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# The Augmented Shopping Trolley: An Ambient Display To Provide Shoppers with Non-Obvious Product Information

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**ABSTRACT**
The Augmented Shopping Trolley consists of an ambient handlebar display connected to a scanner. When a shopper scans an item the handlebar lights up to provide them with information about the product, such as its nutritional, ethical or environmental attributes, that are not obvious from its packaging or label. The system is designed to seamlessly integrate with a shopping experience: it uses familiar supermarket technologies; it keeps both of a shopper's hands free; and the simple ambient display facilitates the 'fast and frugal' decision-making typically observed in a supermarket. Our initial lab-based study shows that the display can be understood at a glance and used to select items based on a product's *nominal* properties (for example, it is organic), *ordinal* properties (for example, it has low, medium or high food miles), as well as a combination of the two at the same time. Where as usability was the focus of our initial design, ethical issues have come to the fore as we develop the system for use in supermarkets and we discuss how these are influencing our design.

**Author Keywords**
Persuasive technologies, ambient display, shopping, product information, ethics.

**ACM Classification Keywords**
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

**INTRODUCTION**
In a supermarket, shoppers tend to make snap judgments based on just a few salient cues (low price, recognized brand and attractive packaging) and they rarely take time to read product information labels [7]. However, recent consumer surveys indicate that shoppers want more information about the global consequences of their consumer decisions [2]. Our goal is to provide 'non-obvious' nutritional, ethical and environmental product information, that is, information that is not immediately obvious from an item's packaging or label, in a form that is as salient as the features that typically inform consumers' decision making. The Augmented Shopping Trolley (Figure 1) is designed so that it fits as seamlessly as possible into a supermarket shopping experience. We use familiar supermarket technologies: augmenting a standard shopping trolley by attaching a scanner and embedding an ambient display in the handlebar. This gives our system two advantages over using mobile devices to provide product information. First, the trolley scanning technology is faster [4] and second, because the ambient display is built into the trolley handlebar a customer's shopping experience is not disrupted by having to repeatedly access and store a mobile display. Underhill [10, see chapter 4] emphasizes the importance of having both hands free during shopping.

**Figure 1. The Augmented Shopping Trolley display consists of 16 LEDs embedded in the handlebar, each of which can be set to green, red or orange**

Our approach to designing an effective ambient display, first outlined in [9], is motivated by studies of ecological rationality which investigate how people make reasonable decisions given the constraints of limited time, information and computational resources that characterize most real world situations [6, 8]. This research indicates that most natural decision making is made on the basis of 'fast and frugal' heuristics – short-cut strategies where people ignore most of the available data and instead focus on the most useful information and process it quickly. Often people make a decision based on a single reason as this strategy is quick and simple and avoids having to weigh up trade-offs between multiple and potentially conflicting options. This approach is not rational in certain environments, namely, those where available pieces of information are approximately equally useful. However, in a shopping environment, the distribution of information usefulness is highly skewed, that is, the most useful piece of information is a lot more important than the second most useful, which in turn is considerably more important than the third, etc. Our handlebar ambient display consists of just sixteen LEDs. When a shopper scans a product, a few pieces of non-obvious information, such as whether it contains nuts, is fair trade or has low food miles, are displayed as a salient pattern on the display.

Given that information salience influences a person's behaviour unconsciously [1], rather than through rational reflection, this raises ethical concerns about the Augmented Shopping Trolley, chief of which is that this system could potentially manipulate people into behaving in ways that they would not otherwise do, and furthermore, that they might not be aware that they had been manipulated. This concern, and also issues to do with privacy and clarifying how our system benefits shoppers, form the ethical considerations that are influencing how we deploy the Augmented Shopping Trolley in a supermarket.

The paper is structured as follows: first, we describe the display hardware and how it conveys product information; second, we describe a lab-based evaluation of the system that demonstrates the efficacy of the ambient handlebar display for conveying non-obvious product information; and third, we describe the ethical issues that are informing the development of the system for use in supermarkets.

## AMBIENT HANDLEBAR DISPLAY DESIGN

The handlebar display was designed to provide shoppers with salient and easy to read information about a scanned product's nominal properties (for example, whether it is organic or contains nuts), its ordinal properties (for example, if it has low, medium or high food miles), as well as a combination of the two at the same time. We constructed the display by attaching 16 bicolour LED units to a piece of wood inside a transparent plastic tube (Figure 1). This replaced the plastic handlebar in a standard shopping trolley. The LEDs are controlled using 2 TLC5940 chips (Texas Instruments) that are driven by an Arduino microcontroller. In our lab-based study this is attached via a USB cable to a laptop running a Processing application. Each LED unit can be set to red, green or orange (when both the green and red LEDs are on). Each time a product is scanned, the display changes in the following way. First, it goes from an all green background (idle state) to a half second sweeping movement of orange that indicates scanning is in progress. There is then a beep, as typically heard at a checkout counter, to signal that scanning is completed and the display then changes to a new state that provides relevant information about the product. If the display is configured to show a nominal property of the product, then it flashes green if the property is present and shows the idle state if it is not. If the display is providing ordinal information about the product, the display employs a bar graph metaphor, with the number of red pixels indicating the degree to which an item has a property. Specifically, if an item has a low degree of a property then pixels 1-3 turn red and 4-16 turn green; if medium then pixels 1-8 turn red and pixels 9-16 turn green; and pixels 1–13 turn red and 14-16 turn green if the item has a high degree of a particular property. Finally, both these representations can be combined to show the value of a nominal and an ordinal property at the same time. In our study, after a participant selected or discarded an item, the display changed back to the all green idle state.

## LAB-BASED SYSTEM EVALUATION

5 adults (1 female, 4 male, aged between 20 and 40) took part in a lab-based evaluation of the Augmented Shopping Trolley. Each participant completed 12 shopping scenarios where they were asked to pick up and scan 5 items of a particular product type and only select those items that met specified criteria. A scanner was attached to the shopping trolley (Figure 1) but was non-functional and the handlebar display was changed using a Wizard of Oz methodology.

On the basis of the changes in the patterns on the handlebar display, participants had to decide whether to select the item and place it in their trolley or discard it and place it on an adjacent table. Since this was an exploratory study, we were intentionally vague about the operation of the ambient display as we wanted to see whether participants could understand it intuitively. We only told participants that the display patterns would change depending on whether a product had a specific property (yes/no), the degree to which a product had some property (high/medium/low) or a combination of the two. Participants were allowed to scan the items as many times as they wanted and in any order, before they made their decision about whether to select a particular item. We used 4 product types: milk; breakfast cereal; wine; and juice. Each shopping scenario used one of the product types and participants were asked to select from 5 different items. For example, select those bottles of wines that meet the specified criterion (fair trade) and put them in the trolley, and place the others on the discarded items table. Each of the items was a real product but we masked any product information on the packaging and told participants to only use the handlebar display to decide whether they should select an item or not. The experimenter playing the Wizard of Oz role sat at a table on which the 20 shopping items were grouped by product type. Each item was individually numbered so that the experimenter could change the display appropriately when the participants scanned a particular item.

In the first 4 shopping scenarios the handlebar display indicated whether a scanned item had a particular nominal property or not: whether a milk product was organic; whether a breakfast cereal contained nuts; whether a bottle of wine was fair trade; and whether a carton of juice contained added sugar. In 2 of these scenarios the participants had to *select* items that had a particular property and in the other half they had to *discard* items if they had a particular property. For example, in the first shopping scenario participants had to select a milk product if it was organic and discard it if it was non-organic; in the second shopping scenario participants had to select a breakfast cereal if it did *not* contain nuts and discard it if it did.

In the next stage of the evaluation, the participants completed 4 shopping scenarios where the display indicated whether a product contained a low, medium or high value of a particular ordinal property. The task was to select items that had a specified property to a particular degree. Specifically, participants were asked to select milk with a medium fat content, cereals with a high sugar content, wine with low food miles and juice with a medium water content. In none of these scenarios were participants asked to discard items if they had properties of a particular degree. The final 4 shopping scenarios tested whether participants could understand the display when it simultaneously showed information about both a nominal and an ordinal property of a scanned item. Participants were asked to select milk that was organic and low fat, cereals that contained nuts and had a medium sugar content, juice that had added sugar and high water content and wine that was not fair trade and had medium food miles. Only in the wine scenario did participants have to reject items on the basis of information about a nominal property of the product.

## USABILITY RESULTS

4 out of the 5 participants were able to interpret the ambient handlebar display and complete all the tasks without any mistakes. The other participant made one consistent error in 2 of the first shopping scenarios where the task was to discard items if they had a particular nominal property: they selected, rather than discarded, them, but did not repeat this error in the final shopping scenario which also required an item to be discarded if it had a particular nominal property. Several participants reported that they found the tasks where they had to discard items with particular properties more difficult and it did seem to increase the cognitive load in all participants, resulting in a slightly slower response time (approximately 2 seconds, rather than 1 second for the other conditions). This could be due to the colours used in the display: a nominal property is indicated by a green blinking display, a colour that many people associate with positive properties, rather than ones that should be avoided. All participants reported that the display was intuitive to use and were able to quickly read it even though they were not given explicit information on the meaning of the display patterns. Only two participants scanned items more than once and this was exploratory activity at the beginning of the evaluation when they were seeing how the interface worked.

## ETHICAL ISSUES AND FURTHER DEVELOPMENT

Whereas usability issues informed our initial design, ethical considerations are shaping the development of the Augmented Shopping Trolley for use in supermarkets. This is because our ambient display not only provides salient product information for shoppers, but also potentially influences what they purchase. The use of persuasive technologies raises ethical concerns for many people. For example, Page and Kray [3] used an online questionnaire to investigate people's views on the ethics of using persuasive technologies to encourage healthy living. 72 participants rated the ethical acceptability of a number of different scenarios which varied in 3 different factors: whether a participant chose to use the technology or an external agency initiated its use; whether there was a clear benefit for the participant or not; and the technology used (text messages to the participant's mobile phone; public announcements in the participant's location; Facebook messages; restrictions on the participant's bank account; and electric shocks). The results indicated that the majority of the participants viewed the use of persuasive technologies in most of the questionnaire scenarios as unethical. When there was no clear benefit to the participant, mobile phone were considered the most ethical persuasive technology. However, approximately the same proportion of participants (40%) considered them very ethical or ethical as the proportion that considered very unethical or unethical when. A large majority of participants found the other technologies very unethical or unethical. In scenarios where the use of a technology would clearly benefit the participant, for example, save their life, then this usage was considered slightly more ethical than the cases where the technology did not benefit the participant. However, it is not clear whether these differences were statistically significant. When people were able to freely choose whether to use a persuasive technology or not, then texts, public announcements and Facebook messages were considered ethical by the majority of respondents, in comparison to the situation where the use of the persuasive technology was initiated by an external entity (for example, the UK's National Health Service). Electric shocks and bank account restrictions were considered very unethical or unethical by the majority of respondents, even when a participant chose to use them.

Page and Kray's findings seem to concur with a central factor identified by applied philosophical analyses of ethical behaviour, for example, the use of persuasion in advertising [5]. Namely, the ethics of an action are determined, to a large degree, by the extent to which that action impacts on an individual's autonomy, that is, their capacity to choose how to act and determine their own life. Page and Kray's research also highlights that privacy and the extent to which a participant benefits are important issues for determining the ethical acceptability of persuasive technologies. All three of these ethical considerations (autonomy, privacy and benefits) are shaping the development of the Augmented Shopping Trolley.

To ensure shopper's autonomy, they will be free to decide whether they use the Augmented Shopping Trolley and also able to choose which particular non-obvious product information they want to be informed about. Given that users can configure the system to provide different product information, privacy is not compromised, even though the handlebar will be visible to other shoppers, as they will not understand what particular LED patterns mean. Some of the product information that will be provided by the Augmented Shopping Trolley can clearly benefit a participant, for example, nutritional data, whereas other information, such as food miles, may not have direct personal benefits. In fact, trying to minimize food miles may lead, literally, to a personal cost. However, we assume that if participants choose to be informed about a particular type of product information then they do so because it is of benefit to them and in keeping with their lifestyle choices. We are currently considering how to use the display to provide aggregate information about the contents of a participant's trolley. The display could indicate how averaged values of all the participant's purchases relate to some norm(s), for example, is the weekly shop below or above the average shopper's food miles. Clearly, there are normalization issues to be resolved to enable such comparisons to be made. One ethical consideration with this type of display is that even if an observer did not know what aspect of product information the aggregate display encoded, under certain conditions it could be evident whether a participant was above or below a norm, thereby compromising a shopper's privacy. For example, if the observer had also used the display themselves and the colour encoding was fixed. One way to ensure privacy is to allow participants to customize aspects of the display, such as the colour encoding used. A second ethical concern with this sort of display is that norms, like salience, typically influence people unconsciously. To ensure that the autonomy of participants is not compromised it seems important to inform them about the methods used in a display and how these typically influence behaviour before they choose to use the Augmented Shopping Trolley

## CONCLUSIONS

Our lab-based study shows that participants can rapidly read a shopping trolley handlebar display to determine both nominal and ordinal properties of a scanned product. Our display is intuitive to use and requires no training. Participants find it easier to select items when they have desirable properties than to not select them because they have undesirable properties. The Augmented Shopping Trolley makes non-obvious nutritional, ethical and environmental product information salient to shoppers and facilitates the fast and frugal decision making typically used in a supermarket. Some of the global consequences of selecting particular products can now be made salient to shoppers at the point of decision making, potentially facilitating changes in consumer behaviour. We argue that our system is an ethical persuasive technology as it enhances the ability of shoppers to buy choose products in accordance with their individual values.

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# Persuasion In-Situ: Shopping for Healthy Food in Supermarkets

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**ABSTRACT**
Healthy lifestyle is a strong trend at the moment, but at the same time a fast growing number of people are becoming over-weight. Persuasive technologies hold promising opportunities to change our lifestyles. In this paper, we introduce a persuasive shopping trolley that integrates two tools of persuasiveness namely reduction and suggestion. The trolley supports shoppers in assessing the nutrition level for supermarket products and provides suggestions for other products to buy. A field trial showed that the persuasive trolley affected the behaviour of some shoppers especially on reduction where shoppers tried to understand how healthy food products are. On the hand, the suggestion part of the system was less successful as our participants made complex decisions when selecting food.

**Author Keywords**
Shopping, health, persuasive, supermarkets.

**ACM Classification Keywords**
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## INTRODUCTION

Healthy lifestyles is a hot topic in most Western societies as a rapid growing number of citizens are either over-weight or obese, e.g. more than 50% of the adult population in Denmark are either over-weight or obese [9]. Over-weight problems come from several circumstances, e.g. the lack of exercise or unhealthy food, but in general people buy and consume food that contains a lot of sugar or fat. Thus, we need to alter people's behaviour and attitude while they shop groceries and other food products in supermarkets.

When supermarket shopping, more studies have shown that consumer behaviour is highly controlled by routine and is not simply changed or altered [8]. In fact, even if shoppers want to change their shopping behaviour and patterns, they find it difficult to understand the nutritious values of many products, e.g. they cannot understand nutrition labels or how much sugar or fat the product contains [5]. Further, one of the fundamental problems resides in the fact that we are confronted with an overwhelming number of different food products and it is often difficult to identify and choose the more healthy ones. Iyengar and Lepper showed in an experimental study that consumers were more satisfied with their own selections when they have fewer options to select from [5]. Schwartz refers to this as the paradox of choice claiming that the huge number of choices decreases people's real choice and decision-making [10]. Thus, people are likely to continue their current routine type of behaviour (as illustrated by Park et al. [8]) and this could potentially prevent them from making healthier choices.

Emerging technologies are increasingly being used to alter people's opinions or behaviour, e.g. smoking cessation [4] or promoting sustainable food choices [7]. Fogg refers to such technologies as persuasive technologies or captology [3]. Fogg states that contemporary computer technologies are currently taking on roles as persuaders including classical roles of influence that traditionally were filled by doctors, teachers, or coaches [3]. Research studies within different disciplines are increasingly concerned with such persuasive technologies that may be used to create or change human thought and behaviour. As examples, Chang et al. [2] propose the Playful Toothbrush that assists parents and teachers to motivate young children to learn thorough tooth brushing skills while Arroyo et al. [1] introduce the Waterbot that motivates behaviour at the sink for increased safety. Both these examples propose rather simple, yet potentially powerful input and feedback that aim to inform users of their own behaviour.

Todd et al. [11] illustrate theoretically how nudging could persuade shoppers to select healthy food products based on simplified information to the shoppers in-situ, but call for empirical understandings of persuasive shopping. We propose a persuasive shopping trolley application called iCART that attempts to motivate change towards more healthy shopping behaviour. First, we outline the idea behind the design of the trolley application and then reports from field studies of use on its effects on behaviour change.

## iCART: INFLUENCING SHOPPING BEHAVIOUR IN-SITU

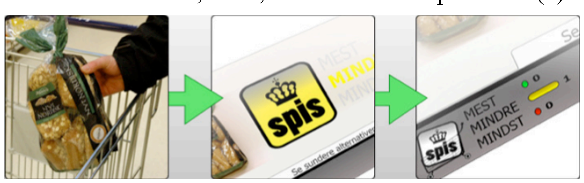
iCART is a persuasive application mounted on a shopping trolley that attempts to persuade the shopper's behaviour and awareness. The system was implemented in C# using

Windows Presentation Foundation for the interface and a Microsoft SQL server.

From our previous research [6], we learned that many consumers actually attempt to buy healthy products when supermarket shopping, but often they would find it difficult to assess the nutrition value or energy level. In fact, several consumers are actually unsure what a healthy food product is. Shoppers find it difficult to understand the nutrition information labels on the food products and they usually don’t bother consulting this information. Supermarket products and groceries are rather diverse, e.g. ranging from simple non-processed products (e.g. an apple) to more complex processed products (e.g. a pizza). Usually people find it difficult to assess how healthy processed products are. Furthermore, people find it difficult to change behavior and usually choose well-known products while shopping.

The overall idea of iCART is that all food products and items in a supermarket can be classified according to nutrition level and this classification will be presented to the user of the trolley every time the shopper puts an item into the trolley. For our persuasive system, we adapt the nutrition label initiative called Eat Most from the Danish Veterinary and Food Administration. For our purpose, it provides a simple classification of food products based on the nutrition values of a product. The classification label includes a table for calculating the value of all food products. According to the label, all products can be classified as Eat Most, Eat Less, or Eat Least.

The typical use situation could be as follows (illustrated in figure 1): The user walks around the supermarket with the trolley, chooses food products and places them in the trolley (a), the trolley recognizes the product and displays its classification according to the Eat Most label (b), and the system updates the status for the entire trolley on numbers of Eat Most, Less, and Least food products (c).




(a) (b) (c)

**Figure 1: Illustrating the process of using iCART**

### Interaction Design

We adapted three persuasive design tool principles from Fogg namely reduction and suggestion [1]. The persuasive shopping trolley should 1) present or visualize product nutrition in a simple way and 2) present alternatives to less healthy products. Finally, we decided that the system should be a walk-up-and-use system on a shopping trolley.


**Figure 2: Three classifications of the Eat-Most nutrition label with eat most (left), eat less (middle), and eat least (right).**

*Reduction* reduces complex behaviour to simple tasks in order to increase the benefit/cost ratio and thereby influence the user to perform the behaviour [3]. As stated above, consumers find it difficult to assess the overall nutrition level for products. The persuasive trolley reduces this nutrition value assessment through the simplification in the Eat Most classification and thereby the assessment now becomes a simple task. This is illustrated in figure 2 where different products have been classified, e.g. milk as eat less (middle picture).


**Figure 3: Example of reduction in persuasion: Classification of the cereal product Havrefras as Eat Least**

We colour-coded the three categories with green, yellow, and red. Figure 3 shows the classification for a cereal product called Havrefras and this product is an eat least product. The implementation in iCART reduces the action of assessing the nutrition value of a product by providing a simple classification of only three categories.

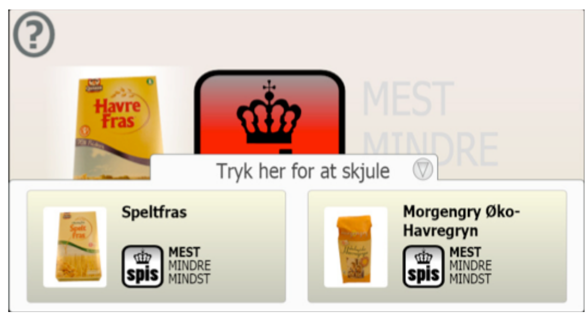



**Figure 4: Examples of suggestion in persuasion: Two alternative cereal products that are both Eat Most products.**

*Suggestion* means that persuasive technologies have greater power if they offer suggestions at opportune moments [3]. Consumers find it difficult to choice healthier alternatives as they often have limited understanding of the relative levels of nutrition between more products. The persuasive trolley offers suggestions for alternative products (Eat Most) within the same product group when the shopper choices an Eat Less or Eat Least product in the trolley. We consider this an opportune moment as the shopper often will find the alternatives in their present supermarket area (as illustrated in figure 4 where two alternative cereals are suggested for the cereal in figure 3).

## FIELD TRIALS

We conducted field trials with the shopping trolley at the local supermarket called føtex. It was rather important to us to understand the use of the system in-situ to facilitate the whole shopping experience.

11 shoppers were recruited through public announcements and we required that they shopped for food products on a regular basis. The shoppers were between 27 and 58 years old and represented different kinds of households and worked in diverse job professions. We asked them to fill in a questionnaire on their supermarket shopping experiences prior to the trials. Some of the participants were highly concerned with nutritious food while others were less concerned. The participants were divided into two groups - one group used iCART while the other group served as a control group using a regular shopping trolley. We balanced them in the two groups based on their self-reported knowledge and attitudes towards nutritious food. Before the trials, we carried out a pilot test to verify and adjust the process and our instructions. Participants were not informed about the purpose of the study in order to minimize study impact and iCART participants were told about the system but not its focus on healthy food products.

The trials consisted of a three parts namely an introduction, the actual shopping, and a debriefing. We instructed the participants to shop items from a pre-generated shopping list using their own normal criteria for food selection. Thus, they should try to shop as they normally would. The shopping list contained 12 items, e.g. milk, cheese, pate. The list included only general product groups (except for one item) leaving the participants to choose within the group, e.g. cheese where they could choose more 20 different cheese products. They were free to choose in which order they would collect the items.

303 food items were entered into a SQL database representing all items in the store within the groups from the shopping list. Data collection was done through 1) a trolley-mounted video camera that captured verbal comments and shopping behaviour and 2) the system logged and time stamped all user interactions enabling to reproduce action sequences afterwards. The sessions were done during normal trading hours and they were not required to check out the collected items.

We evaluated iCART as a Wizard of Oz experiment where one of the authors acted as wizard implementing the actions taken by the participant. When a food product was put into the trolley, the wizard would update this information in the system. Another person observed the participant while shopping in order to facilitate the following interview. The same procedure was used for the control group, but without the trolley-mounted display. The total time spent ranged from 12:08 to 40:28 minutes. Finally, a debriefing session including questionnaires and semi-structured interview was conducted immediately afterwards, e.g. they were asked to assess their own session and the collected items.

## OBSERVATIONS AND DISCUSSION

The five participants using iCART expressed that they liked the system and they would possibly use it if available in supermarkets. While food products in supermarkets already have different labels for determining the health or nutritious level, iCART became a personal technology that guided the shopper while shopping. This also had the advantage that shoppers always knew where to look for the nutritious information for all products. Today, this information is located on the packaging of the product and thereby distributed in the store.

The reduction element of iCART was quite successful. Out of the 60 food products selected by the participants using the system, 30 were classified as Eat Less or Eat Least. Thus, half of the selected products were less healthy. In several cases, the participants were surprised to realize that a certain product was less healthy. For example, one of the participants chose a bag of carrot buns and got surprised to see that these buns were Eat Least: "*I thought they were healthy as they contain carrots*".

On the other hand, several shoppers chose less healthy food products and were aware of it – even without the help from iCART. But the classification made them reflect upon their choices and several of them started talking about nutrition and healthy food. One participant said: "*But the Eat-Least classification makes you think and questions whether you have made the right choice*". From our analysis, it seemed that they acted out of routine behaviour and that they partially knew the consequences of these choices. This confirms the findings by Park et al. [8] on changing shopping routine behaviour. In summary, the reduction element of iCART was quite successful as it raised the awareness of the shoppers on the nutritious level of the chosen products.

The suggestion component of iCART was less successful compared to the reduction. The participants changed their choices 3 times out of 30 (10%). This low number was somewhat surprising, but shoppers gave several reasons for this. Some would not change their choice, as they would rather buy an unhealthy food product that was biodynamic than buy a healthy product that was not. So the shoppers would implement their own classification schemes based on other aspects than nutrition. Also, some shoppers stated that they never bought any light or zero products, which often were the products suggested by our system. They said that they would rather eat less of the unhealthy products than buy a light product.

During the field trials, 18 times did the shoppers take a look at the suggestions made by iCART, but in most situations (14 times) they chose not to follow the suggestion. This indicates that the shoppers are interested in receiving suggestions but the actual suggestions made by the system in the situation were not good enough. As illustrated above, they had different objectives when shopping and perhaps suggestion functionality should be carefully organized.

We identified an interesting observation concerning trust to the system. Some users expressed scepticism towards the suggestion part of the system while none of them really questioned the reduction part. Most of them stated that nutrition labelling whether on the actual product or implemented in an interactive system on the trolley should be controlled and accredited by public authorities. They were more critical when it concerned suggestions than reductions. The problem with suggestion could reside in that it could feel like ads or commercials for other products. That could be a potential problem when implementing suggestion tools. However, as expressed by one of the female participants: "*It is cool to be guide. I don't mind help or receive suggestions, I'm a grown-up who can make my own decisions*". This could imply that to change behaviour designers should focus on providing reduction in complexity of assessing the food product, but they should perhaps not suggest or give recommendations to the user.

Shopping in supermarkets is noisy and complex and it can be stressing due to several multimodal inputs. We noticed how several participants missed reductions or suggestions on the screen while acting in the environment. Thus, they would actually not receive the information proposed by the system. Also, one participant stated that shopping is private even though it takes place in a public environment.

The participants who shopped without the persuasive guidance appeared to have fewer reflections on nutrition and health. In fact, the iCART participants eventually bought 25 food items classified as Eat Least whereas the other participants bought 34 Eat Least products. The difference cannot only be explained in terms of the suggestion tool implemented in iCART, but the interaction made them reflect.

## CONCLUSION

We presented the persuasive shopping trolley iCART that guides supermarket shoppers in choosing more healthy food products by classifying all products in three groups namely Eat More, Eat Less, and Eat Least. Field trials with 11 shoppers showed that iCART proved to provide good input on reduction, e.g. reducing the complex task of assessing whether a product is healthy or less healthy. Our participants noticed when the system classified a product as Eat Least and usually they would start reflecting upon this. Only a few times did this result in change of behaviour where the user changed the original choice. But mostly the suggestion part of the system was less successful. This was mainly due to the fact that several participants had rather specific requirements to their products, e.g. they should be biodynamic or they never bought light-products.

Based on our findings, we see a number of future research avenues. First, rather than optimizing the algorithms behind suggestion tools, we propose that we should design systems that enables shoppers to make their own decisions in-situ. This could require a different approach to reduction. Also, we need to understand the long-term effects of such systems and we plan to conduct more longitudinal studies.

## ACKNOWLEDGMENTS

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# Towards a Mobile Application to Create Sedentary Awareness

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**ABSTRACT**
Prolonged sitting time is a potential health risk, not only for people with an inactive lifestyle, but also for those who do meet the recommended amount of physical activity. In this paper, we evaluate SitCoach, a mobile application to nudge people from their seats. The application is targeted to office workers. SitCoach monitors physical activity and sedentary behavior to provide timely feedback by means of suggesting sitting breaks. A pilot experiment with a group of 8 users learned that the general awareness of the importance of sitting breaks is low. Combined with the belief that the ability to take sitting breaks is highly dependent on external factors, a strategy of proposing break reminders may not be the most successful for this target group. Future work should focus on raising awareness of the problem and providing insights into personal sitting behavior.

**Author Keywords**
Sitting time, mobile persuasion, sedentary awareness, physical activity.

**ACM Classification Keywords**
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## INTRODUCTION
In the past years, a substantial amount of research has been devoted to physical activity promotion through mobile devices. Using the accelerometer embedded in a mobile phone or in a dedicated device, the energy expenditure of the user can be estimated. The user may receive feedback on his past physical activity level in minutes or burned calories.

Several strategies have been explored to influence the user's behavior and promote higher physical activity levels. Most notably, the usage of virtual rewards [1,2], social support [3,9] and goal setting [8] have shown to be successful persuasive strategies to establish an increased amount of physical activity.

Recent medical literature reports that not only an inactive lifestyle may lead to adverse health effects, but also sedentary behavior itself is harmful. Prolonged sitting time is also dangerous for people who meet the WHO guidelines of 30 minutes of physical activity per day [4,12]. The reduction of sedentary behavior is hence identified as a target behavior that contributes to a healthy lifestyle. Support to create awareness of one's sedentary behavior may be beneficial. However, as Owen et al. state in [12], "given the recent recognition of this phenomenon of too much sitting, there are not yet any recommended clinical guidelines. Commonsense might suggest that it may be prudent to try to minimize prolonged sitting with 5 minute breaks every hour".

In this paper, we describe SitCoach, a mobile application that assists the user to create sedentary awareness and to have regular sitting breaks. Such an application can be combined with additional physical activity promotion features. To the best of our knowledge, SitCoach is the first prototype mobile application aimed to reduce sitting time. Using SitCoach, the goal is to collect insights into possibilities to influence people's sitting behavior using a mobile device.

SitCoach targets office workers, a group which is often also assisted by break reminder applications on their PCs. Such applications are developed to prevent their users from repetitive strain injuries. Although such applications show to be successful in reducing complaints [7], they may not always be pleasant to use [10]. Morris et al. [10] introduced SuperBreak, which stimulates break compliance for computer usage. Instead of the usual breaks offered by software packages such as XWrits and WorkRave, SuperBreak offers the possibility to make the break time more productive. By offering the user the possibility to interact with the PC through gestures during the break, break compliance is promoted and the productivity during the break time is increased. Hence, although SuperBreak may increase break compliance for computer work, it does not target a reduction in sitting time. Moreover, neither of the computer packages support break compliance during other sedentary time, e.g. during meetings or while reading.

After describing the SitCoach application in the next chapter, we present a first pilot user experiment to assess the usability of the application. Through a locus of control questionnaire and by means of a semi-structured interview, we gather additional insights on opportunities and techniques to promote sitting break compliance.

## INTRODUCING SITCOACH

SitCoach is an iPhone application that measures physical activity by means of the built-in accelerometer. The application records active time and sitting time at a granularity of one minute.

To fight sitting time and inspire people to take a break once in a while, the SitCoach reminds users after a configurable number of in-active minutes via visual, acoustic and tactile messages. Users set their goals in terms of maximum number of consecutive sitting minutes and number of active minutes per day.

### Identifying Sitting Time

Using the built-in accelerometer in the smart phone, the user's activity is classified in an active and inactive state. Every second a measurement of the phone's x, y and z positioning is taken by the accelerometer. These three values are compared with the previous measurement. When the difference for x,y or z exceeds 0.3 the accelerometer recognizes a movement. The 0.3 was determined empirically: it is low enough to pick up the walking movement of the user without getting a false reading from other possible movements like a small turn with the chair while sitting.

To distinguish walking from other smaller movements like a small turn or just standing up from a chair the movement will be monitored over a certain interval of time. An empirically determined value of 5 seconds proved to be sufficient.

### Creating Sedentary Awareness

To motivate users to become more active, the application stores the number of active minutes per day for each of the users. This provides a social nudge for users to see how others are doing and to comply with the social norm.

When it is time to take a break, SitCoach emits a tactile (vibration) and an acoustic warning. Users can override the acoustic warning. A visual indicator at the main screen shows when a user is moving, giving the user immediate feedback about their current behavior. Figure 1 provides a screenshot of the main screen of SitCoach. The green circle indicates that the application has detect that the user is currently moving and hence the number of active minutes is increasing while in this state. In the state displayed in the figure, the user is nine inactive minutes away from a break reminder. However, if the user is active for a period equal to the actual time of the sitting break, the break timer will be reset.


**Figure 1. SitCoach main screen.**

## A FIRST USER EVALUATION

To assess the usability and user acceptance of the application, SitCoach has been evaluated with users. This evaluation also provides insights into the participants' current sitting behavior and their awareness of the harmfulness of sedentary behavior. The goal of the study is to identify future directions for persuasive applications targeting sedentary awareness.

In the study, the participants are provided with an iPhone with the SitCoach application and are invited to use the application throughout a day at the office. At the end of the day, a semi-structured interview is conducted, to discuss experiences. Moreover, the participants are questioned about current sitting break habits and the awareness of the importance of such breaks is assessed. Apart from the interview, two questionnaires were handed to the participants: one focusing on the utilitarian and hedonic qualities of the application [5,6] and a second one focusing on the locus of control that people perceive with respect to possibilities to reduce their sitting time [13].

### Participants

Eight participants (four females) were invited to participate in the experiment, during one working day. All participants were knowledge workers with high computer dependability.

### Procedure and Design

The participants were scheduled on a day they described as a typical office day. Per participant, a day was selected without having appointments outside the office during working hours.

In the morning after arriving at the office, the participants received a fully charged iPhone 3G. SitCoach was the only application installed, apart from the standard software. The participants were instructed not to use the phone for other purposes. No SIM card was installed, limiting the functionalities of the phone.

During the intake meeting, the participants were explained the functionality of the applications and guided through the features and settings. The standard break timer was set to 60 minutes, prompting for a 5 minute break. The standard activity goal was set to 50 minutes. The participants were free to change the settings throughout the day.

Around 4 o'clock in the afternoon, the participants were interviewed based on a list of pre-defined questions on their sitting behavior, sedentary awareness and the SitCoach application. Moreover, the two questionnaires were handed.

The Attrakdiff2 questionnaire was presented to assess both the pragmatic and hedonic qualities of SitCoach [5,6]. His scores on both qualities are important for the prolonged usage of a product. Specifically, the questionnaire measures perceived pragmatic quality, hedonic quality identification (i.e. does the product contribute to the user's identity in a social context?), hedonic quality stimulation (i.e., does the product help to develop skills or knowledge) and attractiveness (is the product good, bad or ugly?). Each of those four categories contains seven word-pairs on a seven point semantic-differential scale (e.g. discouraging vs. motivating, complicated vs. simple).

To assess the perceived locus of control to influence one's sitting behavior, a locus of control questionnaire was assessed [13]. The commonly used questionnaire, developed by Wallton et al., is adapted for sitting behavior. The questionnaire measures whether the control over the sitting behavior is determined internally (i.e. self-control; example statement*: If I take care of myself, I can avoid long sitting periods*), by others (e.g. *Whenever I feel I sit too much and too long, I should consult a trained professional*.) or by chance (e.g. *No matter what I do, I 'm likely to have long sitting periods*).

**Results**

All participants indicated that they were not aware of the harmfulness of sedentary behavior itself. When taking a break and getting up from their desk, the participants did so because they were aware of the adverse effects of prolonged computer usage and the healthfulness of physical activity. Half of the participants reported to be unhappy with the amount of sitting time during a day in the office. Suitable moments to take a sitting break are in between tasks and when feeling less concentrated. The time spent during such breaks is not seen as productive.

The lack of control is seen as the largest source of annoyance with PC break applications. Only one of the participants is using an RSI prevention program on the PC, which is installed by default. The others have disabled it. For a mobile application to create sedentary awareness, the perceived control over the sitting breaks should remain with the user.

The interviews showed that the phone vibration to signal break alerts was appreciated as it is discrete and easy to ignore when needed, for example during meetings. On the other hand, the buzzing signal was experienced to be distracting: "When I am working, I don't want to be disturbed".

The Locus of Control questionnaire revealed that six out of eight participants scored low on the internality dimension (scores $< 18$ on a range from 6 to 36), while the other scored moderate ($18 \leq$ score $\leq 24$). This implies that the office workers participating in the study believe that they have little control over their sitting behavior. With overall higher scores on the powerful others dimension, it is believed that others (colleagues, managers) strongly determine the participants' sitting behavior.

The Attrakdiff2 questionnaire results show favorable scores on the pragmatic dimension, implying that the participants are generally positive about the interaction with the SitCoach application. No remarks were made about any inaccuracies of the application. This suggests that the current implementation is well usable to distinguish sitting time from active time. Lower scores were reported on the hedonic dimensions, most notably on attractiveness.

**Table 1.** Users' responses to the locus of control questionnaire.

| Participant | Internality | Powerful others externality | Chance externality |
|---|---|---|---|
| Person 1 | Moderate | Moderate | Low |
| Person 2 | Moderate | High | Moderate |
| Person 3 | Low | High | Moderate |
| Person 4 | Low | High | Moderate |
| Person 5 | Low | Moderate | Moderate |
| Person 6 | Low | Moderate | Low |
| Person 7 | Low | High | Low |
| Person 8 | Low | High | High |

Some of the participants reported battery problems with the smart phone. Although the participants received a fully charged phone, the battery time was not enough for the application to run for the whole working day. Hence, in future work, solutions should be researched that take the energy consumption of the phone into account when running such accelerometer-based applications.

The functionality to share the activity minutes on FaceBook or other social media was not well received. Similar to the findings of Munson et al. [11], participants did not feel the need to bother their social network with such details.

**Table 2. Users' responses to the AttrakDif2 questionnaire.**

| Ppn | Pragmatic Quality | Hedonic Quality Identification | Hedonic Quality Stimulation | Attractiveness |
|---|---|---|---|---|
| 1 | High | Moderate | High | Moderate |
| 2 | High | Low | Low | Low |
| 3 | Moderate | Moderate | Moderate | Low |
| 4 | Low | Moderate | Moderate | Low |
| 5 | High | High | Moderate | Moderate |
| 6 | High | High | High | Low |
| 7 | High | Moderate | High | Low |
| 8 | High | Moderate | High | Moderate |

## CONCLUSION AND FUTURE WORK

In this paper, we presented an application to assist people to control their sitting behavior. The mobile application combines feedback on physical activity with insights on the user's sitting periods. SitCoach was developed to gain insights into people's awareness of their sedentary behavior and the user acceptance of a break reminder application.

With SitCoach, we have created an application that detects sitting time with fair accuracy. However, the users involved in the trial showed not to be in the right stage of change to be responsive to the strategies applied in SitCoach. Persuasive strategies to stimulate the user to take sitting breaks are likely to be more successful after having established awareness of the adverse health effects of sitting behavior. This can be done by first providing insights in one' sitting behavior and subsequently suggesting opportunities to reduce sitting time. For users who are aware of the problem and the adverse effects of their behavior, the triggers applied in SitCoach may be revisited.

## ACKNOWLEDGMENTS

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# MONARCA: A Persuasive Personal Monitoring System to Support Management of Bipolar Disorder

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**ABSTRACT**
MONARCA is a persuasive mobile phone application designed to support the treatment and management of bipolar disorder. Behavioral data is monitored through both sensing and manual patient input, while timely feedback is provided based on clinical recommendations to help patients adjust their behavior and manage their illness. This paper presents the design process behind the MONARCA system and initial findings on the challenge of designing a persuasive system for the management of bipolar disorder. We discuss how difficult the design of such technology has turned out to be, for two primary reasons: (1) the inherent challenges of using persuasive metaphors with a complex mental illness, and (2) the tradeoffs encountered due to varying, and sometimes conflicting, stakeholder needs.

**Author Keywords**
Bipolar disorder, mental illness management, user-centered design, personal monitoring systems

**ACM Classification Keywords**
H.5.2 Information Interfaces and Representation: User Interfaces – User-centered design. J.4 Social and behavioral systems: Psychology.

## INTRODUCTION

Persuasive personal monitoring systems seem promising for the management of mental illnesses such as bipolar disorder. Bipolar disorder is characterized by recurring episodes of both depression and mania, with treatment aiming to reduce symptoms and prevent recurrence throughout a patient's lifetime. By applying pervasive healthcare technologies to the treatment of bipolar disorder, we can monitor patients' behavioral and mood data, and provide timely feedback to them in order to help them adjust their behavior. This data supports the treatment and management of the illness in a multitude of ways. For example, patients and their clinicians can use the data to determine the effectiveness of medications, find illness patterns and identify warning signs, or test potentially beneficial behavior changes. Behavioral data collected could be used to predict and prevent the relapse of critical episodes.

Despite the plethora of research into personal monitoring systems targeting behavior change [8], health-related behavior change (e.g., physical activity [5, 1], diet [9], cardiac rehabilitation [6], and others [3]), and even the management of chronic illnesses (e.g., diabetes [7, 11], chronic kidney disease [10], asthma [4]), mental illness has remained relatively unexplored. One explanation for this untapped potential is the complexity and variation of a mental illness like bipolar disorder, which causes uncertainty in how to manage it. Moreover, there is no simple connection between measurable parameters and the course of treatment; mental illness is fundamentally complex and is often tied into physical health problems as well as social problems. In the MONARCA project we aim to overcome this challenge by developing a system that, through pervasive data collection and feedback to the patient, supports the treatment of bipolar disorder.

As such, the MONARCA system can be classified as a persuasive technology [2], similar to other persuasive health-related ubiquitous computing systems. The design of such persuasive systems is, however, extremely difficult. It is very unclear how feedback should be given to the patient in order to influence and change behavior. Numerous studies have proven that that trying to change unhealthy behavior such as smoking, drinking, or lack of exercise is extremely difficult even with the use of intensive counseling. Medicine compliance is also a fundamentally hard problem in healthcare. Therefore, it is quite challenging – some would say naïve – to rely on non-human actors like computers and mobile phones to be able to change unhealthy behavior.

In this paper, we describe the user-centered design process and initial findings on the challenge of designing a persuasive system for the management of bipolar disorder. We discuss how difficult the design of such technology has turned out to be, for two primary reasons: (1) the challenges of using persuasive metaphors with a complex mental illness, and (2) the tradeoffs encountered due to varying, and sometimes conflicting, stakeholder needs.

## METHOD

Patients and clinicians of a bipolar disorder treatment program took part in an in-depth participatory design process. They were instrumental in decision-making about features through collaborative design workshops and iterative prototyping. Patients participated in semi-structured interviews about the treatment and management of their own illness to further inform the design process. Notes and artifacts from these design activities were analyzed for 1) an understanding of each stakeholder's motivations and needs, and 2) indicators of tradeoffs that arose in the design of the system.

Workshops were held every other week for six months. At every workshop, 1-3 individuals attended from each of the following three stakeholder groups: patients, clinicians, and designers. The designers led each three-hour workshop by facilitating discussion about particular design goals and issues; system features and functionality; and feedback on mockups and prototypes of the system. During initial workshops, overall goals of the system were introduced from both clinical and technical perspectives. Sharing these perspectives of the project involved drawing from their respective best practices: both medically and practically, clinicians know what works with patients; and designers are aware of related systems and technologies.

Design activities at workshops began in the early stages with hands-on brainstorming. We provided materials such as documents summarizing the goals of the system, images of existing tools and methods, large poster paper, writing materials, scissors, tape, *etc*. The sketches that came out of this initial brainstorming formed the basis for the first mockups. For the rest of the process, at each workshop we 1) discussed a few design goals and system features in depth, and 2) received feedback on the next iteration of the mockups. Mockups presented during workshops progressed from sketches to wireframes to interactive prototypes.

## SYSTEM DESIGN

The design process resulted in 5 focus areas for a persuasive system for bipolar disorder: self-assessment, activity monitoring, historical data overview, coaching & self-treatment, and data sharing.

### Self-assessment

Subjective data is collected through a mobile phone using a simple one-page self-assessment form. Less than 10 items are entered by the patient on a daily basis, including mood, sleep, level of activity, and medication. Some items are customizable to accommodate patient differences, while others are consistent to provide aggregate data for statistical analysis. A simple alarm reminds the patient to fill out the form.

### Activity monitoring

Using sensors in the phone, objective data is collected to monitor level of engagement in daily activities (based on GPS and accelerometer), and amount of social activity (based on phone calls and text messages). This data is abstracted for analysis, to protect the patient's privacy while still supporting self-assessment using objective data.

### Historical overview of data

The patient and clinician will both have access to the data through a web interface. This will give them the means to explore the data in depth by going back and forth in time, and focusing on specific sets of variables at a time.

### Coaching & self-treatment

Psychotherapy will be supported through everyday reinforcement in two ways. Customizable triggers can be set to have the system notify both patient and clinician when the data potentially indicates a warning sign or critical state. Second, after patients are advised by their clinicians about which actions to take in response to warning signs, they can keep track of and review them through the system.

### Data sharing

In order to strengthen the psychotherapy relationship data and treatment decisions are shared between the patient and his/her clinician. Similarly, sharing data with family members or other caregivers empowers the patient to support the treatment process. Finally, sharing data among patients helps with personal coping and management efforts by reassuring patients that they are not alone, and helping them see how others manage their illness.

## CHALLENGES WITH A PERSUASIVE METAPHOR

One of the main original goals of the user-centered design process was to design a persuasive system for bipolar patients, which could help them constantly adjust their behavior to manage their own illness. In particular, the design process revealed the following three parameters were crucial to keeping a bipolar patient stable:

1. adherence to the prescribed medication – i.e., ensuring that the patient takes his or her medication on a daily basis
2. stable sleep patterns – e.g., sleeping 8 hours every night and going to bed at the same time
3. being physically and socially active – e.g., getting out of the home, meeting with people, going to work.

Now – at first glance, this may seem simple, but numerous studies have shown that each of the above three things are very difficult to achieve for many patients, and achieving all three consistently is inherently challenging in combination with a mental illness. Hence, the core challenge is to create technology that would help – or "persuade" – the patient to do these three things every day.

Most persuasive health-related Ubicomp systems have adopted different metaphors with the goal of motivating the patient to perform healthy behavior. Examples of such metaphors include a garden that grows when the person is physically active; a fish that grows when the person walks more; and a dog that is happier when the person eats healthy meals. Common to these metaphors is a simple-to-understand relationship between behavior (e.g. exercise) and visualizations in the metaphor (e.g. more flowers in the garden).

In the design of the MONARCA project, we tried to adopt the same strategy of creating a metaphor. In total of 5 different metaphors were tested and tried out in a series of design workshops. These metaphors included the use of an abstract color picture, a landscape with a river, a dartboard, a music equalizer, and a scale. The patients and clinicians rejected all of these metaphors – one after the other.

Why did this happen? First we thought that maybe we were just bad at designing the metaphors, and we kept on trying with new ones. But since it turned out to be a persistent "problem", we think that something more fundamental was at stake, which was expressed by one of the patients as:

> *"I do not want my illness to be reduced to a game."*

We think that this is an important insight into the design of persuasive technologies for healthcare and self-management. Many of the technologies and metaphors reported so far deal with personal lifestyle related health management, which is fundamentally different from patients with a diagnosed mental illness. We think that the design of feedback to the patient needs to follow another pattern other than using a metaphor.

## DESIGN TRADEOFFS

During the user-centered design process, we discovered several tradeoffs in the design of the system due to conflicting stakeholder needs and motivations. These tradeoffs relate to the clinical efficacy of the system, the patient's privacy, sustained use of the system, and other issues. In this section, we highlight two of the primary tradeoffs we dealt with during the design of MONARCA.

### Clinically driven vs. patient driven strategies

If a system has a strong clinical focus – meaning that it adopts only clinically proven treatment strategies – it could miss out on patient-driven approaches that may be helpful to some patients. In addition, the system may also ignore novel technological solutions that the clinical field has yet to evaluate. Since our system was designed for a clinical context, it was important that it adhere to clinical practices so that it could be evaluated as a valid intervention. In addition, considering clinical practices was crucial in designing a system to be viable for adoption and acceptance into a patient's treatment, which includes everyday use by the patient and occasional use by the clinician.

The clinicians that took part in our design activities shared with us scenarios, anecdotes, and commonalities about the treatment of their patients. We understood the context we were developing the system for by understanding the practices of clinicians with their patients. A recurring theme was clinicians' limited resources. This turned into a limitation for the functionality of the system, because if something took too much time or attention on the clinician's part, the clinicians would reject it. An example of one such feature was the system suggesting that the patient contact the clinic if data collected indicated possible warning signs – and making it easy for the patient to place this call. The motivation behind this feature was to encourage the patient to reach out for help when needed, but the clinicians ultimately rejected the idea because we could not find a reasonable protocol to make the benefits to the patient outweigh the burden on the clinic's resources. Features of the system also couldn't present a liability for clinicians, so they were more likely to reject ideas and limit the role of the system to be on the safe side. Any kind of text messages or notes written by the patient and made available to the clinic were kept out of our design, because we could not ensure that the clinicians would always read these messages, so we could not make them liable for their content.

We therefore realized that designing our system with primarily a clinical focus was limiting. The clinicians we worked with were clearly most comfortable with strategies that they were familiar with, they had evidence for based on their experiences with patients, and were backed by clinical trials. Deviating from these practices somewhat, and pushing our clinicians a little bit out of their comfort zone, enabled us to explore other potential strategies, from the perspectives of the patients and the designers.

An additional example of a debated feature is reported stress level. A stress level scale was strongly rejected by a clinician who argued that stress is not a clinically useful measure, nor is there any clinical definition of stress that would support accurate data collection. Interestingly, a second clinician was the one who suggested the stress level scale, and argued for it from a very patient-centered perspective based in psychotherapy. This clinician found that external stressors play a significant part in the mood of her patients, and it was useful for her to consider a patient's reported stress level when assessing how that patient was doing. She also believed that patients would find it useful to assess their own level of stress, regardless of the fact that they would be interpreting its meaning for themselves in the absence of a clinical definition. The patients tended to agree with her, so although this feature was under debate for several weeks, the designers opted to keep it in the design because enough participants believed there could be personal value in assessing one's stress.

The patients were creative in suggesting strategies based on their personal experiences. Knowing what behavioral changes have worked for them in the past, and imagining what new strategies might work for them, patients explored technological solutions unrestrained by considerations of clinical efficacy. This unrestrained creativity was productive during the design process for two reasons. First, it revealed what would motivate the patients to use the system, which is critical to adoption and acceptance. Second, it helped us realize which measures, though clinically significant, would ultimately fail because they were too intrusive for the patient to collect, or were not interesting enough to the patient to motivate collection.

### Egocentric patient bias vs. clinician generalizations

Although patients provide valuable insights into the experience of living with and managing bipolar disorder, their input tends to be egocentric, since their knowledge about the disorder mostly comes from their own personal experience with it. Discussions about the amount and type of data to collect were complex due to the different experiences and motivations of the stakeholders: clinicians were interested in data they knew to be relevant for assessment based on clinical studies or their own experiences treating patients; and patients were interested in data they thought would be useful to themselves personally for self-reflection. To balance these sometimes opposing interests, designers focused on what data would be easy and convenient to collect. Without non-intrusive data collection methods, the system will be overloaded with features and burden the patients, who are responsible for collecting the data every day. Here, the designers play an important role in keeping in perspective the implications of collecting different amounts and types of data.

Patients and clinicians disagreed about how to include customizable personal warning signs, which patients would personalize and track on a daily basis. In addition to the universal warning signs that we selected with the help of clinicians to be applicable to most, if not all, patients, we discussed including personal warning signs that each patient could customize based on personal symptoms. Clinicians argued that there should be as few of these items as possible, even stating that one personal warning sign was difficult enough for patients to attempt to track in their daily life. On the other hand, patients argued that having more flexibility would allow them to explore multiple warning signs at once in order to determine which ones applied to them. One patient, who had difficulty understanding her illness and could not identify any of her personal warning signs, asked for a lot flexibility because she would have no idea what to track, so she would need to try many different items. The designers found a solution by suggesting that the feature be limited but flexible. The agreed upon solution would allow patients the option to include as few as one personal warning sign, but no more than three. Those patients who would only be able to handle one item at a time could customize the system to show only one at a time.

## CONCLUSION

In the design of a persuasive personal monitoring system for bipolar disorder, we ran into several challenges unique to using persuasive technology for the management of mental illness. Our findings demonstrate that the design of a system for bipolar disorder is quite different from that of systems that have been explored for other health purposes such as nutrition, physical activity, and chronic physical illnesses. In this paper we have highlighted some of the main issues that emerged during our design process, including using a persuasive metaphor, balancing clinical- and patient-centered strategies, and dealing with the biases of patient and clinician participants. Our work revealed major challenges due to the complexity of the illness, stigma surrounding the illness, and the often-conflicting needs of clinicians and patients.

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# Building Persuasion Profiles in the Wild: Using Mobile Devices as Identifiers.

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#### ABSTRACT
Tailoring — presenting the right message at the right time — has long been identified as one of *the* core opportunities of persuasive systems. In this paper we describe a scenario in which an adaptive persuasive system which identifies users by the Bluetooth key of their mobile phone is used to promote energy savings. By describing this simplistic system and its possible implementation we identify several key-criteria of adaptive persuasive systems.

#### Author Keywords
Persuasive Technology, Influence strategies

#### ACM Classification Keywords
H.1.2 User/Machine Systems: Software psychology.

#### INTRODUCTION
$CHI$2010 attendees were presented with a choice on entering the conference hotel: A large revolving door provided access to the hotel while next to it was a sliding door—some things simply do not fit through a revolving door. With the air conditioning in full operation revolving doors are efficient at keeping the heat in. Sliding doors, however, are not. To help save energy a paper-sign was put up: *"Please take the revolving door"*. A brief observation proved the paper-sign to be effective just over half the time: 60% of the visitors took the revolving door. This scenario, the "Revolving Door Problem", offers a framework to describe *adaptive persuasive systems*. By further elaborating this scenario and exploring a solution we describe the neccesities and difficulties that arise when designing adaptive persuasive systems.

#### The Promises of Persuasive Technology
There are three reasons why employing a persuasive system might be more effective than the current paper-sign: (1) Persuasive technologies function as social actors and can use social influence strategies, (2) they can be context aware, and (3) they can adapt to individual users [5, 8]. While the paper-sign is probably located at the right place and at the right time—when visitors make their choice—the current version does not implement social influence strategies and does not adapt to its users.

#### Social Influence Strategies
Cialdini [2] shows how small changes to messages—such as the message on the door—can increase their effectiveness. For example, a message in a hotel room asking guests to "*reuse their towels*" compared to a message stating "*Join your fellow citizens in helping to save the environment*" led to a difference in towel re-usage of 28.4% [7]. To structure thes types of messages Cialdini [2] identifies six *social influence strategies*: *Authority*, *Consensus*, *Reciprocity*, *Liking*, *Scarcity*, and *Commitment*. The message in the towel re-usage example implements the *Consensus* strategy: people act like other people do. A message (e.g.) stating that "*The general manager of this hotel requests you to re-use...*" would implement the Authority strategy. These social influences strategies can easily be used to improve upon the effectiveness of the paper-sign.

The final promise of persuasive technologies however—adapting influence attempts to individuals—will require some kind of interactive system. While *adaptation* of persuasive strategies to responses by users is mentioned early on in the literature on persuasive technologies Fogg [5, e.g.] we are unaware of any actual implementations.

#### Individual Differences
There is growing evidence that individuals differ in their responses to influence strategies: Constructs like Need For Cognition [1] predict the response of individuals to the usage of social influence strategies. More concretely, Kaptein et al. [9] show that usage of influence strategies for individuals who are low susceptible to these strategies can lead to backfiring: for a portion of participants in their study compliance to a request was lower when the social influence strategy was presented. Next to this overall tendency to respond to influence strategies, some individuals seem more likely to respond to one specific strategy—e.g. an authority argument—while others are more influenced by implementations of other strategies. Cialdini et al. [3] shows that there are sizable and stable individual differences in people's responses to the commitment strategy. Similar results have been obtained when looking at the consensus strategy: Self-reported

susceptibility to this strategy highly correlates with behavioral responses to this strategy [10].

These individual differences in susceptibility to different persuasive strategies imply that persuasive systems should personalize the way in which they attempt to influence individuals. Such a class of systems, which we call *adaptive persuasive systems*, are an unexplored area in that we still need to understand how to model, design and build these systems. This paper takes a concrete but simple example that encapsulates the quintessence of this problem to discuss how to address these challenges.

## SOLVING THE REVOLVING DOOR PROBLEM?

Returning to the revolving door problem, let us consider what is involved in implementing an adaptive persuasive system. We need to (A) identify the visitors entering the lobby—minimally by giving each a unique ID, and (B) measure the effectiveness of a presented message. The Bluetooth key of visitor's mobile phone could be used for identification [11]. This will capture around 12% of the visitors entering the lobby. This same identification method can also be used to measure the effectiveness of each persuasive attempt: One Bluetooth scanner next to the revolving door and one next to the sliding door could determine which entrance was used by the current visitor. Based on this knowledge about the visitor and records of earlier decisions a message implementing the right influence strategy can be selected. In the remainder of this paper, we focus on the mechanism by which these strategies can be selected.

Suppose we have only two messages to show, one implementing the authority strategy—*"The general manager of this hotel urges you to..." (A)*—and one implementing the consensus strategy—*"80% of our visitors always use...etc." (B)*. The system then needs a mechanism to choose the message that is most likely to be effective for the current visitor. It is intuitive that for a *new* visitor the system should present the message which has lead to the highest compliance for other, previously observed, visitors. If this message is successful then there is no need to try different messages on subsequent visits. However, when the selected message is not effective, it might become attractive to present another message on the next visit. This decision logically depends on the initial succes probabilities of the messages under consideration, the variance of effectiveness of messages between visitors, and the number of succes's or failures observed for the current visitor. A collection of estimates of the effectiveness of different influence strategies for an individual is called a *Persuasion Profile* and can be used to select the most-likely-to-be effective message on a next visit.

### Formalizing the Adaptation Problem

The probability of a single visitor taking the revolving door on multiple occasions can be regarded a binomial random variable $B(n, p)$ where $n$ denotes the number of approaches the visitor has made to the doors and $p$ denotes the probability of success: the probability of taking the revolving door. Given $M$ messages one can compute for each individual, for each message, probability $p_m = k_m/n_m$ where $k_m$ is the number of observed successes after representation of message $m$, $n_m$ times to a specific visitor. It makes intuitive sense to present a visitor with the messages with the highest $p_m$.

For a large number of observations $N$ of one visitor this would make perfect sense. However, this will not inform a decision for a newly observed visitor. For a *new* visitor one would present the message $m$ for which $p_m$ is maximized over previously observed visitors[1]. Actually—given Stein's result [4]—for *every* user a weighted average of the $p_m$ for an individual user and those of other users—one where the estimated $\widehat{p}_m$ for an individual is "shrunk" toward the population mean—will provide a better estimate than an estimate based on observations of a single visitor alone. E.g., if the authority message is effective 70% of the time over all visitors and only 30% percent of the time for the specific visitor under consideration, the best estimate of the (real) effectiveness of the authority message $\widehat{p}_A$ for this visitor is a weighted average of these two.

### Adapting to Individuals

To include both the known effectiveness of a message for others, and a specific visitors previous responses to that same message, into a new estimate of message effectiveness, $p_m$, we use a Bayesian approach. A common way of including prior information in a binomial random process is to use the Beta-Binomial model [12]. The Beta $Beta(\alpha, \beta)$ distribution functions as a conjugate prior to the binomial. If we re-parametrize the beta distribution as follows

$$\pi(\theta|\mu, M) = Beta(\mu, M)$$

where $\mu = \frac{\alpha}{\alpha+\beta}$ and $M = \alpha + \beta$, then the expected value of the distribution is given by: $E(\theta|\mu, M) = \mu_m$. In our scenario this represents the expected probability of a successful influence attempt by a specific message. The certainty of this estimated success probability is represented by:

$$Var(\theta|\mu, M) = \sigma^2 = \frac{\mu(1-\mu)}{M+1}$$

After specifying the probability of success $\mu_m$ of message $m$ and the certainty about this estimate $\sigma^2_m$ we can treat this as our prior expectancy about the effectiveness of a specific message and update this expectancy by multiplying it by the likelihood of the observation(s) to obtain the distribution of our posterior expectation:

$$\begin{aligned} p(\theta|k) &\propto l(k|\theta)\pi(\theta|\mu, M) \\ &= Beta(k + M\mu, n - k + M(1-\mu)) \end{aligned}$$

[1]This is assuming the error costs—the effects of presenting the wrong message—are equal for each message.

The newly obtained Beta distribution, $B(\mu, M)$, functions as our probability distribution with a new point-estimate of the effectiveness of the presented message given by:

$$E(\theta|k) = \frac{k + M\mu}{n + M}$$

### *Decision Rule*

The Beta-Binomial model described above allows us to estimate the effectiveness of message $m$, include prior knowledge, and update these estimates based on new observations. A individual's persuasion profile would be a record of both the expected success, $\mu_m$, and the certainty, $\sigma_m^2$ of different influence strategies.

To determine which message to present next, one could pick the message which has the highest $\mu_m$. However, if $\sigma_m^2$ is large this decision might not be feasible given that the difference between effectiveness estimates might not be significant. To address this we can choose to show the message with the highest estimate when this estimate is "certain enough"—in the binomial case only once sufficient observations are obtained. In uncertain situations we can randomly present one of the $H$ messages which have the highest estimates out of the total set of estimates of $M$ messages. This decision rule would avoid presenting each new visitor with only the single most effective message when responses to messages are variant.

Because the Beta distribution is not necessarily symmetrical the variance $\sigma_m^2$ provides and inadequate starting point to compute confidence intervals. This problem can be solved using simulations: By generating a number of draws from the specified Beta distribution and computing (e.g.) the $20^{th}$ and $80^{th}$ percentiles one can compute a empirical confidence interval. The above described decision rule for $M = 2$ would then result in:

$$M_{selected} = \begin{cases} 1 & \mu_1 > Perc(80)_2 \\ 2 & \mu_2 > Perc(80)_1 \\ Rand(1,2) & \text{otherwise} \end{cases}$$

Thus, if the estimated effectiveness of a message 1, $\widehat{p}_1 = \mu_1$, is higher than the $80^{th}$ percentile of message 2, $Perc(80)_2$, the system presents message one.[2] If the confidence interval of two messages overlap the system could randomly present one of these two.

### Simulations

To explore the presented Beta-Binomial approach in the $M = 2$ scenario we simulated a dataset presenting different visitors observed at multiple points in time. The simulated data describes the message success of two different messages for four different groups of visitors with 20 visitors each on 50 approaches to the doors. The four groups represent (1) *general insusceptible visitors*—those that respond favorable to only 10% of the message which implement strategy $A$ and 50% to strategy $B$, (2) *susceptible visitors*, $A = 40\%, B = 90\%$, (3) *visitors susceptible to message* $B$, $A = 10\%, B = 90\%$, and (4) *visitors susceptible to message* $A$, $A = 90\%, B = 10\%$. Table 1 shows an excerpt of the simulated data. Based on these simulated data we first compute our population estimates of message effectiveness for each message: $\widehat{p}_A = 0.38$, $\widehat{p}_B = 0.58$. Thus, message $B$—the consensus message—was most effective.

| | Type | User | Occasion | Mes. A | Mes. B |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 0 |
| 2 | 1 | 1 | 2 | 0 | 0 |
| 3 | 1 | 1 | 3 | 0 | 1 |
| .. | .. | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. |
| 1000 | 4 | 20 | 50 | 1 | 0 |

**Table 1. Overview of the simulated data for the 4 different user groups. Columns *Mes. A* and *Mes. B* represent the success of the influence message at that point in time.**

Next, we simulate for each visitor, each occurrence at the doors. We select the message as specified by our decision rule and record the (simulated) outcome. Next, we update our expectancy for the selected message and iterate through all occurrences. To ensure a flexible starting point for each user we set the prior variance of each estimate at the first encounter to be high: $\sigma_A^2 = \sigma_B^2 = 0.05$.[3]

Figure 1 shows for four users—one out of each group—in separate panels, the estimated probability of success of the two messages (left and right side of each panel). In the upper left panel—representing a *general insusceptible visitor*—convergence to message $B$, whose estimated effect is presented on the right side of the upper left panel, is slow: it takes about 40 observations before $B$ is consistently estimated to be the "best" message. With higher compliance and/or larger differences in effectiveness of the two strategies convergence is much faster. The bottom right of figure 1 shows a user from the *visitors susceptible to message* $A$ group. For this user after 10 observations strategy $A$ is correctly identified as the most successful strategy.

### Limitations of the proposed solution

There are a number of drawbacks of the proposed Beta-Binomial solution to create adaptive persuasive systems. Besides the fact that when the number of strategies grows the number of necessary occasions for convergence will increase, there are three more fundamental issues which are not addressed by this algorithm. First, while including prior information based on other users, the algorithm described here does not use a shrunken estimate on each occasion: After including the initial knowledge of the behavior of other visitors the model is specific for an individual

[2] The $80^{th}$ percentile is an arbitrary choice.

[3] One could estimate this variance based on the between-visitor variance.

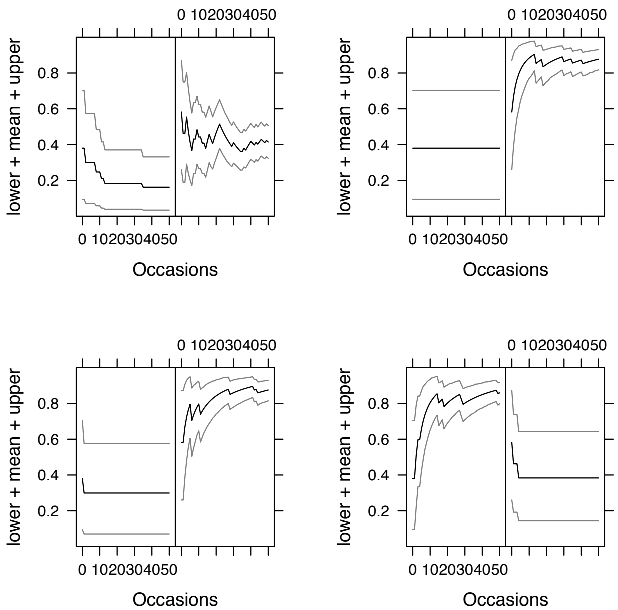


**Figure 1. Progression of point estimates of the effects of two messages on four different users (the four panels). Within each panel the left side shows the estimated effect of message $A$, including in gray its 80% confidence interval, and the right shows the estimates for message $B$. A horizontal section in the estimates of message $A$ indicates that at that point in time the message $B$ was shown and updated.**

visitor. While this provides quick adaptation there is no opportunity to adapt estimates based on changing population wise trends. Second, since the estimates for the effectiveness of the strategies are treated independently there is no way to of "borrowing strength" [6] based on correlations with other strategies. Both of these concerns could be addressed using a multilevel approach. Finally, the proposed model provides no method of including prior believes about the distribution of visitor profiles over a population.

## CONCLUSIONS

We identified two core necessities of adaptive persuasive systems: a means to identify users and a means to measure effectiveness of persuasive attempts. Furthermore, we highlighted a number of challenges associated with the design of these systems. The presented Beta-Binomial solution is lightweight and functions well in simulations with only two messages. More elaborate algorithms which are (1) variant to changing population trends,(2) allow for relationships between strategies, and (3) enable us to include prior beliefs about user profiles should be explored. Given the current state of social science literature on influence strategies we believe that persuasive technologies *should* tailor the influence strategies they use to their users. We described one possible—but limited—implementation of such a system. This, and other, implementations should now be tested empirically.

Mobile devices—as used in our scenario—provide a core opportunity to serve as an identifier for adaptive persuasive technologies. Currently we are operating a system, like the one described here, in real-life and we would like to share our experiences building and deploying this system during the CHI 2011 PINC workshop.

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# Nudging Users Towards Privacy on Mobile Devices

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**ABSTRACT**
By allowing individuals to be permanently connected to the Internet, mobile devices ease the way information can be accessed and shared online, but also raise novel privacy challenges for end users. Recent behavioral research on "soft" or "asymmetric" paternalism has begun exploring ways of helping people make better decisions in different aspects of their lives. We apply that research to privacy decision making, investigating how soft paternalistic solutions (also known as *nudges*) may be used to counter cognitive biases and ameliorate privacy-sensitive behavior. We present the theoretical background of our research, and highlight current industry solutions and research endeavors that could be classified as nudging interventions. We then describe our ongoing work on embedding soft paternalistic mechanisms in location sharing technologies and Twitter privacy agents.

**Author Keywords**
Nudge, Privacy, Security, Location Sharing, Mobile Devices, Soft Paternalism

**ACM Classification Keywords**
H.1.2 User/machine systems: Human information processing; J.4 Social and behavioral sciences: psychology

## INTRODUCTION

As mobile devices and applications become pervasive, privacy risks to their users also grow. The accessibility and ease of use of these devices make it easy to casually broadcast personal information at any time, from anywhere, to friends and strangers. Without a doubt, users benefit from and enjoy such streams of information sharing. However, they also expose themselves to tangible and intangible risks: from tracking by commercial entities interested in exploiting personal information for profit, to surveillance or even stalking by malicious parties. However, it is difficult for individuals to determine the optimal balance between revealing and hiding personal data. Sometimes we are not even aware that information about us is being broadcast, shared, or monitored; other times, while aware of ongoing information flows, we do not understand their consequences, or properly assess their risks. Such challenges are magnified in mobile scenarios. Therefore, a mobile device user may end up sharing information in a manner that goes against her own long-term self interests.

In recent years, there has been growing interest in using lessons from behavioral economics to influence and ameliorate decision making in situations where cognitive and behavioral biases may adversely affect the individual [11, 16]. This approach is often referred to as soft or asymmetric paternalism, or with the more popular term "nudges." Soft paternalism aims at countering and overcoming those biases, so as to assist individual decision making. Our research aims at applying and extending lessons from the nascent field of soft paternalism to the field of privacy decision making. This paper presents an overview of our research agenda in this area. First, we introduce the research exploring cognitive and behavioral biases in privacy decision making. Then, we examine current academic studies and industry products that focus on influencing privacy (and security) decision making, and that therefore may be compared to nudging interventions. Finally, we discuss how we are integrating soft paternalistic mechanisms in our research on privacy in location sharing applications and social networks.

## FROM HURDLES IN PRIVACY DECISION MAKING TO SOFT PATERNALISM

Findings from behavioral economics and behavioral decision research have highlighted hurdles in human decision making that lead, sometimes, to undesirable outcomes. The hurdles are often due to lack of information or insight, cognitive limitations and biases, or lack of self-control [16]. Because of those hurdles, individuals may end up making decisions that they later regret. Those decisions may include (not) saving for retirement, (not) eating well, or smoking cigarettes [11]. They may also include decisions about protecting too much, or not enough, personal information [3]. Privacy decisions are complex and often taken in conditions of information asymmetry (that is, individuals may not have full knowledge of how much of their personal information is being gathered, and how it is being used). Furthermore, privacy decision making may be overwhelming: the cognitive costs associated with considering all the ramifications of a disclosure may hamper decision making [3]. Finally, cognitive biases may affect one's propensity to reveal personal information: for instance, heightened control of one's personal information may, paradoxically, make the user overconfident about sharing information [5].

Paternalistic policies try to solve decision-making hurdles by mandating decisions for individuals. Such policies are often heavy-handed and generate externalities [11]. Soft paternalism, on the other hand, avoids coercion; it seeks to steer users in a direction (believed to be more desirable based on the user's own prior judgement, or on external empirical validation), without impinging on her autonomy. A soft paternalistic solution, for instance, would consist of making an individual aware of the biases, lack of information, or cognitive overload that may affect her decision.

Nudges are tools of soft-paternalism, and may be used to ameliorate privacy (as well as security) decision making [2]. Their application to scenarios involving mobile devices is particularly appealing. In the case of insecure communication channels, or covert data collection through a mobile device, a nudge may take the form of an alert that informs the user of the risk. In the case of mobile devices that store sensitive information (which could be accessed by strangers if the phone was misplaced), a nudge might discourage users from storing private data on mobile phones. When information is being disclosed through a smart-phone, nudges may provide alerts about the recipients, contexts, or type of data being shared.

Many different types of nudging interventions are possible. Some simply consist of informing the user — in which case they relate to privacy research on informed consent. Some focus on making systems simpler to use — in which case, privacy nudges fall into the realm of research on privacy usability. However, other nudges aim at countering specific cognitive and behavioral biases, such as neutralizing the detrimental effects of immediate gratification biases in privacy decision making [1] by altering the individual's perception of the sequence of costs and benefits associated with revealing sensitive information.

The literature on soft paternalism applied to privacy decision making is in its infancy, and therefore extremely scarce. However, a number of recent studies and products focus on mechanisms that may be categorized as nudges. We present a brief overview of them in the following sections.

## PRIVACY NUDGES IN THE LITERATURE

Previous research on the drivers of privacy concerns has demonstrated that users' attitudes towards security and privacy are influenced by numerous factors, including information available, personal beliefs, economic valuations, moral reasoning, social values, cognitive biases, and so on. Therefore, providing adequate information, making privacy tools more evident, or rewarding and punishing users as they make safer or riskier decisions are all ways of nudging or influencing privacy behavior. The privacy literature offers some examples of these approaches.

For example, recent experimental research has shown that users are interested in protecting their privacy and may even pay for it, *if* appropriate tools and salient, simple, and compact privacy information are offered. Specifically, one series of studies explored the impact of making information about privacy practices on web sites more accessible to buyers. The results showed that online customers are more likely to shop online from websites that exhibit more protective privacy policies. Additionally, those customers are willing to pay a premium for privacy. Furthermore, privacy indicators displayed at the moment an individual is shopping online may have an impact on consumer decisions. In particular, they increase the willingness to pay for privacy; however, if the indicator is provided only after the shopper has already chosen the website from which to buy, the user will not change their already-made decisions. The authors find that timing is essential when trying to help people to protect their privacy [17], [6]. Similarly, another study found that merely priming Facebook users with questions about their online disclosure behavior and the visibility of their Facebook profiles was sufficient to trigger changes in their disclosure behavior [13]. Application interface design is also important, and should help users notice when changes in context generate changes in information flows and then help them to maintain their privacy [7].

In the context of location sharing applications, providing feedback to users whose location has been requested by others has been shown to have both positive and negative implications [8]. It can prevent excessive requests and hence protect people's privacy. However, unless appropriate notifications are used, feedback receivers could also be annoyed. In addition, notifications may inhibit users from requesting others locations and hence affect system usage.

## PRIVACY NUDGES IN INDUSTRY

Examples of industry products or solutions that influence decision making in regards to privacy (either to better protect the user, *or instead* to influence her to reveal more information) take various forms, and some have been applied to mobile devices. Some of these solutions may be interpreted as soft paternalistic for privacy protection, in the sense that they nudge towards privacy. They include privacy/security usability solutions, simplifications of privacy settings, or tests and delays before one can post information. More frequent, however, are the examples of products and solutions that nudge individuals to *give up* even more of their privacy, surrendering sensitive information. These include privacy defaults that are open, lack of usability in privacy settings interfaces, poorly designed warnings, and other rewards for sharing data or encouraging friends to share data.

### Connections in social applications

Some applications provide information about who can see your data, who has seen your data, or how many people can see your data. For instance, Flickr.com, a video and image sharing website, provides information on each user-owned picture stating who can see it, followed by a link to edit the privacy settings for that picture. This may be a nudge towards privacy, as users may decide to share certain photos with friends, and share other photos with everyone.

Social networking sites often show the number of connections a user has. These connections may be called followers, friends, or ties. In some cases, connections can have access to all the user's information that is on the application. Twitter and Google Buzz are examples of sites that prominently show the number of connections. In the case of LinkedIn.com, a job searching social network, the user may prefer to add additional connections, even with people they don't know well, in order to grow their job-searching network. However, by opening their information to more connections, they may be compromising their privacy. These applications may nudge users towards increasing their connections and revealing *more* information. Indeed, several online social networks such as Facebook.com and LinkedIn.com periodically encourage users to add new connections by searching the user's email accounts for email contacts.

Connections such as friends in Facebook and followers in Twitter do not set the boundaries for information flow. One's connections may be able to share information with other unintended recipients, or even make it available to the public. In Twitter, for example, re-tweets allow connections to pass on information without the original sender's control. In Facebook, default privacy settings usually allow sharing of individual's information with friends of friends. Therefore, the information provided about the number of connections may mislead the user about the privacy of their data and decrease the likelihood that the user will take an information-protective stance.

### Privacy Settings

The privacy settings allowed in an application impact the user's ability to control how their information is shared. Both the default settings and the usability of the settings user interface create nudges towards and away from privacy [10, 12, 13].

Some websites make privacy options very simple. For example, Pandora.com, an online music station, explicitly gives users two options regarding their profile page: make private or keep public. These clear options allow a user to choose without understanding complex details or settings. Conversely, the lack of granularity may encourage users to make everything public.

Several tools provide simple ratings of privacy settings. PrivacyCheck,[1] and ProfileWatch,[2] give Facebook settings a privacy score. Other services provide a user-friendly layer on the Facebook privacy settings, allowing the user to change the settings. For example, Privacy Defender[3] provides a sliding color scale that allows the user to set their Facebook options as more or less private. These software services actively encourage stricter privacy settings.

### Reduction of Information Disclosure

If an individual expects she may be likely to post information she may later regret, software exists to discourage her from doing so. Sophisticated users may choose to employ software tools to prevent excess disclosure. For example, the Social Media Sobriety Test, `socialmediasobrietytest.com`, and Mail Goggles on Gmail `googlelabs.com` both allow the user to set certain hours of the week when they may typically embarrass themselves, such as weekend evenings after trips to the bar. During these hours, social network sites or Gmail may be blocked until the user can complete a dexterity or cognitive test. The user has the option to bypass the test. Alternatively, a user may set up a warning system if a message is likely to be poorly interpreted. ToneCheck `tonecheck.com` scans emails written in Outlook to discover whether the tone is off-putting, and will ask the user to confirm before sending it. This may help discourage users from sending or posting regrettable information.

Other tools may discourage users from posting information by reminding the user who can see it. NetNanny is a tool that parents can user to protect their children online. It will show a message every time a child posts on a social network. This message reminds the child that her parents will see the post as well `netnanny.com`.

[1] `http://rabidgremlin.com/fbprivacy`
[2] `http://atherionsecurity.com/idpro.html`
[3] `http://privacydefender.net`

## ONGOING WORK WITH MOBILE APPLICATIONS

By studying and understanding the specific biases and user actions in regards to mobile applications, we hope to suggest and test nudges that will help users make decisions that improve their satisfaction and well being. We are moving towards that goal by first understanding users' needs, preferences, biases, and limitations about privacy, and second by using that information to evaluate the efficacy of techniques that exploit biases to improve decision making. As an example, we are currently pursuing foundational studies with two applications developed at Carnegie Mellon: a location sharing application called Locaccino [15] and a privacy agent for Twitter.

Locaccino is a unique location sharing application that allows users to control the conditions under which they make their location visible to others. This includes controlling the times and days of the week when different groups of people can see the user's location as well as the specific locations where the user is willing to be visible. For instance, a user can specify rules such as "I'm willing to let my colleagues see my location but only when I am on company premises and only 9am-5pm on weekdays." Research conducted by our group has shown that this level of expressiveness is critical to capturing the location sharing preferences many people have when it comes to disclosing their locations to others across a broad range of scenarios [4]—in contrast to the much narrower set of scenarios supported by location sharing applications such as Foursquare.

As part of our ongoing research, we are interested in better understanding how different elements of Locaccino functionality effectively nudge people in different directions. This includes experimenting with new interface designs as well as new ways of leveraging some of the machine learning techniques we have been developing, from exposing different sets of default privacy personas to users [14] to helping them refine their privacy preferences [9]. We are looking at the preferences of like-minded users who have been using the system for a while and trying to use their preferences to guide new users. This would have the potential of reducing regret by giving new users the benefit of the experience acquired over time by others. We plan to explore to what extent such an approach can be made to work and to what extent it seems beneficial.

The Twitter privacy agent is an application we are building to help Twitter users behave in a more privacy protective way. We plan to build tools that will provide nudges that guide users to restrict their tweets to smaller groups of followers or discourage them from sending tweets from mobile devices that they may later regret. We plan to empirically test the impact of these nudges on user behavior. We will also examine whether fine-grained privacy controls result in more or less data sharing.

We expect our work on nudges in behavioral advertising, social networks, and location sharing to be effective for improving privacy decisions on mobile devices. We further hope our soft-paternalistic approach to have a broader impact, guiding the development of tools and methods that assist users in privacy and security decision making.

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# From Ethics to Values in the Design of Mobile PINC

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### ABSTRACT
Value Sensitive Design (VSD) is a promising method for addressing ethical issues and opportunities in the design of mobile technologies to promote behavior change. After positioning the work with respect to the PINC strategies (Persuasion, Influence, Nudge, and Coercion), I introduce the VSD method and analyze the role of values inherent to PINC strategies as well as values implicated by the means and ends of behavior change. Finally, I consider value tensions and differences in individual values.

### Author Keywords
Ethics, values, Value Sensitive Design, PINC, persuasive technology, mobile phones

### ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. K.4.2. Computers and society: Social issues.

### General Terms
Human Factors.

### INTRODUCTION
Values underly persuasion. Implicit in persuasion is the judgment that one behavior or outcome is better than another. But better for what? And for whom?

Here, I respond to the call for contributions about ethical issues to the workshop "PINC: Persuasion, Influence, Nudge, and Coercion through mobile devices" [7]. My approach to ethics is from the perspective of human *values* —particularly moral values such as fairness, autonomy, privacy, and human welfare. After discussing my understanding of and relationship to PINC, I introduce the Value Sensitive Design theory and methodology [12]. I then show how ethical goals, principles, and problems of PINC can be framed in terms of values and value tensions.

### PINC AND PERSUASIVE TECHNOLOGY
I approach PINC from the persuasive technology community. Persuasive technology concerns the use of technologically generated or mediated information, experiences, and social cues to influence behaviors and attitudes [10]. There is attention to mobile devices within the persuasive technology community: In a collection of twenty essays on mobile persuasion, Fogg writes about the unique suitability of mobile devices for persuasion: they are intimate ("we marry them"); they are omnipresent; and they have remarkable capabilities [8]. Ethics have been a recurring concern (e.g., [3,6,15,17,20]).

The PINC framing suggests new approaches to behavior change. Cialdini's theory of *influence* gives six specific strategies that are used by people to influence each other; some work in persuasive technology has drawn on these strategies (e.g., [10,15]). *Nudge* comes from the concept of *choice architecture*: that our environment structures the choices available to us, and moreover, that there is an inevitably a default option; designers can carefully select that default to gently nudge to the desired behavior. To the best of my knowledge, this idea has not been studied explicitly in the domain of persuasive technology, although default options can be considered suggestions from the computer [10, p.126]. Finally, *coercion* ensures a particular behavior through threats and force [2]. In his framing of the field of persuasive technology, Fogg explicitly excluded coercion as distinct from persuasion [10, p.15] and always unethical [10, p.226] and . Thus, there has been little study of coercion in the persuasive technology community.

### VALUE SENSITIVE DESIGN
Value Sensitive Design (VSD) is a theoretical and methodological framework intended to help designers account for human values in a principled and comprehensive way throughout the design process [12]. VSD emphasizes values of moral import and thus speaks to ethical concerns in technology design. Key VSD features include its comprehensive attention to stakeholders and its tripartite methodology [12].

VSD demands attention to both direct and indirect stakeholders: not only those who use the technology but those who are affected by its use. VSD also suggests particular attention to vulnerable stakeholders. In the case of mobile persuasion, this may include teens [5,16], U.S. Latinos and blacks [24], and Africans [25] who rely heavily on their mobile phones for communication and Web access, and may not have broadband Internet access as an alternative. Such groups should be neither neglected nor abused in the design of mobile PINC technologies.

VSD's methodology incorporates technical, empirical, and conceptual investigations. Technical investigations concern how system features support or undermine particular values. Empirical investigations address stakeholder conceptions of values and the human response to the artifact. For example, an empirical study might present participants with scenarios designed to push the boundaries of certain values in the design of persuasive technology, similar to Page and Kray's recent study of ethical responses to persuasive technologies [20]. Finally, conceptual investigations explore the values at hand and the tensions between them. The remainder of this paper comprises such a conceptual investigation.

Elsewhere, I have argued that VSD is well-suited to address ethical concerns in persuasive technology [6]. The VSD methodology draws attention to stakeholder values and value tensions throughout the design process, so that barriers can be addressed early [6]. Here, I extend the brief value analysis in that earlier work by considering coercion in addition to persuasion, as well as mobile technology.

## VALUE ANALYSIS

I consider three classes of values related to mobile PINC technologies: values necessarily implicated by the PINC approach, values implicated by particular methods of promoting behavior change, and values implicated by the desired ends. I also consider value tensions and how differences in values may nonetheless lead to the same behavior. I will draw particularly upon my earlier analysis [6] and Berdichevsky and Neuenschwander's ethical principles for persuasive technology [3].

### The values of PINC

The PINC endeavor is intimately tied to the value of autonomy [6]. Autonomy “refers to people's ability to decide, plan, and act in ways that they believe will help them to achieve their goals” [12]. PINC technology thwarts autonomy when it is used to get people to do things that are against their own goals (e.g., to waste money on useless products). But PINC can also uphold autonomy, when it is deployed in support of an individual's goals (e.g., to become more active). Indeed, Oinas-Kukkonen has proposed the development of theory and methodology for *behavior change support systems* as an important direction for the Persuasive Technology community [18].

How do the PINC approaches stand with respect to autonomy? As Fogg notes, persuasion implies voluntary change [10, p.15]. Influence, too, suggests voluntariness; indeed, Cialdini shows how to recognize and circumvent influence attempts [4]. Central to the *nudge* is is the idea of *libertarian paternalism* [22]: though the designers choose a typically “best” option for the default, individuals always have the freedom to choose other options according to their own goals and knowledge. Finally, the force of coercion inherently diminishes the autonomy of the coerced [2].

When might coercion by computers be justified? As Anderson notes, “few believe that [coercion] is always unjustified, since it seems that no society could function without some authorized uses” [2]. Law gives governments a limited authority to use coercion. Deploying computers for law enforcement has potential benefits and costs, as computers lack the contextual awareness and judgment of a human being. While this might be seen as an opportunity to use computers for fair enforcement, unclouded by human biases, it can be surprisingly difficult to produce computer systems that are free of bias. Designers can encode unconscious biases in the system, unintended biases can emerge in use, and new biases can arise as a system is used in new contexts [13]. Further, although humans often blame computers for bad outcomes, computers lack moral accountability [10,14]. We should ask, who *is* held accountable if a computer's act of coercion is unjust? Thus, coercion by computer systems engages the further values of *accountability* and *freedom from bias.*

Coercive tactics such as threats may be acceptable when users have freely chosen the system in support of their own goals. Indeed, Page and Kray report that study participants found coercive “shock tactics” to be acceptable if it was the person's own choice to use the system [20]. This returns us to our earlier definition of autonomy: “people's ability to decide, plan, and act in ways that they believe will help them to achieve their goals” [12].

However, users need information to assess the suitability of the system to their goals. Berdichevsky and Neuenschander state two ethical principles related to disclosure:

- VI) The creators of a persuasive technology should disclose their motivations, methods, and intended outcomes, except when such disclosure would significantly undermine an otherwise ethical goal.
- VII) Persuasive technologies must not misinform in order to achieve their persuasive end. [3]

One step beyond this is the value of *informed consent* [6]: that people should not only be informed, but should have an explicit opportunity to offer or withhold consent. Friedman, Howe, and Felten identified six components of informed consent [11]: *consent* comprises *voluntariness*, *competence*, *agreement*, and *minimal distraction*, while for consent to be *informed* requires not only *disclosure*, as Berdichevsky and Neuenschander exhort, but also *comprehension*. PINC technologies that are undermined by informed consent—for example, Kaptein and Eckles's persuasion profiling [15]—deserve heightened scrutiny regardless of the acceptability of their ends. As Michalski [17] and Kaptein and Eckles [15] point out, the problem is that the natural incentives may be against even disclosure, let alone informed consent.

### The values of means

Once we have decided attempt to change another's behavior, we have a number of means available for doing so. While, for example, the *nudge* approach implies a particular mechanism for influencing choices, *persuasion* encompasses a number of means [10,19].

Many persuasive strategies, such as self-monitoring, personalization, tailoring, and social comparison [19], rely on information about the user's context and activities. Indeed, two of Berdichevsky and Neuenschwander's principles point to *privacy* as a value of particular concern:

IV) The creators of a persuasive technology must ensure that it regards the privacy of users with at least as much respect as they regard their own privacy.

V) Persuasive technologies relaying personal information about a user to a third party must be closely scrutinized for privacy concerns. [3]

Mobile phones can capture an unprecedented amount of information about the user, such as location coordinates, calls, and text messages, accentuating the need for attention to privacy [17]. But channels such as audio, photographs, and proximity also capture information about others nearby—indirect stakeholders [5]. In their empirical study of teen safety scenarios, Czeskis and colleagues learned that teens were more reluctant to indirectly share information about their context and activities with friends' parent than to share such information with their own parents [5]. Thus, in a mobile context, it is important to consider the privacy of companions and bystanders—not only the user.

Although privacy is important to many PINC strategies, we should go beyond privacy to account for values such as *identity*, *courtesy*, and *calmness* [12] when they are implicated by the means used to affect behavior. For example, consider the value of *identity*, “people's understanding of who they are over time” [12]. The persuasive strategy of *social learning*, providing “means to observe other[s] who are performing their target behaviors and to see the outcomes of their behavior” [19], should be more effective when observers share an identity with the observed. Further, if we are “married” to our cell phones, we will be more attached to applications that reflect our identities. As another example, c*ourtesy* and *calmness* are implicated by technologies that use the *suggestion* strategy. Although suggestions must be given at the right time and place to affect behavior [10], suggestions should be polite and allow the user to remain peaceful and composed—unless there is an overriding reason to otherwise.

### The values of ends (target values)

As noted in the introduction, values underly persuasion. In persuading someone to act in one way and not another, we are asserting that the desired behavior will result in a better outcome. Better for what? Better for our health, for our family's safety, for national security, for the environment, and so on. Implicit in every act of persuasion is a value the persuader wants to support, a target value.

Berdichevsky and Neuenschwander address three principles to the ends of persuasion:

I) The intended outcome of any persuasive technology should never be one that would be deemed unethical if the persuasion were undertaken without the technology or if the outcome occurred independently of persuasion

II) The motivations behind the creation of a persuasive technology should never be such that they would be deemed unethical if they led to more traditional persuasion.

VIII) The Golden Rule of Persuasion: The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do. [3]

All three principles focus on unacceptable ends for persuasion. They provide no guidance as to what ends would be desirable. Attention to values can lead to desirable ends for behavior change. Indeed, much persuasive technology has explicitly targeted health or environmental sustainability. Although these are laudable goals, perhaps we should also be designing persuasive technology that helps us to overcome our racial biases (*freedom from bias*), control our anger (*calmness*), and learn to help and rely on our neighbors (*trust*). Further, it is important to understand the values of those we are designing for.

### Value tensions

The most obvious value tensions in PINC technology pit desired behavior changes and the values they implicate against the intention to change behavior and methods for doing so. That is, ends can be in tension with means. We see promoting health, environmental sustainability, and so on, versus preserving autonomy, privacy, and so on.

However, these are not the only types of tensions. First, the act of persuasion inherently privileges the values of the persuader over those of the persuaded. By asking you to change your behavior, I am saying that my values are more important than your values (or at least, the values you seem to be acting on). In the best case, as in behavior change support systems, the persuader and the persuaded agree on a value such as health or environmental sustainability; the persuader provides information or support to help the persuaded act in accordance with this shared value.

Second, people may agree on values but disagree on priorities. We might agree that environmental sustainability is worthwhile—but I might rate the comfort or excitement of driving as more important. Indeed, Rokeach compared individuals' value systems solely on the basis of differences in their rankings of a set of predefined values [21].

### Same behavior, different values

Finally, people may agree on a desired behavior, but have different reasons for valuing that behavior. For example, five people might choose to drive below the speed limit, each for their own reasons: to obey the *law*; to protect *safety*; to practice *thrift*; to reduce dependence on foreign oil and protect *national security*; or to reduce the need for oil drilling and contribute to *environmental sustainability*.

As Fogg points out, the mobile phone is an intimate device [8]. If it does not share our goals, but rather has goals of its own, we feel betrayed [9]. The same would seem to hold for values. Suppose that my highest value is the safety of my children. If I adopt a mobile application to help me avoid speeding, and it shows me pictures of polar bears, I will be upset. Because it challenges my values, I see the application as a threat to my autonomy, and I experience psychological reactance [1]—leading me to drive even faster. Instead, I should be reminded of my value of safety.

I see two approaches to addressing individual users' values. First, designers' value commitments should be made clear through branding and the informed consent process, so that users can make informed choices. Second, interfaces such as Todd, Rogers, and Payne's informative grocery shopping cart [23] should be tailorable. They should uphold user autonomy by allowing users to choose which information among value-laden options (e.g., sustainability, healthfulness, and cost) to display most prominently. A danger is that undisclosed, involuntary tailoring may cross from persuasion to manipulation [15,17].

## CONCLUSION

Attention to values may contribute not only to understanding ethical issues of mobile PINC technology—bringing attention to concerns beyond privacy and disclosure—but also to increasing their scope and effectiveness—their power to do good in the world. Further work should clarify role of these values through empirical and technical investigations of PINC technology.

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# Opportunities and Challenges in Mining Behavioral Economics to Design Persuasive Technology

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**ABSTRACT**
Behavioral economics examines people's decision making processes in everyday situations. I argue that behavioral economics can provide a repertoire of a tool that can inform the design of persuasive technology. In this position paper, I propose strategies drawn from behavioral economics, and identify opportunities and challenges in applying the strategies to the design of persuasive technology. This position paper is a modification of the paper [16].

**Author Keywords**
Persuasive technology, behavioral economics, decision making, decision bias, choices

**ACM Classification Keywords**
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

**General Terms**
Design

## INTRODUCTION

The role of information technology in people's daily decision making is steadily growing. For example, we decide which route and transportation to take to visit a friend's house, which restaurant to go for dinner, or which grocery products to buy based on the information and choices presented in information technology applications. This change offers tremendous opportunities for human-computer interaction (HCI) researchers to provide interventions to assist people to make self-beneficial or pro-social choices.

As one way to promote self-beneficial choices, we suggest approaches drawn from the field of behavioral economics. Behavioral economics examines the gamut of large and small decisions people make about such choices as how much to invest in retirement savings, whether to join a health club, and whether to eat a delicious but caloric candy bar. The persuasive element in this approach consists of presenting choices in a way that leverages people's decision processes and induces them to make self-beneficial choices [17].

We argue that designs for HCI that leverage behavioral economics theory and research are a highly promising avenue for persuasive technologies. Although widely discussed outside the HCI and design communities in both academic and popular arenas (e.g., [24]), this approach has not yet influenced our field. The message of behavioral economics is simple: people are susceptible to decision bias, which often makes it hard for them to make self-beneficial choices. Thus, we should present choices in a way that helps people to make self-beneficial choices and understand the implications of their decisions as well—all without restricting their freedom of choice.

In this paper, I explain several behavioral economics theories and discuss opportunities and challenges in applying the theories to the design of persuasive technology.

## APPLYING BEHAVIORAL ECONOMICS

Departing from the premise of economics that people make rational choices, behavioral economists have shown that people's decision making processes are biased by various situational factors, such as the manner in which options are presented and the times when the choices are offered, and the emotional or visceral state of the person at the time of choice [1, 12]. This understanding of people's decision biases provides a rich repertoire of tools that designers can leverage. In this section, we present five decision biases and discuss how these biases can be leveraged in the design of persuasive technology.

### Default Bias

When people make choices, they tend to favor the default option or the status quo, rather than taking the time to consider and then adopt an alternative state [11, 21]. People tend to take "the path of least resistance," and keep doing what they have been doing, or doing what comes automatically, even when they can make improvements. The reasons for this decision bias could have roots in people's limited attention and tendency to "satisfice" [21], their perception that an organization's selection of a default option constitutes a recommendation (see [6]), and the implied popularity of the default option.

Default biases have been blamed for a wide range of undesirable outcomes, including Americans' excessive consumption of fries and large sodas as part of "supersized" meals at McDonald's [17]. Yet if carefully designed, the default bias can be a powerful tool to propel people toward self-beneficial behaviors (see [5, 23]).

*Opportunities*

**Convenience and salience**. HCI design can leverage the default bias in many ways, by making healthy choices more convenient and salient physically and cognitively. In the domain of snacking, featured healthy snacks can be made easy to access, e.g., on websites, on vending carts, and so forth. For example, on a website, the checkbox of healthy snacks among available options could be selected as the default, reducing the need to select one of these options explicitly. Or when presenting sale items at a bakery, a system could filter and first offer items that are made with whole grain flours. For a kiosk system, the placement of buttons, the number of clicks or the number of screens a user has to access to choose an item could be decreased or increased to change the perceived priority of a snack or sandwich order.

An eldercare robot working in a nursing home could organize the physical placement of food in a way that the healthy food is placed closer to an elder's room. In addition, a snack delivery robot might only deliver healthy snacks to people's offices, but require people to walk to the robot to get unhealthy snacks.

Convenience can be further leveraged using sensing technologies that tell people when they are near healthy snacks. For instance, if shoppers are in a food court in a mall, the system could present healthy choices to them via mobile phone as convenient food options.

Default bias is different with other biases presented in the paper; leveraging default bias can be effective, even with those who are not motivated to change their potentially problematic behaviors, or are not aware of issues with their current behaviors [16].

**Attention span.** People might be more subject to default bias when their attention spans are limited or when they do not have enough time to do exhaustive search. HCI technology can target moments when people's attention spans are limited, such as when they are using mobile devices on the move, or when people are making decisions with limited time, such as when they are ordering food in a fast-food restaurant, or making choices in a public kiosk.

Interface components can be also designed to manipulate people's attention spans. The use of banners or graphic images may be distracting [1], reducing people's attentiveness and efforts in making decision.

*Challenges*

Depending on the way it is implemented, the default strategy may harm people's experience of making a choice [16]. Explicitly suggesting a certain options as default may cause people to feel forced to make those choices. Careful design of the strategy and iterative testing of its efficacy and its impact on people's experiences will be important.

Another caveat in using default strategy might be its lack of educational effect. In comparison to persuasive techniques that use informative messages (e.g., indicating consequences of choices), the default strategy do not provide any information that people can use to reflect on their behaviors and learn the consequences of their choices. If users are subsequently put in a new environment without the interventions, the changed behaviors may not continue. Designers using the default strategy should be aware of this potential problem, and consider using them with educational methods. New research is needed to understand the long-term effects of these techniques.

### Present-biased preference

Present-biased preferences represent people's tendency to weigh the pros and cons of present choices more heavily than future choices, and to underestimate their needs in the future. This decision bias is also known as "time discounting" [18]. The tendency typically promotes unhealthy eating because the immediate pull of tasty food is likely to eclipse considerations of future health consequences. However, present-biased preferences can be used to encourage healthier choices if people are asked to plan ahead. Read and van Leeuwen [19] gave their participants a choice of snack to be eaten in one week or at the time of eating, the next week. They found that their participants chose far more unhealthy snacks for immediate choice than for advance choice.

*Opportunities*

**Strategic design of timing of choice.** Present-biased preferences can be leveraged by strategically designing the time that technology applications prompt users to make certain choices. Researchers in context-aware technology have been designing applications that can sense the current activity of people and learn their routines over time [4]. A meal planning application or a restaurant reservation system that nudges people to make a choice when they are less likely to be hungry (i.e., 1-2 hours after their lunch) might be as effective as the application that uses persuasive messages or calorie information, and it might be felt to be less intrusive.

*Challenges*

The success of the planning strategy may depend on people's satisfaction with the choice made previously at the time of consumption. Even when people spontaneously made choices that would have long-term benefits and delayed gratification (e.g., granola bars over more delicious chocolate bar), they may not like their choices anymore at the moment when they experience the outcomes of their choices. If this experience continues, people may stop using the technology or change their minds at the time of consumption. Systems would need to help people stick with their choices and influence them to stay happy with their choices. Messages that remind people of the positive aspects of their choices may mitigate potential negative feelings.

### Diversification heuristic

Diversification heuristic or naïve diversification means people's tendency to seek variety when making several choices at once [20, 22]. This bias applies to a lesser degree when people make the same type of choices sequentially over time. For example, when people are asked to pick four snacks for one month at once, they tend to choose four different snacks; on the other hand, when people are asked to pick a snack each week, they tend to choose their favorite snack, having the same four snacks for one month.

#### *Opportunities*

Diversification heuristic can be leveraged by prompting people to make another choices for the future when they make short-sighted choices. For example, when people order an unhealthy snack to eat immediately, the system can prompt them to make a choice for their next snack. Both diversification heuristic and present-biased preference suggest that people are more likely to choose healthy snacks as their next snack. On the other hand, when people make healthy choices for immediate consumption, the system may not prompt them for future choices, so that they do not choose unhealthy choices for the sake of diversity.

#### *Challenges*

Providing incentives for people to make choices for future (e.g., a discount) will be important to encourage people to take another step to make a future choice.

### Licensing effect

Licensing effect refers to people's tendency to indulge themselves (i.e., making vice choices) after they make choices that activate a positive self-concept (i.e., making virtue choices) [13]. For example, people may feel that they deserve a high-caloric dessert after having a healthy salad for lunch. Some research suggests that prior choices can influence subsequent choices even in different domains. For instance, after donating their money to a charity, people may feel licensed to buy a luxurious item for themselves.

#### *Opportunities*

Persuasive technology can adaptively change its information presentation to help people avoid licensing effect biases. In a system that tracks people's previous choices, when they have made virtuous choices (e.g., exercising instead of watching TV on a couch, or carpooling instead of driving), the system may not show or emphasize the tracked behaviors in order not to encourage any licensing behaviors.

#### *Challenges*

There is little consensus on how people make decisions in responses to their prior choices. Transtheoretical model suggests that the system needs to applaud people making progresses in changing their behaviors in relation to their goals [8]. Licensing effects suggest that emphasizing their previous good behaviors can induce people to feel deserved to deviate from the good behaviors. More research is needed to better understand what factors cause the differences in their subsequent choices [10].

### Asymmetrically dominated choices

People tend to make choices that are easier to judge as superior than other alternatives. One example of this tendency is the "asymmetric dominated choice" [9], which means placing a choice option next to an inferior option to increase its attractiveness.

#### *Opportunities*

Asymmetrically dominated choices can be leveraged by intentionally including an inferior option when presenting many options. For instance, consider a cookie as compared to a large, shiny Fuji apple and a small withered apple. By pairing the Fuji with the withered apple, the Fuji's value seems much higher, and choices of the Fuji will increase.

#### *Challenges*

Paring only a few options with obviously inferior ones can make users feel suspicious about the systems. In addition, in many choices, finding a clearly inferior option is difficult, which makes this approach practical only to a certain type of choices.

## NEEDS FOR SYSTEMATIC DESIGN AND EVALUATION

In the previous sections, I described several decision biases drawn from behavioral economics, and opportunities and challenges in leveraging them in the design of persuasive technology. Theory-based design should be implemented through iterative design processes and evaluated systematically to test its efficacy as documented in [16]. Previous research has showed that some design features do not work in the real world, even when theory predicted their effect [1, 16]. In the real world, there might be other factors that may eclipse the power of the intervention strategy. Characteristics of different design media (website, mobile phone, and/or robot) can influence how theory would work.

## CONCLUSION

Behavioral economics research suggests that extremely simple changes in user interfaces can have a substantial impact on people's choices. In this workshop, I hope to have a lively discussion on strengths and weaknesses of design strategies drawn from behavioral economics, and identify domains and situations where these approaches would be most appropriate and useful.

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# Gathering and Presenting Social Feedback to Change Domestic Electricity Consumption

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**ABSTRACT**
This paper describes the CHARM Energy Study in which mobile technology is used to study the impact of social group feedback on household energy consumption. We describe the background and rationale behind the study, the technology which supports the study, and the study's methodology. The work described herein builds upon similar studies by using mobile technology and on-line feedback to increase the frequency of accurate social group feedback to the participants.

**Author Keywords**
Nudge, Social Norms, Smart Meters

**ACM Classification Keywords**
H.5.2 Information Interfaces and Presentation: User Interfaces—*Evaluation and Methodology*

## INTRODUCTION

It is widely recognized [10] that lowering domestic energy consumption could make a significant contribution in reducing $CO_2$ emissions and hence mitigate against the risk of anthropogenic climate change and promote economic wellbeing. There are significant challenges to the achievement of this goal; to change a household's energy consumption the householders must be motivated to change and to have the tools available to enact this change.

CHARM is a three-year EPSRC funded UK project that evaluates the impact of individual and social group feedback on behaviour in three different contexts, including electricity consumption. The research aims to develop, evaluate and understand the ways in which digital technology can be used to shape individual behaviour by informing and thereby challenging 'normal' practice. Social norm research suggests that we can influence behaviour by telling people what other people do [14].

Traditional approaches that try to change behaviour by directly influencing attitudes and intentions often prove ineffective [1]. Rather than telling people what to do, it can be more effective to use 'social proof' [6]; influencing behaviour by showing people what others do. Studies in several related disciplines suggest that everyday practices are malleable, and can be 'nudged' in a socially desirable direction by subtle forms of social influence [21]. In particular, research indicates that feedback on an individual's level of performance (e.g. electricity consumption) can change their behaviour, and moreover, that this effect is enhanced if supplemented by feedback on the performance of a relevant social group.



## THEORETICAL FRAMEWORK

Writing from a sociological perspective, Shove [18] explores the social organization of normality and argues that patterns of consumption are shaped by the taken-for-granted practices of everyday life: 'much consumption is customary, governed by collective norms and undertaken in a world of things and socio-technical systems that have stabilizing effects on routines and habits' (p. 9). Shove emphasises the collective conventions that underlie individual conceptions of basic needs such as cleanliness and comfort. Thus, a year-round indoor temperature of 22°C has become an accepted standard of comfort that shapes buildings, clothing habits and energy consumption patterns, while daily showering has become an accepted cleanliness practice in the UK, with consequent impact on energy and water consumption. These expectations are taken-for-granted, and treated as inherent aspects of 'comfort' and 'cleanliness', but their contingency is demonstrated by historical and global variation. Although Shove highlights the complex socio-technical, economic, cultural and symbolic systems that underlie conceptions of 'normal' practices, she argues that what people take to be normal is not fixed but 'immensely malleable' (p. 199). Consequently, she claims, it is important to understand the 'dynamics of normalization', that is, how do the habits and practices of everyday life change and evolve?

Whereas Shove avoids a rational choice model with its focus on individual choices, the relatively new field of behavioural economics retains a focus on individual choice, but contests the assumption of a rational economic agent, in the light of research on the psychology of choice. Thaler and Sunstein[21] argue that choices are inevitably influenced by the context or 'choice architecture', and that it is legitimate to deliberately 'nudge' people's behaviour in order to improve their lives. A 'nudge' is 'any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives' (p. 6). Thaler and Sunstein highlight research in social psychology that shows one can nudge people simply by telling them what other people do.

Whereas earlier research on conformity [5] [12] relied on overt social pressure, more recent research [7] has focused on subtle, indirect influences of which participants may be unaware; these are more analogous to nudges. Cialdini *et al.* [8] distinguish between two types of social norms, descriptive and injunctive. The former simply state what most people actually do, the latter express an overtly normative message about what people should do. Both can be effective, but descriptive norms are less invasive. Social norm research typically [14] includes descriptive social norms, e.g. '70% of students on this campus do not take drugs', and has been widely used in social-norm marketing campaigns aimed at alcohol and substance abuse among young people. Research suggests that the impact of social norms depends on the extent to which they are focal (i.e. salient) and in alignment [7].

Two field studies are directly relevant to electricity efficiency. In these studies participants' electricity meters were read by research assistants who provided feedback on door-hangers. Nolan *et al.* [13] tested descriptive social norms such as:

> In a recent survey of households in your community, researchers at Cal State San Marcos found that 77% of San Marcos residents often use fans instead of air conditioning to keep cool in the summer. Using fans on energy instead of air conditioning — Your Community's Popular Choice!

The study found that these had significantly more effect on consumption than injunctive appeals to self interest, protection of the environment or social responsibility, although respondents in an earlier study (reported in the same paper) thought that the descriptive norm message would be least motivational. A study using a similar methodology by Schultz *et al.*, [17] again used door-hangers, giving participants feedback on their individual and local neighbourhood electricity usage figures. This research compared a feedback only condition (descriptive social norm) with an intervention than combined feedback with a positive or negative emoticon or 'smiley' (descriptive and injunctive social norms). In the feedback only condition, participants who were using more than their neighbours used significantly less after the intervention, but those who were using less moved towards the norm, and started to use more electricity (the 'boomerang' effect). In the second condition, when descriptive and injunctive social norms were combined, the 'destructive' movement towards the norm was avoided: usage of those below the norm remained stable while the usage of those above declined. Note, these two studies used personal meters readers attached handwritten feedback to respondents' front doors; this personal element may have enhanced the normative effect of the communication. A large scale year long trial conducted by Cialdini at Positive Energy (O Power) combines descriptive and injunctive social norms in energy bills, with promising results [3].

The study by Schultz *et al.* combined individual and social group feedback, but did not distinguish between the impacts of these two interventions. There is considerable research on the impact of individual feedback in energy efficiency. Darby [9] identifies feedback as the single most promising method for reducing household energy consumption, and calls for more field testing. Research shows that more frequent feedback is more effective, and that feedback can be effectively conveyed through a website [2]. Research on social group feedback in energy bills is more equivocal. Surveys conducted in the US and Norway indicate that consumers are receptive to comparisons of their energy consumption with relevant social groups, but Roberts *et al.* found the idea of social comparison was unpopular in UK focus group research [15]. Iyer [11] reviews different expressions and formats of comparative social feedback and advocates small comparison groups preferably based on physical location.

**Methodology**

We performed two pilot tests, the former involving ten participants recruited from University staff, the latter twenty participants recruited from two coherent geographical areas chosen to represent different socio-economic groups. Due to the small size of the pilots no statistically valid inferences can be drawn from their output; these trials were performed to test technology, recruitment and communications. The main study includes four hundred and twenty participants professionally recruited in these two target areas. Participants are paid an incentive for their participation. Recruiters administered a pre-trial questionnaire (e.g. ascertaining house type, the number of rooms in the house, heating type, et c..). A matching questionnaire will be administered after the trial to see what change has taken place in the way the participants see themselves and their behaviour. We believe that the CHARM Energy Study is unique in using mobile technology to study the effect of frequent online social feedback in a UK study large enough to enable statistically-valid conclusions to be drawn.

Households were randomly assigned to one of three conditions; control (no feedback), individual feedback only, or both individual and social group feedback. The control groups have their energy use monitored but receive no communications from the team during the study, and do not receive any feedback on their energy use. We will use the data on the control groups' usage to account for environmental factors which effect electricity use (cold weather, mass use of TV to watch landmark events, et c.) and to allow us to take into account the fact that simply having an 'electricity monitor' in the home may have an effect on the energy behaviours of the household.

In addition to the questionnaires, we will conduct approximately 35 face-to-face semi-structured interviews, with a purposive sample of subjects. Interviews will occur in respondents' homes and involve as many adult household members as feasible, and will include observation and discussion of home configuration, energy efficiency features, types of energy consumed and appliances used. A number of respondents will be interviewed both before and after the experiments, in order to benchmark conceptions and practices and to facilitate identification of changes (these respondents will be excluded from the field trial analysis). A number of respondents will be re-interviewed at least six months after the trial to identify any long term changes in overall levels and underlying practices. Respondents will receive an additional incentive for their participation in the interviews. In addition, we plan three professionally moderated focus groups, to elicit discussion of the trials and normative discourse in a social context; the focus groups will be reconvened after a period of six months to explore the longevity of any changes in practices.

#### Technology

Each respondent who volunteers to take part in the study is supplied with a box containing three components

1. A *current-clamp* which attaches to the meter tail and which transmits usage data every two seconds via a 433 MHz wireless link.
2. A *monitor* which stores this data and sends the data to our server via GPRS using a roaming SIM.
3. A *power adapter* which supplies the monitor with power for operation.

There is no real-time display visible to the individuals in the household. It has been shown [4] that real-time displays are a powerful tool in effecting behavioural change since they promote experimentation to see what effect individual appliances have upon power consumption, but have not been included in this study in order to focus on the effects of social feedback.

The monitor and current-clamp make use of a commercially-available off-the-shelf home energy monitor with a real-time display. We hide the display from view in the box that contains the GPRS modem and microcontroller. Using a COTS solution allowed a significant saving in development time and the time taken to meet regulatory and safety requirements.

As a result of field-testing in the pilot studies, the embedded controller has evolved through several iterations to account for network outages, automatically reloads new versions of firmware as we release them, and can be remotely controlled *in situ* to trigger recovery from several abnormal conditions.

Usage information is gathered via GPRS upload by the HTTP 'GET' mechanism to a web-server where it is logged in a relational database. The web-server provides an password-controlled management interface which allows us to track the performance of each monitoring unit and participant household, to determine for example when participants in a household have not viewed their data on the website, and to track the frequency of data transmission from monitors enabling the team to track network outages, request user interventions such as checking the unit is receiving power, ask the householder to reboot the unit, et c..

#### Feedback

Information is supplied to the participants in the individual and social experimental groups in a number of ways. They can view information about their electricity use on the website (see below). They receive weekly emails which encourage them to maintain their participation in the study. Individuals known to be infrequent visitors to the website may receive SMS text messages prompting them to participate, a mechanism which was shown to be an effective way of encouraging re-engagement in the initial field trial.

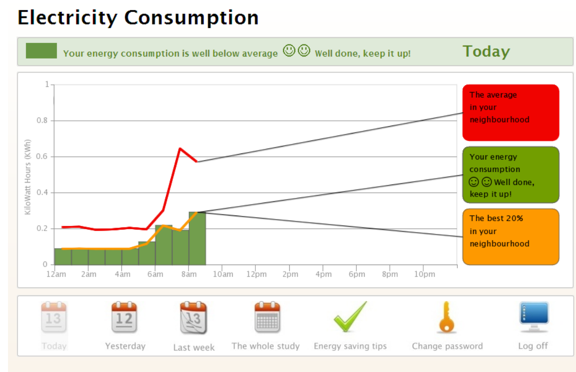


**Figure 1. Social Feedback on Web Interface**

As previously stated, households are assigned to one of three experimental groups which define the type of feedback they receive. The feedback provided to households in the social feedback category is illustrated in fig. 1. We hope to create the conditions where we may most easily see an effect of social proof in changing behaviour in the following ways. Firstly, we attempt to increase saliency as recommended in [7] and focus on small geographic areas as recommended in [11]. Secondly, we provide descriptive and injunctive feedback in the form of emoticons after Schultz [17] to reduce the possibility of the 'boomerang' effect. Finally, we provide easy access to energy saving tips which we hope will provide householders with the means to lower their energy consumption. The website also provides the user with views of his electricity consumption in a context suited to his experimental group for previous time periods; yesterday, last week, and the whole of the study thus far.

Initial results from the participants in the twenty-strong second test indicate that the feedback is viewed as both interesting and useful, and we look forward to reporting the results of the full trial in the near future. Recruitment for the main trial started in January, 2011, and we expect to present results after the trial in the Autumn of that year.

#### Novelty

The CHARM Energy Study differs from the work reviewed above in the following ways. There have been studies involving more people with monthly feedback on paper-based bills [3], and studies involving small numbers of people with weekly paper-based feedback [17]. We believe that ours is the first study testing the social norm approach with frequent automated data collection and feedback. Further, ours is the first such study in the UK where there may be resistance to the social norm approach [15].

### Conclusion

It is planned [19] that all UK homes will have Smart Meters installed by 2020, and the EU Smart Meter market has been predicted [16] to be worth 25 Billion Dollars US in the ten years from 2010 to 2020. Although the emerging UK standard [20] mandates that UK Smart Meters will provide bidirectional communications and support in-house displays, we are unaware that there is yet a standard for the type of information that will be displayed to the consumer.

If the study shows a real reduction in domestic electricity use resulting from social feedback methods, we hope that we may influence the emerging Smart Meter standard to provide for this means of change.

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# Towards Egocentric Fuel Efficiency Feedback

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**ABSTRACT**
Motivated by anecdotal evidence, we hypothesize that an egocentric approach is more appropriate and relevant to providing fuel efficiency feedback than a systemic approach. In this paper we describe a proposed study to test this hypothesis, and present the design of a fuel efficiency feedback system for public transit bus drivers.

**Author Keywords**
Feedback systems, fuel efficiency, public transit bus drivers

**ACM Classification Keywords**
H5.m. Information Interfaces and Presentation (e.g., HCI): Miscellaneous

## Introduction

In 2010 the public transport authority in Madeira, Portugal, installed onboard electronic equipment that gauged driving fuel efficiency by presenting the driver with very simple feedback: 3 green lights progressively suggested that efficiency was increasingly optimum, while 3 red lights progressively suggested that driving efficiency was increasingly sub-optimal. The system was intended to give drivers feedback on their driving and to help them achieve optimal driving efficiency. The result was negative: drivers complained to human resources that the system constantly showed 3 red lights, suggesting that their driving was bad. Human resources complained to operations that the system was bad for morale.

In response, operations attempted to "calibrate" the system by tweaking its thresholds. The result was that the feedback became useless and largely inaccurate, ultimately resulting in the abolishment of the system. In our discussions with the transport authority, it became clear that in addition to the misinterpretation of the feedback by the professional drivers as a rating of their driving, the mountainous terrain of Madeira caused genuinely inefficient driving. There was simply no way to avoid steep hills that took a significant toll on fuel consumption, thereby skewing the feedback towards inefficient driving. The attempts at calibrating the system failed because, effectively, the on-board equipment measured pure fuel consumption which in turn was intricately related to the steep terrain of the environment. On the other hand, drivers perceived the feedback as a reflection of their skills.



Our anecdotal experience with the public transport authority's feedback system caused us to hypothesize that providing feedback on specific driver behaviour, as opposed to overall fuel efficiency, may be a more appropriate way for motivating driver behaviour change. Adopting a systemic approach to this issue, we argue that existing feedback mechanisms relating to efficiency provide a view of the complete system, parts of which the driver has simply no way of effecting (such as the steep terrain). Hence we argue that efficiency feedback focusing on parts of the system that the driver can effect (such as acceleration) may result in more efficient driving behaviour. We term this approach to feedback egocentric.

In this paper we describe a fuel efficiency reporting and advisory system that takes advantage of the multi-sensor and interactive nature of modern smart-phones to present feedback to drivers. More specifically, we are interested in deploying the system in public transit buses to measure its effectiveness on positively influencing drivers' behavior. By continuously capturing real-time sensor data, we can calculate the Vehicle Specific Power (VSP), a surrogate variable that strongly correlates with both fuel consumption and pollutant emission levels, providing a systemic view of efficiency [11]. Crucially, we are able to manipulate the calculation of VSP to ignore environment variables and provide egocentric feedback. Taking advantage of this manipulation, we propose a study where we intend to test our hypothesis about the benefits of egocentric over systemic feedback. We believe that through the use of our system we can promote not only short-term but also medium/long-term positive changes in public transit bus drivers' behaviours.

## Related Work

Research suggests that it is possible to achieve up to 15% of fuel consumption decrease when appropriate driving behavior is used [2, 6–8, 12]. Independent of contextual settings, appropriate driving behavior is characterized by a combination of two main factors: speed and acceleration. Specifically, it is believed that smoothness of driving (i.e. slow acceleration levels) has a considerable effect on fuel consumption. Therefore, fuel efficiency systems should be dedicated to promoting adequate driver feedback in relation to these two essential factors, i.e., reasonable speeds and low acceleration/deceleration levels. Accurately accounting for all factors that influence fuel consumption and consequent pollutant emissions can be a complex exercise. Nevertheless, And & Fwa present a possible vehicular fuel consumption explanatory framework [1]: Physical characteristics of the vehicle; vehicle usage and route characteristics; road characteristics; and driver's behavior.

Of these factors, engine efficiency (physical characteristics of the vehicle) is considered the most important [4]. Still, the driver's attitude and behavior towards the maneuvering of the vehicle can considerably impact fuel consumption levels. Therefore, it is commonly argued that smoothness of driving leads to higher efficiency of fuel consumption.

Raw fuel consumption levels and pollutant emissions can be calculated through the use of Portable Emissions Measurement Systems (PEMS). These are connected to vehicles through their On-Board Diagnostic (OBD) interface, letting the PEMS system access the vehicle's on-board computer and calculate multiple parameters [13]. Still, PEMS systems work primarily as a diagnostic/analysis tool, not as a feedback support mechanism. Furthermore, PEMS systems fail to reflect contextual characteristics such as road gradient values. It is common to augment PEMS with GPS for analysis purposes [13].

The Vehicle Specific Power (VSP) approach is used to approximate and predict actual emissions levels and fuel consumptions [10, 11]. VSP is a model that tries to explain consumption and emission levels from a physical perspective; it corresponds to the Power Demand or Vehicle Engine Load values, therefore correlating strongly with fuel consumption and pollutant emission levels [13]. The VSP model depends on three variable factors: speed, acceleration, and road grade. Through the combination of these factors, along with vehicle specific air and roll resistance coefficients, VSP values are calculated as follows [11]:

$$VSP = v * (a + g * sin(\varphi) + rcoef) + acoef * v^3 \quad (1)$$

where $v$ is speed in $m/s$, $a$ is acceleration in $m/s^2$, $g$ is 9.807 $m/s^2$, $\varphi$ is the road gradient value, $rcoef$ is the rolling resistance term coefficient, and $acoef$ is the air drag term coefficient. Another characteristic of VSP is its ability to support payload modeling, especially important in situations where this value has noticeable impact, such as is the case with public transit buses [11]. Still, VSP does require that we calibrate the model for each type of vehicle, as it is necessary to obtain the ground truth for fuel consumption and pollutant emission levels for the model to be effective.

Devices such as smart-phones possess a wide variety of sensors, like GPS and accelerometers, that enable calculation of vehicle dynamics and consequently VSP values. It is then possible to approximate fuel consumption using solely internal smart-phone sensors. These devices can be easily incorporated into vehicles, and their ability to provide a rich and extensible interaction platform make them a feasible alternative mechanism to provide drivers with fuel efficiency feedback. Furthermore, and comparing with usual commercial systems such as Scania Fuel-Saving Driver Support System[1], smart-phones are not restricted to specific vehicles, and can even be device independent, which is the case when using development platforms such as Google's Android.

Receiving timely feedback is key to motivating behaviour change, people need to be aware of their behaviour in order to change it. Fischer found the most successful feedback was given frequently, clearly presented, used computerised tools and allowed historic or normative comparisons [9]. Our mobile interface reflects these types of feedback. Utilising a mobile display allows frequent opportunities for self-reflection and should increase driver awareness of their behaviour.

Consolvo, McDonald, and Landay [3] suggest a number of design strategies for persuasive technologies that wish to motivate behaviour change. These strategies are based on psychological theories and recent persuasive technology research and we have chosen to follow some of their guidelines.

First, we make use of abstractions rather than counting solely on raw data to display to drivers. Secondly, the data shown should be unobtrusive. This is of paramount importance for safety reasons, as we need the mobile display to support ignorability and not distract the driver unnecessarily. Thirdly, since the data is to be presented in public, we need to present it in a way that the driver will not feel uncomfortable if others are aware of it. Fourthly, we decided to ensure that only positive feedback is given, not punishing any "bad" behavior. Concretely, we aim at rewarding possible low consumption levels, but not use punishment for poor performance. This decision is supported by the notion that positive feedback can indeed increase intrisic motivation by affirming competence [5]. The anecdotal evidence from the use of a commercial system by the public transit company also supports this notion. Finally, we have chosen to provide historical feedback. Doing so allows the driver to reflect on past behaviours in order to make more informed decisions on current behaviour.

#### Research Methodology

We propose an experimental approach to study to what extent we can, through the use of egocentric feedback,

[1]http://www.scania.com/media/feature-stories/sustainability/every-drop-of-fuel-counts.aspx

| | Real-time | Historical |
|---|---|---|
| VSP | Real-time& VSP | Historical &VSP |
| egoVSP | Real-time &egoVSP | Historical &egoVSP |

**Table 1. 2x2 design of combination factors**

influence public transit bus drivers driving behavior. In our study we are interested in the following research questions:

- Can we accurately establish driving behavior profiles for bus drivers through the use of VSP calculations?
- To which extent can we positively influence driving behavior through the use of egocentric feedback techniques?
- Is the use of real-time more effective than the use of historic feedback, or is a combination of the two approaches most effective?

Consequently, and based on the previous mentioned research questions, we raised the following hypotheses:

- H1. The use of the VSP surrogate variable (and its derivatives) allows for accurate driving profile characterisation
- H2. The use of egocentric driver feedback improves average fuel consumption levels
- H3. The use of real-time feedback does not significantly influence driving behavior

To test these hypotheses we propose to develop an Android based software to continuously collect sensor information so that trip instantaneous parameters, such as speed and acceleration, can be calculated. We will also consider the use of additional variable(s) to model the influence of passenger payload on the overall vehicle weight. Then, we intend to install equipment on-board public transit buses and calibrate the VSP model. The ground truth establishment of instantaneous fuel consumption levels is a necessary condition for the success of the VSP model. This may be achieved through the use of a PEMS system or a similar mechanism. Subsequently, we will develop a derivative of VSP called egoVSP, which ignores road gradient and is defined as follows

$$egoVSP = v * (a + rcoef) + acoef * v^3 \qquad (2)$$

Terms of the equation are defined equally as in eq. 1. These two fuel efficiency models, VSP and egoVSP, are one of the two variables we intend to manipulate in our study. The other variable is the type of feedback to provide: real-time versus historical. Table 1 shows the possible combinations of these two variables.

### Ongoing Work

As it stands, the system is a working prototype. Targeted mainly at public transit bus drivers, the system

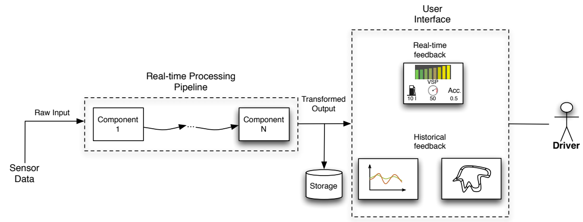


**Figure 1. Overall view of system functionality**

is flexible and extensible enough to provide support for any kind of vehicle.

An overview of the architectural design is seen in Fig. 1, where the mechanism that is used to produce the final output to the driver is visible. Raw sensor data is sampled at several times per second, before it is passed to a real-time processing pipeline. This allows us to execute tasks in parallel that may require some computational complexity, therefore increasing system overall speed and responsiveness. The advantage of such a scheme becomes more evident when, for example, the system is required to perform continuous sensor data integration by means of a Kalman Filter.

The calculation of the vehicle dynamics and the VSP modeling is also included in the processing pipeline. After exiting the pipeline, the transformed output is then fed to the feedback mechanism, which transmits specific information to the driver, according to the type of feedback used. All data is continuously stored in a local database, so that further off-line analysis may be performed. Repeated sampling from sensors will undoubtedly drain the battery in its full in a matter of hours, so there is the need of ensuring that the device is fed continuous power by connecting it to the vehicle's internal electric circuit.

Drivers initiate interaction through the system's main menu (see Fig. 2). In order to use the system, drivers must register themselves before receiving a 3 digit PIN code that uniquely identifies them. Vehicles registration and VSP model calibration is also required to be performed, but this may be done by the developers before the system is made available to the drivers. This will be the case when doing the experimental study with the public transit bus drivers. Besides the VSP model calibration, it is also possible to calibrate both the device accelerometer, as well set up the desired orientation of the phone inside the vehicle. This last step has some limitations, as currently we are working with a phone with only one accelerometer and no gyroscope, which limits the phone's orientation recognition. Just before starting a trip, the driver introduces his PIN code and indicates the vehicle that he is currently using. After this the trip is marked as initiated.

In order to test the effectiveness of the feedback system, we propose using two different types of feedback: real-

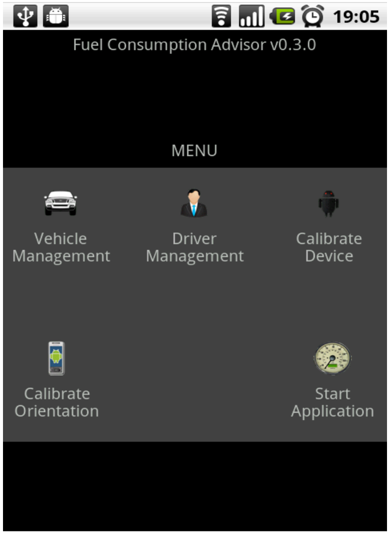


**Figure 2. System main menu**

time and historical. In the first, we will show a real-time VSP graph that represents an approximation to the actual VSP value. The graph is an abstract representation, where it goes from green (low VSP values) to red (high values) with an approximate quadratic function increase. Additionally, actual fuel consumption, speed, and acceleration values are to be represented.

In regard to the historical feedback, our system will make available two modes to the driver. The first will show the distribution of time in the pre-defined VSP bins, and the second will show a heat map of the route, indicating VSP "hot zones". The use of historical feedback gives the driver a more broad perspective of his driving behavior, as it recalls and identifies potential patterns that may be improved. Furthermore, historical feedback will only take place when the driver is not actively driving.

## Conclusion

In this paper we have argued that egocentric feedback on fuel efficiency can be more effective than systemic feedback on motivating driving behaviour change. Motivated by anecdotal evidence, we hypothesise that an egocentric approach is more appropriate and relevant. By re-defining the VSP surrogate metric, we are able to switch between systemic and egocentric feedback while maintaining minimal changes between our experimental conditions. Orthogonal to the manipulation of the efficiency model, we describe our interest in testing the effect of instantaneous versus historic data in the feedback system.

## Acknowledgments

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# Creating 'Cool' Mobile Technologies To Reduce Teen Energy Use

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## ABSTRACT
In this paper we present an overview and initial work from a research project creating 'cool' mobile technologies to educate and inform teenagers in order to reduce their energy use. Teenagers are already becoming consumers and will form the next generation of workers, homeowners, managers and policy makers; a longitudinal change in their habits could have huge impact. However, it is notoriously difficult to engage with teenagers and effect changes in their attitudes or actions. Teenagers are often most motivated by their peer group and what is currently 'cool' or 'uncool'. The challenges of this work are not only the creation of persuasive mobile technologies to encourage teenagers to reduce their energy use, but to make these technologies sufficiently 'cool' that they are desirable and socially acceptable enough to support adoption and appropriation by teenagers. In addition to providing personalised and aggregate energy usage data and educational information in a meaningful way, the mobile technologies we are designing will allow for appropriation in 'cool' ways thereby fostering an active community of teenagers where it is cool to minimise energy use.

### Author Keywords
Energy Use, Teenagers, Mobile Technologies



### ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## INTRODUCTION
Governments across the world are now committed to reducing CO2 emissions and one key area for improvement is reduction in domestic and personal transportation energy usage. In the home CO2 is released primarily in the generation of electricity, the combustion of gas and oil for heating and combustion of fuel in transport. Within the past 20 years there has been a steady increase in the number of appliances in the modern home coupled with growth in the ownership of energy hungry devices such as tumble driers and plasma TVs and an increase in the use of devices with standby facilities [5]. Many of the electrical devices contributing to the rise in domestic energy are used and sometimes owned by teenagers. Research in the UK has indicated that 95% of teenagers had a TV, music system or phone in their rooms, with two thirds having all three [13]. A separate study reported that 400 surveyed teenagers aged 13 to19 were collectively wasting enough energy to power 4,702 schools and a third of the energy being used was a direct consequence of 'standby' behaviour [1].

Our work on the 'taking on the teenagers' projects (www.mad4nrg.org) will engage young people (aged 12-19[1]) in reducing their own personal energy use and make

[1] It is problematic running studies with teenagers from age 14-15 in schools in the UK when they begin preparing for GCSE examinations, we therefore also target pre-teens to ensure we can work the same subjects for the 3 year duration of the project.

positive changes in attitudes towards energy use that will last through adulthood. This will be achieved through the creation of mobile technologies (called MAD: Make A Difference) to educate teens about choices they can make to reduce energy use and provide feedback on energy usage. Mobile technologies will also be used to gather energy usage information through self-report and sensing technologies, for example detecting which transport methods are being used, in addition to more usual energy monitoring in the home. These mobile technologies will make personalised and aggregated energy usage information accessible in meaningful ways to enable comparison and competition between peers to foster an active community of teenagers interested in reducing energy use. The mobile devices will also make available status updates about individual energy use and provide targeted educational material to users.

The popularity of home energy monitors from manufacturers such as AlertMe (www.alertme.com) and Current Cost (www.currentcost.com), and services such as Google PowerMeter (www.google.com/powermeter) mean that monitoring electricity use in the home is inexpensive and uncomplicated. However, even where the energy consumption information is provided, the visualization of this information often cannot easily correlated with consumption behaviour [9]. This is either because the units of measurement are relatively meaningless to users or the information is irrelevant to their interests (e.g. cost information may not mean much for teenagers who do not pay the bills). Furthermore there is a common lack of awareness about the amount of energy consumed by device sin the home and energy-saving options [6].

The key challenge of this work is not only design highly usable mobile technologies to provide access to energy usage information presented in a meaningful way for teenagers, but also to ensure that these technologies that are sufficiently 'cool' that they are desirable and socially acceptable. Having created devices that are used and understood by the teens, we will then use a range of approaches to lead to long-term behavioural modification. To achieve these goals a participatory approach is used which involves working directly with young people in schools to carry out design and evaluation studies.

We now discuss the challenge of 'cool' and our initial findings, the persuasive aspects of the technologies we are creating, and the technological challenges we face. We give an overview of related work and finish with a discussion of key issues and future work.

## THE CHALLENGE OF 'COOL'

While the meaning of 'cool' has been considered, for example [10] [12], there is not a single universally applicable definition. Cool may be anti-social or illicit, it may be expensive and highly desirable, or it may represent innovation (and these are not mutually exclusive categories). In the case of teenagers, peer groups often define the attributes of cool and being 'cool' is often extremely important. From studies of existing literature and initial design sessions we have identified three main levels of coolness in the context of teenager. The first, and easiest to achieve, is the coolness associated with having desirable things that others aspire to (such as latest technology or clothes), the second is coolness associated with actions or activities that gain recognition from peers. The third, and most challenging to achieve, is that of holistically 'being' cool and often results in being admired and often deferred to by peers. It is this latter category that marketing companies often seek to influence as, by virtue, products they associate with become cool and are then desirable by others.

Coolness is generally a challenging property to design into a product and within the three types of cool we have identify the second (associated with actions or activities that gain recognition from peers) as most likely to be achievable within the project. This will be coupled, to a lesser extent, with the first type (having desirable things). The mobile applications we are designing will enable teen users to monitor their energy usage (captured using low cost monitoring technology in the home and mobile devices) and devise their own ways of representing, sharing and comparing the information. Through our participatory approach we will create applications that support customisation and expressivity such that they can be appropriated in a 'cool' ways by teenagers. One scenario we envisage is teenagers being able to compare energy usage using a metric and visualization they themselves have devised and/or adopted (which is assumed to be cool in their peer group) to determine who is the winner (using the least energy) and who is the loser (using the most energy). In this example it is likely that competition will encourage consideration and reduction of energy use. Also, these motivations will be nurtured and supported through use of the MAD technologies that will provide information and advice on measures to reduce energy use, in addition to providing information on current energy usage.

## CHANGING BEHVIOUR

This work will build upon the TTM model of behaviour change [11] and will link into more recent work on emotional engagement for behaviour change ([2],[4]) which demonstrates that behaviour change is more effective, engaging and productive if there is an emotional engagement between the technology and the user. Thus our mobile technologies have to support appropriation in cool ways but also have to be designed in a way that teenagers can easily relate to them and in a manner that is receptive to emotional interpretation (i.e. the systems themselves do not necessarily have to be emotional, they just have to be able to appear emotional even if that effect is projected by the user).

This project works from the assumption that teenagers have the potential to make significant changes to energy usage. Not only can changing teenage behaviour affect their long-term personal use, but they are also in a position where they can use 'pester power' to affect the attitudes and behaviours of their parents, siblings and friends. As many teenagers have a greater amount of leisure time than adults, this can result in the use of many high energy technologies such as computers, games consoles and entertainment systems, while their behaviours are not monitored by parents or guardians in the way a younger child's activities might be. The project will aim to gather more information about teenagers' patterns of energy use in order to understand their behaviours and motivations more, and how they may be influenced.

The initial goal for behaviour change in this work in to influence reduction in electrical and transport energy use. Initially, stories of energy usage will be collected from teenagers in the schools with which we are working. The stories will be composed of text, images, video or audio and will give qualitative insights into teen energy use and attitudes towards energy use (some will be collected in school, others will be collected during focus groups). At a later stage in the project, after we have deployed the MAD1 and MAD2 products, we will then collect energy stories again to allow for qualitative comparison of change in behaviour.

**TEEN TECHNOLOGY**

The project aims to create two key mobile products, one for 13-16 year olds (MAD1) and another for 16-19 year olds (MAD2). A key issue is selecting which mobile platform(s) to target and this is likely to be the trade-off in terms of features provided and device popularity. While smart phones such as Blackberry devices, iPhones, Android devices, and Nokia Symbian handsets are increasingly prevalent among adults in the UK, their high cost often makes them inaccessible to younger teenagers with little spending power and restricted to 'pay as you go' (contract free) call plans. From our current studies in schools with year 7s (age 10-11) and year 10s (age 13-14) it is apparent that the phones they own are basic devices often handed down from an older sibling or parent. We have also found that the children in our initial studies have little interest in owning and using a mobile phone. Boys in particular admitted that they failed to remember to charge their phone or ensure they had enough credit to make calls. Several year 10 boys claimed that they found their mobile phone useful as an alarm clock but little else.

Technologies adopted by older teenagers (17-19) with slightly high spending power are often fashion led, but not necessarily those which hit the mainstream or adult media. For example, in a survey of all new undergraduate entrants to a major UK University, Blackberry devices outnumbered both Nokia's and iPhones, for example. This is partly due to the cost of such devices but also the availability of specific communication channels – Blackberry Messenger being a popular one, but not (easily) accessible without a Blackberry handset. Within the project we have funds to provide a small number of participants with mobile devices (the number depending on the cost of the device), but after initial trials we wish to open the system up to as wider participation as possible.

In order to enable energy monitoring in the home the project will use low cost COTS home energy sensing technologies from manufacturers such as AlertMe and Current Cost that can sense electrical energy use on a per-home and per-appliance granularity, and make it available over the Internet. Sensing kits will be provided for a number of user 'champions' and is hoped that they will help encourage other teens to pester parents into buying the kit so they can take part.

A participatory design process to create MAD1 and MAD2 will be ongoing with several different groups in teenagers in schools across the UK involved. We expect to develop a mixture of education, game-playing and competition, collaboration, peer pressure and self-awareness raising approaches within and around these products to lead to reduction in personal energy use in the short term and long-term behavioural change. In addition to MAD1 and MAD2, a specially designed web portal will be used throughout the project to allow participants in the project to share stories about their energy usage, using narrative, images and video. These will provide a rich source of qualitative data for the project and also allow the identification of change in energy usage habits as the project progresses.

**RELATED WORK**

A small number of wearable/mobile research prototypes and products have been developed for conveying energy usage information. UbiGreen [7] used mobile phones as ambient displays to give user feedback on their transportation behaviours. It relied on the wearable sensing unit, GSM cell signals and the participants' manual input to detect transportation mode. Eco-friendly transportation behaviours, such as carpooling, taking bus and cycling etc. were encouraged and shown as rewards on the ambient display. EnergyLife [3] is a pervasive sensing and feedback system. A server was connected wirelessly via a base station to energy sensors which reported their energy usage every couple minutes. The real time energy consumption information together with device consumption history, energy reservation tips etc. were delivered to a smart phone upon user's request using a Carousel interface. GridCarbon is an iPhone app produced through the iDEaS Project (www.ideasproject.info) which shows the current carbon intensity, the quantity of $CO_2$ produced for 1 kWh of electricity consumed, of the electricity currently being generated in the UK. The intention of the app is that it can be used as a tool to influence energy demand and reduce $CO_2$ emissions. AlertMe provide an iPhone app to allow remote access to data recorded by their home energy monitoring product. The app allows current energy usage to be viewed remotely and provides a 'personal swingometer' which is a simple graphical representation to help convey energy usage in an easily understandable manner. While these examples highlight some innovative approaches to reducing energy use though mobile technologies none of them align with the more holistic and long-term energy reduction aims of this work.

## DISCUSSION

In creating energy saving devices for teenagers we consider that 'cool' is a powerful factor in motivating adoption and appropriation. To make energy saving attractive, we need to tap into the potential for peer pressure, personal goal setting and achievement, and make good use of energy an integral part of the general discourse between teens. Our approach is not to attempt to produce cool products per se, but to create technologies that can be personalised and appropriated in cool ways.

The ethics of persuasion [8] in the context of this project are somewhat mitigated in that the reduction of energy use is accepted to be a necessary move. However, this will be an area we explore in detail as the development of the MAD1 and MAD2 prototypes progress. The project is currently engaged in design sessions with teenagers to explore initial scenarios and requirements for MAD1 and further understand the key characteristics of cool for different groups. In parallel we are also exploring and technical possibilities and expert technical designs, and investigating teenagers' current attitudes towards energy use. We hope that the novel themes in this work will be of interest to the participants of the workshop and provoke interesting discussion.

## ACKNOWLEDGMENTS

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# Nudging People at Work and Other Third-Party Locations


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### ABSTRACT

Nudging people towards positive behaviour change is an important issue recognised by academia, individuals, and even governments. Although much research has been published in this area, little has focused on non-domestic environments such as the workplace. It is widely reported that changing individual behaviour of employees can make a significant contribution to sustainable resource consumption. This position paper focuses on the unique aspects that make nudging consumption behaviour in third-party environments like the workplace a very different problem to that of nudging in people's domestic and private lives. Several studies are discussed to provide context as well as evidence towards our position.



### Author Keywords

Persuasion, Nudge, Work, Ownership, Sustainability, Behaviour Change.

### ACM Classification Keywords

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

### General Terms

Theory, Human Factors, Design.


### INTRODUCTION

The HCI community has recently shown a great deal of interest in the development of interactive systems that facilitate behaviour change for sustainability. Much of this research has exploited ideas recently re-popularised by Thaler and Sunstein [10] in that individuals can be 'nudged' to make better lifestyle decisions, given the right information and the environment in which to do so. Much of this work has focused on how individuals might improve their own private and domestic lifestyle, behaviour, and sustainable resource consumption; however such work has rarely taken account of the fact that people spend a significant amount of their waking hours at work where they also contribute towards resource consumption.



A recent report [1] has indicated that if the 17 million UK workers, who regularly use a desktop PC, powered it off at night this would reduce $CO_2$ emissions by 1.3 million tons - the equivalent of removing 245,000 cars from the road. Similarly, if a UK business with 10,000 computers leaves them on all night for one year, it will cost £168,000 ($220,000) and emit 828 tonnes of $CO_2$. The same report, however, suggested that at least three in ten workers in the UK do not always power off their PC overnight. Further, many more machines are in use or provide services 24 hours a day, all year round.

As an example in our own context, Figure 1 compares the electricity usage at the University of Lincoln campus for the first week in December in 2009 and 2010. There are two compelling features of Figure 1 that characterise the typical energy consumption of a workplace. First, the graph clearly shows how little energy the university uses at the weekend. Second, this period in 2010 coincided with severe weather that meant that many staff members were unable to travel to the campus. The dramatic reduction in energy consumption can be clearly seen in the first 3 days of the graph and highlights that people can have a significant impact on consumption at work, as well as in their own personal environments.

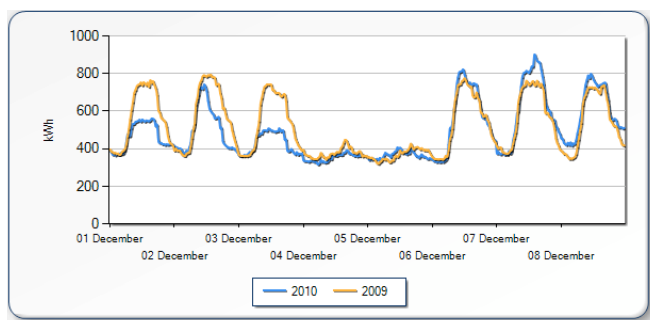


**Figure 1 Campus electricity usage December 2009/10**

Despite environmental concerns now playing an established role in the public sector, as well as the corporate and business agenda, there is still much to gain by exploring new ways of persuading people to adopt positive energy usage behaviour. The first and obvious research question is: Do domestic PINC (Persuasion, Influence, Nudge & Coercion) methods simply translate to workplace and other third-party environments? In this position statement we review initial evidence that they do not, and discuss the reasons why. We propose a framework for thinking about Nudge methods in different contexts, and discuss our future work in this area.

## RELATED WORK

Thaler and Sunstein [10] have recently re-popularised the interest in the idea of Nudge, where the right environments and the right information delivered at the right time can encourage people to adapt and improve their behaviours. Much research has focused on directly improving one's own behaviour, whether it be reminders to exercise, or to notably reduce energy consumption. Research into simple home energy monitors [3], for example, suggests that pay-as-you-go meters typically reduce consumption by only 3%, while those that focus on reducing their payments often reduce their consumption by 0-10%. Having an in-house monitor that provides instant feedback has been shown to reduce consumption by between 5 and 15%. Other prototype systems, such as Kuznetsov and Paulos's domestic ambient light display [7] successfully encouraged people to reduce their water consumption, by visualising better or worse consumption to their previous average use.

Other research typically provides anonymous averages from a group or community to a user, so that the user can see their own behaviour or consumption in the context of others. In previous work [5], we reduced domestic energy consumption through a carefully designed mixture of online social media and home energy monitors. Our findings suggested that the use of energy feedback delivered in a social context significantly reduced consumption when compared to energy feedback without a social context. We have also shown similar results in a personal fitness/activity domain [4].

A related approach involves facilitating 'friendly' competitive behaviour; for instance it has already been shown that the work environment affords powerful opportunities for facilitating such behaviour – for instance Siero et al [8] demonstrated that when a group of employees received information not only about their own energy usage, but also about that of a 'competing' group of employees from the same company but a different workplace, they significantly altered their energy usage behaviour compared to a situation in which they only received information about their own usage.

Despite the success of the work by Siero et al some thirteen years ago, little research since has explored energy behaviour interventions based on competition between employees. Therefore, a key question for Nudge researchers going forward is how do differences between the work and domestic leisurely sides of life affect the potential of behaviour change interventions? Also, what theoretical grounding can we draw upon to begin to explore any differences? Stebbins [9] introduced a seminal framework for understanding people's leisure time. For some, being environmentally friendly is, as Stebbins called it, a Serious Leisure, where people work hard at achieving their goals. Installing home technology is often a temporary project, and can be seen as Project Leisure, where people take behaviour change to be a new task. The aim of much nudging research, however, is to be embedded in people's Casual Leisure, so that good consumption is encouraged simply and unobtrusively within our lives. These forms of leisure, however, are very different from our work lives, which are goal-oriented, formalised, and externally driven.

## EARLY EXPERIMENTAL FINDINGS

### Study 1 – Water Consumption in the Work Place

One early finding in this space was from Kuznetsov and Paulos [7] who anecdotally saw unexpected results in a work environment, and so proceeded to focus on domestic scenarios. Their anecdotal findings saw consumption *increase – double* in fact.

One of our recent studies in Swansea University, UK, focused directly on this surprising issue. We created a series of feedback installations, and installed them in a shared work-place kitchen. Like the work by Kuznetsov and Paulos, the installations used a Phidget microphone to track water flow through the pipes. The installations were supported by informational posters, which included a link to a website to provide feedback. Otherwise, we remained as un-intrusive as possible in order to record normal usage as closely as possible. After recording baseline average readings, we first recreated the ambient light display provided used by Kuznetsov and Paulos, which: glowed green with less-than-average consumption; glowed yellow 10% either side of the mean; and glowed red thereafter.

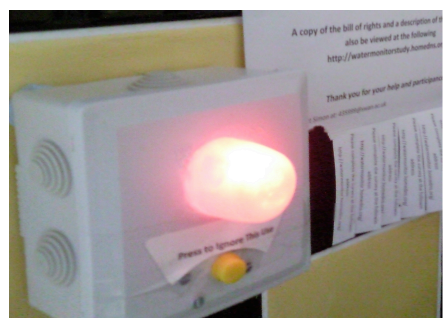

**Figure 2: Our ambient-light installation**

Three further displays were installed in subsequent weeks. The first used similar measures, in respect to average consumption, to create competitive gaming-style text-oriented messages on an LED display, such as: "You're beating most people" and "Sorry, you lost". The second display converted the light system into a series of audible beeps. The final display tried a different tack altogether, by simply providing environmental information relating to their water consumption, such as the average amount of water available to people in the third world on a daily basis.

Initially, as per the prior anecdotal evidence, the ambient light display did double the average consumption of water during the 2 weeks it was displayed. In comparing studying the additional displays, we saw all but the audio condition increase the consumption. While the increase shown by these alternatives was significantly less than the ambient light display in particular, none were significant. Although the audio feedback did marginally reduce consumption, we also recorded a significant number of opt-out button presses in the audio condition, indicating that people disliked this particular installation. Qualitative comments from an optional online survey confirmed this. Given the surprising increase created by the ambient light display, we concluded the study by reinstalling the ambient light display for a final week. Although not quite double the average consumption, we again saw a significant increase in energy consumption.

In the end, none of the displays managed to significantly decrease consumption of water. It is promising, however, that not all the displays increased consumption significantly. This means that such displays do not simply have the opposite effect in work environments. Instead, the results suggest that people simply do not care for the consumption of the company as a whole, and potentially do not mind entertaining themselves with the resources of the company by using additional resources. The fact that significantly more users opted out of the audio display, which was the only one to reduce average consumption, further indicates that people do not mind avoiding resources in this area; that they do not feel personally motivated to accept the nudging technology.

### Study 2 – Energy Consumption in the Work Place

Our recently commenced Electro-Magnates study [6] aims to reduce energy usage in the workplace by utilising a suite of social persuasive applications to encourage pro-environmental behaviours. Personal desktop applications (social widgets) and situated displays will be used to deliver energy feedback to individuals, groups and communities about their own – and others' – energy usage to foster exchange of performance and to support constructive competition to reduce consumption. The workplace in the context of this study is educational and public sector work-place environments in the county of Lincolnshire, UK.

In previous work [5], we reduced domestic energy consumption through social norms and social technology. However, designing a similar system for the workplace presents greater challenges across a range of design, ethical and technical issues. From our study focus groups in the domestic environment we discovered that for some people *cost* was the primary motivating reason to reduce their energy use. In the workplace employees are not typically responsible for paying energy costs, neither are they directly responsible for meeting any governmental carbon policies in place that could lead to institutional 'carbon' fines.

To mitigate the absence of financial motivation in employees and to develop workplace energy metaphors, we intend to run a series of focus groups and participatory design workshops to engage and empower the employee in developing an understanding of both the economic and environmental impact of their working practices. The participatory design workshops will provide an opportunity for employees to be directly involved in designing the UX element of Electro-Magnates therefore helping to address ethical concerns over privacy and appropriate disclosure of energy data.

Early work to date includes prototyping a high-impact energy interface for overall energy usage in Figure 3, page viewed on 09/01/2011, as well as a competitive league table for buildings. Both prototypes are designed for large situated displays and are abstracted presentations of what is possible with raw energy sensor data which in itself is intangible and difficult to interpret.

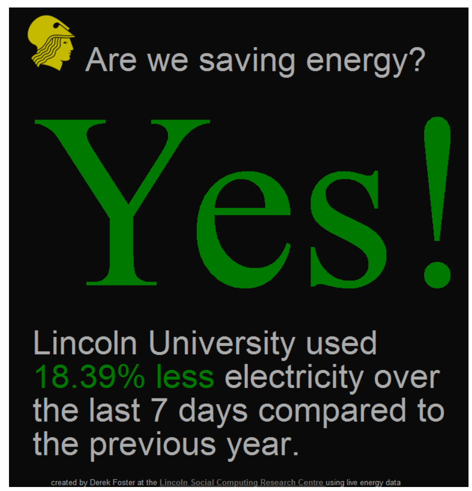


**Figure 3 High-impact visualisation of overall energy usage**

### DISCUSSION

The workplace, as an example of a non-domestic, non-personal environment, creates many unique issues for the ideas behind nudging behaviour. Consequently, we have identified three initial dimensions that differentiate domestic and workplace environments that might be used as a formative framework for thinking about applying nudging technology in different environments:-

***Expression of Self.*** First, the workplace may be termed a special environment in that there are usually constraints and rules in how employees can interact and carry out activities in the workplace compared to their less inhibited personal life. This is particularly important when considering employee consumption of resources with emphasis on ownership, freedom of choice and sustainable behaviour. Ironically, an individual may be committed to pro-environmental behaviour when at home but is forced to engage in negative practices at work such as using inefficient energy-intensive equipment or sitting in an over-heated environment.

***Sense of Responsibility.*** Second, prior research typically assumes that individuals are trying to change their behaviour, or reduce their consumption, but for many the workplace is not their own and not their responsibility. Consequently, not only is the environment and technology controlled for them, people have a diminished sense of responsibility for the energy costs and environmental impact.

***External Constraints.*** Third, the workplace or type of work has its own requirements – they may need to maintain 24-7-365 server support. It may be normal for some businesses to have 3 or more machines running per individual, but unusual for others to have a computer at all. This kind of top-down requirement might make individuals feel out of control of the environment and its consumption, leading to lack of motivation.

Given these limiting and influential factors, it is hard to consider how we can utilise the same nudging technology that we typically apply in domestic contexts. The few successful workplace nudging installations have typically been dependent on a driven community. The CleanSink project [2] saw some positive influence in hospitals, where cleanliness is both required and important for care. Our on-going study on energy consumption in Lincoln, is focusing on driving community motivation, which may encourage expression of self and increase sense of ownership, whilst working within the external constraints of the workplace.

## CONCLUSIONS AND FUTURE WORK

Much of the prior research on Nudge, and other PINC issues, has assumed that individuals are focusing on their environments, behaviours, consumption, and other things that they are in some control over. How does Nudge fare in environments, like the workplace, that are typically outside of an individual's control? Such questions are important for larger organisations who want to improve their collective behaviour, whether it is a business trying to reduce its own consumption or meet it's quota of carbon credits, or a government trying to reduce the nation's consumption.

In our future work, we are focusing on this issue in two ways. First, our funded research is focusing further on encouraging community-driven nudges for reducing business and employee consumption. Second, we are planning future studies that specifically investigate the nudge of groups and communities rather than of individuals, as to meet the UN's Millennium Goals[1], we need to nudge the behaviour of the global community and not just that of individuals.

[1] http://www.un.org/millenniumgoals/

## ACKNOWLEDGMENTS

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