regularly interacting with a computer or mobile phone. In comparison, a user could potentially glance at a wearable ambient display any time that they are wearing it.

Positioning is an important consideration for wearable ambient displays. Lim et al. developed a display to be worn on a user's shoe [6]. Pediluma would slowly illuminate over a period of five minutes when the user started to walk or run, and fade out over a period of 15 minutes when the user was sedentary. However

figure 1. ActivMON on a user's wrist

Harrison et al. report this is the least effective location for a wearable display [5].

Ananthanarayan et al. proposed a wrist-worn activity monitor targeted at children, consisting of a series of lights that would illuminate based on the user's level of physical activity [1]. According to Harrison et al. the wrist should be a better location for a wearable display, however Ananthanarayan's paper was a gedanken rather than a report of an actual device.

Another consideration is whether a device integrates a social dimension. Consolvo et al. stress the importance of supporting social influence – allowing users to co-operate, compete or communicate with others in their social group [3]. Lim et al. claimed that Pediluma supported social influence through other people seeing the user's device. There would be no social element if the user was alone. Fish'n'Steps represented group activity using the fish bowl display however this information was only updated once per day.

Design

We developed ActivMON, a low-complexity low-engagement ambient display worn on the wrist which supports social influence by notifying the user in near real-time when other people in their social group are physically active.

ActivMON incorporates a multicolour light-emitting diode (LED), three-axis accelerometer, microcontroller, flash memory and battery (fig. 1). The LED lights up red at the start of the day (when no activity has been performed) and changes colour through shades of yellow toward green (as the user approaches a daily activity goal).

The three-axis accelerometer is used to monitor the movement of the user's arm. The magnitude of any acceleration, over a certain threshold, is progressively added to an activity counter. ActivMON then calculates an activity rate by comparing the current and previous activity counter values for the user. An activity level is then calculated by comparing the current rate of activity to a running average. An explanation of this process was previously reported by Burns et al. [2].

ActivMON supports not only individual users but also groups. Through a central server, ActivMON uploads the user's activity counter and downloads information on the activity levels of other ActivMON users. If any other group members are physically active, the user's device will flash for five minutes. The speed of the flashing pattern is proportional to the aggregate activity level of all users. This means, for example, that if two or three other group members are performing physical activity the rate of flashing will be faster than if only one other user was physically active.

Evaluation

We trialled ActivMON over a two week period with a group of five users (three female, two male). For any study involving wearable devices, the presence of usability issues may affect usage rates and impact on the study results. We therefore opted for a small-scale study in order to rapidly identify any such issues so that they could be addressed prior to carrying out a more thorough evaluation.

We deliberately selected five people who worked with one another, in order to observe the effectiveness of ActivMON's group activity display within an existing social structure. Each user was provided with an

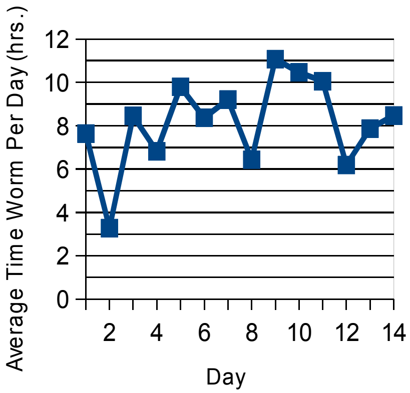

figure 2. Average time users wore ActivMON each day.

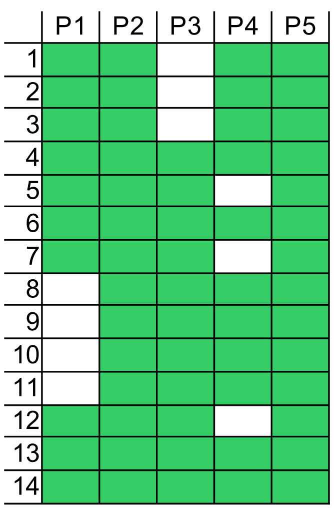

figure 3. Filled grid positions indicate a user's device returned data for a particular day.

ActivMON device and a mobile phone through which the device could access the server. Users were asked to wear ActivMON on either wrist during their waking hours, to keep the mobile phone within close proximity and to charge both ActivMON and the phone regularly.

In the first week of the study ActivMON recorded and uploaded data only. At the end of the first week we calculated an average daily activity level for each user, and set a personalised goal for the second week of 105% of their first week average. Both the individual and group displays (LED colour and flashing) were activated at the start of the second week.

At the end of the second week users were requested to complete an on-line questionnaire, with questions relating to ActivMON's size, charging requirements, colour and flashing indications. Four of the five users responded to the questionnaire. We then conducted a semi-structured interview with each user, guided by the matters raised in the questionnaire.

Analysis of the data sent back from each ActivMON revealed users wore the device around eight hours a day on average (fig. 2). Data were collected fairly consistently from all users, with the exception of P1 whose device suffered a communications failure and P3 who started the study three days late (fig. 3).

User questionnaires and interviews revealed a number of issues with regard to the design and function of ActivMON. The LED on the ActivMON prototype could not be disabled (short of turning the device off) and remained at the same brightness level regardless of the light level. Users saw this as both a positive and negative aspect:

"The brightness was a good level. It's good that it's that bright because it gets your attention when it starts flashing. Even when it changes colour your notice it."

"The brightness wasn't a problem. Although it would be good if it adjusted itself to room brightness, as it was bright in a room with low light levels at night. But you can see your way using the device with the room lights off."

Some users questioned the accuracy of the device when engaging in different forms of physical activity:

"I question when you have it on your wrist how accurate it is. Is it properly recording all activities?"

"There was no visible connection between the type of exercise done and the lights."

Users were split on whether their individually set goal (which upon being reached would turn the light blue) was too easy or too difficult to achieve:

"It went from red to blue on a single run"

"There were about three occasions on a work day when it went blue. Blue was easy to get to on the weekend"

Users were split on whether they felt motivated to do physical activity as a result of using ActivMON. Two found the device helpful. Another two reacted negatively to the device and the other felt it didn't provide them with enough information:

"It takes more than a glowing light to make me exercise."

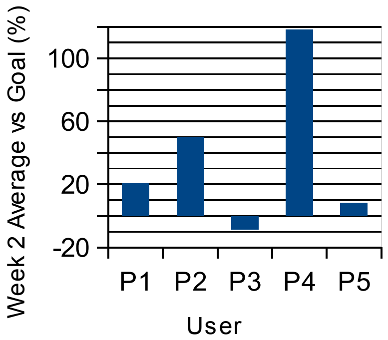

figure 4. Users' week 2 average activity levels vs. individual goal (%)

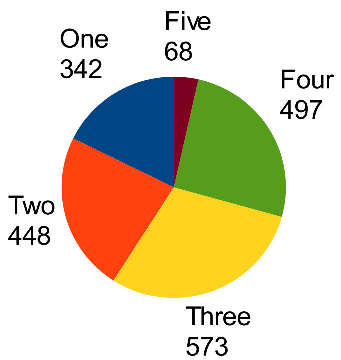

figure 5. Number of activity reports where a certain number of devices were operating simultaneously.

"I was far more aware of exercise wearing [ActivMON] than not wearing it. I feel I did more exercise because of it."

Despite this, all users with the exception of P3 achieved an average activity level in the second week above the goal set at the end of week one (fig. 4).

The effectiveness of the group flashing notification was dependent on multiple users wearing ActivMON at the same time. When a device returned an activity report to the server, in 82% of cases at least one other user was also wearing their device (fig. 5). Very rarely were all five users wearing their devices simultaneously.

A total of 146 group notifications were delivered to users in week two. Each user on average could expect to receive one notification for every 90 minutes that they were wearing ActivMON. Four of the five users reported seeing the device flash during the second week of the study:

"When it starts flashing you wonder who's exercising. It's a bit of fun."

"When it started flashing I thought 'I should be doing some exercise'. It brings out your competitive side. It put me into a panic when it started flashing and I couldn't go and do exercise."

The ActivMON prototype used in the study could operate for 16 hours on a single charge. Users were instructed to recharge the device every night. All users who responded to the questionnaire expressed dissatisfaction at the battery life, but noted in interviews that this problem was common with other common electronic devices:

"I have an iPhone and I already charge that every night."

Users reported in the questionnaire that the device needed to be smaller. The female participants in particular identified this as an issue:

"The device was cumbersome for a lady. I had to put it on my watch arm or else I was very aware of it."

Discussion

A possible disadvantage of wearable ambient displays such as ActivMON is a lack of privacy. The users in this study reported that they did not mind others knowing they were monitoring their activity. However this may not be the case for everyone.

Users responded unanimously that ActivMON was bulky and uncomfortable to wear. This likely affected the amount of time each day users were willing to wear the device. Future versions of ActivMON should be smaller, perhaps integrated into a watch or bracelet. This would also make the device less conspicuous. Lowering the brightness of the LEDs based on ambient light levels may make the device more discreet and extend battery life.

ActivMON is limited in which forms of physical activity it is able to detect. It has previously been shown that the device is capable of discriminating between sitting and walking [2]. However ActivMON is unable to detect activities that involve mainly lower-body movement such as cycling. This could be addressed by adding more sensors (heart rate, respiration, etc.) or allowing the device to be worn on different parts of the body.

Conclusions

Our hypothesis is that users who are moderately motivated to do physical activity will respond to a low-complexity low-engagement interface such as that employed by ActivMON. Rigorous testing of this hypothesis would ultimately involve undertaking a long-term study with a large number of users. However the presence of usability issues may result in users wearing the device infrequently or not at all, confounding the results of such a study.

Therefore it was important to undertake a small-scale study with an initial prototype in order to enumerate those issues and users' responses to them. Some users reacted positively to ActivMON, saying it made them more aware of their level of physical activity. We discovered that size and form, accuracy and battery life were important to users and affect their acceptance of ActivMON.

The next step in this research is to design out these usability issues and to undertake a larger study over a longer period of time. This would likely involve grouping users by their motivation to perform physical activity, and examining their preference or usage of ActivMON versus a high-complexity interface delivering similar information.

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