NIMD2010

Proceedings of the First International Workshop on Nudge & Influence through Mobile Devices

http://www.pinc-research.org/?page_id=20

Held at MobileHCI 2010 in
Lisbon, Portugal
7th September 2010

Workshop Chairs
Parisa Eslambolchiar
Max L. Wilson
Andreas Komninos

This work was the first in a series of workshops dedicated to the scenarios, motivators, methods, and ethics of encouraging better, healthier, and more sustainable lifestyles through the use of pervasive mobile technology. Held at MobileHCI2010, the first workshop attracted a wide range of authors working on a variety of projects, which highlighted the depth and breadth of fields relating to this work, including: social psychology, sociology, HCI, computer science, and more. During the workshop, discussions covered a) the ethics of trying to influence behaviour, b) focused examples of ethnographic work in this area, c) 7 dimensions of methods for nudging people, d) focal behaviours for nudging, including consumption, addiction, exercise, crime, and bad habits. Further, discussion highlighted some additional related work, leading to the suggestion for a new name for this work: Persuasion, Influence, Nudge, and Coercion (PINC).

Work on this topic will now be centered at http://www.pinc-research.org. The successful workshop will be followed up by future workshops, with the next being held at CHI2011 in Vancouver: PINC2011.

Table of Contents

Encouraging an Active Lifestyle with Personal Mobile Devices: Motivational Tools and Techniques

Richard Byrne
Computer Science Department
Swansea University
Wales, SA2 8PP, UK
csbyrne@swansea.ac.uk

Parisa Eslambolchilar
Computer Science Department
Swansea University
Wales, SA2 8PP, UK
csparisa@swansea.ac.uk

ABSTRACT

Encouraging physical activity amongst different groups, age ranges and cultures can be a difficult task. As such research has been undertaken in order to find methods of allowing people to monitor their own activity levels and hence allow them to alter their lifestyle in such a way as they become more active. It is possible to achieve this aim through a number of methods, ranging for individual personal devices to making use of social groups and social feedback in order to further encourage physical activity through the notion that friends can also monitor our progress. In this review paper we look at some of the work undertaken in understanding the desire of those who wish to become more active, paying particular attention to those with sedentary lifestyles. We also take a look at the technologies and methods utilised to aid and motivate these people in achieving their goals.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User-centred design, Input/Output de- vices, Strategies, Hardware technologies, Interaction Styles

General Terms

Design, Human Factors

Keywords

Mobile learning, User experiences, Nudge, Social norms

1. INTRODUCTION

Motivating and encouraging physical activity can be a challenging feat. At one time or another many of us are struck with the desire to join the local gym, go for a run or tackle the latest fad diet. The difficulty comes in keeping up the commitment to pursue the goal we initially set out to achieve. Within a few weeks the motivation to go to the gym can wain and that run we promised to go on can be put off because we know that we will *definitely* go tomorrow. For those of us with sedentary jobs these goals can be even more of a struggle. As such, research has been ongoing in creating a design methodology and technologies with the purpose of encouraging and maintaining an active lifestyle.

This paper gives an overview of some key literature relating to the subject of encouraging an active lifestyle and gives mention to how this aim was carried out by the respective authors and the results that they achieved. We then outline some design guidelines for mobile based motivational activity monitoring applications that we hope to apply in our own future work.

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3/10/09.

2. RELATED WORK

In this section we will discuss various technologies and areas of research relating to the study of encouraging a more active lifestyle. We have categorised the topics into three sections and describe the relevant topics within those sections.

2.1 Personal Activity Monitoring Devices

With people's will to become more active and healthy there is no surprise that there has been a great deal of personal portable devices released in order to allow people to more accurately monitor and maintain their own levels of fitness. The most common form of these devices is the pedometer, a simple, small and unobtrusive device which monitors the wearer's step count. These devices are usually attached at the hip and the most basic use mechanical parts that move when the wearer walks and thus registers a step count. Research has shown that the physical presence alone of the pedometer (screen is off) can increase the activity level in adults [5].

However these devices can be more complex and allow for more information than just the step count to be displayed. One example is the PAM system[1] which, like a normal pedometer is worn on the hip and measures the wearers activity level. The PAM makes use of an accelerometer in built in the system which monitors all the movements of the wearer and displays the activity level as a PAM score. This score can be viewed on the accompanying website, which allows the user to monitor their progress and set goals such as weight loss and find what their average score is. Slootmaker et al.[16] found that the PAM was a useful and accurate tool for both monitoring and encouraging an active lifestyle.

The fitbit system[2] is another unobtrusive activity monitoring system that can be worn discreetly by the user and is used to monitor both activity levels and sleep patterns. The system wirelessly communicates with a base station in the home which in turn uploads the activity progress to a website. The system monitors calories burned and steps taken and the website is used in order to set goals to aim for and to keep track of the user's activity patterns.

Obesity is seen as a rising problem in both adults and children and can lead to many other health problems such as cardiovascular disease and diabetes. Arteaga et al. [4]

[1] `http://www.pam.com/index.php?pid=3`
[2] `http://www.fitbit.com/`

argue in their paper that the key to combating obesity in adults is to target teenagers and educate them about the potential health risks of overeating and leading a non-active lifestyle, thus believing that it is better to teach the issues sooner rather than later. Targeting younger generations in order to teach them the value of leading an active lifestyle is something that's also been undertaken by large corporations. In particular Nintendo released an activity monitoring game for their DS system entitled Walk With Me[3]. This game comes bundled with two pedometer accelerometers in order to encourage more than one member of the household to take part in monitoring their levels of physical activity. The system allows the user to set a step target and is then used in much the same way as similar step counters, however, at the end of the day they can transmit the results to the DS system where they can view a detailed breakdown of their activity levels for that day. This in turn provides the user with monthly and weekly averages of their step counts and allows them to set new goals as and when they want to. Their step counts can also be used to play mini games on the system, allowing for a competitive nature within the family household. The system is even designed so it can be used with a pet dog, so that the user can also monitor their pets activity in comparison to their own. In all it is a fun system which has been designed in order to make the monitoring of physical activity levels feel less like a chore and to encourage individuals to keep going and reach the goals which they may have set.

Tesco Diets Active[4] offers an online personalised coaching programme. After enrolling to the programme, a wrist-band called miband is sent to the customer. The miband records everything the user does throughout the week, from housework to workouts and everything in between. The user can synchronise their miband on a weekly basis with the online coaching system via a Bluetooth connection. The online system allows the customer to set up weekly basis goals i.e. the distance to traverse. This is also combined with a range of tasty healthy eating plans to facilitate a full healthy lifestyle makeover.

There are also devices available to monitor and track individual's progress for those people who already lead an active life and want to maintain their own progress. The Nike Plus system, developed by Nike and Apple, allows a user's iPod to be used as a running aid which allows them to set distance goals and keep track of their progress as they train. The system allows the user to specify a goal, such as the amount of calories to burn or the distance to traverse. Also at anytime the user can press a button and receive audio information relating to their current distance, run time and pace. If they have set a goal then at key points along their route they will receive an audio prompt notifying them that them have completed some or all of their set goal.In addition the system also includes the voices of several prominent athletes who, at the end of the workout, congratulates the user if they have achieved a new personal best.This information can be uploaded to the Nike plus website which, as well as allowing you to challenge friends, gives a breakdown of user's progress and a complete history of previous workouts.

[3] `http://www.nintendo.co.uk/NOE/en_GB/games/nds/walk_with_me_do_you_know_your_walking_routine_10465.html`

[4] `http://www.tescodiets.com/index.cfm?code=370027`

2.2 Personal Activity Monitoring on Mobile Platforms

Although, personal activity monitoring devices like pedometers are practical for some people, for others it becomes another thing to remember to carry. As such there has been work examining the porting of activity monitoring applications onto mobile platforms and, in particular, mobile phones. A quick browse of either the iPhone App store or the Android marketplace at the time of writing returns many results regarding pedometer applications or activity monitoring applications. All applications give an indication of your step count by making use of the onboard accelerometers commonly found in many modern phones and some (such as CardioTrainer) also include inbuilt GPS services allowing user's to more accurately track their fitness progress and, for example, their walking routes.

An extensive body of research has been conducted regarding the subject of mobile based personal activity monitoring applications. One such system is the UbiFit system [7, 11], developed by Consolvo et al. The UbiFit system transforms the background wallpaper on a mobile phone into a garden scene. As users become more active or indulge in physical activity throughout the week the garden grows, with several different flowers representing various activities such as walking, cardio or strength training. At the end of the week the screen is wiped blank and flowers are regrown as activity is undertaken again. The system also makes use of butterflies in the garden to represent goals that have been met by the user and these butterflies remain when the rest of the garden is erased as a reminder that the user previously managed to reach their goals. The UbiFit system is not soley contained to just the phone however and does make use of an external activity monitoring device known as an MSP (Mobile Sensing Platform)[6] which has been trained to automatically recognise in real time various activities such as walking and running. The system does also have an activity diary feature so that any activities that cant be automatically inferred can still be manually entered. It is suggested, that although this system makes use of an external module that eventualy phones will include the majority of sensors required allowing for a user to simply slip their phone into their pocket at the start of the day, with no need to remember to wear an extra device, improving in cases where it may be impractical to attach a pedometer or MSP type device to the waist and making it impossible to actually forget the extra device since the phone is all you would requite.

Nokia has conducted work into how such mobile based applications should be designed. The findings of which appear in several papers by Ahtinen et al. [1, 2, 3] and discuss the design and user experiences of wellness applications. These papers study issues that need to be considered when designing for cross cultural wellness applications, the social features of such applications and also the user interface design of the applications. The research has found that offering a gaming experience, social sharing opportunities and proper feedback resulted in improved motivation from participants. This work also provides a nice framework regarding design considerations and these findings are supported by additional work by Consolvo et al. who have also provided their thoughts on design for such applications in [9, 10]. These papers also study the use of persuasive applications on mobile devices and how the design of goal-setting technologies in these systems can best be combined in order to create a comprehensive system that will yield the best results for those wishing to pursue a more active lifestyle.

2.3 Beyond the Physical Devices

Many systems make use of activity trackers and the ability to set goals to aim for and achieve and some of these systems allow users to involve their friends in this goal setting process, sharing their own progress and comparing it to that of their friends. Friends are able to view and compare their own progress to the user's and also create group goals and begin friendly competitions. In the literature there exists work relating to the design of interactive games promoting active lifestyles and this goal setting process. In this section we discuss this work and also work regarding the power of social influence when promoting an active lifestyle.

Consolvo et al. [8] make goal-setting the subject of another of their papers which again details their UbiFit system. In this paper they argue how goal-setting in persuasive technologies could be an effective way to encourage behaviour change and in particular, people's attitudes to being physically active. From their study they found that the ability for participants to self set their own goals was preferred and that goal timeframes set throughout a calendar week was most beneficial to the users, especially if they could choose when the week started.

The importance and competence of self-setting physical activity goals is examined in Saini and Lacroix [15]. In this paper the authors examined how people would set their own personal goals and in turn how these goals were achieved, alongside examining how committed the participants were in achieving their own self assigned goals. This paper differs from the findings of Consolvo et al. in that the authors found that often goals were not achieved since the participants were often too ambitious in the self-assigning of their goals. They also discussed how they found that participants would, in general, often create goals which showed their intentions but didn't accurately reflect their ability to accomplish them. However they argue that goal setting in general was quite well followed and that it is likely a very important factor in motivational behaviour change with regards to encouraging physical activity. It is suggested that the over ambitiousness of participants likely stems from their novice experience with monitoring their own physical activity levels and their initial beginner experience regarding setting goals and changing their lifestyles.

In a previous paper, Lacroix et al. [12] received similar results when they examined the relationship between goal difficulty and performance of their participants. In this paper they discovered that previously in-active participants improved their activity levels by setting goals for themselves. It was also found, however, that participants who already had an active lifestyle did not increase their own activity levels to the same degree as the beginners. This is generally to be expected though, since those with an active lifestyle are likely already doing what they can to maintain it. These papers do support the findings of the papers we have discussed in previous sections though, as they show how there is still a willingness in the participants to at least attempt to accomplish the goals that they set.

Arteaga et al. [4] target teenagers in their study and created a mobile phone based game which suggests different games that can be played based on the users personality. The system consists of games based in the real world, such as searching for treasure shown on screen or using the accelerometer of the phone to act out sword fighting. The system also made use of motivational agents - two avatar figures of a man and women, who would recite motivational phrases to the player based on their personality. The male figure was more assertive whereas the female was more encouraging offering supportive comments to motivate the user to keep playing the games. Their main aim is in attempting to positively reinforce the feelings and experience of playing the game and hence keeping fit, with the memories of the fun and positive feelings the system attempts to create.

Fish'n'steps, developed by Lin et al. [13] is a game of sorts whereby participants manually submit the amount of steps they have walked each day to a team of researchers. These researchers then use this information to update an avatar of a fish, which is used to represent the activity level of the participant. In order to convey the activity level the researchers made use of emotion and size as a simple way of conveying the activity, with the fish getting bigger and happier based on greater amounts of activity, and sadder and smaller based on less activity. Some participants were also randomly assigned to a group where they could see a fish based on the overall group activity and the results in turn were used to investigate social influence and pressure to keep active. Lin et al. found that the game did indeed increase peoples awareness of their own activity levels and educated the participants so that when the study ceased the game was no longer needed as the participants had a concrete understanding of their own activity levels.

Ahtinen et al. also tackle the issue of social influence in [2]. Ahtinen et al. examine in this work how to design social features and they detail a study in India which examined the design of wellness applications and the social interaction between people. The study found that role models, family and other people striving for the same results as the participants was a good motivational social tool that helped the users to better achieve their aims.

Another system that makes good use of social encouragement is detailed in Mueller [14]. The Jogging the Distance system is targeted at runners. In particular it is targeted at people who like to run together but due to broad geographical differences in location often find it infeasible to meet in person. As such the system makes use of GPS technology and 3D sound in order to simulate to one user the respective position of the other. This is used as a motivational tool in order to provide support to individual runners and encourage them to keep going since their friend is still running and offering words of support.

3. DESIGN GUIDELINES

From the papers that have been discussed it is possible to outline design guidelines for mobile based motivational activity monitoring applications. For example much of the discussed literature agrees that social influence and the ability to set and aim for goals can be extremely helpful in encouraging participants to strive for the more active lifestyle that they desire. As such it is possible to outline the features such a system could make use of:

1. Goal Setting - In [8, 15, 12] goal setting was found to be of great use and a key component in motivating the user's of their systems in keeping active. It would be beneficial therefore to include some form of goal setting and reward system for users in mobile based systems as a way of motivating users to use the system and to track their progress.

2. Social features - The ability for users to share their progress to other users of the system is also a powerful motivational factor. Allowing participants to view their progress alongside that of their friends or other users in their group showed in [2, 14], that it helped to encourage that user to be more active themselves. The loyalty to a group or the knowledge that others will know when you have not been as active or met your own goals could be very motivational, also the ability to invite friends could help to provide a feeling of comfort and camaraderie as in the Jogging the Distance system and would be a powerful addition to a mobile based activity monitoring application.
3. Feedback - In all the literature the way feedback is presented is an important factor. We believe It is important to allow users to track and monitor their progress and to also be able to compare their progress with that of other people. As such it would be beneficial to allow the users to access a system that provided a breakdown of their activity patterns so they can see them changing over time. In addition consideration is needed regarding the use of a subtle or a direct reward feature based on the user's progress.
4. Reminders - The benefit of consolidating the pedometer functionality onto a mobile device loses the reminder an external device subtly gives the user and so it is possible that users may become less aware or less motivated as time goes on since they forget the system is running on their phone. A solution is to provide regular reminders much like the subtle wallpaper reminder included in the UbiFit system or similar so that the users are continuously aware that there activity is being monitored.

4. CONCLUSION AND FUTURE WORK

In this paper we have discussed previous work relating to the study of promoting physical activity. We have discussed the benefits of existing products such as pedometers, the Nike Plus system and the PAM and discussed how these systems can be applied to mobile platforms. We have also discussed work relating to the more encompassing issues of promoting an active lifestyle, such as how to keep people interested and motivated in achieving their goals and how goal setting and social influence are possible ways of doing this. As such, the discussed literature allows us to construct guidelines which will aid us in designing a unique mobile activity monitoring application that will motivate people in pursuing a more active lifestyle. In addition the application will aid users in increasing their knowledge of their own physical activity levels as well as those of others, resulting in them adapting their lifestyle habits accordingly.

5. REFERENCES

[1] A. Ahtinen. Wellness applications – ui design to support long-term usage motivation. In *CHI '08: CHI '08 extended abstracts on Human factors in computing systems*, pages 2669–2672, New York, NY, USA, 2008. ACM.

[2] A. Ahtinen, M. Isomursu, M. Mukhtar, J. Mäntyjärvi, J. Häkkilä, and J. Blom. Designing social features for mobile and ubiquitous wellness applications. In *MUM '09: Proceedings of the 8th International Conference on Mobile and Ubiquitous Multimedia*, pages 1–10, NY, USA, 2009. ACM.

[3] A. Ahtinen, E. Mattila, A. Vaatanen, L. Hynninen, J. Salminen, E. Koskinen, and K. Laine. User experiences of mobile wellness applications in health promotion: User study of wellness diary, mobile coach and selfrelax. In *Pervasive Computing Technologies for Healthcare, 2009. PervasiveHealth 2009. 3rd International Conference on*, pages 1–8, 2009.

[4] S. M. Arteaga, M. Kudeki, and A. Woodworth. Combating obesity trends in teenagers through persuasive mobile technology. *SIGACCESS Access. Comput.*, (94):17–25, 2009.

[5] D. M. Bravata, C. Smith-Spangler, and V. Sundaram. Review: use of pedometers increases physical activity in adults. In *BMJ Publishing Group Ltd and RCN Publishing Company Ltd, Evid Based Nurs 2008*, volume 11, 2008.

[6] T. Choudhury, G. Borriello, S. Consolvo, D. Haehnel, B. Harrison, B. Hemingway, J. Hightower, P. P. Klasnja, K. Koscher, A. LaMarca, J. A. Landay, L. LeGrand, J. Lester, A. Rahimi, A. Rea, and D. Wyatt. The mobile sensing platform: An embedded activity recognition system. In *IEEE Pervasive Computing*, volume 7, pages 32–41, 2008.

[7] S. Consolvo, P. Klasnja, D. W. McDonald, D. Avrahami, J. Froehlich, L. LeGrand, R. Libby, K. Mosher, and J. A. Landay. Flowers or a robot army?: encouraging awareness & activity with personal, mobile displays. In *UbiComp '08: Proceedings of the 10th international conference on Ubiquitous computing*, pages 54–63, NY, USA, 2008. ACM.

[8] S. Consolvo, P. Klasnja, D. W. McDonald, and J. A. Landay. Goal-setting considerations for persuasive technologies that encourage physical activity. In *Persuasive '09: Proceedings of the 4th International Conference on Persuasive Technology*, pages 1–8, NY, USA, 2009. ACM.

[9] S. Consolvo, K. Markle, K. Patrick, and K. Chanasyk. Designing for persuasion: mobile services for health behavior change. In *Persuasive '09: Proceedings of the 4th International Conference on Persuasive Technology*, NY, USA, 2009. ACM.

[10] S. Consolvo, D. W. McDonald, and J. A. Landay. Theory-driven design strategies for technologies that support behavior change in everyday life. In *CHI '09: Proceedings of the 27th international conference on Human factors in computing systems*, pages 405–414, NY, USA, 2009. ACM.

[11] S. Consolvo, D. W. McDonald, T. Toscos, M. Y. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby, I. Smith, and J. A. Landay. Activity sensing in the wild: a field trial of ubifit garden. In *CHI '08: Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, pages 1797–1806, NY, USA, 2008. ACM.

[12] J. Lacroix, P. Saini, and R. Holmes. The relationship between goal difficulty and performance in the context of a physical activity intervention program. In *MobileHCI '08: Proceedings of the 10th international conference on Human computer interaction with mobile devices and services*, pages 415–418, NY, USA, 2008. ACM.

[13] J. Lin, L. Mamykina, S. Lindtner, G. Delajoux, and H. Strub. Fish'n'steps: Encouraging physical activity with an interactive computer game. pages 261–278. 2006.

[14] S. O'Brien and F. F. Mueller. Jogging the distance. In *CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 523–526, New York, NY, USA, 2007. ACM.

[15] P. Saini and J. Lacroix. Self-setting of physical activity goals and effects on perceived difficulty, importance and competence. In *Persuasive '09: Proceedings of the 4th International Conference on Persuasive Technology*, pages 1–7, New York, NY, USA, 2009. ACM.

[16] S. M. Slootmaker, M. J. M. C. A. Paw, A. J. Schuit, W. van Mechelen, and L. L. J. Koppes. Concurrent validity of the pam accelerometer relative to the mti actigraph using oxygen consumption as a reference. In *Scandinavian Journal of Medicine & Science in Sports*, 2007.

Neighbourhood *Watt*ch - Community Based Energy Visualisation For The Home

Chris Elsmore, Max L. Wilson, Matt Jones, Parisa Eslambolchilar
Future Interaction Technology Lab
Swansea University, SA2 8PP, UK
elsmorian@gmail.com, {m.l.wilson, matt.jones, p.eslambolchilar}@swansea.ac.uk

ABSTRACT

In this paper we describe an investigation into a social, community-based electricity and waste visualisation. We present a system that, through visualisations suitable for all ages, can display the electricity consumption and waste production of a community. This system, originally deployed online, was analysed during a month-long user study, which found that, although eliciting an initial popular response, was not sufficiently embedded in daily life to have a long term effect. Thus a separate device was prototyped to give the system a permanent, more pervasive presence in a household. Additionally, we argue that such a system could be easily adapted for personalised mobile use, and would benefit from the more frequent interactions with, for example, a user's mobile phone. We also present challenges in producing this interface on a mobile device, and open discussion on how this is best achieved.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User-centred design—*Input devices and strategies, Interaction Styles, Prototyping*

General Terms

Design, Human Factors

Keywords

Nudge, behaviour, influence, energy, consumption

1. INTRODUCTION

Current scientific reports and investigations into the causes and extent of climate change, such as the IPCC Fourth Assessment Report on Climate Change [8], together with other green issues such as peak oil, rainforest destruction and renewable energy (which received significant investment of over $150 billion in 2008 alone [7])have heightened public interest in environmental issues. This interest is spurred on by increased media coverage and campaigns such as *10:10*[1], which aims to cut 10% of UK emissions in 2010, and the *Prince's Rainforest Project*[2], a campaign spearheaded by HRH The Prince of Wales against rainforest deforestation.

[1]More information available at http://www.1010uk.org/.
[2]Available at http://www.rainforestsos.org/.

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3/10/09.

Many systems have been developed to help individuals track their own energy consumption or waste production, as discussed in the next section, but we are unlikely to reduce global energy consumption without working together. We sought to develop a system that a) was accessible to the whole household, and b) places our energy consumption in the context of other people in our communities. The aim is to help households work together, with each other and other households, to reduce global energy consumption. We believe that the implications of adding social awareness and a mobility to household metering has not been properly researched, and that it may have a significant influence on the long term behaviour of users.

In the rest of this paper, we first introduce a system designed to be both accessible to the whole family and socially aware. We then describe a study where this system was deployed within five households for one month. Our findings indicate that although an online social network provides good motivation for change, it is not sufficiently built into daily routine to have a long term benefit. We then describe an initial investigation into a prototype device that places this socially aware system more pervasively into the living space and conclude with our hypothesis that a mobile deployment of this socially aware system will provide a more personalised experience to nudge and influence energy consumption behaviours.

2. BACKGROUND & RELATED WORK

In light of the recent interest in 'green' living, table-top style household electricity monitors have increased in popularity as a method of gathering precise realtime domestic electricity data conveniently, instead of the imprecise data from a typically difficult to access household electricity meter. Installing these monitors is arguably a proven way of reducing a household's consumption- a study for the Department of Environment Farming and Rural Affairs by the University of Oxford identified a saving of 5-15% on average household consumption from the addition of a monitor, as the occupants of the home became more aware of their usage [3]. However, the current range of table-top monitors provide limited feedback to users, usually based on a numerical display which requires knowledge of the units of power - Watts (W), and energy - Kilowatt Hours (kWh), which are used to represent electricity consumption. A notable exception to this is the Wattson device, which glows in different colours depending on the amount of electricity being consumed. In addition to this, despite supporting user experimentation in the home with relation to how different devices affect overall household electricity consumption, current monitors feature no further incentive to reduce consumption, and after an initial interest, the energy savings can decrease as the novelty factor of the monitor itself wears off for the occupants of the home [2] in a boomerang effect.

Future visualisations based on the data already available from such commercial monitors could be used to create more engaging and meaningful visualisations for households. Current research is being done into the possibilities of using local household data in new ways, to increase the visibility of such data in everyday lives such as the Weigh Your Waste [6], and WattBot [9]projects. Weigh Your Waste involves an in-home visualisation of the status of a user's rubbish bin, and uses the weight of the waste currently in the bin to calculate the cost of disposal. The WattBot project aims to create an iPhone application that shows a user's home electrical use, broken down by the room or appliance, to indicate where the majority of energy is being consumed, and how different rooms and appliances compare. We believe these systems can be made increasingly effective by the addition of other households' data, providing both a reference point, and a possible goal to aim for. This social side of such a system is ideal for mobile use where comparisons of energy usage, recycling amounts and tips on how to improve could be shared between individuals using mobile devices.

3. NEIGHBOURHOOD WATTCH

Our goal was to design a system that was accessible to the whole family, and so we used the participatory design method [1] to engage with a class of school children to design a suitable visualisation. In this case it was used to form initial ideas regarding the types of visualisation children felt were suitable for showing waste and electricity data in the home. As Druin and colleagues suggest [5], children can offer valuable insight into how they themselves think, what they like and dislike, and what they can relate to.

A group of 10 and 11 year old children in a class at a local primary school took part in a design session, creating ideas to represent both electricity use and waste production. This age group lies on the upper bounds of where children are the most descriptive and self-reflective whilst still lacking pre-conceived ideas and methods, often resulting in truly original ideas [4]. The children were presented with two examples of existing electricity monitors, and then asked to produce one waste and one electricity design to represent the same information through a visualisation.

These visualisations were then analysed for common features, and used as a basis for designing the final visualisation used in the system. The children's designs had a number of popular themes in common, for example the use of colour such as traffic light style devices or lights that lit up in the same green, amber and red colours, which were popular for depicting electricity usage. Other themes included depictions of forests which changed in size, depictions of themselves or people close to them changing in size or getting older and younger, and pictures of rubbish bins that got progressively full of recycling or rubbish. These themes were combined to create the final visualisation used in the system - a house depicts each different household, with rubbish and recycling use mapped to the amount of black bags and recycling bins, and the electricity use mapped to the number of trees and window colours, as can be seen in Figure 1.

The system we developed consisted of this visualisation

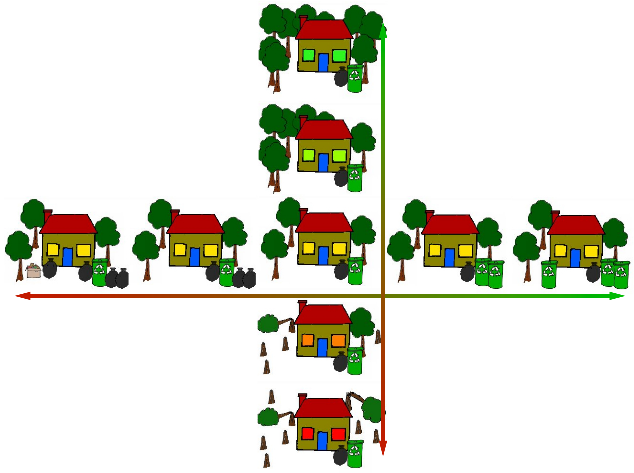

Figure 1: Scale of visualisations through electricity and waste consumption and production.

Figure 2: The visualisation for the community.

implemented through a website as shown in Figure 2. The site took readings of waste and electricity data from each participant, and used this to generate the visualisation along with other statistics, displaying this data when the participant logged in.

4. USER STUDY

A qualitative user study was designed to investigate the impact that the Neighbourhood *Watt*ch system had on a household's perceptions and behaviours regarding their electricity usage and waste production. Further the study recorded their actual usage throughout the month when using a system that visualised multiple households' electricity and waste data alongside the user's own. Finally the study explored the energy usage and waste production of households with young children in general.

The study took place over a period of four weeks. Each participating household was supplied with an electricity monitor, and a set of weighing scales to measuring the weight of rubbish they threw out. In the first stage which lasted one week, participants' daily electricity use, as reported by the monitor, and the weight of their rubbish and recycling, were recorded onto a sheet of paper, to get them used to using the monitoring hardware. The second stage also ran for one week and involved recording the same data but using the website described previously, however participants could only see their own data. The third and final stage made up the remaining two weeks, and used the same website as in the previous stage, but enabled the community visualisations.

Prospective households were contacted via the class that was involved in the visualisation participatory design exercise. Five households willing to partake in the study were found, each of which had at least one child in their final years (9 and 10 years old) at school. Apart from this similarity other aspects of the households varied, such as the property sizes, attitudes towards the environment and 'green issues'; three of the five households recycled materials such as tin foil, TetraPaks and batteries, which were not collected from the kerb-side and therefore required a separate trip to the municipal site, whilst one reported recycling very little. These different households gave the study a wider scope to investigate the effectiveness of visualisations on households with differing attitudes and behaviours.

5. RESULTS

All participants experimented with the electricity monitor when it was first installed, exploring how much energy different devices use in their homes (which confirmed findings by Darby et al. [3]), and for a number of participants the study served as a constant reminder to be more energy conscious. The community section of the website provoked interest among participants, but the electricity monitor was the primary cause for behaviour change in the households.

Despite the focus on the monitor, participants were still aware of their presence on the website, and how they appeared to other participants. Participants felt guilty when seeing the community page and identifying other people who were using less energy them them; one household, for example, commented: *"I looked at other people's houses online, and saw averages of less than four and I thought ooh oh dear!"*. Another stated: *"We trimmed all the hedges! We should have put that in see, that would have made us better!"*, reaffirming their wish to look good to other people on the community section of the site.

Whilst the system was well received by all participants, a number of common and key issues arose through the study period. Whilst the website received praise from participants regarding its functionality and ease-of-use, when changing from the paper sheet recording to using the website, participants did not record as many readings. When queried, the participants admitted they did not use their computer on a daily basis and turning it on just to enter the reading was considered too time consuming: *"Everyday I noted it down on the calendar usually what it was at the end of the night, but I didn't always have the energy to put it in - I don't always have the computer on everyday."* Another household commented *"It's quite a responsibility doing it every night"*, *"Unless you're in the habit of going on the computer every night for something anyway"*.

In addition, the participants did not generally use or explore the website apart from updating readings, thus the main feedback from the electricity use came from the energy monitor itself, with most participants only looking through the community section of the site once or twice during the study.

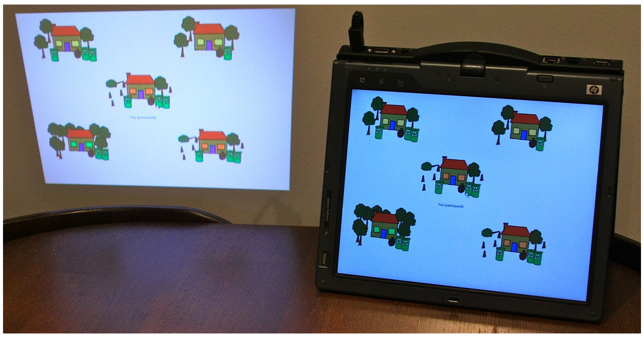

Figure 3: Revised system prototype with projector display, showing the community visualisation.

6. REVISED SYSTEM

Further to these results a refined, more pervasive system was prototyped, designed taking into account the issues that participants had identified with the existing system, and to address these problems it was decided that the refined system must consist of a device similar to the electricity monitor, but be capable of displaying the same information as the website. The table-top electricity monitor was attractive to the households as it required nothing more than a casual glance to assess how much electricity was currently being used. By comparison the website required logging in, and in some cases the additional time of turning the computer on. It was decided the new system would also support automatic updating of waste production, using a method similar to the *Weigh Your Waste* project [6], involving wireless scales fitted to rubbish bins to monitor the weight of the contained waste.

The refined system was prototyped before being presented to the participants of the previous study for feedback in a think aloud session. The new system, shown in Figure 3 was designed to include a table-top display device that would show the community visualisation, whilst automatically recording the electricity and waste use from the household providing a more pervasive interaction than the previous system.

6.1 Reactions

The new system was met with enthusiasm from most participants, with all but one household agreeing that it was better than the first system. This participant liked the refined system, but commented that it wasn't a system they would use in their home, they thought they were as green as they could possibly be: *"It's not for me, as we turn off electricity as much as possible anyway, and we also recycle as much as possible."* They did however state that they would be willing to use such a system for research purposes, to help refine it further.

All other households expressed an interest in the new device, and all said they would use it in their homes. They much preferred the fact that the device provided all the information on its own display and did not require using a computer, for both accessibility and speed reasons – two households stated they thought the new system was easier to use, with the large display being *"Clear and easy to understand"* and *"More user friendly, and I don't need to log in - time efficient."* They also commented that if it was in the home directly, *"The children would like the interactivity of it"*, and all households stated they would prefer to place this device in the kitchen or dining room, in places they frequent in the home.

6.2 Towards Mobile Device Design

While it is clear that the socially aware aspect had a positive impact on people's energy consumption, the exact form of Neighbourhood *Watt*ch requires additional research. One logical hypothesis is that Neighbourhood *Watt*ch should be deployed on mobile devices, so that it can be integrated even more into daily practices. The revised prototype presented above had the benefit of being better integrated into routine, but several participants were unsure about the use of additional technology in the house to reduce energy consumption. There are several advantages to creating more personalised mobile device applications for Neighbourhood *Watt*ch: 1) many people keep mobile devices on their person throughout the day; 2) it allows the user to keep track of their consumption while out of the house; 3) it allows individuals to track finer-grained physical spaces such as their own room; 4) individuals can have a personalised age-appropriate view of their energy consumption; 5) it allows people to share and compare their energy consumption when visiting others. One downside is that it may be harder for families to engage with the visualisation together. Another is that the physical presence of the monitor in the house is taken away. We would suggest that the presence of Neighbourhood *Watt*ch on a mobile phone should be made permanent by an icon in the corner or an ambient indicator, to capture the same benefits as a permanent installation in the house. These pros and cons should be discussed fully in a workshop environment, to identify if they are valid goals for the technology and gauge wether or not these are features users would want to interact with and use in a mobile context.

The transition from web-based interactions to mobile ones for this technology depends highly on the mobile technology being used. A recent smartphone released in the last couple of years is fully capable of displaying the web interface used in the study, and so are more recent popular form factors such as Apple's iPad. Re-designing the interface into one based in a native application for these devices would increase the speed of determining energy usage, however a different visualisation may be more suitable. Older phones such as one without touch screen or colour display would not support the web interface as is, and would require a redesigned interface specifically for them which we believe would still not provide a compelling and engaging experience due to the hardware limitations of such devices.

Newer devices however present an increased range of possible interactions. GPS and location data available from these newer devices could be used to determine how households in the immediate vicinity of the user compare to their own use, or remind user when they have left their home which appliances have been left on for example. Additionally, the feedback from actuators such as a devices screen brightness, vibration levers or even auditory signals could be used to further nudge and persuade users. As mentioned above, having a mobile display of energy information when visiting friends could also be a conversation point for discussing how savings were made.

The rise of such social tools such as Twitter and Facebook combined with ubiquitous internet connected mobile devices has meant that for a lot of people, they are in constant communication with friends and colleagues. This social network popularity could be exploited with revisions of neighbourhood *Watt*ch into a social service. This would have scope from comparing individuals in a home and how they contribute to the overall energy use, how they compare individually and as a family to other individuals and households, how houses in a street compare in a town, or how towns compare throughout the country, possibly including such motivators as weekly goals, or challenges and leader boards. We believe tight integration with existing social networking services combined with mobile alerts, or notifications of such challenges would highly increase it's effectiveness.

7. CONCLUSIONS

In this paper, we have described an investigation into a system that promotes and facilitates better awareness of energy consumption by placing it in the context of a user's community. Neighbourhood *Watt*ch lets users know not only whether they have reduced their energy consumption, but allows them to see whether or not their consumption is good or bad when compared to other people. While our investigation indicates that social awareness of energy consumption did motivate better energy consumption, the visualisations had to be pervasive and embedded in daily routines to have long term effects. We believe that Neighbourhood *Watt*ch would be better able to nudge and influence behaviour if deployed on users existing mobile-devices, but must maintain permanent presence to be effective.

8. REFERENCES

[1] S. Bødker, K. Grønb, and M. Kyng. *Human-computer interaction: toward the year 2000*. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1995.

[2] E. Carroll and M. Brown. Research to inform design of residential energy use behaviour change pilot. Conservation Improvement Program Presentation, hosted by Minnesota Office of Energy Security., July 2009.

[3] S. Darby. The effectiveness of feedback on energy consumption. Technical report, DEFRA and Environmental Change Institute, University of Oxford, April 2006.

[4] A. Druin, editor. *The Design Of Children's Technology*. Morgan Kaufmann Publishers Inc., 1998.

[5] A. Druin. Cooperative inquiry: Developing new technologies for children with children. In *Proc. CHI 1999*, pages 592–599, 1999.

[6] A. A. Gartland and P. Piasek. Weigh your waste: a sustainable way to reduce waste. In *Proc. CHI 2009*, pages 2853 – 2858, 2009.

[7] C. Greenwood, V. Sonntag-O'Brien, and E. Usher. Global trends in sustainable energy investment 2009. Report, UNEP and New Energy Finance Research, 2009.

[8] R. Pachauri and A. Reisinger. Contribution of working groups i, ii and iii to the fourth assessment report of the IPCC. Technical report, IPCC, 2007.

[9] D. Petersen, J. Steele, and J. Wilkerson. Wattbot: a residential electricity monitoring and feedback system. In *Proc. CHI 2009*, pages 2847 – 2852, 2009.

Motivating physical activity at work: Using persuasive social media extensions for simple mobile devices

Derek Foster, Conor Linehan and Shaun Lawson
Lincoln Social Computing Research Centre (LiSC)
University of Lincoln, Brayford Pool
Lincoln, LN6 7TS
+44 (1522) 837086
defoster@lincoln.ac.uk

ABSTRACT

Powerful behaviour change programmes can be developed through a combination of very simple, accessible technology, and an understanding of the psychological processes that drive behaviour change. We present a study in which very basic digital pedometers were used to record the number of steps taken by participants over the course of a normal working day. A Facebook application, named Step Matron, was utilised to provide a social and competitive context for pedometer readings. We were particularly interested in whether interactions between users via the application more successfully motivated physical activity than simply recording daily step counts in a similar application. Ten participants (1 male), all nurses working in a UK hospital, used the application across two conditions over the course of the study. In the socially-enabled condition, participants could view each other's step data and make comparisons and comments. In the non-social condition, participants could only view their own personal step data. A significant increase in step activity was observed in the socially enabled condition. Our findings highlight the potential of social media as a means for generating positive behaviour change. They also suggest that simple mobile devices can function as an inexpensive, accessible and powerful trigger towards this behaviour change without necessitating the use of overly complex and expensive mobile applications or devices.

Categories and Subject Descriptors

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

General Terms

Design, Experimentation, Human Factors

Keywords

Persuasive technology, lifestyle, health, mobile devices, pedometers

1. INTRODUCTION

Modern lifestyles are becoming increasingly sedentary [10]. In the UK only 11.6% of adults are classed as physically active by taking part in moderate exercise 5 times or more a week [4]. Physical exercise has also been shown to improve health conditions such as heart disease and depression [2]. This paper reports on the use of a simple mobile device (SMD) – a digital pedometer - and a social application to improve physical health in a specific environment: the workplace. As figures suggest that UK workers spend up to 60% of their waking hours at work [9] there is scope to utilise some of this non-social time to encourage more physical activity.

In recent years a number of researchers have conducted studies to evaluate the potential of using pedometers as health interventions in the workplace (e.g. [5], [3]). Chan et al. [3] report a substantial study involving 1442 employees over a 12 week period in which pedometers were used to measure the effects of two types of motivational structures on physical activity. These two motivational structures were; health education (control group), and personal/team goal setting (intervention group). Analysis of the study's activity data revealed that 51% of participants in the intervention group met the US governments recommendations compared to 31% in the control group. It appears that the social interactions and competitiveness engendered by the team goal setting, including the use of posters displaying and comparing team performances, may have had a significant impact on the results observed.

Interestingly, Chen et al. [3], did not utilise any technology-enabled feedback other than the pedometer display itself, in either the control or intervention groups. Thus, the social and competitive feedback presented to participants was indirect, infrequent and over a long period of time. The current paper suggests that offering users more direct and frequent online social feedback, could lead to both a more enjoyable experience for the user and more positive gains in recorded physical activity.

In this study we leveraged an extremely popular contemporary online social network (OSN) - Facebook - in combination with SMD's in order to engage participants in a timely and playfully competitive manner with their step activity. The intention was to demonstrate the value of using an online social application to record data, display feedback and facilitate on-topic discussion, thus eliminating the need for the user to wear anything other than a cheap off-the-shelf pedometer. We are engaged in a number of studies in which we are evaluating the viability of using social

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3/10/09.

platforms *in general* to motivate and encourage positive behavioural change. For instance, this approach has been used successfully in raising awareness of the ecological impact of energy use in the home [8].

We designed and developed the Facebook application Step Matron using the Facebook API [6] and then evaluated it through a user study. The user study followed a within subjects design with each participant taking part in two conditions or social modes. In condition A, Step Matron was socially enabled, for example participants could see their friends' step data as well as their own; in condition B the Step Matron application was manipulated so that there were no social features available and so participants could only see their own personal step activity. Our hypothesis was that participants would be more active when using the socially enabled condition of Step Matron when compared to the non-social condition.

2. Experimental Method

2.1 Participants

Ten Registered Nurses (Nine females and one male) were recruited through a personal contact to trial Step Matron. All of the nurses were employed within the same hospital ward and personally knew each other as friends. Additional criteria for recruitment were that they must have been regular users of Facebook for the past 12 months and that all participants must be on each other's friends list on Facebook.

2.2 Design

In order to examine whether the social interaction element of the application was necessary over just recording and displaying feedback, we created two conditions; socially-enabled and non-social. In the socially-enabled condition, participants could view each other's step data and make comparisons and comments. In the non-social condition, participants could only view their own personal step data. The independent variable was therefore Step Matron's interaction mode, either social or non-social. The dependent variable was the number of steps taken by each participant, with a total step count being recorded in each condition for each participant.

The experiment's conditions were counterbalanced to avoid ordering effects. This was done by creating two groups quasi-randomly, each group containing 5 participants. Group 1 started in the social condition, group 2 in the non-social condition and the condition that each participant experienced was switched halfway through the experiment. Thus, each participant experienced both conditions, and order effects were controlled for as carefully as possible.

2.3 Materials

In order to generate activity data that we could use within the Step Matron application we used a commercial off-the-shelf pedometer – the 'Silva Ex3 plus' [12] as shown in figure 1.

Figure 1. Silva Ex3 Plus Pedometer used in study

In the study conducted here, participants manually self-reported their step count data as a task in the Step Matron software. Step Matron then offered users the ability to compare their step data with other users and also to post comments on their peers' activity. Additionally, personalised Facebook notifications were sent to each of the participants in the study who had all added Step Matron to their Facebook profile, as shown in figure 2.

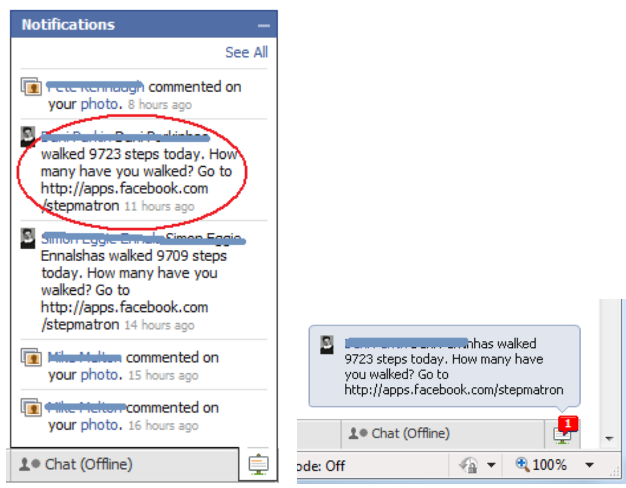

Figure 2. Notifications to other participants who are using Step Matron

A rankings interface displayed the total step count for each participant in a table format with the highest total step count placed at the top of the table. Each participant in the table was selectable for a breakdown of their previous 7 day step count and for personal messaging. At the bottom of the rankings table a *public* comments board was available for posting messages viewable by all. The rankings table provided the competitive attribute of Step Matron - as well as providing an opportunity for social interaction to take place, centred on step activity.

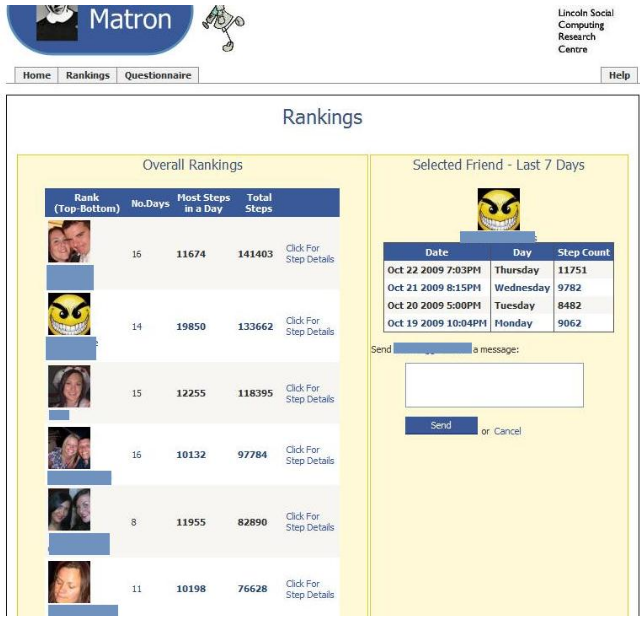

Figure 3. Step Matron Rankings interface

Other goal-driven features were implemented such as displaying who has walked the 'most steps in one day' on the rankings interface with a star rating. This provides the participants with a mini-goal to work towards which supplemented the goal of attaining highest total step count. An overall group measurement was incorporated which showed the total number of steps taken by all participants with the equivalent mileage walked.

Submitted step data from the participants was stored in an MS SQL database, with all data stored anonymously. The Google analytics service was also used to record the number of Facebook application page views for each of Step Matron's interfaces.

2.4 Procedure

Each participant gave their informed consent and undertook the experiment by carrying a Silva Ex3 pedometer during working hours and entering their step data into Step Matron after each working shift was completed. The experiment took place over a period of 21 days with each participant submitting 5 working days of step activity in each condition. Half of the participants started in the social condition with the other half starting in the non-social condition. Once all participants in each group had submitted 5 working days of step data they were sent an email and notification through Facebook informing them of the changeover of conditions. Step Matron was then reprogrammed to perform in the alternative conditions with the relevant participants. Crucially, in order to deter participants from over-reporting step-count data, all participants were briefed at the beginning of the study that the pedometers stored historical activity, and that this would allow researchers at the end of the study to validate the accuracy of all self-reports.

2.5 Results

The steps recorded for each participant in both conditions are summarised in figure 4. Analysis found that 9/10 participants walked more steps in the social condition than in the non-social condition, with mean step ratings of 42004.4 and 38132.1 for social and non-social conditions respectively.

A Wilcoxon statistical test for repeated measures of non-parametric data showed that the total number of steps taken was significantly higher when participants used the social condition ($Z= -2.5$, $N=10$, $p=0.013$).

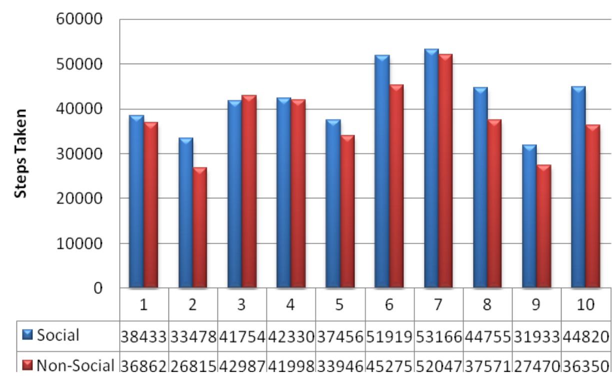

Figure 4: Participant step activity in each condition

Additional data collected from Google Analytics provided an insight into how often the participants across both conditions logged on to Step Matron. In the 21 days the experiment was run, there were 1142 pages views, with 224 unique visits to the Step Matron application, equalling 5 page views per visit. The average time spent during each visit was 6 minutes 11 seconds, highlighting that users of the application were willing to spend some of their own time in interacting with Step Matron. Additionally, the users spent an average of 1 minute 46 seconds on the step input interface, but spent almost a minute longer when interacting with the rankings interface at 2 minutes 37 seconds. It may be assumed that participants enjoyed the rankings interface due to its social and game like properties – a league table and comments board.

3. Discussion

This paper has described the design, deployment and evaluation of a system that utilises a Facebook application to extend and support an SMD in persuading participants to increase physical activity in the workplace. Participants recorded a significantly higher number of steps in the social condition than in the non-social condition. This finding suggests that social interaction over an online social network, such as viewing each other's step counts, comparing own usage to that of peers, and commenting on each other's progress, can help motivate participants to increase physical activity in the workplace.

Comments from the participants showed they enjoyed the competitive aspect with feedback such as "*ooooh im number 1 so far :-)*". Interestingly, a comment was made that moved the context of the physical activity from the workplace out into the personal social space, "*was out dancing fri night, can you imagine how many steps that would have been!!!*" with a response from another participant showing empathy over the 'lost' steps, "*aaahhh shame! Wouldve bin loads x*".

The increased effectiveness of the social condition over the non-social condition in the current study may be explained by literature on social psychology. The desire to belong and willingness to adapt behaviour to follow what others are doing has been seen as a fundamental motivator [1]. Social norms such as peer pressure have also been seen as a means of changing behaviour to align with the ideals or beliefs of groups [11]. Whilst there is insufficient space to give a full account of the psychological theories of social motivation, effecting behavioural change through computer mediated social applications seems promising.

Behavioural change is no easy feat and more often than not technological endeavours fail to make an impression on the target users [7]. It has been suggested that one of the main reasons for this is that designers of persuasive technologies often set goals that are too difficult for users to attain and work towards, ultimately they give up trying. Effectively, the results of this study indicate that the participants themselves can provide motivational goals for each other by simply allowing them to interact over a competitive social networking application.

Interestingly, the current study suggests that SMDs can function as successful triggers for positive behaviour change, when delivered as part of a larger programme. Specifically, the conclusion drawn above was that the social and competitive interactions occasioned by the social version of the Step Matron Facebook application motivated participants to become more physically active during work. However, it is difficult to understand the process through which this competition was maintained, as participants did not have access to the Facebook application during working hours. Rather, participants only had access to a simple digital read-out of their daily step-count from the pedometer during working hours. Thus, it is apparent that the competitive activities occasioned by the Facebook application were not only in action while participants used the application, but also throughout the rest of the day; and that the SMD functioned as a trigger for these competitive activities.

This study also demonstrates that social network applications can serve as a powerful context that allows participants to understand quantitative behavioural measures as more than mere numbers. For example, when participants in the current study occasionally viewed their step-counts while working, it is possible that these were considered not purely as the number of steps taken, but as steps closer to beating their friend, steps closer to winning, or as a performance that needed to change in order to achieve equality with fellow participants. Without the competitive Facebook application, this would not have been possible.

4. Conclusion

The current study demonstrates that the carefully considered combination of two simple technological elements, informed by an understanding of successful behaviour modification programmes, can be effective in motivating behaviour change. This finding could prove valuable when designing the architecture of future persuasive technology, as it suggests that complex applications on complex devices are not necessary to motivate real behaviour change in users. Although the paper describes a relatively small scale study, it provides encouraging results and presents scope for a scalable implementation in a larger workplace investigation. In particular, there is potential to improve the design of the experiment by empowering teams of participants as well as the individuals directly. Future work direction would likely include game like mini-goals for both the individual and team orientations.

5. ACKNOWLEDGMENTS

This work was funded by NHS Lincolnshire. Our thanks go to the nurses of the Haematology units at the Royal Hallamshire Teaching Hospital (Sheffield, UK).

6. REFERENCES

[1] Baumeister, R.F., and Leary, M.R. “The need to belong: Desire for interpersonal attachments as a fundamental human motivation.” *Psychological Bulletin, 117,* 1995, 497–529.

[2] Bravata, D.M.. “Using pedometers to increase physical activity and improve health: A systematic review.” *JAMA, 298*, 2008, 2296-2304.

[3] Chan, C.B., Ryan, D.A.J. and Tudor-Locke, C. (2004) “Health benefits of a pedometer-based physical activity intervention.” In *Preventive Medicine, 39*, 2004, 1215-1222.

[4] Department of Health (2008) *Health Profile of England 2008 : Department of Health – Publications*, available from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_093465

[5] Dishman, R., DeJoy, D., Wilson, M., and Vandenberg, R. “Move to Improve, A Randomized Workplace Trial to Increase Physical Activity.” *American Journal of Preventive Medicine*, *36*, 2009, 133-141.

[6] Facebook, (2010) *Facebook Developers*, available from http://developers.facebook.com/

[7] Fogg, B. “Three possible futures for persuasive technology.” In *Proceedings of the 4th international Conference on Persuasive Technology*, 2009, Article Number 18.

[8] Foster, D., Blythe, M., Cairns, P., and Lawson, S. “Competitive carbon counting: can social networking sites make saving energy more enjoyable?” In *Proceedings of the 28th of the international Conference Extended Abstracts on Human Factors in Computing Systems*, 2010, 4039-4044.

[9] Peersman G, Harden A, and Oliver S. *Effectiveness of Health Promotion Interventions in the Workplace: A Review*. London: HEA, 1998.

[10] Rajaratnam, S., and Arendt, J. “Health in a 24-h society.” *The Lancet*, *358*, 2001, 999-1005.

[11] Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldsteing, N.J., and Griskevicius, V. “The Constructive, Destructive and Reconstructive Power of Social Norms.” *Psychological Science*, *18*, 2007, 429-434.

[12] Silva, (2009) *Pedometers – Silva5*, available from http://www.silva.se/en/Products/Exercise-4-life/Pedometers/

Designing Mobile Technology to Promote Sustainable Food Choices

Conor Linehan, Jonathan Ryan, Mark Doughty, Ben Kirman, Shaun Lawson
Lincoln Social Computing Research Centre
University of Lincoln, Brayford Pool
Lincoln, LN6 7TS, UK.
++44 01522 837084

clinehan@lincoln.ac.uk

ABSTRACT
This paper is an experience report based on challenges encountered when designing scalable mobile persuasive HCI applications to help users make informed choices over their food consumption. We recently developed *Tagliatelle*, a social tagging system to help users to accurately monitor and assess their dietary behaviour and to promote healthier food choices. In this paper we propose a similar system in order to help users understand the sustainability of their food choices. We discuss the challenges inherent in doing so, and extrapolate some important issues that need to be addressed by technological developments that aim to persuade users to adopt more sustainable behaviours.

Categories and Subject Descriptors
H.5.3 [Group and Organization Interfaces]: *collaborative computing*.

General Terms
Design, Human Factors, Theory.

Keywords
Eco-feedback, sustainability, sustainable consumption, tagging, feedback, persuasive.

1. INTRODUCTION

1.1 Background
Recent studies have identified that topsoil erosion [17], depletion of fish stocks [13], tainting of meat products, depletion of oil reserves and climate change can all be linked to the method in which food is currently produced, distributed and consumed [17]. It is clear that reaching and understanding of, and improving the sustainability of, food that we purchase and consume is of growing interest [9]. As social computing researchers we are interested in how online mobile and social technology may facilitate these goals. In particular, we believe there is a need to directly engage the individual consumer in the process.

It is also clear, however, that, there is currently no all-encompassing measure of sustainability that we can use to deliver feedback to users. For instance, there are a number of different issues that the term 'sustainability' can refer to; these include *environmental* sustainability and *social* sustainability. Indeed, within environmental sustainability, there exist subtleties that make it hard to define how sustainable any given item is. For example, the question of whether it is preferable to grow fruit at a low carbon cost in the third world and air freight it to the UK, or to grow the fruit at a higher carbon cost in the UK, is a dilemma that currently appears to be a value judgment. Since the problem domain is so unclear, it is difficult at present to create meaningful applications that give judgement on an objective level. Complicating the issue further, there is currently no requirement for manufacturers to disclose where ingredients and components have been sourced (known as *supply chain transparency* [1]).

Nevertheless, in order to design mobile tools to encourage more sustainable consumption, we must have some useable definition of sustainability. As such, in our recent work, we have adopted the goals of the "Slow Food" movement, which emphasises the consumption of local and seasonal produce over that which is imported and/or out-of-season (see http://www.slowfood.com for more details). Hence, in the technology proposed here, users' food consumption will be evaluated in terms of how closely it adheres to the goals of the "Slow Food" movement.

Figure 1. In Winter the UK imports potatoes from Egypt, grown in the desert with seed from Scotland, water from 350m deep wells, and packed in peat from Ireland.

There are also a number of challenges facing any programme, technological or otherwise, that aims to change consumer habits. For example, although reports show that consumers are prepared to pay more for eco-friendly items [5], and rate sustainable items

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3/10/09.

as of high importance, in fact they rarely purchase such items [14]. It appears that in order to bridge this attitude-behaviour gap, consumers need both access to sustainable produce and confidence in their ability to identify sustainable produce [11]. We believe that significant potential exists with existing mobile technology to develop tools that allow people to identify the overall sustainability of their personal food purchases and take action to improve it. Indeed, the inclusion of motivational tools such as visual feedback, goal-setting and mini-games may help persuade consumers to make more sustainable choices.

1.2 Tagliatelle

In previous work, we attempted to utilise the persuasive power of social media as a means of facilitating dietary behaviour change [7]. Specifically, we identified that the development of new and innovative methodologies aimed at helping people determine the nutritional content of their own food intake and motivating them to choose healthier options is an urgent goal. We proposed that exposing participants' eating habits to each other may act as triggers [6] for motivating both healthier food choices and the maintenance of those choices over an extended period of time. In order to examine this, we developed an application in which users uploaded digital photos of meals that they had eaten to a server, which anonymously distributed these photos to other users for tagging. Each user was required to tag one photo that had been previously uploaded by another user before they could upload a photo of their own. In addition, users were free to visit the website at any time in order to tag randomly selected images. Thus, each photo uploaded was tagged several times by different users, generating a rich history of tags for each photograph uploaded.

Figure 2. Screenshot of image tagging in the prototype tagliatelle application.

An evaluation of a basic prototype of Tagliatelle [7] suggested that although we encountered problems extrapolating valid nutritional information from the tags generated by participants, the activity of tagging fellow users' uploaded food photographs was very popular among participants. This finding is consistent with work in the field of human computation ([15][16]), where games are used to motivate users to tag digital images with relevant content labels that can later be used in text-based image retrieval. In effect, the players of these games function as a data analysis tool. It seems that this type of crowd-sourced image analysis may prove useful for a number of different tasks, including food sustainability.

2. A MOBILE APPLICATION TO ENCOURAGE SUSTAINABILITY IN FOOD CONSUMPTION

We are interested in exploring the possibility of harnessing the apparently intrinsically motivating activity of tagging images as a means of creating mobile applications that allow users to accurately monitor, assess and change the sustainability of food they consume. We believe that this type of approach may prove very effective in helping users to gain an overall picture of the sustainability of their own food choices. The main advantages of designing a system with a social tagging architecture are both the lack of need for expert involvement and huge potential for scalability.

Thus, we propose a system based on our experiences in the design, development and evaluation of the Tagliatelle project. However, instead of taking photographs of prepared meals, participants will photograph their food at the point of purchase. In addition, as mentioned above food consumption will be evaluated in terms of how closely it adheres to the goals of the "Slow Food" movement.

The system will be composed of a mobile phone application and a server-side database. Users will interact with the database primarily through the mobile application, although it is envisioned that a standalone website will also be created. The application will allow three interactive experiences: uploading of photos, tagging of photos and presenting of feedback. These are now discussed in turn.

2.1 Photo Uploading

The mobile phone application will allow users to take photographs of their purchases and to easily upload these photos to their personal profile on the server with one button click. The server will anonymously assign all uploaded photos to other users for later tagging.

One particular challenge lies in motivating users to photograph each individual item that they purchase and upload these items to the server. Failure to report a significant proportion of food items, or the selective uploading of only 'good' items would lead to inappropriate feedback. Exactly which tools are most effective at motivating honest participation is an empirical question that we intend to pursue over the course of this and related work.

2.2 Photo Tagging

Users will have the option of tagging photographs either through the mobile phone application itself, or through a standalone website. Specifically, a mini-game, inspired by [15] and [16] will be created in which users rate the food content of the photos presented in terms of sustainability. As in [16], ratings will only be accepted if agreement is reached between independent raters. Exactly what form these ratings will take is, at this time, an empirical question. There is no obviously superior option between numerical, visual or other methodologies. However, we do recognize that a vital part of this research will involve educating users on how closely items do or do not adhere to the goals of "Slow Food."

2.3 Providing Feedback

Each user will receive feedback on the overall sustainability of their food choices through a number of possible methods such as graphs and mini-games. This feedback will be reported both in terms of personal goals and in comparison to the mean results for other users.

3. DESIGNING USEFUL FEEDBACK FOR PERSUASIVE APPLICATIONS

Apart from the very specific problems of ensuring that food is tagged validly and reliably, and that participants photograph and upload appropriate quantities of their food, there are some basic issues that need to be dealt with when setting out to design any technology that promotes sustainable consumption.

One criticism that can be leveled at the vast majority of persuasive tools, mobile or otherwise, is that although these technologies are designed with the specific aim of effecting change in user behaviour, very few have implemented empirically established methods for doing so (see [8]). Indeed, very little of the published work on persuasive technology gives any specific insights into the processes involved in behaviour change, nor specific examples on how to apply these processes. Fortunately, however, there is an entire academic discipline that sets out to examine precisely these questions.

Behaviour analysis is the scientific study of learning [3]. It is, by definition, practical and pragmatic, as it presumes that all behaviour is determined by interactions with and feedback from the surrounding environment [12]. Successful behaviour is maintained, while unsuccessful behaviour is not. Crucially, behavioural psychologists suggest that because behaviour is determined by the environment, it can be changed readily by analysis and manipulation of that environment (see [10] for an excellent introduction to behavioural interventions; [4] for an in-depth analysis). Hence, the field of behaviour analysis has spent decades investigating exactly how to deliver feedback in order to generate real and lasting behaviour change. We believe that, regardless of the target behaviour, in order to create effective persuasive technologies, the science and methodologies of behaviour analysis must be employed as an integral design phase. Indeed, assuming that the principles of behaviour don't apply when a person is interacting with a computing device is a stance that is uninformed, and will lead to a large amount of duplication of effort in addressing questions that have already been comprehensively answered.

In the application introduced in section 2, the way in which feedback is delivered to participants will be informed by the methods of behaviour analysis. Specifically, we will endeavour to provide consistent, regular and specific feedback, regardless of whether participants reach their goals or not. This will, at times, necessitate the considered use of aversive feedback [8]. We will also design the system so that there is a range of available reward structures, such as mini-games, social networking and competitive leader boards, and will ensure that the system is adaptive enough to recognize and utilize the types of rewards that are most effective for each participant.

4. CONCLUSION

A discussion addressing the problems facing any mobile application that attempts to promote sustainable food choices has been presented. We have proposed the design of a system based around the popular activity of photograph tagging that may help users to gain an overall picture of the sustainability of their own food choices. We have also discussed how behaviour analysis can help HCI researchers design the way in which feedback is delivered to users, in order to create applications that are both engaging and useful.

5. REFERENCES

[1] Bonanni, L. Hockenberry, M. Zwarg, D. Csikszentmihalyi, C. and Ishii, H. 2010. Small business applications of sourcemap: a web tool for sustainable design and supply chain transparency, In *Proceedings of the 28th international conference on Human factors in computing systems*, 937-946.

[2] Brown, B., Chetty, M., Grimes, A., and Harmon, E. 2006. Reflecting on health: a system for students to monitor diet and exercise. In *Proceedings of the 24th international conference extended abstracts on Human factors in computing systems*,, 1807 – 1812.

[3] Catania, C. A. 1998. *Learning (4th ed).* Cornwall-on-Hudson, NY: Sloan Publishing.

[4] Cooper, J.O. Heron, T.E. and Heward, W.L. 2007. *Applied Behavior Analysis (2nd Ed).* New Jersey: Pearson/Prentice Hall.

[5] De Pelsmacker, P. Janssens, W. and Mielants, C. 2005. Consumer values and fair-trade beliefs, attitudes and buying behaviour. *International Review on Public and Nonprofit Marketing, 2*, 50-69.

[6] Fogg, B.J. 2009. A Behavior Model for Persuasive Design. In *Proceedings of the 4th International Conference on Persuasive Technology,* Article 40.

[7] Linehan, C. Doughty, M. Lawson, S., Kirman, B. Olivier, P. and Moynihan, P. 2010. Tagliatelle: Social Tagging to Encourage Healthier Eating. . In *Proceedings of the 28th international conference extended abstracts on Human factors in computing systems*, 3331-3336.

[8] Kirman, B. Linehan, C. Lawson, S. Foster, D. and Doughty, M. 2010. There's a Monster in my Kitchen: Using Aversive Feedback to Motivate Behaviour Change. In *Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems*, 2685-2694.

[9] Pachauri, R.K. and Reisinger, A. 2007. *Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland: IPCC.

[10] Pryor, K. 1999. *Don't Shoot the Dog.* New York: Bantam.

[11] Robinson, R. and Smith, C. 2002. Psychosocial and Demographic Variables Associated with Consumer Intention to Purchase Sustainably Produced Foods as Defined by the Midwest Food Alliance. *Journal of Nutrition Education and Behavior, 34*, 316-325.

[12] Skinner, B.F. 1974. *About Behaviorism.* New York: Random House.

[13] Thurstan, R.H. Brockington, S. and Callum, M.R. 2010. The effects of 118 years of industrial fishing on UK bottom trawl fisheries. *Nature Communications, 1*, Article 15.

[14] Vermeir, I. and Verbeke, W. 2004. Sustainable Food Consumption: Exploring the Consumer Attitude Behaviour Gap. *Journal of Agricultural and Environmental Ethics, 19,* 169-194.

[15] Von Ahn, L. Liu, R. and Blum, M. 2006. Peekaboom: a game for locating objects in images. In Proceedings of the SIGCHI conference on Human Factors in computing systems, 55 – 64.

[16] Von Ahn, L. 2007. Human computation. In *Proceedings of the 4th international conference on knowledge capture,* 5-6.

[17] Weber, K. 2009. *Food, INC.* Participant Media.

Ethics and Persuasive Technology: An Exploratory Study in the Context of Healthy Living

Rachel E. Page
School of Computing Science
Newcastle University
Newcastle upon Tyne, UK
r.e.page1@ncl.ac.uk

Christian Kray
School of Computing Science
Newcastle University
Newcastle upon Tyne, UK
c.kray@ncl.ac.uk

ABSTRACT
Persuasive Technology has been heralded as a new paradigm to change people's behavior to improve various aspects of everyday life. In combination with mobile and ubiquitous delivery mechanisms, persuasive technology has the potential to reach and influence people everywhere and at any time. While there are clear benefits to be gained from this approach, there are obviously ethical considerations that need to be taken into account and that currently are not well understood. This paper aims to contribute towards a better understanding of ethics in persuasive technology. We present results from a focus group session and an online survey on the use of persuasive technology in the context of healthy living. The results indicate that the "golden rule of persuasion" [5] might not always be applicable to persuasive technology, that self-initiated persuasion per se may always be acceptable, and that there may be a link between the purpose of persuasion and the means used to persuade. The findings can be used to inform the design of future persuasive interventions.

Categories and Subject Descriptors
H.5.m [**Information Systems**]: Information interfaces and presentation – *miscellaneous.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Persuasive technology, ethics, healthy living, user studies.

1. MOTIVATION
Persuasive technology can be defined as "any interactive computing system designed to change people's attitudes or behavior" [4], which can be applied in a wide range of scenarios. Mobile (and ubiquitous) devices are very well suited for the delivery of persuasive content as they can sense contextual factors of relevance to a specific user (such as location and/or task) and tailor messages so that they are delivered in the most effective way. Considerable potential has been attributed to this technology in terms of helping people to change their behavior [10].

One key area, which could greatly benefit from persuasive technology, is healthy living. For example, it could be applied to areas such as disease management and prevention, improving care and assisting people in living a healthy lifestyle. Particularly in industrialized nations, the latter is rapidly becoming a very pressing issue. In the UK, for example, and estimated 24.2% of adults are considered to be obese [1], a condition which has been shown to cause a number of short and long-term illnesses such as diabetes. Alcohol abuse is a similar problem of comparable proportion and impact [9]. These two issues are predominantly a result of misbehavior, and specific persuasive technologies could be created to help to correct this behavior and thus to reduce the number of people affected by these problems. However the use of such technology does also raise some ethical questions, e.g. with respect to which measures are acceptable in what context, and it is these ethical issues that this paper is investigating.

Ethics can be defined as "the moral principles governing or influencing conduct" [2], and it is clearly dependent on the cultural context, as moral principles will differ between cultures. (Therefore, the results of the studies are limited to Western European/British context.) When considering ethical implications of persuasive technology, there are a number of factors that could potentially play an important role in determining whether a particular piece of persuasive technology is considered ethical or not. These factors include: the user of the persuasive technology; the commissioner behind the persuasive message; the persuasion method used; and the technology being used. One goal we were pursuing with our research was thus to identify the relative importance and relationships of these factors.

In the following, we first briefly summarize related work before discussing insights gained through a focus group session. We then present the questionnaire study we conducted based on the findings of the focus group, and discuss its results as well as its implications for the design of persuasive technology. A brief summary concludes the paper.

2. BACKGROUND
Persuasive technology [3] is a relatively new area in Human-Computer Interaction, which focuses on using technology (such as mobile phones, web sites and other means) to change the behavior or attitude of people. According to Fogg [3], computers benefit from several advantages over humans when persuading others such as being able to persist indefinitely or the option to exploit the positive image of computers. Fogg also asserts that one has to analyze intentions, methods and outcomes of an instance of persuasive technology in order assess its ethical implications [4]. In our studies we considered these as well as further factors.

1st int. Workshop on Nudge & Influence Through Mobile Devices
MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.

Berdichevsky and Neuenschwander [5] focus directly on the ethics of persuasive technology. They outline ten principles for ethical design of persuasive technology, including the so-called *golden rule of persuasion.* It states that designers of persuasive technology should not create any artifact that persuades someone to do or think something that they (the designers) would not want to be persuaded of themselves. One of the goals of the work reported in this paper is to test this golden rule in a specific context (i.e. healthy living).

Persuasive technology does not exist in a vacuum, so we need to select an application domain. We chose to focus on healthy living [6] not only to control the complexity of the user study but also because it is a global and growing problem that has been identified as a key future research challenge [7]. Chaterjee and Price [8] provide an overview of specific issues and challenges. The study presented in this paper expands on their work by including further persuasive methods and empirically assessing their ethical implications.

Our work uses key factors of ethical relevance that were identified in previous work. We extend the list of these factors and study the ethical acceptability of specific combinations through focus group sessions and a questionnaire-based survey.

3. FOCUS GROUP SESSIONS

In order to gain a better understanding of relevant aspects relating to ethics and persuasive technology in the context of healthy living, we organized two focus group sessions. We were particularly interested in people's understanding of persuasive technology, their reaction to different types of persuasive techniques, and which combination of factors would be perceived as being ethically acceptable. In addition, we wanted to test a set of scenarios in order to select the most useful ones for the subsequent survey study.

In total, seven students from local universities were recruited through word of mouth and via a group set up on a social networking website. We ran two separate focus groups to keep the number of participants manageable. Both sessions were recorded on video, which was later partially transcribed. After a brief initial discussion about ethics and persuasive technology in general, participants were asked to fill out a brief questionnaire, where they had to rank several scenarios according to how ethically acceptable they were. The scenarios were then discussed within the group on and individual basis first. At the end of the session, we encourage subjects to discussing and comparing all scenarios.

In total, we designed five scenarios based on the factors identified in previous work (intent, methods, outcome) but we also included the commissioner of a piece of persuasive technology, the influencer as well as the actual recipient of the persuasive content. By focusing the discussion on five distinct scenarios, we aimed to limit high-level/matter of principle types of discussion, and to probe specific combinations of factors. We also hoped that concrete examples would provide participants with a better understanding of what persuasive technology could be in practice.

3.1 Scenarios

Scenario A was a food diary mobile phone application for teenage girls that provided incentives and motivated the users to follow a healthy diet. It was created and influenced by a private company. We designed this scenario to spark a discussion about using persuasive technology on a group that may be vulnerable in a certain area, as teenage girls often are with regards to weight and body image. We also hoped that the fact of a private company being behind it would be picked up by the focus group.

Scenario B was a website for young adults to monitor their alcohol intake and be persuaded to drink less through social comparisons. The website was provided by the Government to support people to change their own behavior. Questions driving this scenario were whether website would be perceived as an effective way of delivering persuasive content relating to healthy living, and what subjects would make of the use of social comparisons in this context.

Scenario C was a purpose built embedded device for morbidly obese adults to change their eating habits by delivering drastic messages such as "Keep eating like that and you'll be dead soon". It was commissioned by their doctor and paid for by the NHS. This scenario was designed to test extreme conditions and their impact on perception of what would be ethically acceptable. It was also meant to evoke an emotional response to be discussed and any limits that should be placed upon this kind of technology.

Scenario D was a text message system, similar to the warnings on cigarette packets, which were being sent to a mobile phone at the time when the user was about to have a cigarette. A commercial company was presumed to be behind the messages. Key features of this scenario were the pro-active delivery of persuasion as well as the inclusion of contextual factors into the equation.

Finally, scenario E investigated the use of a game to persuade children to eat more fruit. It encouraged them to ask their parents for fruit. The initiators in the scenario were their teachers, who encouraged them to play the game. The main goal of this scenario was to investigate if manipulating children in this way was acceptable and whether 'disguising' persuasion as a game would raise any concerns.

3.2 Outcomes and Observations

The results from the ranking task administered prior to the discussion are summarized in Figure 1. The diagram highlights that except for scenarios A and D there was a very clear ordering, where C was rated as being lowest, E rated highest, and B second highest. While the limited number of scenarios used prevents a

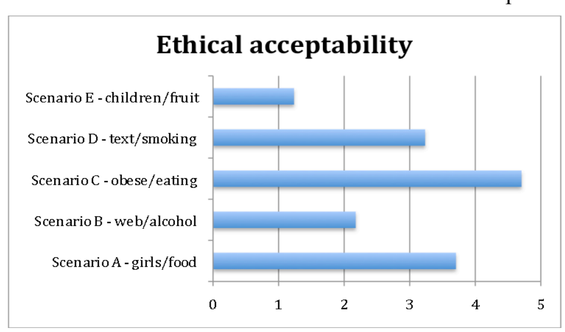

Figure 1 – Ranking of scenarios according to how ethically acceptable they were rated, 1=very ethical, 5=very unethical.

direct analysis with respect to which factors are the key drivers behind people ranking the scenarios as they did, the ranking provides some initial indication that the severity of an outcome may have some considerable impact. Results with respect to the vulnerability of the recipients of persuasion are somewhat inconclusive (as the two scenarios including children and girls) are rated quite differently. We were somewhat surprised by the comparatively low ranking of the texting + smoking scenario, which we believed to be much more acceptable. This might indicate that the proactive delivery of persuasive content may be an important factor to consider (which is a key reason why mobile devices and ubiquitous environments are considered to be very well suited for persuasive technology).

From the video material we also transcribed a number of comments that highlighted various aspects and relationships with respect to applying persuasive technology in the context of healthy living. For scenario A, one participant remarked that “if the NHS was behind it and it was backed up by research it would be ok, the problem is the private investor and influencer”, which hints at the importance of who is commissioning an instance of persuasive technology when assessing it’s ethical acceptability. Another subject stated that “girls have their mobile phones with them all the time and might receive the incentives all the time, but it still encourages healthy eating so it’s still a good thing”, which provides some evidence that context-awareness may be considered ethical under certain circumstances.

Most comments about scenario B questioned the effectiveness of this approach (“people would use this to compete on how much they could drink, especially groups of guys on a night out”) but were not concerned about the ethical implications it might have (“It is not unethical but unworkable, you wouldn’t check the website as you were drinking”).

Scenario C attracted a lot of discussion, in particular with respect to the ‘shock tactics’ being used. Participants voiced concerns about the effects of this method on people’s well-being, e.g. “people who are obese may have low self esteem and if they use this it may make them depressed”, “this is controversial because of the messages, if users are repeatedly told they are going to die, they might give up and eat more anyway”, or “the messages can’t be impersonal and attack people or it will have an effect on their psychological well-being.” However, subjects also came back to the question of who commissioned the technology: “The use of this device depends on a persons character and self esteem, it’s ok if it’s their choice to use it, it’s person specific.”, “It is being given to them by their doctor so it will be ok, their doctor will check their mental stability.”

This aspect of who was behind the persuasive message was discussed for scenario D as well: “c company is making money and they could use it to take advantage, if the NHS were behind it, it would be ok; if it is promoting other products such as patches, then it is unethical.”, “but some private companies already prompt people not to smoke, it is just another venture.” The discussion also brought up a general benefit of computer-based persuasion compared to a human trying to persuade someone: “you would get cross at friends trying to make you stop, it’s a good thing, persistence is good.”

4. SURVEY STUDY

Based on the observations and feedback we gathered during the focus group sessions, we created an online questionnaire to investigate ethical issues pertaining to the use of persuasive technology in the context of healthy living. In order to narrow down the number of factors being investigated simultaneously, we chose to focus on the three aspects that were mentioned most frequently during the focus group sessions: the recipient, the commissioner and the means of delivery.

4.1 Material and Procedure

Three scenarios from the focus group sessions were adapted for the questionnaire: one scenario related to encouraging people to exercise more while at a gym, a second one picked up on helping people to quit smoking, and the final one was built around helping people to change their eating habits. Instead of fixing the three factors mentioned above, we systematically varied them and then asked participants to rate them on a five point Likert scale.

For each scenario, we asked people to assess the ethical appropriateness of a particular technique for two distinct groups of people: healthy people and people who had a condition, which meant that they could greatly benefit from changing their behavior. For the eating scenario, for example, we asked the same questions twice: once for regular people and once for morbidly obese people.

In terms of initiator we also considered two levels for each scenario. One always referred to self-persuasion (i.e. the user chose to use a piece of persuasive technology to change their behavior) and the other one was an external entity. In the first scenario, this entity was the gym (a commercial company), in the second on it was the NHS (National Health Service – a governmental institution), and in the third one the Quick Smoking Campaign (a not-for-profit organization).

The final key factor identified during the focus group sessions was the means use to persuade people. We chose five different techniques, four of which are feasible with today’s technology, in particular using mobile phones, and one that was meant to be an extreme example (electric shocks). The four feasible techniques were: text messages sent to a users mobile phone, public announcements at the location of the user (so that bystanders would know about the failure of the user to change their behavior), notification of friends on Facebook (so that friends would learn about a user’s performance), and restrictions to the user’s bank account (e.g. restricting the amount of money being available to the user depending on their behavior).

For each scenario, there were 20 questions, where participants hat to rate the ethical acceptability of statements describing a specific combination of factors in the context of this specific scenario. We published the survey on a commercial web service and advertised it through a number of mailing lists, web sites and groups on social networking sites. 72 participants (36 male, 36 female) completed the survey. The majority of subjects (61%) fell into the 18-25 years old bracket, with a further 9.7% reporting being between 26 and 35 years old. Equal numbers (11.1% each) indicated their age as being between 36 and 45, respectively 46 and 60. 6.9% reported being over 60 years old.

4.2 Results

We analyzed the results according to different dimensions and factors but due to space (and time) restrictions, not all results of the study can be reported here. In the following paragraphs we summarize some key results that potentially have some implications for the design of persuasive technology in the future.

With respect to the initiator/commissioner of an instance of persuasive technology, we re-affirmed that if a person decides to use persuasive technology, then even drastic measures such as electric shocks are considered predominately unethical. Figure 2 summarizes the responses we obtained for the three scenarios.

The picture was more diverse when looking at how ethically acceptable rated various scenarios. We were not able to identify a clear trend across all three scenarios. When analyzing different means to deliver persuasive content, we found that they varied considerably in terms of how ethical they were considered to be. Text messages were the least problematic, followed by public announcements and Facebook notifications. Interestingly, Facebook announcement appeared to be rated slightly more unethical than public announcements. The most unethical means were bank account restrictions and electric shocks, with the latter consistently being rated as being unethical or very unethical.

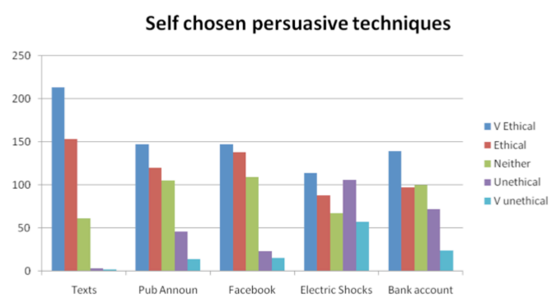

Figure 2. Ethical acceptability of different means to deliver persuasion when self-chosen

The third factor that we had identified during the focus group sessions was the recipient of the persuasive content. For each scenario, we had asked about a healthy and an ill adult. Figure 3 depicts the results we obtained when plotted according to this dimension. As can be seen from the graph, there are considerable differences in terms what participants deemed to be ethically acceptable depending on whether or not the recipient is healthy or ill. For example, almost twice as many subjects considered it to be ethical or very ethical to restrict access to a person's bank account if they were ill (and would thus suffer potentially fatal consequences if they did not respond to the persuasive message.

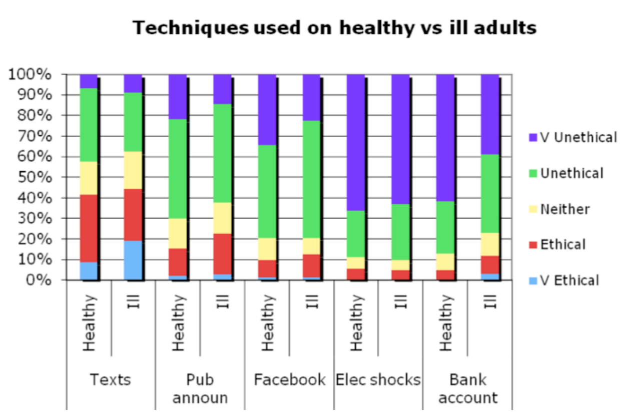

Figure 3. Distribution of ratings sorted by technique used contrasting ill and healthy recipients

5. CONCLUDING REMARKS

The results reported in the previous section as well as the outcomes of the focus group sessions provide some initial insights into the ethics of using persuasive technology to promote healthy living. One interesting aspect relates to the golden rule of persuasion [5] – based on our observations, this rule may have to be revisited as self-chosen persuasive technology appeared to be perceived as being generally more ethically acceptable irrespective of the means being used. Related to this, there also was a trend to rate more drastic measures (such as electric shocks) more ethically acceptable in cases where there was much at stake (such as persuading people with cardio-related illnesses to exercise in order to improve their condition).

There are some lessons designers of future persuasive technology can draw from our studies. We identified three factors that seem to be relevant for people to assess the ethical acceptability of this kind of technology: the recipient, the commissioner, and the means of delivery. It may thus make sense to clearly convey these aspects to users when implementing persuasive technology. We also found evidence that social pressure, such as caused by public announcement or automatic posting on Facebook groups, can be very problematic. Consequently, such techniques need to be carefully analyzed before being implemented. Finally, we specifically included aspects of context adaptation, which are key benefits of persuasive technology built on mobile devices and ubiquitous environments. The focus group sessions hinted at this being perceived as ethically questionable but we did not find a clear trend with respect to this aspect in the survey study. Further research in this area is therefore needed.

6. ACKNOWLEDGEMENTS

This work reported in this paper was partially supported by the EU-funded Balance@Home project.

7. REFERENCES

[1] BBC News. 2009. Obesity in Statistics. http://news.bbc.co.uk/1/hi/health/7151813.stm, retrieved 10 May 2010.

[2] Def. of ethics, Compact Oxford English Dictionary, 2009.

[3] Fogg, B.J. 1998. Persuasive Computers: perspectives and research directions. Proc. of CHI 98, ACM, 225-232.

[4] Fogg, B.J. 2003. Persuasive Technology: Using computers to change what we think and do. Morgan Kaufman Publishers.

[5] Berdichevsky, D., and Neuenschwander, E. 1999. Toward an ethics of persuasive technology. Communications of the ACM, (42) 2, 51-58.

[6] IJsselsteijn, W., de Kort, Y., Midden, C., Eggen, B., and van den Hoven, E. 2006. Persuasive technology for human well-being: setting the scene. Proc. Persuasive '06, Springer, 1-5.

[7] Intille, S. 2004. A new research challenge: persuasive technology to motivate healthy ageing. IEEE Transactions on Information Technology in Biomedicine, 8 (3), 235-237.

[8] Chaterjee , S., and Price, A. 2009. Healthy living with persuasive technologies: framework, issues and challenges. American Medial Information Association, 16 (2), 171-178.

[9] Lehto, T., and Oinas-Kukkonen, H. 2009. The persuasiveness of web-based alcohol interventions. Proc. of I3E '09, 316-327.

[10] Tørning, K., and Oinas-Kukkonen, H. 2009. Persuasive system design: state of the art and future directions. Proc. of Persuasive 2009, 30

Nudging the cart in the supermarket: How much is enough information for food shoppers?

Peter M. Todd
Indiana University
Bloomington
IN 47406, USA
001 812 855-3914
pmtodd@indiana.edu

Yvonne Rogers
The Open University
Milton Keynes
MK7 6AA, UK
011 44 1908 652346
y.rogers@open.ac.uk

Stephen J. Payne
University of Bath
Bath
BA2 7AY, UK
011 44 1225 384085
s.j.payne@bath.ac.uk

ABSTRACT
The amount of information available to help decide what foods to buy and eat is increasing rapidly with the advent of concerns about, and data on, health impacts, environmental effects, and economic consequences. But this glut of information can be distracting or overwhelming when presented within the context of a high time-pressure, low involvement activity such as supermarket shopping. How can we nudge people's food shopping behavior in desired directions through targeted delivery of appropriate information? We are investigating whether augmented reality can deliver relevant 'instant information', that can be interpreted and acted upon *in situ*, enabling people to make more informed choices. The challenge is to balance the need to simplify and streamline the information presented with the need to provide enough information that shoppers can adjust their behavior toward meeting their goals.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Evaluation/methodology.

General Terms
Design, Experimentation, Human Factors.

Keywords
Food information displays, supermarket shopping, ambient information interfaces, simple heuristics

1. INTRODUCTION
Increasingly we are told about the risks, costs, and benefits of particular food choices. In response, a flood of information is becoming available, online, on food labels, in information leaflets and books, from a variety of sources, aimed at informing the consumer so that better decisions can be made while shopping. But all this information risks overwhelming and overloading the shopper trying to navigate the complex store environment in a hurry, leading to the opposite outcome—poor decisions made without the proper input. How can all this information be consolidated, pruned down, and presented to supermarket shoppers in an easy to understand and meaningful form that will actually help them make better choices about values they care about? Technology pundits and researchers are beginning to promote 'augmented reality' that uses Smartphones and other ubiquitous technologies as the latest solution to this problem. Kuang [7], for example, marvels at the possibility: "What if all the food in your grocery store was marked with a QR code — you could compare the carbon footprints of two batches of produce… without having to spend any time or effort looking it up…" He continues by claiming it is "The best chance we have to speed crucial information about our world to the people living in it". This vision, however, begs the research questions: *Will people be able to read and act upon such 'instant information'? Will just throwing more information at people have the desired galvanizing effect of encouraging and empowering people to act upon various social causes (e.g., reducing carbon emissions) or improve their well-being (e.g., changing their diet)? Or do we need to tailor that information glut into simple nudges that make behavior change easy to achieve? And if so, what kind of nudges will work?*

Having instant information at one's fingertips is certainly a promising technological approach but for it to succeed in changing people's behavior we need to understand how new forms of augmented reality are interpreted and used, especially when *in situ*. While the capabilities of the emerging technologies are impressive in how they can project contextualised information, there is a paucity of research into whether people can process and exploit that extra information profitably. While it is easy to imagine soda drinkers enjoying the surprise of being presented with a new branded game or a funny website on their mobile phone it is less clear whether people will make greener and healthier choices whilst managing their weekly budget when presented with extra information of one form or another in the middle of their busy shopping trip. Thus, research is needed, firstly, to determine whether instant information will enable people to make better-informed choices when shopping and secondly, to ascertain whether and how such information is able to change people's behavior in the longer term.

Technology for ubiquitous information delivery must balance giving people enough new information to improve their decisions against overwhelming them with new things to consider. Ambient information displays, as already used in homes and offices to provide feedback about energy consumption and nudge users toward greater conservation, may strike the right balance in food purchase and consumption as well. However, as we discuss below, moving beyond momentary nudges toward long-term

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3/10/09.

behavior change requires providing detailed-enough feedback to enable learning what to do in the future, for instance on the next shopping trip. We argue that we must improve our (currently limited) understanding of whether and how people attend to and learn from visualizations of multi-dimensional information while engaged in an ongoing activity such as food shopping, using cognitive science models of decision-making and learning together with design principles for information visualization and interaction design.

2. BACKGROUND

Rational theories of decision-making [e.g., 15] posit that making a choice involves weighing up the costs and benefits of different courses of action. When alternatives are ordered on more than one relative dimension, this involves compensatory strategies where information is processed exhaustively and trade-offs made between features. Such strategies are very costly in computational and informational terms – not least because they require the decision-maker to find a way to compare apples and oranges. Non-compensatory strategies may be used instead as a form of bounded rationality where not all of the available information is used and trade-offs can be ignored [10]. Furthermore, recent research in cognitive psychology has shown people tend to use simple heuristics of this sort when making decisions [6]. A theoretical explanation is that human minds have evolved to act quickly, making 'just good enough' decisions by using fast and frugal heuristics. We typically ignore most of the available information and rely only on a few important cues. In the supermarket, shoppers make snap judgments based on a paucity of information, such as buying brands they recognize, are low-priced, or have attractive packaging [12] – seldom reading other package information.

At the same time, recent consumer surveys reveal that shoppers are demanding more information about the products they buy and are becoming increasingly aware of the global consequences of the decisions they make [4]. This raises the question of whether it is possible to encourage people to pay attention to *more* information, such as nutritional, ethical, *and* environmental features, when making their food purchases and subsequently deciding how to use what they have bought to make healthy meals that have a low carbon footprint.

However, there is a scarcity of research on how people use multi-dimensional information under time pressure and the extent to which it effects rapid decision-making [5]. Visualization research has tended to adopt an unbounded rationality perspective, assuming that people have the time and cognitive capacity to pull out and use whatever information the displays provide. Within the field of Information Visualization there have been a number of tools that have been developed specifically to represent multidimensional data that allow for comparisons [1]. Other simple canonical forms such as tables and trend graphs have been developed for web-based decision-making activities, including online shopping, making investments, choosing insurance policies or buying a house. An innovative approach has been to develop interactive visualizations that show some aspects of the performance of objects for a range of different parameter values. An early example was the Influence Explorer [14] that allowed a user to compare how products (e.g., a light bulb) perform on core values (e.g., brightness and working life) when varying multiple parameters (e.g., diameter, length, material and number of coils). More recently, Bargrams have been developed for e-commerce applications. For example, EZChooser helps consumers choose one item from many (e.g., cars) through selecting attributes that are visualized as parallel horizontal interactive histograms along a number of dimensions [16].

But even though these kinds of visualizations are mostly targeted at non-expert users, they are essentially visual query languages that require considerable cognitive effort to interpret. Can relevant dimensions of products such as food be represented in simple ways that can be glanced at and perceived rapidly to guide shopping decisions *in situ*?

3. DISPLAYING NUDGES

We propose that rather than providing ever more information to enable consumers to compare products in minute detail when making a choice, a better strategy is to design technological interventions that provide just *enough* information and in the *right* form to facilitate good choices. One solution is to exploit new forms of augmented reality technology that enable 'information-frugal' decision-making, in the context of an intensive activity replete with distractions (i.e., shopping in a supermarket or deciding at the kitchen table what to have for dinner).

An important consideration when representing multiple dimensions that can be glanced at and perceived rapidly is to enable comparisons to be made and cumulative information inferred *in situ*. For example, simple contrasting icons (e.g., thermometer icons, percentage bars, balls that change in color) can be presented which increase or decrease in amount in relation to the values being represented. Another approach is to fuse relative measures on different dimensions (e.g., greenness, price, fat level) into singular displays where shape carries the salient information, such as a rectangle that gets taller to convey a nutritional dimension that is general (healthiness) or specific (e.g., salt content) and wider to convey price. A third dimension, such as 'greenness', could be added by filling in the rectangle with a shade from red to green to show the amount of carbon emissions for that product. Similar to the idea behind Chernoff faces, the visualizations will be placed side by side to enable quick comparisons.

Another important question is whether to use 'emotive' visualizations that can persuade people to select food items they might not otherwise choose. Various persuasive technologies have recently been developed to encourage people to take more exercise. Examples include Fish'n'Steps [8]; Chick Clique ([13] and UbiFit [2] where various types of graphic representations (e.g., butterflies, flowers, bar charts) are used to represent amount of exercise type performed, e.g., cardio, strength training, and walking. Findings from a three-month field trial of UbiFit showed that these display systems can be motivating, encouraging participants to maintain fitness levels that were significantly higher than for a control group without the visualizations [3].

More dramatically, Shultz et al. [11] have shown how emoticons can have a powerful effect on changing behavior for energy consumption. In their study, a number of householders were told exactly how much energy they had used and the average consumption of energy by others in their neighborhood. The above-average energy users then significantly decreased their energy use while the below-average energy users significantly increased theirs (presumably because they felt they had more room to increase their consumption). But then the researchers tested the effect of instead giving householders who consumed more than average an unhappy smiley icon – suggesting it was socially disapproved – and those who consumed less than the norm a happy smiley icon – suggesting their energy consumption was socially approved. The impact of providing these two visualizations was dramatic: The big energy users showed an even *larger* decrease in their energy use while the below-average users did not change their energy consumption upward (presumably because the addition of the happy emoticon suggested they were doing just fine).

4. LEARNING FROM NUDGES

What then is a good way to provide appropriate information quickly and simply to shoppers in order to aid their decision-making during the hectic, distracting setting of a trip to the supermarket? Here we assume the shoppers have selected a particular dimension that they care about and want to change in terms of their buying behavior—for instance, choosing products that are lower fat, or more sustainably grown. To inform shoppers about how they are doing in achieving this particular goal during their shopping expedition, cumulative values of the dimensions of interest across all products chosen so far could be summed up and displayed in an ambient manner as the current ongoing overall score "projected" onto the handle of the shopping cart as a color. For example, a green handle could signify that the shopper has obtained a 'carbon footprint' or 'fat content' score below their target (or below some population average), while a red handle would indicate that the cart's contents are above the desired level, with intermediate levels indicated by intermediate colors (see Figure 1).

Figure 1: Two hypothetical shopping carts with (a) red and (b) green glowing handles, indicating aggregate 'healthiness' of products selected relative to the average for a weekly shop for a family of four

Such an ambient and publicly visible display must first be studied to see if it fits with how people want to shop, or engenders unexpected side-effects. Will people be more or less likely to change their behavior when information about the contents of their shopping cart is publicly visible for all to see rather than being privately displayed? Would shoppers try to fill their cart with healthy and green foods and on finding they were under the average then treat themselves to luxury goods high in fat and food miles? Would having their shopping cart glow green at the check-out, indicating the contents were well below the average, make them feel good in front of other shoppers [11]? Would the prospect of others seeing just how much butter and cheese they are buying make shoppers think about buying less, or just thinking about shopping elsewhere?

Assuming such an ambient information display *Cumulative Tool* achieves the desired features of providing some feedback without overloading the decision maker, without undesired effects of scaring shoppers off or making them "boomerang" and offset their good behavior with poorer choices, the question remains whether this kind of simple display provides *enough* feedback to allow the shopper to adjust behavior in the desired direction, e.g. reduced sodium or enhanced green-ness. Seeing that one's entire cart is red-lining above the goal level may motivate behavior, but it does not directly indicate what to do to bring the level back down. Thus, we must develop and test methods for ensuring that the (minimal) information delivered is actually actionable and conducive to behavior change.

There are at least three approaches that can be taken to solving this problem, which is essentially one of allocating global feedback appropriately to individual choices of products (akin to the "credit assignment" problem in machine learning). First, we could leave it all up to the users, and assume (or hope) that when they end their shop with a "green" cart, they will buy more things like those the next time around, and when they get a "red" cart, they will buy different things next time. This leverages the human shopper's intelligent ability to learn from diffuse reinforcement over time, but it will probably be slow, requiring many shopping outings before reliable change occurs. Second, to speed up this process, we could provide more specific feedback about each product that goes into the cart, for instance momentarily flashing the ambient display with a color corresponding to the box of sugar-frosted chocolate bombs or bag of figs being chosen. This will allow shoppers to make more targeted decisions about each product, provided they remember that individual feedback.

Third, to remove the need for such memory, a further interface can be developed to let shoppers query how they should adjust their purchases to come closer to their goal. This could take two main forms. A *Comparative Tool* could run as a 'private' mobile application on a smartphone or PDA and be displayed on the device or somewhere in the environment, such as the shopper's hand or the product package itself. After identifying the product via a photo or code scanner, the tool will show the product values on the dimensions of interest, and indicate whether this product helps or hinders the achievement of the current shopping goal. This interface could also be used in a comparative manner, scanning two or more products while they are still on the shelf and then showing at a glance which product is best based on the selected dimensions.

As a second 'off-line' form of providing more explicit feedback, a *Collaborative Tool* running on a home computer or surface display would allow shoppers to find out further information about the products they have bought once they get them home, along with input from their families. Multiple users could reflect and discuss together the decisions behind their food purchases with a view to attaining their goals at their next weekly shop, exploiting collaborative planning and social pressures that take place in a family setting. An interactive planner application would enable family members to find out more about particular dimensions (e.g., nutritional values) on a product, meal, or weekly-shop basis, and provide recipe-specific visualizations enabling items to be swapped. For example, a suggestion by dad to cook coq-au-vin for dinner will show it is low on 'greenness' (because of a large carbon footprint). This is a dimension the son has selected as an informational layer. Alternative items can be swapped with the chicken, such as tofu, which may then be shown by the application to have a higher greenness value (i.e., smaller carbon footprint). Finally, specific shopping lists could be generated that would achieve the goals set by the shopper and others involved.

To test whether any of these approaches succeeds in nudging shoppers' behaviour in specific directions within a reasonable time-span, both lab-based experiments and field studies are needed. One line of investigation must assess how the different information displays for the tools described above affect user decision-making strategy, focusing on when and how the interactive display of information enables fast and frugal decisions. This must then be tested further in supermarket studies, using techniques such as mobile eye tracking, observation and talk aloud methods to determine what people look at and how they use the comparative and cumulative tools. Longitudinal studies are also needed to determine whether the tools proposed have long-term impact on behavior, and how quickly such change occurs. Various kinds of households (e.g., family, young people, retired single) should be compared in terms of whether and how their shopping patterns and meal planning behavior change when using the tools—different groups of people may be more or less influenced by different types of nudges, and we cannot assume a one-size-fits-all approach.

Whether these various kinds of information delivery can help move people in the direction of better decisions—in the food shopping domain, or in other applications—remains to be seen. Emerging research suggests that simple visualizations can be designed to be information-frugal and emotive – encouraging people to change their behavior at the point of decision-making. But the trick will be balancing frugality and simplicity with *enough* feedback detail to allow people to change their choices at a pace that is sufficiently rapid and noticeable to be rewarding and motivating for long-term behavior change.

5. ACKNOWLEDGEMENTS

Thanks to Ricky Morris for creating Figure 1.

6. REFERENCES

[1] Card, S., Mackinlay, J., Shneidermann, B. (1999) *Readings in Information Visualization*. Academic Press.

[2] Consolvo, S., Klasnja, P., McDonald, D. W., et al. (2008) Flowers or a robot army?: encouraging awareness & activity with personal, mobile displays. *Proc. UbiComp'08,* 54-63.

[3] Consolvo, S., McDonald, D.W., and Landay, J.A. (2009) Theory-driven design strategies for technologies that support behavior change in everyday life. *Proc. CHI '09,* 405-414.

[4] EDS IDG Shopping Report (2007) Shopping Choices: attraction or distraction? Downloaded 28/08/09 http://www.eds.com/industries/cir/downloads/EDSIDGReport_aw_final.pdf

[5] Feunekes G., Gortemaker, I.. Willems, A., et al (2008) Front-of-pack nutrition labelling: Testing effectiveness of different nutrition labelling formats front-of-pack in 4 European countries, *Appetite,* 50, 57-70

[6] Gigerenzer, G., Todd, P.M., and the ABC Research Group (1999) *Simple heuristics that make us smart*. New York: Oxford University Press.

[7] Kuang, C. (2009) Better Choices through technology. Downloaded http://www.good.is/post/better-choices-through-technology/ 28/8/09

[8] Lin, J.J. Mamykina, L., Lindtner, S., Delajoux, G. and Strub, H. (2006) Fish 'n' Steps: Encouraging Physical Activity with an Interactive Computer Game. *Proceedings of UbiComp*. 261-278.

[9] Rogers, Y., Lim, Y. Hazlewood, W. and Marshall, P. (2009) Equal opportunities: Do shareable interfaces promote more group participation than single users displays? *Human-Computer Interaction*, 24 (2), 79-116.

[10] Rothrock, L & Yin, J. (2008) Integrating compensatory and non-compensatory decision making strategies in dynamic task environments. In T Kugler et al. (eds) *Decision Modeling and Behavior in Complex Environments*. NY: Springer

[11] Shultz, W., Nolan, J., Cialdini, R., Goldstein, N., and Griskevicius, V. (2007) The constructive, destructive and reconstructive power of social norms. *Psychological Science,* 18, 429-34.

[12] Todd, P.M. (2007) How much information do we need? *European Journal of Operational Research,* 177, 1317-1332.

[13] Toscos, T., Faber, A.M., An, S. and Gandhi, M. (2006) Chick clique: persuasive technology to motivate teenage girls to exercise. *Proc. CHI Extended Abstracts,* 1873-1878.

[14] Tweedie, L., Spence, B., Williams, D., Bhogal, R. (1994) The attribute explorer. *CHI Companion Proceedings*, 435-436.

[15] von Neumann, J. and Morgenstern, O. (1944) *Theory of Games and Economic Behavior.* Princeton University Press.

[16] Wittenburg, K., Lanning, T., Heinrichs, M. and Stanton, M. (2001) Parallel bargrams for consumer-based information exploration and choice. *UIST Proceedings,* 51-60.

Motivate Environmentally Sustainable Thermostat-Use through Goal-Setting, Just-In-Time Recommendations, and Behavior Reflection

Christian Koehler
M-ITI, University of Madeira
Campus da Penteada
9020-105, Funchal, Madeira
christian@m-iti.org

Anind K. Dey
HCI Institute
Carnegie Mellon University
Pittsburgh, PA 15213 USA
anind@cs.cmu.edu

Jennifer Mankoff
HCI Institute
Carnegie Mellon University
Pittsburgh, PA 15213 USA
jmankoff@cs.cmu.edu

Ian Oakley
M-ITI, University of Madeira
Campus da Penteada
9020-105, Funchal, Madeira
ian@uma.pt

ABSTRACT

Rising power demands resulting from technological advancements is an increasingly important global issue. One way to tackle this problem is to motivate individual behavior change, for which the ubiquity of mobile phones offer an ideal platform to influence consumption behavior of users. In this paper we explore the possibilities for using timely recommendations, goal-setting, immediate feedback, and visualization of past consumption behavior in order to motivate people to reduce power consumption resulting from heating/cooling devices. We describe a mobile application which gives the user direct access to the thermostat and provides feedback everyday on how sustainable the user was on the previous day. In addition to this feedback, it gives recommendations to improve the behavior and also offers a behavior overview. The contributions of this paper include a working system for remote control over the thermostat and a goal-setting, recommendation, and feedback application designed to influence a user's behavior.

Categories and Subject Descriptors

H5.m. [**Information interfaces and presentation**]: e.g., HCI

Keywords

Eco-feedback, Sustainability, Environmental HCI

General Terms

Design, Human Factors

1. INTRODUCTION

Technological advancements over the past few decades have allowed us to live more comfortable lives at the cost of consuming increased amounts of energy. Devices like refrigerators, air conditioning units, or home entertainment systems provide quality of life improvements at the cost of placing strain on limited global resources. As recognition and awareness of this trend have grown, there have been increasing calls for citizens to use resources responsibly. Investigations into how energy is consumed in homes provide valuable suggestions for how this goal can be achieved and indicate that temperature regulation systems (such as furnaces and air conditioners) are a key target. They are reported to be responsible for nearly 25% of the consumption in an average American household [7].

Despite the high-energy consumption (and costs) incurred by these systems, studies indicate that there are problems with devices intended to increase their efficiency. For instance, programmable thermostats are capable of decreasing the energy use of a temperature regulation system by relaxing the maintained temperatures during particular time periods, such as when homes are empty during the workday. However, 14% of users are reported to not own such a system and, of those that do possess one, over 40% do not use it [8]. Widespread misconceptions also exist regarding suitable home temperatures. For instance, a 2007 interview study [5] reported that 41% of interviewees believed that room temperatures should be lower in summer than in winter. The authors concluded this results in overly cool rooms in summer wasting a lot of power.

These findings also suggest that, generally, people have poor awareness of how their consumption choices and behavior affects the environment. Sensing technologies capable of capturing a user's activity can be combined with digital displays of consumption (e.g., websites, ambient displays, mobile devices) to address this issue and raise awareness of the impact of particular choices. Such systems and devices, which are intended to inform users about the current state of their consumption and their impact on the environment, are known as "eco-feedback technology" [3]. Eco-feedback technology can be used to motivate users to change their long-term behavior.

Research in psychology can inform the development of systems that change a user's behavior. In a recent survey paper, He et al. [4] discussed a wide range of psychological literature and developed a "motivational framework based on

MobileHCI 2010 September 7-10, 2010, Lisboa, Portugal.
ACM 978-1-60558-835-3.

the Transtheoretical (or Stages of Behavior Change) Model". One of their conclusions was that behavior change happens in stages and that each stage should be supported by qualitatively different kinds of feedback.

An earlier review of environmental psychology papers performed by Abrahamse et al. [1] evaluated the effectiveness of two intervention strategies - antecedent and consequence strategies. They described antecedent intervention to "influence one or more determinants prior to the performance of behavior" and considered four techniques: commitment, goal setting, information, and modeling. One of the conclusions they drew was that presenting the user with one of these interventions alone is not sufficient, but for example combining them with other techniques such as feedback proved effective in influencing behavior. Consequence strategies on the other hand are based on the assumption that providing users with positive or negative consequences will influence behavior. They analyzed how different forms of feedback (e.g., continuous, daily, weekly, monthly, or comparative) and the presence of real world rewards influence behavior.They concluded that individual feedback combined with comparative feedback provided also energy reduction in the long run. Rewards on the other hand had only a short-term effect according to their analysis. This strongly suggests that making users aware of their consumption behaviors is an effective method for encouraging their reduction. This is the approach adopted in this work.

We suggest that mobile devices are an ideal platform on which to offer motivation to users and convey benefits incompatible with the functionality of stationary devices. For example, we can use sensors provided by mobile phones (e.g., location sensor, accelerometer, etc.) to infer the user's current activity and predict future ones. This functionality can be used to provide just-in-time feedback about the outcome of actions and provide live recommendations of alternatives.

Integrating all this literature, this paper introduces a mobile application designed to give users feedback about their past behavior, provide timely recommendations to promote behavior change related to temperature regulation power consumption, and to support users in the achievement of the long-term goal of consuming less power in temperature regulation while they are not at home. The application we developed allows users to remotely and conveniently control the thermostat in their apartment using their phone. We believe that the system can be deployed most effectively in the motivations stages of Preparation, Action, and Maintenance identified in the Transtheoretical model described above. The remainder of the paper provides a description of the application and outlines the structure of a study that we intend to run as the next stage of our work.

2. SYSTEM DESCRIPTION

We designed a system to help people reduce power consumption resulting from domestic heating and cooling devices. It informs the user about his behavior by giving an overview over past consumption in the form of a graph. Studies have shown [1] that providing the user with tailored information about their consumption can result in reduced energy consumption. Through timely recommendations on how to save energy, the system aims to help the user's decision-making process to behave more environmentally sustainably. In order to further motivate the user, he is given a savings goal and the application indicates how well this goal was met the day before, the current week, or the current month. We provide the user with the challenging goal of reducing at-home temperature to 65°F, because previous work has shown that more attainable goals, although easier to achieve, have lower rates of success [1].The system is designed to inform the user and motivate him to change his long-term behavior. We intentionally combined goal-setting with feedback techniques and tailored information to increase the chances that people will reduce energy consumption.

Through a mobile phone application, the user is offered remote control over the thermostat. This allows error recovery in case the user forgot to set the thermostat before leaving the house. In addition to supporting manual and programmatic control of the at-home temperature, we also offer automatic control over the thermostat, reducing energy consumption when the user is not at home, and returning the at-home temperature to a desired level when the system predicts the user is returning home. In doing so, the system aims to support the user in setting the right temperatures.

The advantage the system offers a user is not only error recovery through remote control, but also feedback if a behavior was environmentally positive or negative. Additionally it provides positive reinforcement if the behavior the day before was positive or timely suggestions on how to improve the behavior in case it was not positive.

To support the automated control of the thermostat, we gather continuous location information using a mobile application. Using the current location and past movement data we are able to determine the time a user is predicted to return home. We leverage a robust location prediction algorithm developed by our research group, which aims to predict future destinations based on prior and current movement data ([9]). Using this predicted return time, we can automatically control the thermostat as described above. The location information is not only used for predicting a user's return time, but also to calculate how much power was consumed by heating/cooling devices during the time the user is not at home and while he is at home.

In addition to location information we also collect inside, outside, and the thermostat's temperature setting for the user's apartment. This information is used to provide feedback on the user's behavior and also to give recommendations on how to improve an environmentally negative behavior. To understand a user's reasoning for changing the thermostat's set temperature, we also query the user immediately after a manual change to a higher temperature has occurred.

The system was based on a commercial home automation system from Insteon [6] and a custom mobile phone application written on Google Android. Logically it consists of three main parts: the home automation system, the mobile phone, and a central server. The following two sections will give a short description of the home automation system and then describe the mobile phone application.

2.1 Home Automation System

Home automation - the use of small modules to extend appliances with remote control and automation features - is a commercially available technology. The Insteon system used in this work allows the remote regulation of home temperature and also provides support for the calculation of power consumption. Calculating the power consumption of heating or cooling devices (e.g., furnaces or air conditioner) is a complex problem, because it not only depends on the length of time a device is active, but also on a set of complex variables including: the efficiency of the heating/cooling device, the volume of the home space, the current inside and outside temperature, the thickness and material of the walls, the number of walls exposed to outside conditions, and the number and kind of windows in the walls, to name a few issues. Because measuring these data is challenging for individual users the system presented in this paper used a simplified set of calculations using an equation provided by the U.S. Department of Energy:

$$\text{AHC(city)} = \text{C}_{adj} * (\frac{hdd_{city}}{hdd_{us}}) * (1 + S * (T_{wAvg} - T_{typ}))$$

Legend:

AHC(city)	=	Annual Heating Costs for city
C_{adj}	=	Adjusted consumption (gas furnace) in mBTU
$\text{hdd}_{city/us}$	=	Average number of Heating Degree Days
S	=	Savings per degree of setback temperature in percent
T_{wAvg}	=	Set temperature as weighted average
T_{typ}	=	Typical indoor temperature during heating season

This equation assumes standard values for some of these variables and uses differences between inside and outside temperature and the number of hours the user was at home and away from home to calculate the power consumption. We believe the results of this calculation to be sufficiently indicative of real consumption to serve as effective feedback.

2.2 Mobile Phone Application

The mobile phone application was developed and deployed on T-Mobile G1 phones running Google Android. It consists of several components and is the core of the system described in this paper. Its key function is to collect and transmit its current location to a central server in real time and support the motivational techniques described in the beginning of this chapter. Using the transmitted location it enables us to estimate whether or not a user is at home, or whether they are likely to return home in the near future. Furthermore we are able to calculate the power consumption while the user is at home or out and about in the world. The application provides an interface composed of three main components: a temperature control screen which allows remote control over the home automation system, a graph overview showing past behavior, and a recommendation screen. Each of these components is introduced in the following subsections.

2.3 Temperature Control

This interface component allows users to view and control the current temperature in their homes. This feature was intended to support error recovery (for instance, by allowing correction after forgetting to adjust the temperature settings prior to leaving home) but also to provide a sense of security and control - to reassure users that they remain in control of the system even though it incorporates significant automated elements. Such privacy and lack of control

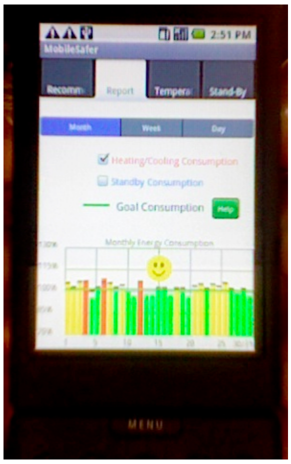

Figure 1: Screenshot of Graph Overview Screen.

concerns are often raised with novel technology incorporating automation or context sensing control and can result in users developing negative opinions about the systems. By providing a manual override, the system presented in this paper hopes to avoid this problem. In addition to remote control we also ask the user why he increased the temperature in the apartment, because we also strive to understand a user's reasoning it.

2.4 Graph Overview

The graph overview is one of the core feedback mechanisms in the application. As illustrated in **Figure 1**, it offers users a consumption overview split into daily, weekly, and monthly activity. Each sub-graph includes a goal line highlighting the difference between intended and achieved levels of consumption. This is highlighted using a simple red, yellow, and green color scheme. This visualization is designed so that users can see at a glance their performance over days, weeks and months. By including these longer periods of time, the system aims to convey a sense of mounting achievement and provide motivation to continue with and/or improve sustainable behaviors. In order to further support this and provide positive reinforcement, a small smiley face is shown if users achieve green behavior for more than half of the days in a particular week or month. As described in [4], individuals profit from positive reinforcement of their actions, which gives them a feeling of success and competence. The graph system is designed to provide such feedback.

2.5 Recommendations

The recommendations screen aims to provide recommendations to users on how to achieve consumption goals through behaving sustainably. Once again, to present a clear visual representation we adopted a simple red, yellow and green color scheme for this UI. The user is shown a green screen when he behaves sustainably the previous day, by turning down the temperature while away from home to at least 60°F and turning down the temperature to 65°F while at home. If the user sets a higher temperature while at home, he is shown a yellow screen. If the temperature is consistently high throughout the day, the system will show him a red screen. For the yellow and red screen we give the user a recommendation on how to achieve sustainable behavior, which is in essence an explanation about why his behavior was not sustainable. We also suggest wearing additional clothing to compensate for cool temperatures at home.

In addition to recommendations and behavior indications we also inform users about the environmental impact of the wasteful behavior of leaving temperature regulation systems active in empty homes. This is done simply by calculating and presenting the number of 60W light bulbs that could have be powered by the wasted energy.

The recommendations screen is the first screen shown to the user upon application startup. Every morning the phone notifies the user about the previous days consumption data by flashing the onboard LED and vibrating. The goal of this feedback is to provide positive reinforcement for sustainable behavior and to inform users about the impact of their behavior on the environment. In this way, we hope to provide an incentive for users to alter unsustainable behaviors. Our application informs users about problematic behaviors, highlights the impact of these behaviors, and gives specific recommendations on how to enact change. By showing this information in the mornings, prior to regular departures to work, we hope to be able influence the user's behavior in a timely and appropriate fashion. Studies have shown [2] that frequently updated feedbacks with multiple feedback options such as comparisons of several days or providing additional information sources like recommendations are most effective.

3. STUDY DESCRIPTION

In order to test the system and evaluate whether or not it can influence a user's behavior and awareness of environmental issues, a field study of the system is planned. This will take place in winter 2010/2011 and will use a group of 20 recruited participants residing in a city which experiences sub-zero temperatures and significant snowfall for several months. The group will be split into 2 sub-groups, with each group initially being in a manual condition where the user has to change the temperature on his own volition or an automatic condition where the system automatically sets the away-from-home temperature The study will be separated into two phases and each phase will go for 4 weeks, with a study length of 8 weeks in total. After 4 weeks the two sub-groups will switch conditions.

Prior to the study, GPS location data will be captured from each user and used to train the location prediction model and to calculate baseline consumption data. In order to measure environmental attitudes and temperature comfort levels both before and after the study participants will be required to fill out a survey every week. The survey is split into two categories, a temperature survey that will be distributed weekly and a survey to measure environmental attitude, locus-of-control, and self-efficacy that will be conducted at the beginning, middle, and end of the study. The temperature comfort survey will give us data on how the subjective comfort of the user changes through use of our system. We believe that a successful application that aims at changing a users environmental behavior also has to consider a user's comfort level. A system that disregards an individual's subjective comfort level could be unsuccessful because the user rejects it. One goal of our system is to change a user's environmental behavior, thus we need a way to evaluate the impact our two versions of the system have on the environmental awareness of the users. Because we also give the user information about his environmental behavior and recommend actions to change environmentally bad behavior, we measure the locus-of-control and self-efficacy of a user at the beginning, middle, and end of the study. This information will tell us if there was a change, for example, from external locus-of-control, the state where outside sources influence events happening in our life's, to internal locus-of-control, the state where the user himself affects events. Measuring self-efficacy will tell us if our system had a self-empowering effect on users, where they increasingly got confident to influence their environmental behavior.

4. SUMMARY

In this paper we first gave an introduction into the problem space of home power consumption and explained some of the problems with the current use of thermostats. Additionally we highlight how research results from psychology can help to influence a user's behavior and reduce power consumption resulting from heating/cooling devices.

We then described a working prototype of a mobile application designed to influence a user's sustainable practices. Our prototype allows remote control and automated control over the thermostat, gives the user a goal to achieve, provides daily feedback on how well this goal was met, recommendations to achieve the goal (or positive reinforcement in case the goal met), and an overview over past consumption behavior. Our immediate next work is to conduct a study of this prototype with 20 people in the fall.

5. REFERENCES

[1] Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology.

[2] Fischer, C. Feedback on household electricity consumption: a tool for saving energy? Energy Efficiency 1.

[3] Froehlich, J., Findlater, L., and Landay, J. The design of eco-feedback technology. Proc. CHI 2010.

[4] He, H. A., Greenberg, S., and Huang, E. M. One size does not fit all: Applying the transtheoretical model to energy feedback technology design. Proc. CHI 2010.

[5] Karjalainen, S., and VastamŁki, R. *Occupants Have a False Idea of Comfortable Summer Season Temperatures. Proc. Clima.*

[6] Smarthome*. Insteon Home Automation Systems. http://www.insteon.net/.*

[7] US Dept. of Energy*. Energy information administration, US Household Electricity Report, 2005.* $www.eia.doe.gov/emeu/reps/enduse/er01_us.html$.

[8] US Dept. of Energy*. Energy Information Administration, international energy outlook, 2008. www.eia.doe.gov/oiaf/ieo/enduse.html.*

[9] Ziebart, B. D., Maas, A. L., Dey, A. K., and Bagnell, J. A. *Navigate Like a Cabbie: Probabilistic Reasoning from Observed Context-Aware Behavior. Ubicomp.*