Colours That Move You: Persuasive Ambient Activity Displays

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Abstract. Regular physical activity is essential for maintaining good health. Unfortunately due to the increasingly sedentary nature of modern life many people are not active enough. Although most have the ability to be more active they lack sufficient motivation. Persuasive technology could help to address this problem. We discuss the use of persuasive ambient displays, specifically wearable ambient displays, to motivate users to be more active. We show that it is critical to carefully consider how best to visualise data with a display in order to realise maximum persuasive effect. We present as a case study our ongoing design and development of ActivMON, a wearable persuasive ambient display.

1 Introduction

Regular physical activity is essential to maintaining a healthy body and mind. Unfortunately due to increasingly sedentary lifestyles many people are not active enough. The subsequent rise in the rate of overweight and obesity has resulted in a concomitant rise in the prevalence of certain chronic diseases such as type 2 diabetes and cardiovascular diseases [1]. Technology could play a role in addressing this problem by persuading or motivating users to engage in and sustain regular physical activity.

Of the different approaches to using technology to encourage physical activity, each varies in terms of the level of persuasion employed. Technologies using an activity tracking or information-based approach, such as pedometers or smartphone activity trackers, persuade implicitly on the basis that self-monitoring can encourage behaviour change [2]. Technologies such as exergames persuade implicitly in that physical activity is linked to an enjoyable or interesting activity – gaming. Technologies using motivational messages or virtual coaching employ more direct persuasion, operating in the role of a social actor [3].

Fogg's Behavior Model postulates that motivation, ability and a trigger must converge at the same moment for behaviour to occur [4]. Healthy adults would place moderate to high on the scale of ability to do exercise. Although there are barriers such as lack of time, lack of money (to join a gym or take up a sport), or the weather, most people could find some time during their day to do some sort of physical activity

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if they wanted to. Arguably the central reason people fail to become more active and to pass Fogg's "activation threshold" is a lack of motivation, compounded to an extent by a lack of appropriate triggers. Therefore it is sensible that persuasive exercise technologies attempt to motivate the user in some fashion and provide a behavioural trigger.

The same model could be applied to users' willingness to engage with activity motivating technologies. The complexity and usability of a technology affects users' ability to engage with it. The perceived usefulness of a technology affects users' motivation to engage with it. With reference to Fogg's parabolic activation threshold [4], users would need to be highly motivated to engage with a technology that was hard to use. A simpler technology would cater to less motivated users.

Ubiquitous computing technologies, and specifically ambient displays, are an example of a technology that is intuitive and easy to engage with [5]. There are a number of examples in the literature: Lin et al. [6] represented users' state of activity using virtual fish in a fish tank – users could see if they were active enough from the size of their fish. Consolvo et al. [7] used a garden metaphor where the appearance of flowers and butterflies represented activities performed. Rogers et al. [8] used abstract artwork in a building to represent the occupants' stair use behaviour. Lim et al. [9] developed a display for a user's shoes that lit when they walked.

Expanding on the above works, we developed ActivMON – a wrist-based ambient display that detects users' activity using a motion sensor and represents this activity with a coloured light (Fig. 1). The light is red at the start of each day (no activity performed) and changes on a continuous spectrum through yellow to green as the user performs activity toward a daily goal.

Fig. 1. ActivMON ambient display

Fig. 2 illustrates the ActivMON visualisation. At the end of each week the user's historical activity level h is calculated as an average of each day's activity over the past week. A new daily goal for the coming week is set at 10% above h, shown as goal line g. On the y axis c represents the user's current activity level. At the beginning of each day c would be reset to zero resulting in a red visualization. As the current activity level c increased toward the goal g the light colour would change from red through yellow to green. We considered having users set their own goals but felt that it was more interesting to explore the possibility of adaptive goal setting, particularly given the desire to maintain a simple interface and minimise user burden.

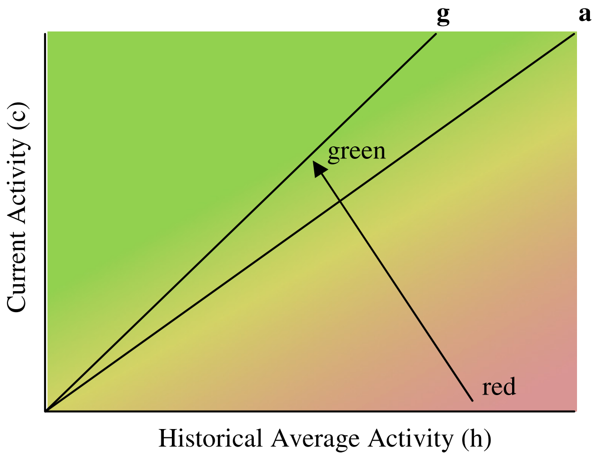

Fig. 2. ActivMON activity to colour visualisation

We evaluated ActivMON in a pilot study with five users over two weeks (results reported in [10]) and discovered that its persuasive or dissuasive effects were closely linked to the operation of the chosen visualisation. Users said the red-to-green visualisation was intuitive – that "red is bad and green is good" – but users' response to the visualisation varied. One user said it was like "climbing the hill each day". Another said that the natural 24-hour cycle of the device was not ideal, as some people do more or less activity each day over the course of a week. Users reported that on some days it was too easy to make the device turn green and that they were no longer motivated when they reached their daily goal.

These problems were due to our approach of treating each day's physical activity as a discrete unit. Goals were based on daily activity and only activity over a single day was shown on the display. We found that users' day to day activity levels are volatile and were too sensitive a measure to display directly. However, the current level of physical activity can also be represented as a continuum over a longer period of time with rises and falls in activity. A continuum visualisation would be more stable, allowing users to focus on time variant trends rather than short term activity fluctuations. We present this new visualisation and argue that it could be applied to represent any recurring activity or behaviour.

2 A Continuum Approach

Rather than visualising cumulative activity over the course of a day a continuum display would show average daily activity over a sliding window of some period of time, such as the past seven days. Goals would continue to be set at the end of each week, however rather than trying to reach a goal every day users would try to maintain an average activity level as close to the goal as possible. Users would need

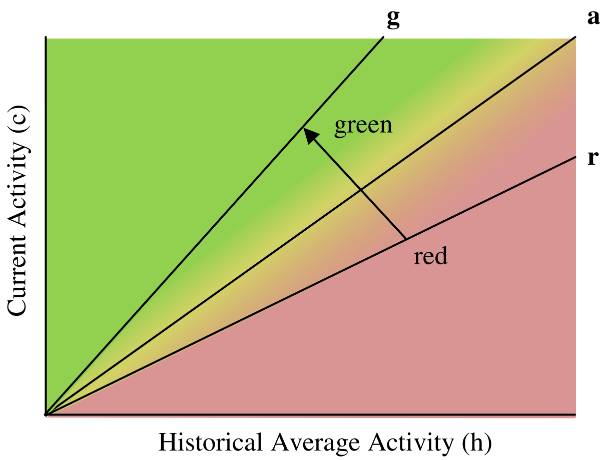

Fig. 3. Continuum colour to activity visualisation

to maintain a consistent level of activity to keep the light green. Inactivity would cause the light to slide backwards into yellow and red.

Fig. 3 illustrates the continuum visualisation. As before at the end of each week the user's historical activity level *h* is calculated as an average of daily activity over the past week. A new daily goal for the coming week *g* is set at 10% above *h*. However, current activity *c* is no longer reset to zero at the beginning of each day. Instead *c* is calculated as an average of current and past daily activity over a seven day sliding window. The region over which the light changes from red to green no longer starts at c=0 but instead is bounded at the green end by the goal line *g* and at the red end by a new "red line" *r*. As the user's current activity level *c* approaches *g* the light will turn green. If *c* drops to *a* and then to *r* the light will change through yellow to red.

As an example, imagine that we have already collected a week's worth of activity data from a user. With reference to the continuum shown in Fig. 4, let her average activity level over the past week be a_1. Her goal g_1 is to try over the coming week to sustain a new average activity level greater than the previous week. At the start of the week her current average activity level over a seven day sliding window will equal her previous week's historical average ($c = a_1$) and she will receive a yellow indication. Assume that she is very active on the first day of the week. Her current average activity level will rise toward g_1 and the ambient visualisation will change toward green. Assume that she then becomes busy with work the next day and is very inactive. Her current average activity level will drop back toward a_1 and she will see a yellow colour. If she is inactive the next day as well her activity level will drop further and as she approaches r_1 she will see a red colour. She may then compensate with more activity over the next few days and move her activity level back toward g_1 and therefore into the green zone.

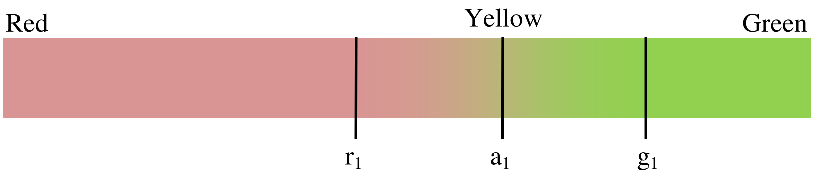

Fig. 4. Example red to green visualisation

By treating physical activity as a continuum rather than a series of discrete events we are able to create a visualisation that smooths over the natural variability of day-to-day activity. This smoothed visualisation should allow users to focus on trends and consistency rather than short-term changes.

The distance of the goal and red lines *g* and *r* from the average line *a* will affect the perceived difficulty of achieving the set goal as well as the leniency of the system to recidivism. The closer *g* is to *a* the easier the goal will be to achieve. The closer *r* is to *a* the less leniency there will be when the user has one or two inactive days in a week. These variables may affect the persuasiveness of the visualisation to the user. As was found in our preliminary evaluation, a goal (getting to the green zone) that is too easy to achieve provides little challenge, but a goal that is too difficult can be de-motivating (the light is always yellow or red). A system that is not lenient enough (where one day of sedentary behaviour produces a red indication) could be disheartening whereas a system that is too lenient might provide little incentive to maintain a consistent level of activity [11].

We intend to undertake a further user study to determine optimum values for each of the variables in the visualisation. That is, the way in which goals are set based on average activity (using a constant or proportional increase) and the placement of the "red line". We will create a number of variations and test each with a small group of users, assessing the persuasiveness of each variation through post-study questionnaires and semi-structured interviews.

3 Conclusions

We argue that Fogg's Behavioral Model provides an answer not only to the question of why people are not more physically active, but also to the question of which types of technology might be more effective in persuading people to be more active. We suggest a focus on technology that makes activity information simple to engage with, for example ambient displays.

We discussed the results of our initial evaluation of an ambient exercise display where we found that the ambient visualisation used was closely linked to the persuasive or dissuasive effect of the display on users. We presented a new "continuum" visualisation design for individual activity that we have developed in response to user feedback. This continuum approach could apply to visualisation of any recurring activity that can be represented on a linear scale, such as frequency of drinking, smoking or fast food consumption.

It is clear that careful attention to design is warranted to avoid creating a visualisation that could be ineffective, or worse dissuasive to users. We intend to conduct further user studies to ascertain the optimal settings for the continuum visualisation with a view to integrating it into a future wearable ambient display.

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