Mobile Persuasive Technology

» *Promoting pro-environmental behaviour*

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ABSTRACT:

This Master's thesis explores the possibility to use mobile persuasive technology to persuade people's pro-environmental behaviour. This was done by designing, implementing and deploying two mobile applications in two domains (water conservation and power-consumption).

Ten households were deployed in Denmark and Australia. Based on the deployments, several themes has been elicited and discussed.

Finally, the thesis sum-up the two research projects, and eight guidelines has been elicited and described out of the common findings. The guidelines are instructive to consider when designing mobile persuasive technology to promote a pro-environmental behaviour.

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THESIS ONLINE

The thesis can be read and downloaded online as a PDF.
Furthermore pictures from both projects are presented.

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CONTENTS

RESUME

This Master's Thesis revolves around the theme: "Mobile Persuasive Technology" and focuses on using mobile persuasive technology to promote pro-environmental behaviour. The thesis primarily consists of two research projects resulting in two scientific research papers.

The first paper explores the possibility to use a mobile device as a supportive tool for gardening to persuade residents to become conscious about their water consumption. An early version of this mobile application was built to explore the role of three different information sources (weather, expert's advice and community information). The paper presents the design, implementation, and evaluation of the provided mobile application. Based on the evaluation, several themes for designing mobile technologies to promote a pro-environmental behaviour in the water-domain are elicited and discussed.

The second paper takes origin in the experience gained from the first paper, and explores the use of mobile devices in another domain, i.e. power consumption. The paper discusses a system that tries to promote a pro-environmental behaviour at residents in their households. By providing tailored information to citizens in a mobile application it raise awareness of consumption. As with the first paper, the second paper explores three different information sources (personal power consumption, expert's advice and community information).
The design, implementation, and evaluation of the mobile application are described. Subsequently, the paper presents the findings from the project to support design suggestions for energy consumption in mobile applications.

The two projects are tied around a summary report, where a guideline of eight points has been elicited and described out of the commonly found findings from the two projects. The listed guidelines are instructive to consider, when designing mobile persuasive technology to promote pro-environmental behaviour. The main contribution of this thesis is that there is a big potential in using mobile devices to persuade people to promote a pro-environmental behaviour.

PREFACE

This Master's thesis is the final step taken in becoming a M.Sc. in Informatics at Aalborg University. During the thesis-writing period, I was a visiting research assistant trainee at the Department of Information Systems, University of Melbourne, Australia, in the period July 2010 – December 2010.

While in Melbourne, I was associated with the research project Smart Garden Watering (SGW), funded by the Smart Water Fund (Vic) [9, 15]. Even though I produced the work of this thesis, the research grounding this thesis has been conducted in collaboration with employees from the University of Melbourne.

I would like to thank Dr. Jon M. Pearce and Dr. Wally Smith, both employees at the University of Melbourne, for their valuable and rewarding collaboration. I could not have conducted the various field studies with the participating Australian families without your help. These families who participated in these field studies also deserve my utmost gratitude. I would also like to thank my supervisor Dr. Jesper Kjeldskov for his invaluable support during the last year.

Especially I would also like to thank Christian Vang, Henrik Andersen & Michael Juhl from Modstrøm A/S for their help in retrieving participants for the study in Denmark, and providing Automatic Meter Reading equipment for the study [7].

Finally, I would like to thank *F-studienævnet* and *Internationaliseringspuljen* at Aalborg University and also *Oticon Fonden, Knud Højgaards Fond, Nordea Danmark Fonden, Rudolph Als Fondet and IDA's Låne & Hjælpe Fond* for financial support making my six-month stay at the University of Melbourne possible.

Literature references will use the ACM CHI Conference reference format [1]. A list of relevant literature can be found in the back of the report. The appendices to this thesis can be found in a separate report and contains material from the entire thesis, including data from the two research papers. A CD is provided along the report with digital data, such as interviews, program-code etc.

Rahuvaran Pathmanathan

Aalborg, June 2011

READING INSTRUCTIONS

This thesis is composed of two research papers and a report that combines the two papers based on the topic: Mobile Persuasive Technology: *Promoting pro-environmental behaviour.*

Each of the research papers can be read individually. The report unifies concepts covered in the papers and provides a red line throughout the entire work. Both papers are written in the ACM CHI Conference Publication Format [1].

1. INTRODUCTION

Introduces to the environmental problem, the concepts of persuasive technology and eco-feedback technology, and the use of these technologies to promote a pro-environmental behaviour to bridge the environmental literacy gap.

2. RESEARCH CONTRIBUTIONS

Presents an overview of each research paper. The summary of each paper presents the motivation, the method, and the results from the study.

3. LESSONS LEARNED

Covers the lessons learned from the two research papers. An illustration of the commonly key-findings from the two papers is lillustrated. A list of instructive guidelines is described, to be considering when designing mobile persuasive technology promoting pro-environmental behaviour.

4. CONCLUSION

Describes the main contributions from the two research projects, and lists the important points to consider, when designing technology promoting pro-environmental behaviour. Subsequently the future work is described.

5. RESEARCH PAPER I

Presents the first research paper: "Using Mobile Phones for Promoting Water Conservation"

6. RESEARCH PAPER II

Presents the second research paper: "Using Mobile Phones for Raising Awareness of Power Consumption"

7. REFERENCES

A shared list of references, used throughout the thesis-process for both research projects. For each research paper an individual reference-list is listed in each.

1. INTRODUCTION

The phrase about "being responsible for the environment" has for the last 10 years been on almost every politician's lips and many campaigns worldwide have tried to raise awareness regarding the individual's responsibility to contribute to a better and more sustainable world. As citizens of this planet we are all responsible for the environment to some degree. We all need to take small steps to reduce the negative impact we are having on our planet.

The real problem has less to do with issues like greenhouse gasses, oil spills, and toxic waste; instead, it is more related to our inherent ambition to become a better citizen that cares about the environment. Small steps in which we are able to "succeed" on this ambition, are, for instance, reducing our personal ecological footprint, educate ourselves on environmental issues, and changing our lifestyles to consume less and care more. However, if one person or your neighbour down the street does take the responsibility, this will certainly not be enough to make a huge difference. There is a need to change the society to become better citizens. Still, there is a lack of knowledge in the general community about how to take responsibility for the environment [3]. A way to inform, educate, and persuade the society to change their behaviour in becoming more concerned about the environment could be by using technology. Persuasive technology might be a solution to raise awareness.

The founder of Stanford Persuasive Technology Lab, B.J. Fogg, defines persuasive technology as *"Technology that is designed to change attitudes or behaviour through persuasion and social influence, but not through coercion"* [2]. These technologies have over the last numerous years been applied in domains such as: sales, diplomacy, politics, religion, public health, and latest e-business, and may potentially be used in area of human to human or human-computer interaction. In the human-computer-interaction research field persuasive technology has been focused on interactive, computational technologies including desktop computers, Internet services, video games, and more recently on mobile devices [8]. Technologies designed to provide feedback on individual- or group behaviour with the goal to reduce the environmental impact is called Eco-feedback technology [3].
This term goes back more than 40 years and originates from the field of environmental psychology. Within this research domain the term relates to the working hypothesis that people lack knowledge and awareness about how their everyday behaviour, e.g. showering, doing their laundry, and driving to work affects the environment. A way of bridging this environmental literacy gap could be by using persuasive technology [3].

Triggered by these issues, the research question for this thesis is formulated to be:

How can technology be designed to persuade citizens to promote a pro-environmental behaviour?

This thesis tries to bridge the gap by using mobile technologies to persuade users to a pro-environmental behaviour change. Two research projects in two different domains, i.e. water and electricity, have been conducted and their common key-findings have been elicited and described.

2. RESEARCH CONTRIBUTIONS

The main part of this thesis comprises two research papers (Chapter 5 and Chapter 6). Each of these papers is written exclusively on the 10th semester of my study and neither has been submitted as part of the 9th semester project in any way.
Furthermore, the first paper will be submitted to OzCHI Conference 2011 in a revised version and the second paper will be submitted to CHI Conference 2012 in a revised version.

The common ground for both papers is that:

» the research explores mobile persuasive technology in a pro-environmental domain.

» the research design and process is conducted in the same way.

» the data collection and analysis is done based on the grounded theory approach [16].

» a mobile application is analysed in a case study period of 3 weeks with ten participants.

Each paper is written as a stand-alone contribution. It should be noted that the second paper builds on some of the findings from the first paper, so a sequential reading would be preferable.

The following two sections presents the two research papers in one-page summaries.

2.1 USING MOBILE PHONES FOR PROMOTING WATER CONSERVATION

Water is precious, and as with many other countries, Australia has for many years been through persistent drought and the effects of climate change. Therefore, water restrictions are currently set in place in many states and cities in Australia. By setting up water restrictions for the general households, people become aware of when they are allowed to water for instance their gardens. Still there is a lack of knowledge in the general community about how to save water for the environment.

The paper introduces an application called "SGW Advisor", which aims at supporting gardeners to promote water conservation [14]. With the aim to persuade gardeners to use water more wisely an effective method is tailored information technology. Therefore, the paper seeks to investigate how a mobile application influences gardeners to conserve water in their garden according to their garden watering-practice. By implementing three different information sources, i.e. weather information, an expert's advice, and community information, it was able to explore how the gardeners understand the information and what information influences them to promote water conservation. The application was designed to run on mobile devices and desktop PC's. The application was tested on both platforms, to explore what platform that was the most preferred.

By means of a case-based approach, ten participants, who used the application on a daily basis, were followed for a three-week period. The participants were located in the greater metropolitan area of Melbourne. The participants received a potted pea plant seedling they had to look after during the case study period; furthermore, the participants had to answer to the incoming messages in the application. Interviews before and after the case study made it possible to go into greater detail on key elements that were important to consider when designing persuasive mobile technology to promote a pro-environmental behaviour.

Data from interviews and questionnaires were analysed on the Grounded Theory approach. Open Coding was used to discover in total 273 different properties, which identified 72 phenomena. By using Axial Coding relations between the different phenomena were categorized into 12 categories and then split into four main themes.

Results showed that the gardeners found the provided prototype as a supportive tool to use in their gardening practice. They perceived the provided sources of information as useful. Though, they mentioned that their own judgment had a greater impact on them than the provided three information sources. Furthermore, the results also indicated that the gardeners wanted more tailored and contextualized information to be persuaded to promote water conservation. The gardeners found the messages containing different sources of information as very credible and demanded more messages containing mixed sources of information because it created a greater trust, and ability to become more pro-environmental.

2.2 USING MOBILE PHONES FOR RAISING AWARENESS OF POWER CONSUMPTION

The society has recently become more concerned about the environment, and a major focus has been put on people's responsibility to save energy. People are still unaware of when and where their power consumption occurs and rely on their monthly invoice that typically reports limited or irrelevant consumption information. To promote power consumption the paper explores the possibility to persuade consumers to become more conscious about their own consumption through a mobile application called "Power Advisor" [11].

The paper explores how to design mobile technology to persuade residents to raise awareness about power consumption. This was done by implementing three different information sources, i.e. information about their personal power consumption, expert's advice, and information about the energy consumption of other residents in the community. The system was built to run on both smartphones and Tablet PCs to investigate which platform the users preferred.

Similarly as the previous study, ten participants, who used the application on a daily basis, were followed during a period of three weeks. The participants received in total nine messages with different sources of information messages on which they had to respond. The application obtained information about the participant's own consumption through an Automatic Meter Reader (AMR), which was provided by the utility company Modstrøm A/S [7]. The AMR's took a picture for every hour of the residents' meter reader, analysed the picture, and was interpreted by the application to view on the participant's own profile in the application. The participants all lived I Northern Jutland, Denmark, and were found through Modstrøm's customer list.

Data collection was conducted through interviews before and after the case study. This made it possible to go into greater detail on key elements, which were important to consider when designing persuasive mobile technology to promote power consumption. Data from interviews and questionnaires were analysed on the Grounded Theory approach. Open Coding was used to discover in total 601 different properties, which identified 22 phenomena. By using Axial Coding relations between the different phenomena were categorized into 12 categories and then split among three main themes.

Results showed that the residents using the application found it a supportive tool to use in their households. The participants indicated that by using the application over a longer timespan it had a big opportunity to change the behaviour of the residents. They found the receiving information sources as credible. The most important information source, which made most impact on the participants, was the information about their personal power consumption. The community information and the expert's advice information messages were only found credible as long they were combined with information about their personal power consumption. The results also indicated that the motivational factors such as saving money for buying a specific product or saving money to charity to local organizations could have a possibility to persuade residents to become more aware of their power consumption.

3. LESSONS LEARNED

The two research projects have individually contributed with several interesting findings when designing persuasive mobile technology to raise awareness in a specific domain. Some of findings about persuading people to a pro-environmental behaviour were common in the two projects. This chapter attempts to identify the shared contributions that are possible to elicit from the two research projects. These can be considered when designing persuasive mobile technology to persuade any pro-environmental behaviour.

The model on Figure 1, illustrate the key-findings from the two papers that are almost similar. The findings from the two projects that stand-alone are shown in the left (water project) and right side (power project) of the model. The shared findings are shown in the middle. In total eight shared findings were discovered from the two research projects.

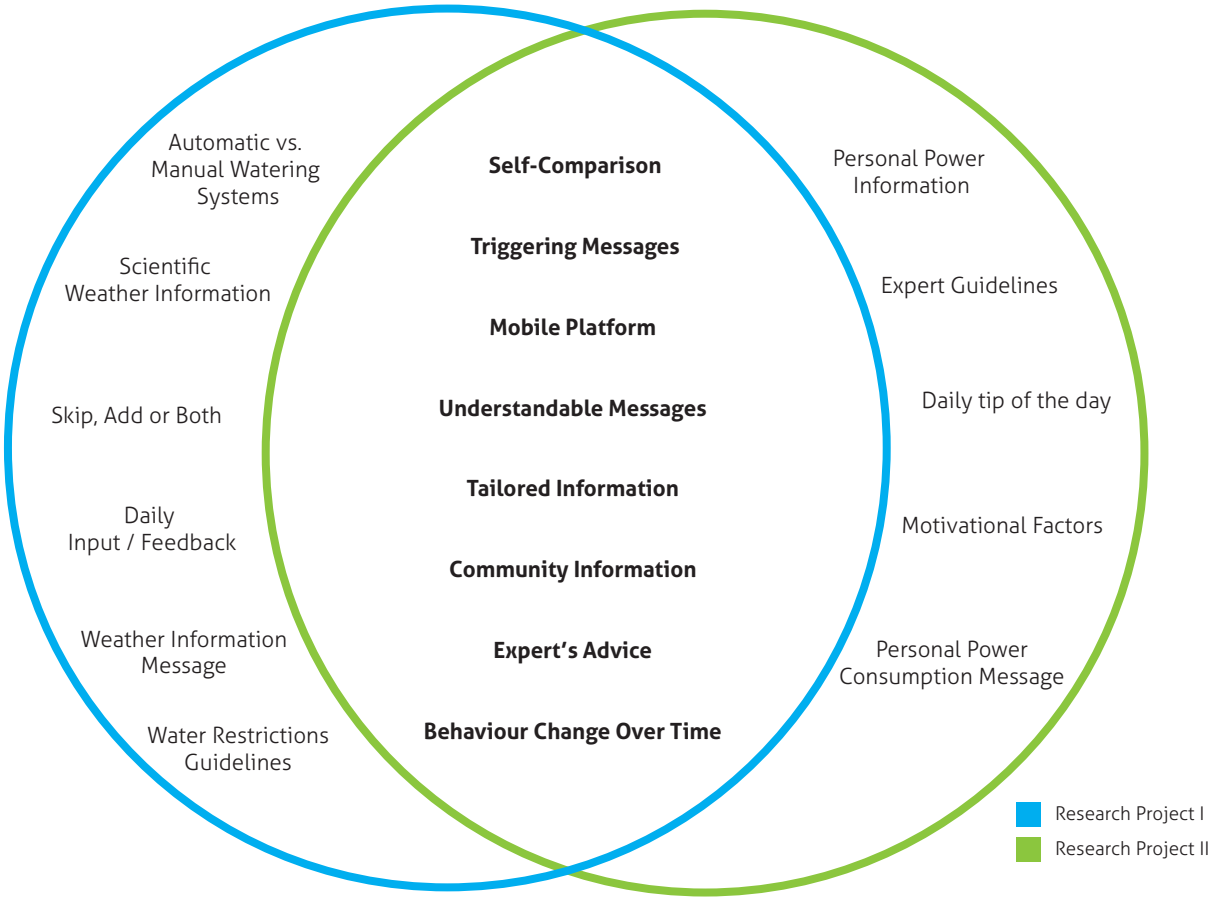

Figure 1. Common findings derived from the two research studies

3.1 EIGHT INSTRUCTIVE POINTS

In the next sections, each of the shared contributions will be described and discussed. The outcome of this process is a guideline with eight points to be aware of when designing persuasive mobile technology to promote a pro-environmental behaviour. It is important to note that these points are made on behalf of the research studies and are instructive to consider when designing persuasive mobile technology.

The eight points are underneath listed with a link to the shared findings from the two projects (see Figure 1.).

Self-Comparison
1. Self-comparison is an important factor.

Triggering Messages
2. Triggering messages to push the user in a proposed direction.

Mobile Platform
3.The smartphone is a desired platform.

Understandable Messages
4. Use smileys and combine positive & negative reinforcement-messages.

Tailored Information
5. Tailored information opens for persuasion.

Community Information
6. Use community information for comparison.

Expert's Advice
7. Use expert's advice for comparison.

Behaviour Change Over Time
8. Mobile persuasive technology changes behaviour over time.

In the further sections the eight points is described and discussed individually.

3.2 SELF-COMPARISON IS AN IMPORTANT FACTOR

The results from the water-research project showed that the participants' own judgment had a greater impact on them than the provided sources of information in the application when they had to make a decision whether to follow the information containing in the receiving message or not.

The outcome from the power-research project showed a similar result. The participants mentioned that no matter which type of message they received during the case study they always compared to their own situation and to the information displaying their own consumption.

Therefore it is important to have a big focus on the users' own situation when trying to persuade the users to become more aware of the environment. This point supports Yann et al.'s study, about raising awareness on the individual, which had a big potential of adjusting the users' behaviour and reduction in consumption, by providing personal information about the user's own consumption [17].

3.3 TRIGGERING MESSAGES TO PUSH THE USER IN A PROPOSED DIRECTION

In the water-research project the majority of the participants demanded the information to be pushed to them into the application. The participants in this project in particular indicated that the incoming SMS messages were a good method to trigger them to act and made them check the incoming message in the inbox of the application.

The same finding was found in the power-research project where the participants mentioned that the SMS messages were a good triggering-technique to raise awareness of their power consumption.

Therefore using triggering messages reminds the user to be focused on the environmental behaviour and can be used to push the user in a proposed direction. Same point was mentioned in Froehlich's study describing ten design dimensions of feedback technology in a pro-environmental domain [4]. By using prompting messages there is a possibility to trigger the user to raise awareness and change behaviour, if the messages are provided in the right place at the right time.

3.4 THE SMARTPHONE IS A DESIRED PLATFORM

In the water-research project, half of participants used the provided application on mobile device and the other half on a desktop PC. Nine out of ten preferred the application on a mobile platform because they found the information received on the mobile device much handier and easier to react on compared to the application on a desktop PC.

In the power-research project, the participants used the provided application on different mobile devices; from different smartphones to tablet PCs. The same question about the preferred platform was asked. The majority of the participants preferred to use the system on a smartphone because of the flexibility to receive SMS-messages on the smartphone. The ability to check the receiving messages on the same platform was received as handy, quick, and easy.

Therefore we can argue that the platform the application should be on a mobile device; a smartphone to create the biggest opportunity to persuade the users. This was also mentioned in Petersen et al.'s study [10]. A key to encourage people to engage with their power consumption is to make it truly portable, available at any time, and by taking advantage of the smartphone it is able to create a compelling experience for the users and expanding the opportunities to influence their behaviour.

3.5 USE SMILEYS AND COMBINED POSITIVE & NEGATIVE REINFORCEMENT-MESSAGES

Some of the participants in the water-research project expressed the difficulty in understanding some of the receiving messages, which could lead to a misinterpretation of the actual message. An important issue to be concerned about is designing the messages easy to understand, such it can raise the possibility to persuade in a proposed direction.

In preparing the power-research project we dealt with the communication issue encountered in the water-research project. For that reason, during the power-research project, the participants received different messages with smileys to communicate approval or disapproval for the amount of power they were consuming. The majority of the participant expressed the smileys were easy to understand and interpret. Another method used to provide the participants with understandable information was by providing positive and negative reinforcement messages to the participants. The participants mentioned that the messages were easy to understand because it was clearly described if the participant was a good or bad consumer.

By using smileys and combined positive & negative reinforcement-messages it can avoid any eventual misinterpretation of the messages provided in the application to persuade the user in a proposed direction. However the positive and negative messages should not be used all the time, and only be used in the right place at the right time. The message should contain both positive and negative message. Especially this was preferred to prevent the users to "rest on its laurels", by only providing a praising message. This result was also mentioned in Helen et al.'s & Kirman et al.'s study [5, 6]

3.6 TAILORED INFORMATION OPENS FOR PERSUASION

From the water-research project, results showed that the participants demanded more tailored information in the messages they received. They claimed that messages with more tailored information might have persuaded them to pay more attention to incoming messages. By processing the message more thorough, accept the information, and believing the output they would be more open for persuasion.

The lesson learned from the water-research project created a stronger focus on using tailored information in the power-research project. By providing personalised information about the participant's own consumption, e.g. with the link to the Automatic Meter Reader (AMR), the application was able to provide the participant with personalised information.
The participants expressed that providing tailored information about their own consumption made them think more actively and the application had a much higher credibility. They expressed that the tailored information was better than general information from brochures, TV campaigns, etc.

On behalf of the two research studies we can derive that a tailored application has the tendency to be more effective than generic information. It has a greater possibility to persuade users to change behaviour and this supports B.J. Fogg's principle of tailored information will be more persuasive if the information is tailored to the individual's needs, interests, personality or usage context [2].

3.7 USE COMMUNITY INFORMATION FOR COMPARISON

Findings from the water-research project showed that the participants had different views on the information coming from the community. Some of the participants judged the messages about the community as useful in making decisions on what they planned to do in their garden. Other participants demanded more tailored information about the community to be able to compare to their own situation.

Some of the findings about the community information from the water-research projects were considered in the design of the power-research project application. The participants' own consumption was shown to the participants in much detail. The majority of the participants felt the community information was very useful and easy to compare against their own consumption level. Despite the fact that it was not possible to compare the consumption on a device level, participants expressed the detailed information about the other residents was a good motivating factor.

From the two projects we can derive that displaying information about what the community are doing can persuade users to change behaviour. However, it is important to show information about the participant's own situation before there is an opportunity to persuade through the community information. Numerious studies refer to this point of using community information as a comparison method to persuade the users [3, 4, 13].

3.8 USE EXPERT'S ADVICE FOR COMPARISON

The participants from the water-research project found the messages from the expert as reinforcing according to what they were or planning to do. They found the information trustworthy. Some of the participant did mention that they demanded more information about the identity of the expert to find the messages credible.

In the power-research project an extra button with more information about the expert was added to prevent participants wondering whom the expert was and how this expert obtained his or her knowledge. When discussing the different types of expert-messages the participants received the majority of the participants expressed that the messages containing their own personal consumption linked to tailored expert's advice had the best opportunity to persuade them.

Therefore we can derive that the expert's advices were a good method to persuade users. However, it is important to link the expert's advice to the users own situation to make them open for persuasion. B. J. Fogg also mention to use suggestion-technology as a method to open the user for persuasion [2].

3.9 MOBILE PERSUASIVE TECHNOLOGY CHANGES BEHAVIOUR OVER TIME

In the water-research project the participants expressed that they found the mixed messages with information from more than one source as very interesting. It was easier for the participants to interpret and understand these messages and the probability to perceive the messages as credible was greater. Different information in one single message also had the opportunity to educate the participants to become more conscious about the water conservation. The majority of the participants saw the system as an education tool and the results also showed that the participants tend to skip more watering-days and added less watering-days over the three weeks.

In the power-research project the participants received more messages with mixed sources of information. The participants expressed that they raised their awareness and were more conscious on their power consumption. Discussing this topic, the participants expressed that the application had the opportunity to change their behaviour but only by using the application over a longer timespan.

A mobile application that keep reminding people with small messages containing different sources of information about their own situation compared to an expert's advice and what the community are doing is a useful tool to raise awareness. From raising awareness the application can over a longer timespan getting people ready to take any action and then change their behaviour.
This point supports Prochaska's Stage Changing Model (TTM) [12]. People have to go through different stages, from being unaware to become aware that their behaviour is problematic. Then intend to take action, to then take action and thereby change their behaviour. Subsequently maintain the changed behaviour.

Based on the eight points on how to design mobile technology to provide a pro-environmental behaviour emerged from the two projects, a conclusion of this thesis can be drawn.

4. CONCLUSION

This thesis deals with the use of mobile persuasive technology to raise awareness and to persuade citizens to a pro-environmental behaviour. This has been approached from two different domains, i.e. water and electricity.

The main research question of this thesis was formulated as follows:

How can technology be designed to persuade citizens to promote a pro-environmental behaviour?

To answer this question, two applications had been distributed in two independent projects with the aim to explore what role these technologies are playing in promoting a pro-environmental behaviour.

The main contribution of the two projects is that there is a big potential in using mobile devices to persuade citizens to promote a pro-environmental behaviour. By using persuasive technology there is a possibility to encourage citizens to act pro-environmental. A list of common key-findings from the two projects has been elicited and eight instructive points have been described for developers to consider when designing mobile technologies to encourage a pro-environmental behaviour.

One of the eight points that was raised from the studies is the focus on the individual (self-comparison). The study indicated that providing personal information about the users' own situation opens for persuasion. This relates to the next point about designing a tailored application, which had the tendency to be more effective than providing only generic information. In addition, tailored information has a greater possibility to persuade users to change their behaviour.

Results from the study indicated that the desired platform on which this application should be running is on a mobile device, i.e. a smartphone. The smartphone was preferred because of the ability to read the received SMS-messages and to check the incoming advising-messages on the same platform.
This led to an instructive point regarding the use of triggering messages to remind the users. By using triggering messages it is possible to push the user in a proposed direction. The issue about misinterpretation-messages was discussed and therefore an instructive point to be aware of these messages was elicited. The results showed that by using smileys, and combined positive & negative reinforcement-messages had a possibility to prevent any eventual misinterpretation.

Another way to persuade users could be by displaying information about what the community is doing. However, it is important to show information about the users' own situation in combination with the information from the community before there is an opportunity to persuade the users.
The results from the studies also showed that the expert's advises were a good method to persuade users and educate them to be more aware and open for persuasion. When providing community information messages, it is important to link the users' own situation to the community information to promote a pro-environmental behaviour.

Finally, the topic about using the applications to change behaviour was discussed and both projects indicate that a mobile persuasive technology has the possibility to change behaviour of people over time. The mobile persuasive technology can be used as one step in many to promote a pro-environmental behaviour and change the attitude of people over time. Using the system over a longer timespan might have the ability to change people to think, react, and act pro-environmental.

The future work for this study could involve a further investigation of how mobile persuasive technology changes behaviour over time. For that reason, longer projects with the application over a longer timespan must be conducted to draw any conclusion whether the mobile persuasive technology does actually change behaviour.

5. RESEARCH PAPER I

Using Mobile Phones for Promoting Water Conservation

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ABSTRACT

Globally, water is one of the most precious and rapidly declining natural resource. However, there are still many opportunities to conserve it. One specific opportunity for water conservation is in our home settings - in the garden. An effective method to encourage people to use water more wisely is the use of tailored information mobile technologies. In this paper, we therefore promote water conservation by providing tailored information technologies to gardeners in the form of a mobile application. An early version of the software was built to explore the role of three different sources of information (weather, expert's advice and community information). This paper presents the design, implementation and evaluation of the mobile application, and how it can be designed for gardeners to use as a software tool. Based on the evaluation, several themes for designing mobile technologies for gardeners are elicited and discussed. Findings from the study show that gardeners want more tailored information in the messages received from the system, and advice should come from more than one piece of information, to have a greater opportunity to persuade.

INTRODUCTION

> *"We need a global approach to this from all sides. We need to educate people, we need the scientists to create new technologies, we need the engineers to create the networks, we need every human being to be aware of how precious water is and save it. Everybody has to be involved in a very firm and assertive way." - Isabel Allende [25]*

Water is precious, and as with many other countries in the world, Australia has for many years been through persistent drought and the effects of climate change. It is the driest inhabited continent in the world. The climate is highly variable across the continent as well as from year to year [4].

A consequence of this is that water restrictions are currently in place in many states and cities all over Australia. Depending on the location, there are restrictions on people watering their lawns, using sprinkler systems, hosing in paved areas, washing vehicles, and refilling spas and swimming pools.

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In the Melbourne metropolitan area, Victoria, the water storage was at its lowest for years in June 2009, at 25.6 percentage [15] and led to very harsh water restrictions. These restrictions meant that people were limited to water only on specified days and some activities, such as washing cars or watering lawns, was prohibited.

With the restrictions in progress, people become aware of when they were allowed to water their gardens, but there was and is still a lack of knowledge in the general community about how much water their plants need [17]. People tend to overwater their plants and let their watering systems run for a set amount of time. They are allowed to water even though their plants may not need it. The main issue here is the adaptability of knowledge presented. People have different gardens with different plants, and water restrictions given by the water utilities are hard for the community to interpret and adapt into their own personal garden practice. Thus watering behaviours are often far from optimal. The main goal is to change people's behaviour to reduce the amount of unnecessary water usage, with a view to collectively decreasing the water wastage throughout the Melbourne area. As a secondary effect, this would also result in more healthy and sustainable gardens.

First, we present the related work done trying to make people more conscious about their use of water in the private households. An on-going study around garden watering is presented. This is then followed by research on using mobile devices as a platform to change people's behaviour; we also list some research done in behavioural change of people in their home settings.

The process of designing, implementing and deploying a prototype of a mobile application is presented. Finally, findings from the analysis are presented and discussed by eliciting themes for designing technology to help people adapt information / knowledge into their gardening practice.

RELATED WORK

Several previous studies about changing people's water-use behaviour in private households have in the past been conducted [3, 13, 14, 18, 20]

Arroyo et al. presents numerous persuasive techniques to increase awareness of water conservation in the domain of the sink, and created the WaterBot; a system that motivates people to turn off the tap when not using the water [3]. Kappel et al. and Kuznetov et al. developed UpStream [13] and Show-Me [14]; both physical installations in the shower, which give information about their current water usage, with the goal of reducing their water usage.

The outcomes of these studies showed that the developed technologies did have a positive impact on people's use of water.

Whilst the above techniques address the issues relating to water use within the home, Pearce et al. [18, 20] conducted a 4-year (2006-2010) and still on-going study about developing and evaluating an online desktop application to advice people on watering their gardens more efficiently.

The first part of the study described a project-design to design an internet-based application to support gardeners' reasoning about the water demands and water supply for their gardens [18]. After the first study was conducted, an online-application SmartGardenWatering (SGW) [23] was developed in collaboration with horticultural scientists and interaction designers.

A later study then described the investigation of how gardeners responded to advice from the SmartGardenWatering software (SGW)[20, 23].

The SGW - software [23] takes the form of simulating the environment where the gardener first defines a various set of parameters for his/her garden, and based on these data, a profile of water demand for their personal garden is visualized through watering schedule attached that shows the ideal frequency of when to water and the duration of watering. The findings from a second study [20] focused on the types of factors that brought confidence or lack of trust in the visualized horticultural model and its application to a specific garden. An issue raised in a later study [19] was the disconnection between sitting at a desktop computer and exploring the horticultural issues in a technological context and actual garden practice. This issue of disconnection between being in the garden and at the desktop leads us to look at research done using other technology platforms to persuade people to change their behaviours.

The founder of Stanford Persuasive Technology Lab, B.J. Fogg [8, 5], a few years ago predicted that mobile devices would be the dominant platform for persuasion, and he mentioned that mobile platforms could motivate people to achieve their own personal goals. He saw the mobile phone as helping to succeed like a magic wand. He also said:

> *"Mobile technology can layer information into our moment-by-moment lives in a way that changes our behaviour".*

Thus we argue that the power of mobile persuasion can be used to enhance the quality of today's society, by motivating people to use water more wisely via their watering practice.

There is the potential of exploring how mobile technology can be used to motivate people to change their behaviour towards use of water in a home setting. The mobile device is nowadays a strong and important platform that can change human behaviour.

The use of mobile phones is ubiquitous and commonly used as an integral part of our daily life regardless of if we are at home, work or travelling.

Furthermore, our mobile devices are able to gather and report current and localized information that is relevant to us and our goals in context. For that reason, mobile devices can help motivate people more effectively than any other platform that they use in their daily life.

The functionality of the mobile devices has gone through a drastic change in the past 5 years. From solely providing basic applications e.g. calculator or converter, to more tailored and advanced programs. By looking at the present market for mobile applications, Apple's "App Store", which today is the world's largest application store [2], recently announced its 6.5 billionth download, which shows the great demand for tailored applications in today's world.

According to B.J. Fogg [8] and previous psychology research [11] tailored applications have the tendency to be more effective than generic information in changing attitudes and behaviours:

> *"Information provided by computing technology will be more persuasive if it is tailored to the individual's needs, interests, personality, usage context or other factors relevant to the individual" [5].*

Several projects have in various ways tried to persuade people with technology to become more conscious about reducing environmental impact (Eco-feedback technology) [10, 13, 14]. Froehlich et al conducted a comparative study of 89 environmental psychology and 44 papers from the HCI literature. The outcome of the study was a summary of key motivational techniques that HCI-designers must be aware of to promote proenvironmental behaviour.

One of the important topics mentioned from the study was in what way information can be used to persuade people's to make this change in their pro-environmental behaviour.

> *"Information must be easy to understand, trusted, attract attention and is remembered"[6].*

Using information as a key motivation technique, Al Mahmud et al. conducted a study exploring the information presented using three different visualization media (text, audio and video)[1]. The goal was to make people more conscious of their energy use in their home setting. They developed a mobile application called EZ Phone: Energy Zaving Phone, and conducted a pilot study in which they explored the three medias effectiveness in persuading users to conserve energy. The outcomes from the study were that text was perceived to be most persuasive, and video was the least persuasive in changing people's behaviour to be more aware of energy use.

A similar study done by Roubroeks et al. [21], explored given information given about energy conservation through three different information-methods (text only, text+picture, text+video).

The developed and tested a screen-based system. Findings from Roubroeks et al.'s study showed that the most effective way to persuade people in adapting their behaviour in a proposed direction was by using pictures to illustrate or expand on text.

Thus, drawing on research described above [5, 6, 10, 21] it suggests that information the gardeners should receive in the goal of changing their environmental behaviour, should be received on a mobile device, mediated as text with pictures. The information should be trustful and attract attention. This should maximize the chance of persuading people to change their behaviour.

This paper reports research that explored given to persuade people to change or correct their environmental behaviour. We present the design, development and evaluation of an early prototype, which is described in the next section.

RESEARCH DESIGN

The previous work described above or limited studies have not yet explored the role the actual source of information plays in persuading people to change their behaviour. Does it mean anything? What type of information is provided and who is the sender/source of the information is?

This study is trying to bridge the gap between mobile persuasion and the use of different source of information in persuading people to change their environmental behaviour. The study explored three sources of information (scientific weather data, expert's choice, community information) on a mobile device, and investigates the roles each source's plays to adapt their behaviour appropriately.

The study

The primary goal of this study was to explore the role of mobile devices as a tool to support people in their watering practice in their gardens. Furthermore, the goal was also to explore what role of the actual source of information plays in persuading people to be more conscious about their water use.

As earlier mentioned, the study examines three sources of information; scientific weather information, information from an expert, and information about what other people in the community are doing in their gardens. These three sources of information were provided in a mobile web-application called *SGW Advisor* [22].

Process

The methodology used in this study is a modification of an approach used by Pearce et al. [20, 23]. An early prototype of a mobile application with data logging capabilities was deployed to 10 gardeners in a study lasting 5 weeks.

The prototype advised gardeners when to make a change in their current watering schedule and updated the gardener with the latest weather information. This will be further described in the next section. The participants were interviewed before and after they had used the prototype in a period of 3 weeks.

The pre-use interviews focused on exploring and understanding the participant's current garden knowledge and their use of IT-devices in their daily life. The pre-interview session was also used as an introduction to the given prototype [22]. The deployed prototype explored different ways of supporting gardeners with information, to make them become more water-wise and change or correct their watering behaviours. The post-use interview focused on how the prototype presented information to the participants, and their reflections on the three different sources of information they had been introduced to during the 3 weeks case study in the SGW Advisor

THE SMART GARDEN WATERING ADVISOR

The main goal with the Smart Garden Watering Advisor (SGW Advisor) is to explore whether the gardeners found the mobile application supportive by giving them helpful information about their garden watering and if this is the case. Additionally, we wanted to understand the roles that sources of information play in their decision to either water or skip a watering in their current watering schedule? Furthermore, we also wanted to explore whether, the gardeners found the provided information trustful, and do aced on it?

The SGW Advisor system and the case needed to be as realistic as possible. Therefore, the given weather information was given in real-time and localized to the nearest weather station. Even though the system presented in this paper, can be viewed as a prototype, the goal was to explore the role of the different sources of information provided to the participants in the case study rather than exploring technical or usability matters.

The menus

The SGW Advisor application was designed with a "home-screen" as its main window. The main window contains four menus: Weather, Schedule, Advisor and Daily Input – see Figure 3

Weather menu

The Weather menu provides information about the local weather for the current weather station that the user lives closest to. It gives specific information about the current temperature, latest rainfall and humidity – see Figure 3. Furthermore it also provides information about the last 2 days min/max temperature, total rainfall, evaporation and average humidity.

Schedule menu

The Schedule menu gives information to the user about their current watering schedule for the next 3 days. The watering schedule is regulated after the user's settings and in regulation to the actual water restrictions in the current state [15]. They are also provided with the information about what level the current water restrictions [15] is on and what type of restrictions they are in the different watering purposes (hand, manual or automatic watering).

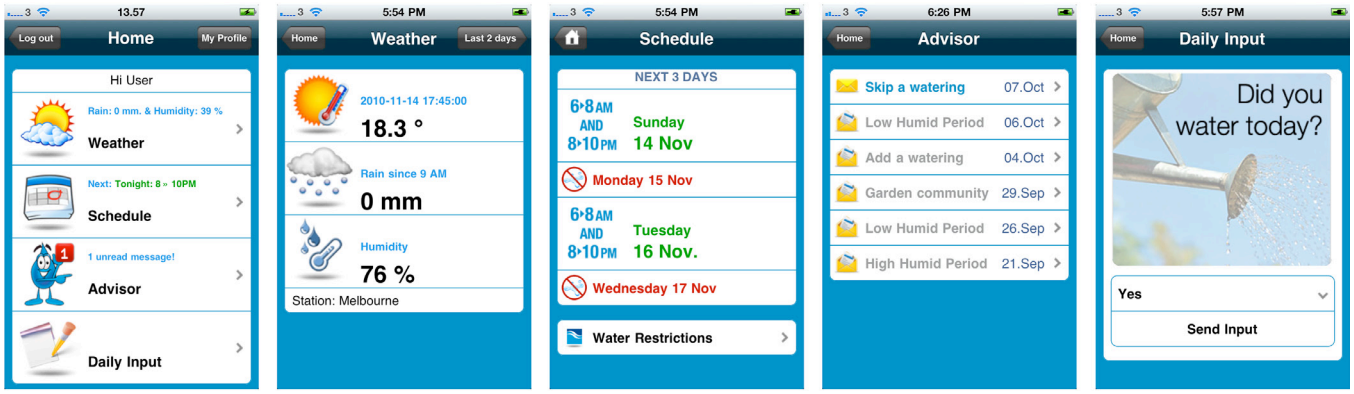

Figure 3. The menus in the SGW Advisor

Advisor menu
The Advisor menu presents an overview over the incoming messages from the system. The unread message(s) from the system are shown with an icon of an "unopened envelope" and read message(s) are shown as an opened envelope. By clicking on each message, the message will open up and the message opens up to display the message. This menu was the most important part of the system, because of the incoming messages, which explored the three information sources.

Daily Input menu
The Daily Input menu is where the user is able to feed information into the system such as whether they have been watering the current day or not. The information is sent to a database, which is described in detail in a section later.

Three information sources
The three different sources of information explored in this study were information about weather, expert's choice and garden community – see Figure 2.

Figure 2. Icons for the three information sources

Expert's Choice
Messages with advice from an expert system were the popular choice. The expert system measured scientific weather data [4], combine it with information from a knowledge database e.g. SGW [23] and provided information in inbox, whether to skip, add or follow the regular watering schedule. The messages were sent to the participants from an animated water drop, and labelled as "Expert's Choice" – see Figure 2.

Garden Community
This relates to the messages that provided information regarding what other gardeners were planning to, or already doing in their gardens.

This information could be whether the majority intended to change their pre-planned watering schedule by skipping or adding an extra watering to their garden.

Weather
Messages received in the inbox, were the scientific weather information from the local Bureau of Meteorology (BOM) [4]. The information provided in the weather messages, were scientifically objective and accurate information, in comparison to the other sources mentioned above. This message was also provided, to have a diversity of information in the given messages.

The six incoming messages
During the three weeks of the case study, the participants in the case study received six different messages in the Advisor inbox from the three different sources. The six messages that were received advised on whether to add an extra watering day or to skip a watering day compared to the current schedule. Every time a message was sent to the Advisor inbox, the participants received a SMS on their mobile phone. B.J. Fogg conducted a healthcare study, where he mentioned that using SMS messages to notifying people has a great potential to trigger them to a proposed behaviour [7].

The first three messages sent to the gardeners shown on Figure 4 were the messages that each presented information from only one type of information source: the weather, expert's choice and the garden community, individually.

Figure 4. The three messages with only one source of information in each message.

The last three messages were mixed messages, each with two different sources of information - see Figure 5.

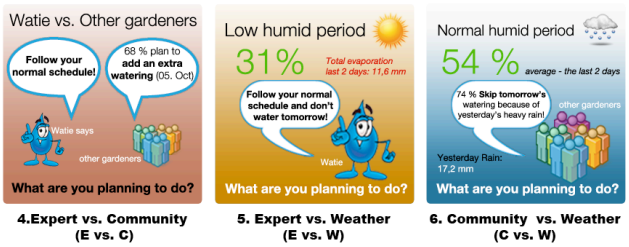

Figure 5. The last three messages, each with two different sources of information

For instance, the 4th message the participants received was information about the expert advising about the appropriate behaviour. While the information about garden community disagreed with the expert's choice, by adding an extra watering according to the regular watering schedule - see Figure 5.

Technical design

The system and prototype software was implemented in 1½-month time by a single researcher. In order not to rely on one specific mobile platform, the system was not implemented as a mobile application (e.g. iPhone/Android application), but implemented as a mobile website.

The mobile website was developed by using an open-source framework called iWebkit for iPhone mobile websites [12].

The system communicates using PHP with a MySQL database in real-time, to ensure that actions from the users of the system are logged to the system. The scientific weather information in the system, was obtained a script, extracting the data from the Bureau of Meteorology's (BOM) website [4], and saved in the MySQL Server database. The SGW Advisor then extracts the weather information from the MySQL Server database and adds the information to the user's screen on the weather information page. When a user interacted with the SGW Advisor and entered information into the system, the data were saved in the MySQL Server database. The technical design is illustrated in Figure 6.

LONGITUDINAL FIELD STUDY

The prototype was deployed in a 3-week case study with 10 participating gardeners. The objective was to explore how the gardeners used the prototype, and their choice and preferences of the given messages from three different information sources throughout the case study.

Participants

The participating gardeners were recruited through a gardening course at Burnley Campus, University of Melbourne, Australia and some through a Danish society called Young Vikings, in Melbourne, Australia.

Each participant had to meet a basic set of requirements to be selected for participation in the case study. The participants had to have a garden and had to be located in the greater Melbourne area. They were also required to have either a smartphone that allowed them to browse the Internet (Apple iPhone, HTC-mobile or BlackBerry) or a Google Chrome / Safari Internet browser on their personal computers. Furthermore, all the participants were required to have a mobile phone, which could receive SMS-messages for the notification about the incoming messages in the *SGW Advisor* - se example in Figure 8.

The participants were asked to use the SGW Advisor, at least once a day for the normal "Daily Input" data entry, which approximately took only a couple of minutes to do. Furthermore they were also asked to check their mobile phones for incoming SMS-messages, and read and response to the received messages in the SGW Advisor Inbox, during the case study. The participants could use the SGW Advisor whenever they wanted to do it, throughout the day.

The participants varied in age, from 25 – 57 years. Their garden knowledge was also various, with 4 novices, 4 intermediate and 2 expert gardeners. Out of the 10 participants in the study, 5 participants had a smartphone that allowed them to browse the Internet, and the rest used a Google Chrome or Safari Internet browser on their personal computer.

Method and data collection

A quick tour of their garden was conducted, where the researcher and the participant had a small talk about their garden and watering systems. The intention with the small talk was to "break the ice" between the participant and the researcher. This was followed by a semi-structured interview was conducted, to obtain a general understanding of the participant's garden knowledge and current gardening practice.

Among the questions asked were questions relating to the their current use of IT-device was asked and how they obtain information about appropriate gardening. The interview lasted 20 minutes. The early version of the SGW Advisor was introduced to the participant. The researcher went through the SGW Advisor with the participant, and the participant was free to ask questions about the case study.

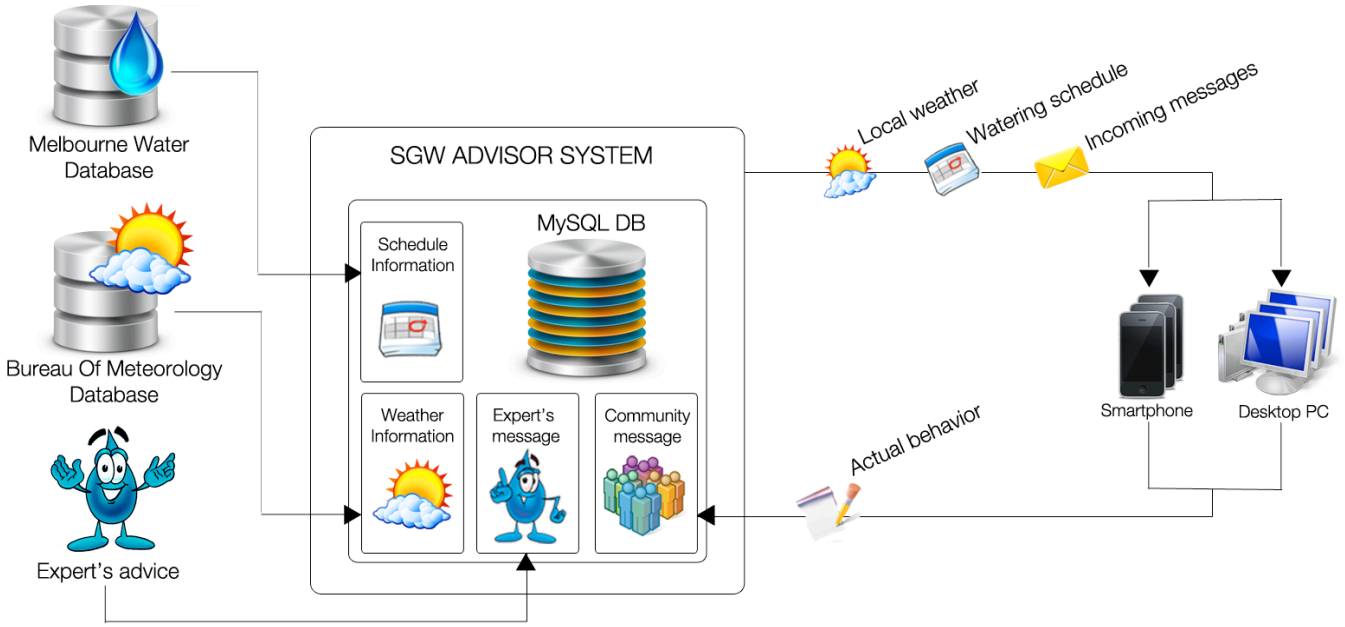

Figure 6. Technical structure of the system

With the introduction, the participants received a manual that described the system step by step, to prevent any problems during the case study.

The study was conducted during spring – at a time when most people living in the metropolitan area of Melbourne do not need to water their plants. Thus, in order to provide a "precise" environment to maintain, a potted pea plant seedling was given to each participant.

Each participant had to look after their plant during the 3 weeks of the case study, which consisted of watering it and use the SGW Advisor. The participants had to enter information every day into the system, whether they had watered the plant or not for the current day.

The day before the actual case study begun, the participants received a document with their regular watering schedule for the provided peas plant and descriptive information about the three information sources they would receive incoming messages from during the case study.

While the system was being used during the case study, it was monitored remotely for any technical problems with the system were solved as quickly as possible. Every time a participant used the SGW Advisor and entered information whether they have been watered the current day or not, or responded to a message in the SGW Advisor inbox, the answer was saved in the database of the system.

After the three-week case-study period, a second semi-structured interview was conducted. The purpose of this interview was to investigate how the participants found the different information sources they received as 6 incoming messages; what information source they liked and disliked, and what message they found most credible and useful.

The post-interview was structured with first, questions reflecting on using a mobile device as a supportive tool in their gardening practice. Then the three different sources of information were discussed. Each of the 6 messages was discussed one by one. To remind the participants about the messages, small laminated cards were given during the questionnaires with a physical illustration of each message. Finally, a discussion about the whole research was carried out exploring the benefits the participants saw in the SGW Advisor system were discussed for the purpose of further development.

The system was tested on both smart-phones and on personal computers for a good reason. For the participants with smart-phones, the system was tested on a smart-phone to get reflections on the usage of the system on a mobile device and to see whether the participants found it persuasive on a mobile device [8]. For the participants that used the system on a desktop and to discover if the there was any concerning disconnect between sitting at the desktop and doing the working in their garden [19]. The participants used the system almost every day and each participant remembered to respond on the 6 incoming messages.

Data analysis

For analysing the data, different techniques from Grounded Theory were conducted [24]. Twenty audio recordings of the 10 pre- and 10 post-interview with the participants in the case study were transcribed and structured into columns. The total amount of recording was approximately 9 hours.

Using an Open Coding process, 273 properties were identified. These were subsequently categorized into 72 different phenomena.

By using Axial Coding [24], connections between the different phenomena were made and categorized into 12 categories. The 12 categories were divided among 4 themes. The processes included interviewing the participants; transcribing the audio recording; using selective coding and finding themes, took almost 47 hours.

FINDINGS

Each of the 3 themes revealed is central to the analysis and is treated in the next sections in this section.

Mobile devices as garden tools

One of the research questions was to explore whether gardeners found the mobile device to be a supportive tool in the gardening context.

To find out whether they found the mobile device as a supportive tool, the incoming 6 messages during the case study were used to explore this question. The results from using the three information sources will be described in this section, and later discussed in the next section.

Actual vs. Preferred platform

Out of the 10 participants in the study, 5 participants used the system on a mobile platform and the rest on a personal computer. The participants were asked to discuss the used platform during the case study. Nine out of 10 participants preferred the system on a mobile device. One of the participants expressed:

> *"I found it very useful to have something in my hand and mobile. I could see it on my mobile, instead of looking it all up on my laptop. So you have the whole world in your hand - a gardener would always be outside, so I found it more useful for me."*

Another participant who used the system on his laptop said:

> "*I found it boring to do it on the computer. It would be more handy and mobile, using the system on a phone than the computer."*

The participants agreed that the preferred platform in the case study should was on a mobile platform rather than on a personal computer.

Skip, Add or Both

Another topic that was discussed in the interviews was whether the participants should receive information about when to add an extra watering or not. Nine out of 10 participants wanted the system to advise them on when to add an extra watering session if their plants needed water. A participant said that both notifications methods were useful because:

> "*...even in summer you sometimes need to water an extra or skip a watering, suddenly because of heavy rain.".*

Push vs. Pull information

The question whether the participants in the study wanted the information to be pushed to them, or they wanted to pull the information from the system was discussed. Nine out of 10 participants demanded to be notified and reminded when there was a message in the system.

The notification using SMS was for the majority of the participant a good method, and triggered them go online and check their message. One participant expressed:

> *"SMS was very good, and really like the way it remembered me about to check my system for messages".*

The SMS messages were good reminders for the participants to take action and make decisions.

Automatic vs. Manual system

The participants were asked about what type of watering system the SGW Advisor system would be best for. The majority of the participants thought that the system would work best in gardens with manual watering systems, rather than automatic watering systems because manual systems required less effort to skip a watering:

> *"I think it would work best on a manual system, than an automatic system, because you don't need to switch the system on and off, and it would be problematic."*

Educational tool

8 out of 10 participants saw the system as an educational tool. One of the novice participants mentioned:

> *"The application makes people more conscious and teaches them to have a better and more sustainable garden."*

And another intermediate gardener expressed:

> *"Qualitatively, you try to teach and make people more conscious about the water use - and I like that I can see that the information that I read, make me feel I am learning."*

If we look at the number of times the participants tended to add/skip a watering day according to the provided messages in the case study, it is possible see a progression in the three weeks of study.

The number of skipped watering days increased from 4 in the first week to 9 in the last week of the study. Meanwhile, the number of added watering days decreased from 6 in the first week, to 2 in the last week of the study. The participants tended to skip more watering-days and added fewer watering-days – and may be because they learned to understand the messages with the time.

Three sources of information

In total 6 messages were sent to the participants from three different information sources. For each information source we observed their response in comparison to the discussed topics in the interviews.

Weather Information

Ten out of 10 participants found the information from the incoming messages about the weather conditions trustworthy. One of the participants in the case study expressed that:

> *"I found the weather information valuable and believable, because the weather was hot, and the information about a low humid period was real and trustworthy".*

The majority of the participants rated the weather messages as very useful and they found the information given about humidity and rainfall realistic according to the weather throughout the case study. In the interviews a participant mentioned:

> *"Weather information is the most useful for me, because I assume that the weather information comes from the BoM."*

The participants in the case study thus had great trust in the scientific weather information from the Bureau of Meteorology that led them to assess it as very useful information source. Though, some of the participants mentioned that the messages they received were a bit hard to understand. A participant expressed:

> *"I haven't found out what high and low humidity means to the garden,"*

Another participant noted,

> *"I didn't understand the humidity information".*

These misinterpretations of the humidity information in the weather messages will be discussed further in the next session.

Expert's choice

The messages with information from the expert had a more mixed impact on the participants in the study. Only 7 out of 10 participants found the information from the expert trustworthy. Some of the participants didn't find him reliable. One participant noted:

> "*Expert's choice – My problem with him, is that I don't know him, and I don't know how he is finding the results. I am not sure, what to do with him."*

None of the participants complained about the information source, but they demanded more information about where the expert got his information from.

> *"Watie should have more information, before I would find him more useful and I might be triggered to change my first decision, because of the extra information"*

However, not everyone questioned the expert's information source, and some of the participants expressed:

> *"The expert's choice was also okay for me. Because he is the expert, and he knows what's right, so I believed him.*" and "*...I believed him – I took his advice, because I thought he was analysing the weather more than I do, and gave me an advice – that I could use."*

The majority of the participants found the information from the expert reinforcing what they were going to do, and therefore they found the information trustworthy:

> *"Expert's choice, that was fine, it kind of reinforced, what I was going to do, anyway."*

Garden Community

The information from the garden community was received as believable from the participants in the study. Eight out of 10 participants found the information much believable and the majority found the information useful in the way of making decisions of what action they should take. One participant said:

> *"I found those gardeners more believable in my decision whether to follow the advice or not….I would always listen to people than a machine telling me something…".*

Few participants expressed that not all information provided in the messages from the garden community was believable and one expressed:

> *"The garden community out there, is already pretty bad, when I think about it. Think about all these people that don't have any clue what they are doing in their garden"* and *"I know that we as a population we way too much overwater our gardens."*

Because of the lack of trust, their own decision had a bigger credibility than the received messages. Some ideas were put forward; one participant noted:

> *"More tailored information from other gardeners with same type of plants, I would definitely find the information more believable and it might have changed my decision"*

The lack of trust and the idea with more tailored information in the messages will be discussed in the next section.

The three mixed messages

The 4th, 5th and 6th messages the participants received in the case study were each a mix from two information sources. They found them very useful and to one of the messages they received a participant expressed:

> *"This message made me more comfortable about skipping the watering, by seeing information about what other people did, and the rainfall number."*

The sixth message was also rated to be the most believable message and 9 out of 10 participants followed the advice, where they chose to skip a watering. The mixed information messages will be discussed further in next section.

DISCUSSION

From the findings, four interesting themes emerged from our analysis. Even though, the themes are elicited based on empirical data from gardeners, we hypnotize that they are also relevant to consider when designing mobile technology to persuade peoples proenvironmental behaviour in other domains, as the themes explores the human computer interaction, rather than the issues in the gardening context.

Own Judgment

While discussing the three different sources of information the participants received, 6 out of 10 participants mentioned that their own judgment had the biggest impact when making any decisions whether to add, skip or keep following the normal schedule.

Some of the participants expressed that the messages they received only reinforced their own judgment of what to do, and the messages themselves were not driving their decisions. One of the goals with the study was to explore the three different sources of information.

We found out that neither one of the three information sources prompted the majority of the participants to make a new judgment based on the provided information alone. The weighting of the information sources, were so low that they essentially dropped out. The gardeners' own judgment had a greater impact on their decisions than the provided information.

We can view this in the following way:

Own judgment → Behaviour

Where the desired result we are hoping to achieve was:

Own Judgment + (w+e+g) → New judgment → Behaviour

A study conducted by Pearce et al. also found that often expert gardeners felt their intimate and detailed knowledge about water usage was greater than the provided information in a system [17].

This raises another challenging issue: how can we cater for different levels of gardeners, from novice to intermediate to experts? It might be good to provide differing information depending on the level of expertise of the gardener. For example, novice gardeners only received information about the garden community and the expert, whilst expert gardeners only received information from BoM.

Misinterpretation of messages

Some of the participants in the study expressed in the interview that they found some messages hard to understand. This might have led to the misinterpretation of the actual advice. Such messages could be perceived less believable, and thereby reduce the possibility to persuade. B.J. Fogg outlines this as the Prominence-Interpretation Theory. He explains that to get a credibility assessment both prominence (the user is notified of and understands the information) and interpretation (the user makes a judgment about it) has to happen [9].

Therefore, the provided information to the user of the system has to be understandable [6] such it can be interpreted and be able to persuade to make a judgment. Therefore, words like "*low humidity"* should be explained in further details, such as the user understand what is meant, by using the word in the advice.

More tailored information

The participants in the study wanted more tailored information in the messages they received.

With more tailored information they might have been able to pay more attention to the messages. They would then process the information more deeply, accept the advices in the messages and by believing the output, be more likely to be persuaded.

This supports B.J. Fogg's theory about credibility. If the information is perceived as credible, it will have increased power to persuade. According to B.J. Fogg, credibility especially matters in HCI when systems like the SGW Advisor has to instruct or advice users, report measurements or provide information and analysis [8]. Therefore, a focus on more information in the messages, such as contextualized weather information in suburbs and information about the smaller garden communities with similar plants in one's neighbourhood could be more effective in persuading the user.

Mixed sources of information – better impact

The participants expressed that they found the mixed messages with information from more than one information source, very interesting. The possibility to understand the message, were for them greater. Furthermore, there was a greater probability to perceive the message as credible and hence make a new judgment.

However, the use of too much information from different sources in a message may imply, the user will feel frustrated and do not understand the message. It may result in no decision being taken on the basis of the information sources. It is therefore also important to consider which type of gardener the message is sent to and how much information is needed to persuasive. For instance, an expert gardener might need more facts, especially from different information sources to be convinced, where a novice gardener might be persuaded with a single message from one information source.

CONCLUSION

This paper has explored how to design mobile technology to persuade gardeners to use water more consciously. The design, implementation and deployment of a mobile application in the form of a prototype have been described and discussed and several themes have been elicited.

The gardeners found the prototype to be a supportive tool to use in their gardening and perceived the three provided sources of information as useful in their watering practice.

However, results indicate that gardeners' own judgment has a greater impact on them than the provided sources of information in the prototype. A lack of trust in the information sources was shown, and the gardeners demanded more tailored, contextualized information in order to perceive the information sources as credible. The gardeners found the messages in the prototype with mixed sources of information as most credible, and demanded more information in the received messages to create a greater trust.

Another important issue identified was the importance of using a known vocabulary, such that the gardeners understand the sources of information. With focus on the results described above, a mobile technology will have a great opportunity to change the gardeners' behaviour to reduce the amount of unnecessary water usage. It is hoped these themes will help fellow researchers when designing mobile technology that uses information to influence people's proenvironmental behaviour.

Using mobile devices to push tailored information from mixed information sources to the user appears to be a promising way to support this behavioural change.

FUTURE WORK

This study has shown the potential of mobile applications as supportive tools in changing peoples' behaviour in relation to garden watering practice. It is planned that the "lessons learned" from this study will be applied in a new study in another domain (electrical consumption). We will explore how the findings relate to this new domain and what differences exist in changing people's pro-environmental behaviour in the use of electricity.

ACKNOWLEDGMENTS

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6. RESEARCH PAPER II

Using Smartphones for Raising Awareness of Power Consumption

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ABSTRACT

The recent focus on sustainability has made consumers more aware of their responsibility for energy saving resources. Consumers now have the opportunity to understand in detail how to save electricity by being aware of their own consumption beyond the typical monthly electricity bill. We conducted a case study to understand consumers' awareness and understanding of electricity consumption in their homes. In this paper, we discuss a system that promotes electricity consumption by providing tailored information to consumers in the form of a mobile web-application called Power Advisor. We then present the findings from our case study, to support design suggestions for energy consumption in mobile applications.

INTRODUCTION

Our society has become increasingly concerned about the environment within the last 10 years. A major focus has been put on people's responsibility to save energy resources. However, many people are unaware of when and where electricity consumption occurs, which can hinder the efforts to reduce electricity consumptions in their households [1, 3]. Consumers mainly rely on their monthly bill, which typically reports limited or irrelevant consumption information. Additionally, studies have shown that monthly feedback is not sufficient [1].

With the replacement of old meters with smart meter units, detailed electricity consumption data is becoming more readily available, and can now provide households with their consumption information wirelessly and more regularly. These devices are also mentioned as eco-feedback technology appliances, which provide feedback on individual or group behaviours with the goal of reducing environmental impact [5]. The technology used is based on the working hypothesis that the majority of the consumers are unaware of how their everyday activities impact the environment.

Research has shown that, in order to raise awareness about electricity consumption, timely consumption feedback and guidance is required in order to stimulate conservation and enable users to change their behaviour in a way that decreases their power demand.

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By providing detailed and daily feedback, consumers can save between 5% and 15% of the electrical household energy consumption [1]. Furthermore, the availability of sensing systems for environmentally related activities and interactive feedback displays provide a big opportunity for new types of eco-feedback solutions [9, 15, 11, 19]. With these new eco-feedback solutions, the amount of data is increasing. New ways to use this data to help people become more aware of their consumption are still largely unexplored [1, 5].

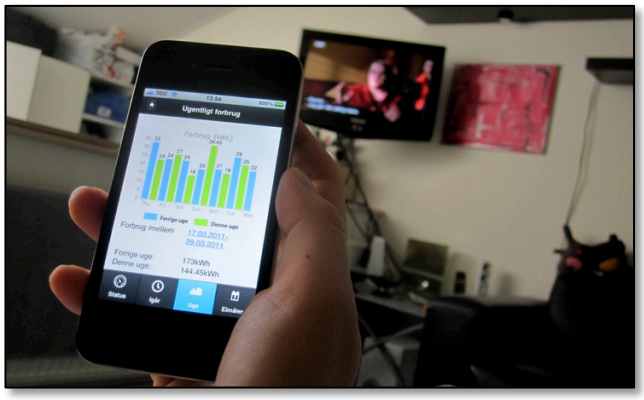

Figure 1. Power Advisor App

In this paper, we first present the related work conducted to raise awareness about electricity consumption by using several techniques to persuade consumers. This is then followed by research using mobile devices as a platform to change people's environmental behaviour and list some unexplored issues. The process of designing, implementing and deploying a prototype of a mobile application is presented, followed by findings from an analysis are presented and discussed. The main contribution from this paper indicate that participants using the mobile application found the application as supportive tool to raise awareness about their own consumption, and several themes were elicited for designing technology to help consumers adapt information into their life cycle.

RELATED WORK

Several research projects have studied the use of energy consumption feedback technologies [2, 9, 14, 19, 20].

Froehlich et al. conducted a comparative study of 133 papers from the HCI and environmental psychology literatures. The outcome of the study was a summary of key motivational techniques that HCI-designers must be aware of promoting pro-environmental behaviour.

One of the important issues they mentioned was the use of information to persuade people's environmental behaviour:

> *"…it must be easy to understand, trusted, presented in a way that attracts attention and is remembered" [6].*

Also considering the principles of attracting attention and raising awareness about electricity conservation, Yann et al. present a study exploring the requirements of an always-on feedback electricity consumption system [20]. The outcome of the study was a three-stage approach to support electricity conservation routines: raise awareness, inform complex changes and maintain sustainable routines. One of the design implications mentioned in the study was about raising awareness with detailed electricity consumption information. The participating consumers expressed that they would raise awareness about their consumption, if they could get detailed information about their past history – for example, one day ago or comparison between previous week vs. the current week. The same results were mentioned in a study conducted by Weiss et al., where they recommended showing information about the user's past consumption history, to raise awareness about their consumption patterns [19].

In the motivational psychology literature, Helen, H.A. et al. conducted an analysis synthesizing a wide range of studies to develop a motivational framework at different stages of readiness and motivation to change [7]. The Trans Theoretical Model (TTM) splits behavioural change of individuals into several stages [13], and is a list of recommendations to motivate individuals at different stages. One of the recommendations to make the consumers more aware of their electricity consumption is to present personalized feedback, which acknowledges both the benefits and consequences of the individual's non-sustainable energy-behaviour in a neutral non-biased way. Another recommendation is to use injunctive normative messages and provide understandable feedback to consumers with already known symbols and signs. For instance, smileys and thumbs-up signs are used. The third recommendation is to use personal self-set goals, which have the possibility of leading to higher performance and commitment [7].

A study trying to promote household energy conservation through normative messages was conducted by Schultz et al. [14]. The study was conducted with 290 households over a period of 7 weeks. The households were divided into two groups who received two types of feedback messages: half received feedback messages containing descriptive-norm-only messages and the other half received messages containing descriptive-plus-injunction information. The descriptive-norm-only message condition contained information about how much energy (kilowatt hours per day) they had used in the previous week. The descriptive-plus-injunction-messages contained the same information as the descriptive-norm-only message, but with one key addition:

If the household had consumed less than the average in the community, the researcher drew a happy face (☺): if the household has consumed more than the average, the researcher drew a sad face (☹). The use of the smileys was to try and make the messages more understandable.

The results from the experiments show that households consuming above the average decreased their consumption. Households consuming less than average, receiving only descriptive-norm-information, increased their consumption and created this boomerang effect. By adding a happy face (injunctive), households consuming less than average continued to consume at the desirable low rate. The results thereby highlight the reconstructive potential of social norms.

The founder of Stanford's Persuasive Technology Lab, B.J. Fogg, conducted several studies on computers as persuasive social actors. In his book "Persuasive Technology: *Using Computers to Change What We Think and Do",* he describes the five types of social cues: Psychical, Psychological, Language, Social dynamics and Social roles [4]. He mentioned that by using praise via words, images, symbols or sounds, computing technology could lead users to be more open to persuasion. In his list of principles, he also advised persuasive designers to use reciprocity because consumers will feed the need to reciprocate when computing technology has done a favour for them. According to Fogg, using roles of authority in computing technology also enhances its power for persuasion.

To motivate behavioural change in users, Kirman et al. conducted a study exploring several ways of using persuasive technology [9]. In their paper, they claimed that many technology products fail to exploit the established body of empirical research within behavioural science. Persuasive technologies rely too much on positive reinforcement [4]. They highlight that existing persuasive technology products fail to take advantage of negative reinforcement, such as using sad faces and text with a negative tone. They say that one way to effect positive changes are by using negative reinforcement as complaining messages or bad smileys. Therefore they argue that it is important to also make use of negative reinforcement to promote change of behaviour.

Whilst the above describes different techniques to use information to persuade people's environmental behaviour, the Danish energy company DONG Energy launched an energy saving project called *E-flex* in corporation with GreenWave Reality [2]. The project is demand-response oriented and designed to evaluate the readiness and motivation of household customers to use energy in a more flexible manner. They conducted a study with 155 households in Denmark. Every household has been provided with home energy management solution that enables the residents to monitor and control the energy consumption through a mobile device.

They can then individually notice and register the impacts and effects that their changes in behaviour can cause in the electricity distribution system and on the environment. This study is still on going and results have yet not been published.

The preceding work described above has not yet explored the role that actual source of information plays in persuading people change in behaviour. The recent *E-flex* project tries to persuade residents to be more aware of their consumption by providing detailed information about their own consumption. However, the study does not explore other information sources that might have an impact on behavioural change. Our study is trying to bridge the gap between mobile persuasion and the use of other information sources in persuading people to change their environmental behaviour.

RESEARCH DESIGN

The primary goal of this study was to explore whether a tailored mobile application could raise awareness of consumer's power consumption in their households. Furthermore, the goal was also to explore what role the actual source of the information plays in persuading people to change their environmental behaviour.

The study explores three sources of information: personal power consumption, an expert's advice and information about the community. The information is provided on a smartphone or tablet. Furthermore, the study investigates the role each source plays in persuading people to adapt their behaviour in a proposed direction. The three sources of information were provided in a mobile web application called Power Advisor [12].

Process

The present study is based on a similar approach used in persuading people to use water more wisely. An early prototype of a mobile application with data logging capabilities was deployed to 10 people in their households over 3 weeks. The prototype had the function of helping users be more aware of their current power consumption, by providing them with information about their level of power consumption vs. the average consumption rate. This will be further described in the next sections.

The participants in the study were involved in interviews, before and after they had used the prototype for a period of 3 weeks. The pre-use interviews focused on exploring and understanding their use of power devices in their households, their current power consumption knowledge and the use of mobile devices as tools in their households in their daily life. The pre-interview session was also used as an introduction to the provided prototype [12]. The post-use interview focused on how the prototype communicated information to the participants, and their reflections on the three different sources of information they had been introduced to during the case study period.

POWER ADVISOR

In 2008, the Danish utility company Modstrøm launched an automatic meter reader (AMR), which automatically reads the power meters in the households of their customers. The power consumption is shown online in small graphs and numbers to the customers [10].

Though the customers now have the opportunity to read their own power consumption online, the information provided to the customers was only informative and not trying to persuade them in a proposed direction (Figure 2).

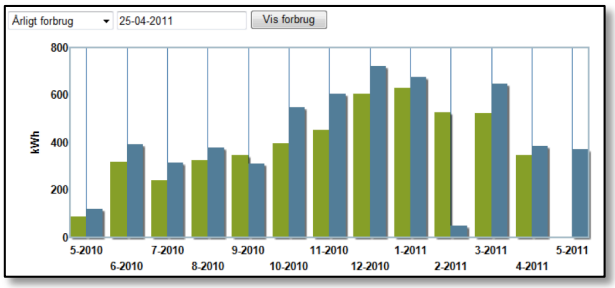

Figure 2. Modstrøm's online visualization of online consumption (yearly view)

The goal with the Power Advisor mobile application is to explore whether the users find the application supportive, by providing them with helpful information about their power consumption. Mobile persuasive technology theories are therefore applied to explore, firstly, the role the actual source of information plays, and secondly whether it makes users more aware of their power usage. Furthermore, do the users find the provided information in the application trustful? And do they act on the given personal information about their own power usage? The Power Advisor system and the case study should be as realistic as possible, and therefore the provided information about their current power-usage is real, and the advice is contextualized, according to the household size.

Figure 3. AMR on participant's meter-reader

To get the participants' realistic electricity usage, Modstrøm's AMRs were installed in the households of the participants (Figure 3).

The AMRs takes a picture of the meter reader number every hour and send the picture through the Modstrøm's server to the Power Advisor application. This is further described later in this section. The goal of this paper is to explore the role of the different sources of personal information provided to the participants in the case study rather than to explore technical or usability matters.

The Menu

The Power Advisor consists of one "Home-screen" as its main window. The main window contains four menus: *My Consumption, Enok's Guide, Inbox* and *Tip Of The Day*– see Figure 4.

Figure 4. Home-screen in Power Advisor

My Consumption

The *My Consumption* menu provides personal information about the user's electricity consumption. In this menu, it shows information about the last 24 hours' power usage on a graph and the last week's consumption vs. the week before. Furthermore it shows the last taken picture from the AMR and gives the user a smiley after his/her consumption over the last 7 days, according to the average consumption rate in Northern Denmark.

Enok's Guide

The *Enok's Guide* menu provides general information and advice to the user about power consumption in the household. The advice provided in the menu is about lightning, domestic white ware, IT and home office settings and the indoor climate. The advice comes from the Danish Energy Saving Trust (DEST) [17]. An earlier study by Shiraishi et al. has shown that people tend to increase their energy consumption knowledge by simply viewing a list of advice [15].

Inbox

The *Inbox* menu shows an overview over the incoming messages in the system. The unread message(s) from the system will be shown with an icon of an unopened envelope and read message(s) are shown as an opened envelope. By tapping on each message, the message will open up and the user is able to read the content of the message. This menu is the most important part of the system because the incoming messages explore the three different information sources, which is the main goal with the study.

Tip of the day

The *Tip Of The Day* menu shows random daily advice about power consumption. The advice is retrieved from the same pool of tips as used in the *Enok's Guide* menu.

Three information sources

Three different sources of information are explored in this study: personal power consumption, an expert's advice and what the other people in the community are saying and doing (Figure 5).

Figure 5. Icons of the three information sources

Expert's Advice

The expert's advice message is information provided to the users with information and advice about power consumption. The expert system measures the user's power consumption, combines it with information from the knowledge database of DEST [17] and provides information in the inbox about whether to change their power-consumption behaviour. The messages were sent to the participants from an animated Eskimo named Enok. Enok is also known from a commercial TV-advert provided from DEST [18], a month before and during the case study period – See Figure 5.

Community

The community message consists of information about what other users are planning or already doing in their households. The information could for instance be whether the majority of the community achieved their goal to reduce their electrical consumption for the week, and how the user is doing in relation to the wider community.

Personal Power Consumption

Messages received in the inbox from Personal Power Consumption are information about the user's own personal power consumption. The information provided in these messages is objective information about the user's consumption and is detailed, compared to the other sources mentioned above. This information is also provided to have a diversity of information in the provided messages, from using smileys to graphs and bars.

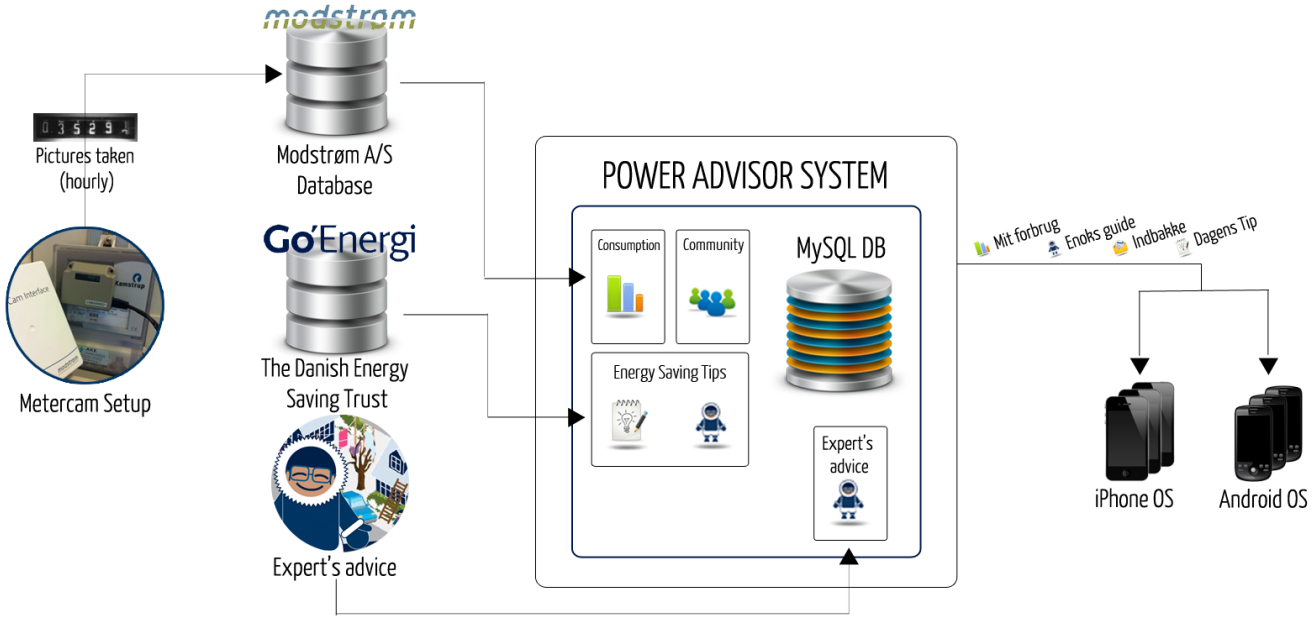

Figure 6. Technical Structure of the Power Advisor System

The nine incoming messages

During the three weeks of the case study, the participants received nine different messages containing information from the three information sources explored in this study. Each participant received three messages about their personal power consumption, three messages about the community and three messages from the expert. An example of one message is shown in Figure 7.

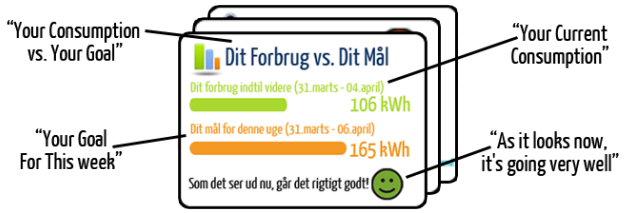

Figure 7. An example of one message provided to a participant in the case study.

Technical design

The system was implemented in one month by a single researcher. To not rely on one specific mobile platform, the system was implemented as a mobile website, and not as a mobile application (e.g. iPhone/Android application). The mobile website was developed by using an open-source framework named jQuery Mobile which is touch-optimized for Smartphones & Tablets [8].

The system communicates using PHP with a MySQL database in real-time, to ensure that actions from the users are logged to the system. The information about each user's personal power usage was shown by running a daily script, extracting the data from the utility company Modstrøm, and saving this in the MySQL Server database. Power Advisor then extracts the power-consumption information about each user from the MySQL Server database.

It shows the information on each user's screen in the *My Consumption* information page through visual graphs with bars and charts.

Every time the user interacts with the Power Advisor and submits information into the system, the data was saved in the MySQL Server database. A technical design is illustrated in Figure 6.

LONGITUDINAL FIELD STUDY

The prototype was deployed in a 3-week case study with ten participants. The objective was to explore how users used the prototype, and their choice and preferences of the provided messages from different information sources throughout the case study.

Participants

The participants in the study were recruited through the utility company Modstrøm, which used their customer database to find interested people. Each participant had to meet a basic set of requirements to be selected to participate in the study. The participants had to be customers of the energy company and had to be located in the Northern Jutland area. The participants were also required to have a Smartphone/Tablet that allowed them to browse the Internet (Apple iPhone/ iPad, HTC Mobile etc.).

Furthermore, all the participants were required to have a mobile phone, which could receive SMS-messages for the notification about the unread messages in the Power Advisor. To gather information about the user's current power-usage the participants were also required to have a power-meter that allowed the Modstrøm to gather information. These requirements were put in place to ensure that the participants would, and could invest the time required to generate useful data for the study.

The participants were asked to use the Power Advisor, at least once a day for the "get a view" on their current power-consumption, which approximately took at most 1-2 minutes to do. Furthermore they were also asked during the case study to check for incoming SMS-messages on their mobile phones as well as to read and respond to the messages in the system. The participants were able to use the Power Advisor, whenever they wanted to use it, throughout the day.

In total 15 people volunteered to participate in the case study, of which ten participants were selected. There was a good diversity in age and household size in the study, with participants ranging from 24 to 59 years old, with household size from 1 to 5 people.

Method & data collection

First, a quick tour in the house was conducted, where the researcher and the participant had a small talk about the participant's electric appliances, and the use of them. The intention of the small talk was to "break the ice" between the researcher and the participant. Secondly, the researcher installed the Automatic Meter Reader (AMR) in the house of the participants, which did not have an AMR previously.

Finally a smaller semi-structured interview was conducted, to get a general understanding of the participant's power-consumption knowledge, and current use of electric appliances. The interview should be able to create small personas of the participants in the study.

The week before the case study; the researcher visited the participants, and introduced them to the prototype. The researcher went through the Power Advisor with the participant, and the participant was free to ask any questions about the case study.

With the introduction, the participants received a small manual that described the system, and a link to a video tutorial of how to use the prototype, to prevent any problems during the case study. The day before the actual case study, the participants received a PDF-document with login-information and descriptive information about the three information sources they would receive messages from throughout the case study.

While the system was used during the case study, it was monitored remotely and any technical problems with the system were solved as quickly as possible. Every time a participant used the system, and responded on an incoming message, the answer was saved in the database.

After the case study ended, a second semi-structured interview was conducted. The purpose of this interview was to explore how the participants found the different information sources they received in the incoming messages and what information source they liked and The second interview started with questions reflecting on using a mobile device as a supportive tool in household.

Then the three different sources of information were discussed. Each of the incoming messages was discussed one by one. To remind the participants about the messages, small laminated cards were given during the questionnaires with a physical illustration of each message.

Finally, the benefits the participants saw in the Power Advisor system was discussed for the purpose of further development of the system. The system was tested on both Smartphones and Tablets, and the participants used the system almost every day and each participant remembered to respond to all 9 incoming messages.

Data analysis

Techniques from Grounded Theory were conducted in analysing the data. [16]. 10 audio-recordings from the final interview with the participants in the case study, were transcribed then translated and structured into columns. The total amount of the recording was approximately 12 hours. The first column in the transcripts contained a pseudonym for the participant. The second column contained a direct transcription of the speech from the interview. During this process, whenever an interesting topic was mentioned, the direct transcription of the speech were coloured and provided a specific number, representing the properties in Open Coding [16].

The total amounts of identified properties were 601, which were subsequently categorized into 22 different phenomena. By using Axial Coding [16], relations between the different phenomena were made and categorized into 12 categories. These categories were split among 3 themes. The processes included interviewing the participants; transcribing the audio recording; using selective coding and finding themes, took almost 87 hours.

FINDINGS

Each of the 3 themes revealed is central to the analysis and is treated in the next sections in this section.

Tailored mobile application as a tool to raise awareness

One of the research questions in the study was whether a tailored mobile application did have the opportunity to raise awareness of people's power consumption. To find out whether the provided mobile application could be used to raise awareness, the incoming nine messages during the case study were used as a basis for discussion. The results using the three information sources will be described in this section and later discussed in the next section.

The application on a smartphone

Out of the ten participants, eight participants used the Power Advisor application on their smartphone and two participants on a Tablet PC (Apple iPad). All the participants in the study were asked to discuss the used platform during the case study.

The eight participants using the mobile phone as their platform expressed their preference for using a Smartphone. One of the Tablet PC using participants expressed:

> *"I see it as an advantage to have it on a mobile phone because I still get an SMS on my mobile. Therefore it is easier to check the application on it than to pull my iPad up for that purpose. Furthermore, it is not always I have my iPad with me, but I always keep my phone with me."*

The majority of the participants therefore preferred to use the system on a smartphone, because of the flexibility to receive messages on the phone and the ability to check the system on the same platform was quick and easy.

Triggering SMS messages

Another topic discussed in using the mobile as a preferred platform, was whether the incoming SMS messages had the opportunity to contact the participant or not. All ten participants mentioned that they liked to be notified and reminded when there was an unread message in the application. A participant expressed:

> *"When there is such a message there so you will be reminded of it constantly. Then you are much more aware of it. So it works well."*

A SMS is therefore a useful triggering information-device to raise awareness of the power consumption, and can be used to push the users in a proposed direction.

Use of smileys

During the case study, the participants received different messages with small smileys, to communicate an injunctive message of approval or disapproval for the amount of electricity being consumed. The majority of the participants indicated that the smileys were easy to understand and interpret. A discussion regarding when to make use of the smileys was held.

A participant who received a happy smiley, when only being 3% percentage better than the average:

> *"I would here perhaps have a tendency to rest on its laurels."*

Another participant expressed that by receiving a bad smiley there were two options:

> *"Either one thinks that it was bad and do something by not getting a red smiley again, or then you are indifferent and are opposed to the message next time.*

This supports Schultz et al.'s study that it is important to know, when and where to make use of the injunctive messages, to promote a pro-environmental behaviour.

Positive and negative reinforcement

The discussion about using smileys in the messages led us to the next topic, whether to provide positive and negative comments to promote a change of behaviour. With regards to the use of positive messages, the majority of the participants expressed that it was a good motivating method.

However for some participants, the positive messages did make them not do anything different and they suggested that by expanding the positive message with a text such as:

> *"You make it excellent, but you're 10% worse than the best!"*

This would have the possibility to still motivate the user to do better.

Some participants found the negative messages motivating whilst others expressed the negative messages as demotivating. One participant expressed:

> *"If there are too many negative messages, I might be thinking: Argh, this stuff bother me no more – these stupid messages"*

Therefore, there is a potential to use positive and negative messages and it supports B.J. Fogg's principle that by using praise with words, this can lead to people being more open-minded to persuasion, and Kirman et al.'s study, to use negative reinforcement to promote a change of behaviour.

Self-setting goals as a motivating factors

After ten days of case study, the participants received a message, containing information about the previous two weeks of power consumption, and were asked to self-set a goal for the power consumption for the forthcoming week. The majority of the participants felt good about setting up their own goal for the power consumption. They expressed that is a very motivating factor, to get the opportunity to compete with themselves. A participant expressed:

> *"It's interesting, because it enabled me. It forces me to relate myself to what I consume."*

While discussing this topic, a few participants mentioned, that it also was very important to keep reminding the users about their own goal, to insure they are being kept aware in order to achieve their goals. Some participants specially expressed to repeat this goal-setting function for each time a goal-setting period had ended.

We can thereby argue, that there is a big potential in using self-setting goals to persuade and raise awareness of the power consumption that also supports Helen et al.'s recommendation.

A personal application that persuade

Ten out of ten participants rated the Power Advisor application as being personal and tailored with personal information. The information was self-produced and the information provided in the application had a high credibility, and thereby ability to persuade. Some participants expressed:

> *"The fact that it is linked up on my own consumption, it is what makes me go out and do something."*

It is therefore much better to use the tailored information with the purpose to persuade users to move in a proposed direction.

General information such as brochures, TV campaigns, shall be linked to the users own consumption, to be able to persuade users to change behaviour.

Three sources of Information

In total nine messages were sent to the participants from three different information sources. For each information source we observed their response in comparison to the discussed topics in the interviews.

Personal Power Consumption

All participants in the study found the information about the participant's own power consumption as the best informative message. The participants expressed that the messages with information about their own consumption, had a greater opportunity to persuade them to be more conscious about their consumption.

The participant received three messages consisting only of information about their personal power consumption. The first message contained a bar showing the participant's highest consumption, the lowest consumption and the average consumption for a household of the participant's size. The participants expressed that they found the message very interesting, and made them get aware of where they stood relative to the average consumption rate.

The second and the third message consisted of information about their previous consumption, and made the participants set up a goal for their own consumption for the forthcoming week. These messages were rated as most useful out of all received messages during the case study. One participant especially expressed:

> *"With these messages, I have become more conscious of how much we consume and then you can maybe try to work with it, if you want to bring it down."*

The majority of the participants therefore found the incoming messages from the personal power consumption, very easy to understand, user-friendly and easy to react on.

Expert's Advice

The participants expressed that they found the incoming messages from the expert system interesting and useful. The messages had a high credibility, and the advices were very easy to understand. In total three messages from the expert system were sent to the participants.

One of the messages contained only information with general advice about consuming less power, whereas the two other messages contained information about the participant's own consumption, linked with advices according to their own consumption.

While discussing the two different types of expert-messages, the majority of the participants expressed the messages containing personal consumption information linked to tailored advices had the best possibility to persuade.

One participant expressed after receiving one message containing his own consumption with tailored advice:

> *"It is always better when it is your own consumption instead of some general advice, because you are more inclined to listen!"*

The advice in the incoming messages from the expert, known to the participants:

> *"Some of the advices here are something you have been told many times before, so it's like: Ohhh Yes, that's true – and because you've heard them before, the advices are action oriented."*

Therefore the use of already known advices, that is easy to act on and with a linkage to the personal consumption, has a big potential to create a pro-environmental behaviour for the user.

Community

The majority of the participants felt the information messages about how the other participants in the community were doing was very useful. Some participants expressed that they used the information about the others in community, to compare with their own consumption. One participant noted:

> *"Absolutely, measuring up against other people gives med something feeling about my own consumption as I need to identify whether I'm doing something wrong or right."*

It was natural for some of the participants to be compared and one participant describes humans as being:

> *"We are gregarious animals somewhere. We measure ourselves and consider ourselves in relation to each other all the time."*

Therefore the majority of the participants said it was important to give information about what others are doing in order to be persuaded to conserve less electricity.

Not everybody had the same feelings about the community messages, and two out of the ten participants expressed the opposite. The appliances in the participants' households could be different and other parameters such as income, household-size and occupation, could mean that it was hard to compare against. A participant expressed:

> *"I really do not care how others are, it does not change anything for my consumption. So therefore it has no value to me to be compared with others."*

While discussing the visualization of the community messages, an important notice was discussed. When showing information about what and how the community is doing compared to the participant, it was important for the information being presented to the participant, to be able to persuade.

For example if the community average is a bit better than the participants, the percentage or number may not be displayed, and instead smileys and coloured messages should be shown to prevent this boomerang effect. If the community is way better than the participant the percentage and power consumption units can be used to show the difference. A common discussion point with the participants regarding the community messages was the importance of being compared to one's own consumption all the time as opposed to being able to persuade through community messages.

DISCUSSION

From the findings, three interesting themes emerged from our analysis. Even though, themes are elicited based on empirical data from Modstrøm customers, we hypothesize that they are also relevant to consider when designing mobile technology to persuade peoples pro-environmental behaviour in other domains, as the themes explores the human computer interaction, rather than the issues in the power consumption context.

Self-comparison

While discussing the three different sources of information with most of the participants, they mentioned that no matter which type of message they received, they always wanted to compare the information to their own consumption.

Some of the participants also mentioned in the interviews that for them it was irrelevant where the information came from, but the important thing was to combine the different sources of information together, with a special focus on the users own history, consumption or situation.

Therefore the information in the messages should be information about the individual, compared to the community, with a link to some advice from an expert system to persuade them to take action to become better pro-environmentalist. It is important to not make use of the "one-size-fits-all" solution, by providing the same type of advice, and information about the community to the user, because each user is different and their motivational factors are different. Use of different new motivational factors will be discussed later in this section.

Another issue that needs to be explored is, how to combine the three different information sources, in one single message to the user on a mobile platform. Due to the screen resolution and space, it is important to be aware of the usability and readability issues there must occur, when providing three information sources in one single advising message.

Motivational factors

While discussing the incoming nine messages in the interview, a discussion about motivational factors were further discussed.

Several participants mentioned that a motivational factor could be to be informed about the amount of power consumption measured in money or CO_2 units.
The system could inform the participant about these conversions. Another motivational factor could be to save money, and be informed about the savings process.

For instance, the participants could be able to choose a product they wished to save up to, and be informed about the saving status for each month, to motivate the participants to identify potential savings. While discussing the saving of consumption, another motivational factor could be to donate money to charity or to the nearby community organizations, sports club etc.

The participants mentioned that it was important to be able make their own choice of how the money should be saved up, but it was important to get the feeling that they were saving money. Receiving a certificate of proof regarding a donation made to charity would serve as huge motivation for the participant to conserve more energy.

Therefore the system should be able to automatically inform the user about the status of savings, and how they have saved money for their specific purpose.

A third motivational factor, which a participant mentioned a specific store nearby they could get some good deals. By saving up money, each month, they could achieve some bonus points, which could be used to get discounts on several items.

Common for all the motivational factors mentioned above, were focused on the individual – using personal information with the purpose to persuade them to conserve more. Thereby motivational factors were used, to raise their consciousness and become more pro-environmental.

Possibility to change behaviour

After the three-week case study of using the Power Advisor application, all participants expressed their raised awareness and consciousness on power consumption. The participants mentioned the application had given them a feeling of how they were doing, and were now able to follow and understand their consumption day by day.

While discussing the raised awareness on power consumption, thoughts about changing behaviour were discussed. The participants said, that the application had the opportunity to change the behaviour of people, if, and only if the use of the application was over a longer timespan. Using the system over several months, with the same information sources, and pushed information with reminders about their own consumption, could have a possibility to change people's behaviour.

Participants mentioned, that by reminding people over a longer timespan, it will be in their consciousness, for instance the next time they are buying new appliances for their household – to be more aware and buy more energy-friendly products etc.

The longer the time with raised awareness, the bigger the change in people's behaviour over time, which supports Prochaska's Stage Changing Model (TTM) [13]. People have to go through different stages, from being unaware, become aware that their behaviour is problematic, intend to take action, to then take action and thereby change behaviour. Subsequently maintain the changed behaviour.

The Power Advisor application is therefore a useful tool to raise awareness about the power consumption, and over a longer timespan getting people ready to take action and then change behaviour. The goal-setting messages and other informative messages should be reminders to maintain the changed behaviour to prevent a relapse.

CONCLUSION

This paper has explored how to design mobile technology to persuade residents to raise awareness about power consumption. The design, implementation and deployment of a mobile application in the form of a prototype have been described, discussed and several themes have been elicited.

The residents testing the prototype found the application a supportive tool to use in their home, and found the three information sources useful in the way of raising awareness of their own power consumption. Though, results indicate that the personal power consumption had the greatest impact on them. The information about the community and the advices from the expert system were only useful as long as the personal power consumption information was part of the message.

The residents demanded a mixed message, containing all three information sources, in one message. This is still unexplored, and is an issue, that needs to be explored more. Another issue discussed in the study was the use of different motivational factors that persuade users to become more aware of their power consumption. Different approaches were demanded, from saving money using the system to buy personal things or using the money to charity or other associations etc.

FUTURE WORK

Future Development of a system in corporation with the energy company Modstrøm, and build on the lessons learned from the study.

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