IMPROVING RESIDENTIAL ENERGY CONSUMPTION AT LARGE USING PERSUASIVE SYSTEMS

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Abstract

The paper presents a persuasive web application that stimulates residential energy conservation. The users of the application received consumption feedback that is based on electricity meter readings which they entered over a period of 6 months and which accounted for specific household characteristics. In a large scale field study which we conducted between April and September of 2010, 6'921 participants used the application. From a research perspective, the system allowed us to experimentally assess the effects of different socio-psychological concepts with regard to different measures such as popularity, choice, and energy conservation. The large user base and the real-world setting contributed to the validity of the findings. The discussion presented is structured along a behavioural change framework we adapted from Ölander's and J. Thøgersen's motivation – ability – opportunity model. Besides presenting the quantitative results of multiple studies and providing theoretical cues to outline the mechanisms behind the behaviour, we formulate guidelines that support the development of similar applications in research and industry.

Keywords: Persuasive systems, energy conservation, behaviour, behavioural change support systems

1 Introduction

The widespread use of the Internet led to the emergence of websites with the purpose of persuading people to change their attitudes and behaviours (Fogg, 1998). Such interactive websites, designed for changing user's attitudes or behaviours, are referred to as persuasive systems. Oinas-Kukkonen and Harjumaa (2008) defined persuasive systems as "computerized software or information systems to reinforce, change or shape attitudes or behaviours or both without using coercion or deception". There are certain areas where persuasive systems may be especially useful. In this paper, we focus on websites that persuade users to engage in energy conservation. The benefits of such websites are manifold: First, they support users in reducing their electricity bill and saving money. Second, persuasive websites can contribute to reduce the ever-increasing residential energy consumption and its environmental impacts (residential energy consumption accounts for close to one third of the total energy use in Europe[1]). Third, due the widespread use of the Internet, persuasive websites scale in terms of outreach as they are capable of cost-effectively addressing a large number of users. Fourth, the systems could help utility companies to compensate for lost sales as they constitute a channel to market energy efficiency services. Finally, within a liberalized energy sector, such websites are expected to increase customer satisfaction and prevent customers from switching utility companies.

However, it is a challenge to enthuse people about energy conservation. Only few people know how much energy they consume, how much it costs, and how it affects the environment (Wood & Newborough, 2007). Purely providing people with feedback about how much energy they consume does not lead to behaviour change (Abrahamse & Steg & Vlek & Rothengatter, 2007). In order to motivate a broad range of people to conserve energy, it seems important to combine feedback with socio-psychological concepts. These concepts consist of findings from sociology and psychology about how human behaviour can be influenced. Hence, there is a complementary research cycle between design science and behavioural science to address essential problems in the effective application of information technology (Hevner & Chatterjee, 2010).

We built a persuasive website called "Velix" in cooperation with an Austrian utility company (see Figure 1). Velix, the name of the comic-like mascot of the website, is an electricity meter that has become alive, helps users to learn about their energy consumption, and enables them to become more energy efficient. The website combines energy book keeping with game-like tasks. The user reads the electricity meter status and enters the meter reading into Velix. After entering the second meter reading, Velix calculates the energy consumption and provides the user with feedback in order to stimulate energy conservation. In the first six months since the launch of the website in April 2010, 6'921 users have joined Velix and entered more than 178'183 meter readings. Velix has about 500 visitors per day with an average time spent on the portal of about 5.5 minutes. We built Velix for two reasons: First, we wanted to persuade a large number of users to engage in energy conservation by providing them with feedback. Second, we intended to build an online application that allows experimentally assessing in a real-world setting the effectiveness of different socio-psychological concepts in order to stimulate residential energy conservation. The web application allows for evaluating different concepts by conducting experiments with a large number of users that have been recruited by the utility as for regular efficiency campaigns and thus form a typical user base of such a system. Every new user is automatically assigned to an experimental condition. Based on the assignment, the participant sees a slightly modified version of the Velix website. This is similar to A/B testing that is applied by many commercial websites to test the impact of different visualizations an offerings on purchase or registration probabilities (Kausshik, 2009). In the first months, we conducted experiments on social norms and goal setting and gathered extensive usage data of all the functionalities of the website.

[1] See www.eea.europa.eu/data-and-maps/figures/final-electricity-consumption-by-sector-eu-27-1

Persuasive theory combined with socio-psychological concepts can be a powerful motivator for people to conserve energy (Abrahamse & Steg & Vlek & Rothengatter, 2005). We used multiple persuasive techniques to motivate utility customers to use the Velix application repeatedly and to conserve energy. In this paper, we introduce a framework and guidelines about how to design persuasive systems that successfully promote residential energy conservations through socio-psychological concepts. We exemplify the framework and its guidelines in two steps: First, we describe how we put them into practice in Velix. Second, we report findings on the effectiveness of the implemented socio-psychological concepts with regard to multiple measures such as usage, choice, and energy consumption. These findings are based on experiments that we conducted with Velix as well as on the analysis of how users behaved on the website. The data is based on a sample of 6'921 participants who were using the website within the first six months, if not specified otherwise. In the following section, we present the theoretical model that served as the theoretical foundation of the framework and enabled us to structure the guidelines.

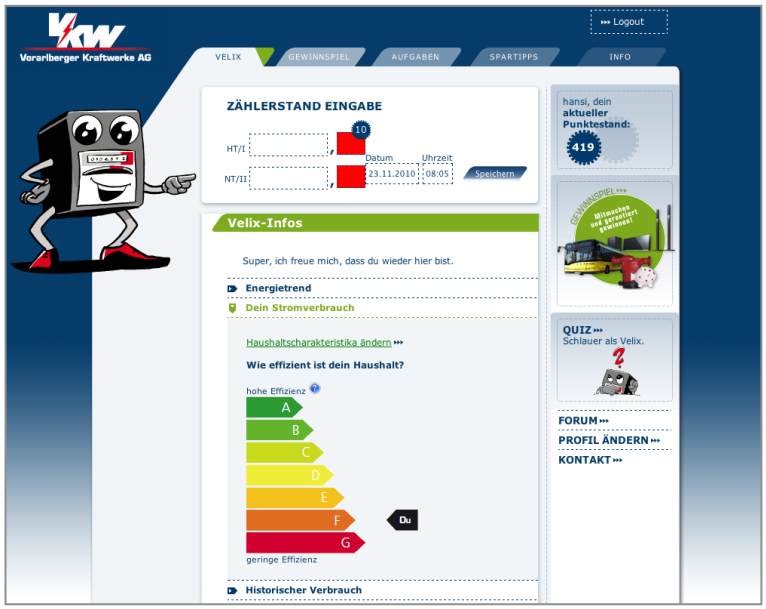

Figure 1. *Screenshot of the persuasive web application Velix. Shown is the feedback page where users can enter their electricity meter readings and receive feedback on their energy efficiency.*

2 Framework for Velix

Several socio-psychological theories evolved to explain and predict environmental behaviour. Researchers considering environmental behaviour as pro-socially motivated often use the "Norm-Activation-Model" (Schwartz, 1977) or "Value-Belief-Norm-Model" (Stern & Dietz & Abel & Guagnano & Kalof, 1999) as a theoretical framework, whereas researchers who view self-interest as the more important motive often rely on rational choice models like the "Theory of reasoned Action" or the successor, the "Theory of planned Behaviour" (Armitage & Connor 2001). All models assume that the intention to perform certain behaviour can be facilitated or hampered by contextual factors such as individual opportunities and abilities.

A model that integrates motivation, contextual and habitual factors into a single model of pro-environmental behaviour is the "Motivation-Opportunity-Ability-Model" (MOA-model; Ölander & Thøgersen, 1995). Habitual factors are especially important in energy related behaviour, because it is often based on non-conscious decisions and routines. The MOA-model (see Figure 2) is a validated and well-established model in behavioural science. It has been applied in various research areas, such

as information systems and environmental behaviour (Hughes, 2007). Due to these facts, we use the MOA-model to structure socio-psychological concepts and persuasive techniques.

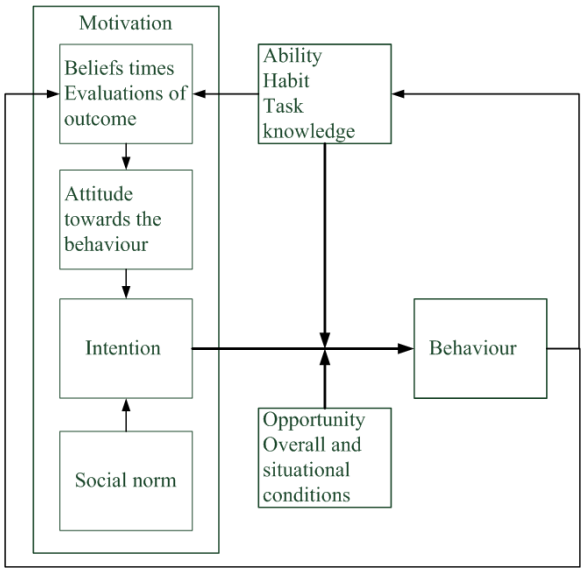

Figure 2. The "Motivation-Opportunity-Ability-Model" (Ölander & Thøgersen, 1995)

The MOA-model assumes that behaviour is best predicted by the intention to perform the target behaviour. Whether a person intends to behave sustainably or not depends, besides beliefs about the perceived outcome, on the attitude towards the behaviour and on social norms. A person with a positive attitude believes that the benefits of taking action exceed the involved costs. Social norms (i.e. the behaviour or attitude of family, friends or other people valued by someone) have a strong influence on a person's intention (Ajzen, 1991). Nevertheless, it is widely accepted that people do not always turn good intentions into behaviour. A person might not have the ability to change behaviour due to lacking knowledge or established habits that are hard to overcome. Even if people know what to do, they might not have the opportunity to act. In addition, external factors like budget, housing or their physical abilities might hinder them in changing their behaviour. The MOA-model addresses one-time behaviour as well as recurring behaviour. For the latter, habit is an influencing factor, as it is not easy to break habits and establish new ones (Jackson, 2004). To effectively support sustainable behaviour change, each of the categories, attitude, social norms, ability, and opportunity have to be addressed. The MOA-model incorporates contextual factors that play an important role in energy conservation. Thus, it provides an adequate structure to investigate how socio-psychological concepts should be integrated into feedback and presented to the user. In the following section we describe each category of the model, suggest specific guidelines for persuasive websites, exemplify them by describing the implementation of the concepts in Velix, and provide results from conducted experiments and usage data analysis.

2.1 Attitudes

For most people, energy consumption is a low involvement topic (Watson & Viney & Schomaker, 2002). Hence, it is challenging to persuade people to think about their daily energy consumption and search for ways to conserve energy. To overcome this challenge, we applied a reward system in Velix.

Influencing the evaluation of perceived benefits through rewards

People evaluate earnings they get in the future differently than earnings they can get right away (Chapman & Elstein, 1995). Promising and giving rewards alongside with an action is a strong extrinsic motivation. Rewards can be either monetary or virtual. Virtual rewards may be points that reflect engagement and level of progress. These points do not even have to be redeemable. People like

to see their score increase (Graml & Loock & Staake & Fleisch 2010). Rewards can be used either in contingent (i.e. dependent on the degree of behaviour change) or in a fixed amount (e.g. for drawing attention to and rewarding an initial action; Abrahamse et al., 2005). This implies for persuasive systems that any measured behaviour change should be transformed into feedback that is perceived as rewarding for the customer. For example, when tracking travel behaviour through GPS (Froehlich, 2009) or instead of providing the overall CO_2 footprint, users should be rewarded with bonus points for using an environmentally friendly transportation option.

Adaptation to Velix: We employed various rewards in Velix. To promote the application in the first place, a lottery was designed with attractive prices for every user that entered at least one meter reading. To motivate users to input further readings, a guaranteed welcome gift after entering three readings is offered. The lottery prices and the welcome gifts are chosen in such a way that a broad range of user interests are addressed (see Figure 3). Fifty-five percent of all users choose a welcome gift with a value of 10 Euros. The left side of Figure 3 shows the distribution of the chosen welcome gifts. The right side of Figure 3 shows that users that choose a welcome gift used the website significantly longer than users who did not choose a gift (M = 29.25 logins (SD = 35.93) vs. M = 4.92 logins (SD = 21.75); $t(6464.17) = 34.76$, $p < .05$). Another form of reward employed in Velix is the point system. The users receive 10 points for every meter reading they enter and between 10 and 90 points for every task they complete (e.g. survey). The users earned a total of 995‘565 points within six months with an average of 143.85 points (SD = 162.94). When it comes to incentives, research has found that incentives sometimes corrupt intrinsic motivation (Deci & Koestner & Ryan, 1999): People who use the website due to intrinsic motives (e.g. curiosity) may attribute their activities to the extrinsic reward and as a consequence will stop showing the desirable behaviour as soon as the rewards are removed. However, we found that only 8% stopped participating. We attribute this to the manifold benefits the website offers.

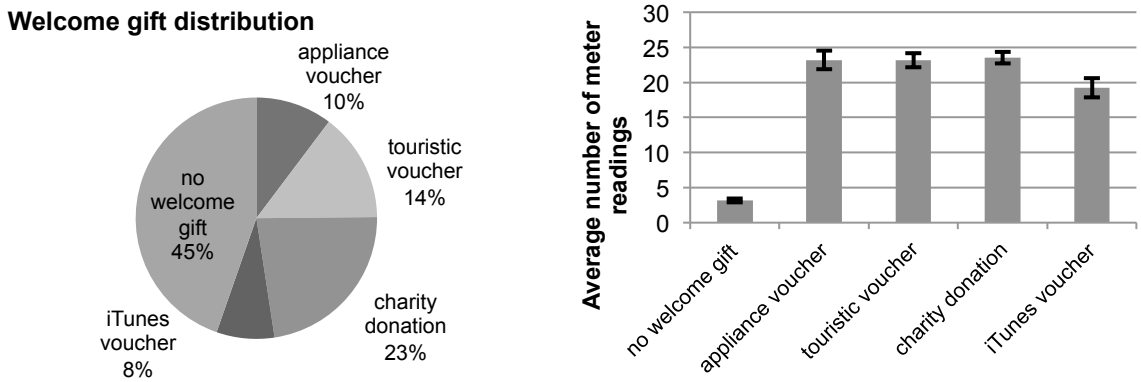

Figure 3. Distribution of welcome gift selection that users received after entering electricity readings for three weeks (left side). Average number of readings in relation to the selected welcome gift (right side).

Using emotions to motivate different user groups

Emotional connection is important in shaping a person’s beliefs, values, and attitudes towards the environment (Chawla, 1999). Emotions like joy, surprise, anticipation, or assurance are useful to address user groups that do not have pro-environmental attitudes. For these groups, emotions lower the entry barriers and are very effective in triggering initial participation. For example, joyful games or surprising quizzes can be used to raise the users’ interest and later engage them in environmental topics. Quizzes are also a good means to make users come back regularly and answer new questions (Graml, 2010). To conclude, persuasive systems should provide information in an emotional and personal way to make pro-environmental behaviour tangible for a broad range of people with distinct interests. Furthermore, this helps to keep users engaged in the long run.

Adaptation to Velix: Together with the Austrian utility company, we adapted the design and the contents of Velix to fit the regional characteristics. In order to not only address people with a distinct interest in conserving energy, a mascot was designed for Velix that communicates with the users in a personal (by addressing the user informally and by name) and in an emotional way (by praising the user for his commitment). The mascot Velix is a cartoon character and its childish appearance (e.g. big eyes) motivated especially children and their parents to participate (see Figure 1). This is reflected in the size of participating households which were bigger in size (M = 3.22, SD = 1.41) than the average household size in the considered region in Austria (M = 2.43). While planning the efficiency campaign and the public communication around Velix we realized that even the project group held different opinions about the usage of the mascot Velix. The pros included the appeal of Velix to younger users and the high memorability as well as the playful interaction. The cons comprise the risk of customer complaints due to the informal communication and the reactance of older users to the childish appearance of the mascot which might cause a lack of perceived seriousness. In the end, the team decided that playful interaction is critical for the success of Velix and therefore agreed on using the mascot. We asked twenty users about their opinion on Velix and found that 16 out of 20 appreciated the mascot because it makes the topic of energy efficiency more entertaining and decreases its abstractness. However, 4 out of 20 thought that the mascot is too childish.

Providing specific and hard to reach goals

Being told that it is necessary to improve one's performance before even starting any action is often discouraging to people. Still, many environmental campaigns currently take this approach and thus only reach a limited set of people. In contrast, goal setting is an effective method to motivate people. Goal setting influences the effort, persistence, and strategic direction of individual performance (Bandura, 1977). The goal setting theory suggests that specific and difficult goals produce the highest outcomes (Locke & Shaw & Saari & Latham, 1981). Ambitious goals proved to affect persistence: When participants can decide what amount of time they would like to invest in solving a task, hard goals prolong effort (LaPorte & Nath, 1976). Committing oneself to take a certain action (e.g. "I will reduce my showering time by one minute next week") is an understandable and action-oriented goal. Persuasive systems should provide specific and ambitious goals to be motivating to the user. One important premise for goal achievement is goal commitment which can be obtained if people can set goals on their own.

Adaptation to Velix: In order to get people to set themselves ambitious goals in Velix, we used defaults, a concept known from marketing and e-commerce. A default is the option "...the consumer will automatically receive if he/she does not explicitly specify otherwise" (Brown & Krishna, 2004). The users could either choose a saving goal without reference (control condition) or were assigned to one of three default levels: 0%, 15%, or 30% reduction in energy consumption within a certain period of time. Eight hundred and eighty-seven users participated in the experiment. They could either stick to the default goal or adjust it. We found that the default level significantly affects the goal choice. We found a significant effect of default level on goal choice ($F(3, 887) = 53.0$, $p < .05$). Customers in the low default condition chose on average a goal of 3.95%, customers in the medium default condition an average goal of 12.22% and customers in the high default condition 19.36%. In the no-default condition customers set their goal on average at 14.01%.

2.2 Social norms

Using comparative and injunctive feedback in combination to prevent boomerang effects for some user groups

Social norms tell us what kind of behaviour is performed by others (descriptive norms) as well as what behaviour is appreciated by others (injunctive norms; Schultz & Nolan & Cialdini & Goldstein & Griskevicius, 2007). Social norms powerfully guide behaviour in situations of uncertainty. Comparative feedback shows the relationship between an individual performance relatively to the

performance of others, so to say a benchmark (Abrahamse et al., 2005). This is effective because it arouses feelings of competition or social pressure. The effectiveness can be enhanced when people receive feedback on the performance of groups they belong to (Siero, Bakker, Dekker & Van den Burg, 1996). However, using comparative feedback can have negative effects if not used right. As an example shows, households who are better than the benchmark in energy consumption increase their usage, thus changing behaviour in a less sustainable way (Schultz, et al., 2007). In order to balance this effect, injunctive feedback is suitable because it takes advantage of the fact that others appreciate sustainable behaviour. However, the comparison group has to be chosen wisely and has to be personalized for each user to maximize the overall effect. Persuasive systems have a strong benefit here. Due to their potential ability to measure social relationships (Miluzzo & Lane & Fodor & Peterson & Lu & Musolesi et al., 2008), they can select a suitable comparison group.

Adaptation to Velix: Descriptive and injunctive normative feedback are main elements of Velix. We experimentally assessed the effectiveness of both forms of feedback similar to Schultz et al. (2007). We used historical data from all of the customers at the utility company to provide the user with descriptive normative feedback on their consumption of electricity. The customers in the descriptive feedback condition were given a bar chart that compared their weekly energy consumption (in kilowatt hours) to the average energy consumption of similar households (regarding size and heating system) in the considered region of Austria. The injunctive feedback was represented using grades from A to G, with A representing a high level of approval of the customer's energy consumption and G representing a high level of disapproval. We combined both types of feedback to investigate the joint effect of injunctive and descriptive normative feedback compared to the descriptive normative feedback only. The feedback types were randomly assigned in a between-subjects design to different users (N = 211). The baseline level of consumption was calculated using the readings that were obtained during the first two participation weeks of each user. The intervention was initiated immediately after the baseline was measured, and the consumption was monitored weekly over the following four weeks.

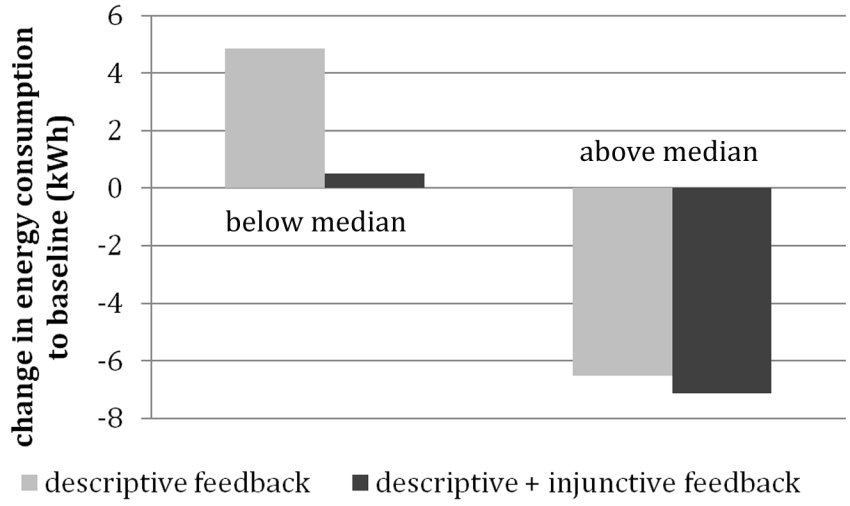

Figure 4. This chart shows the difference in weekly electricity consumption after 6 weeks of using Velix for users with a low consumption (below median) and with a high consumption (above median).

The results show that descriptive feedback does have a negative effect if given to low consumers (baseline: 58.85 kWh/week); they consume 4.85 kWh more per week. That means that for below-average energy consumers, descriptive feedback increases consumption. However, above-average energy consumers reduce (baseline: 106.11 kWh/week) their consumption on average by 7.13 kWh (SD = 31.89, $t(112) = 3.53$, $p < .05$). The combination of injunctive and descriptive feedback in contrast maintains energy consumption at a desirable, low level for below-average energy consumers

(M = 0.52, SD = 12.54) and also decreases energy consumption for above-average energy consumers (M = -7.13, SD = 31.89). That means that the combination of descriptive and injunctive normative feedback is effective for both above- and below average energy consumers ($t(95) = 1.57$, $p > 0.5$, see Figure 4). These findings confirm the results that were reported by (Schultz et al., 2007) and lead to the conclusion that descriptive and injunctive feedback should always be used in combination to prevent boomerang effects for some user groups.

Using public commitment to keep the motivation high

Commitment refers to a pledge or promise in order to change behaviour, which individuals make voluntarily (Abrahamse et al., 2005). If made public it is even more effective (Mack, 2007) for two reasons: First, the person making the commitment feels obliged to stick to it. Second, people perceiving the commitment are told what their environment does (descriptive norm). Public commitment, e.g. via status postings, is an effective way of motivating people because it makes them stick to their obligation in order to keep social status. Persuasive systems should be used to show what other people are doing and should allow users to share their behaviour automatically.

Adaptation to Velix: We implemented both private and public commitment in Velix. By defining a routine on when to read the electricity meter, users commit themselves to reading the meter regularly. Public commitment is covered twice: First, we ask users to give a statement on why they use Velix and publish it in combination with a photo on the starting page of Velix. Second, users can invite friends and therefore show their commitment to using Velix publicly. Velix-users sent 2'647 mails to invite their friends (2.7 on average). Two hundred and fifty-six new users were generated by invitation mails (9.7%).

2.3 Ability

Guiding the user with how-to instructions

To behave in a pro-environmental manner, it is important to know what kind of behaviour is good for the environment. This knowledge can be conveyed in various forms, such as general information, tips or how-to instructions. In the context of household energy consumption, general information has proven not to be effective (Abrahamse et al., 2005). It leads to higher knowledge levels, but does not induce behavioural change. Moreover, automated home energy audits often fail because provided information is either irrelevant or annoying to users (Abrahamse et al., 2005). Therefore, it is necessary to provide the user with simple and action-oriented information. Detailed information becomes important as soon as people are motivated to change their behaviour and need more information for their specific situation. Persuasive systems should reduce the complexity and avoid information overload by providing action-guiding next steps.

Adaptation to Velix: Within Velix, a whole section helps users to understand their energy behaviour better and to support them in becoming more energy efficient. This section consists of tasks and actions that users can either do directly online or in the real word. The completion of these tasks is then rewarded with points. An example for such a task is meter sleep. It instructs users to try to turn off all electric devices in their household and to see if they can manage to put their meter to rest. By doing so, they are enabled to find previously unknown electricity consumers. For example, one user found that the recharger of his mobile phones consumes surprisingly much electricity.

Supporting repeated behaviour with prompts and reminders

A socio-psychological measure that is closely related to providing instructions is prompting. Prompts, i.e. cues that remind people to carry out an action, are thus an effective way to induce behavioural change and keep emotional engagement levels high (Froehlich, 2009). However, a critical point in using prompts is that applications have to find a balance between effective output and annoying people

by sending prompts too often (Froehlich, 2009). Persuasive systems should therefore deliver information about a desired behaviour at the right time and directly at the place of action.

Adaptation to Velix: The most frequently performed task on Velix is to set reminders (51.8%). Setting an Email or SMS reminder (e.g., for meter reading) is done voluntarily and ensures that people come back regularly. Users who set themselves reminders use the website more often than those who don't ($F(3, 6910) = 328.27$, $p < .05$, see Figure 5). Users who do not use reminders log in on average 6.97 times (SD = 27.46), whereas users with Email reminders come back 30.10 times (SD = 34.53) compared to 25.06 times (27.32) with SMS reminders. The combination of Email and SMS reminder proved to be the most effective combination for motivating usage (M = 36.82, SD = 35.22). Another support tool is "choosing a routine". People can decide when they want to read their electricity meter by choosing a routine from the list (e.g., "whenever I take down the garbage") or by defining a personalized one. Of all users, 41.4% chose a routine. As figure 5 shows, users that set themselves reminders enter more than four times as many readings on a weekly basis than users that do not have reminders in place.

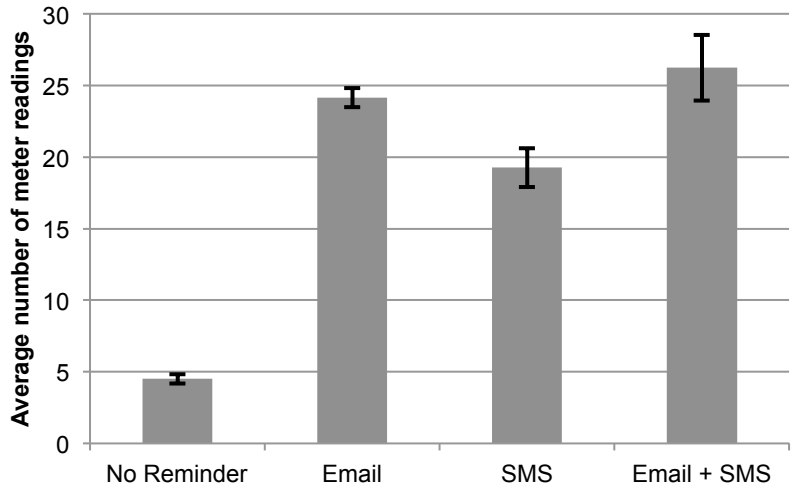

Figure 5. This chart shows the average number of readings entered by users with no reminder set, with only Email, or only SMS reminder or with both reminders set.

2.4 Opportunity

Learning by doing through immediate feedback

Feedback, for example on one's energy efficiency level, arouses curiosity: People want to know how good they are. Most people have a rather positive self-image and want to confirm this self-perception (Heine & Lehman & Markus & Kitayama, 1999). Feedback can either be direct, i.e. right after the action and directly attributable, or indirect, i.e. available later or in an aggregated from. Most behavioural changes towards increasing sustainability relate to daily routines and repeated tasks that became habits. Thus, feedback should be given immediately in a direct from after certain behaviour occurs. As a result, people can connect the feedback to certain behaviour and as a consequence perform it more or less often (Darby, 2006; Hayes & Cone, 1981). Feedback should be used by persuasive systems to support learning and motivate through showing users progress in close proximity to the desired behaviour.

Adaptation to Velix: Another guideline we have incorporated in Velix is direct feedback concerning consumption behaviour and changes to it. The feedback on the user's electricity consumption is not as direct as it would be using smart meter technology, but we tried to indicate changes in consumption behaviour in a prominent way.. So did for example the energy efficiency level update immediately

each time a user provided new details about his housing conditions. This concept of giving information back to the user for every data that is entered was also applied in surveys on Velix. After answering a survey questions feedback was given on how other users replied to this question. Thus users could correlate their behaviour with others.

Simplify actions and personalize behaviours

Even if motivated and able to perform a task, people are often constrained through a very specific situation, e.g. housing type or budget constraints. To overcome this "intention-behaviour gap" (Kollmuss & Agyeman, 2002), it is necessary to provide personalized support and continuous improvement of supportive actions. Pervasive systems enable us to communicate with other users and things (Fleisch & Mattern, 2005) whenever and wherever wanted. The combination of consumption information and a personalization system allows building persuasive systems that deliver highly specific information and provide context specific services (Abowed & Brown & Davies & Smith & Steggles, 1999).

Adaptation to Velix: We consistently broke down large tasks, e.g. to do an energy audit, into smaller tasks that can be done independently of the specific housing situation. Through the personalized selection of only three saving tips and tasks at a time, we managed to reduce complexity for the users and kept task completion high.

Summary of guidelines
1 Influence the evaluation of perceived benefits through giving rewards
2 Use tailored emotional communication to motivate different user groups
3 Provide specific and hard to reach goals
4 Use descriptive feedback only in combination with injunctive feedback
5 Use public commitment to keep the motivation high
6 Guide the user with how-to instructions
7 Support repeated behaviour with prompts and reminders
8 Learning by doing through immediate feedback
9 Simplify actions and personalize behaviours

Table 1. Summary of all guidelines discussed this paper to design persuasive systems that successfully promote residential energy conservation.

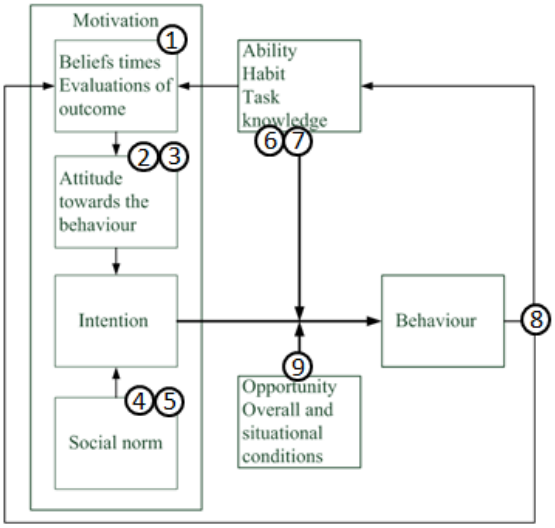

Figure 6. MOA-model with markers where guidelines of Table 1 support energy conservation behaviour.

3 Discussion and Future Research

In this paper we presented the persuasive website Velix that allows evaluating which socio-psychological concepts are best suited to stimulate residential energy conservation in a large scale and real-world setting. The Velix website is an ongoing project and allows different researches to conduct studies on persuasive concepts at large. We report findings of the first 6 months of Velix usage and show results of the first experiments conducted during this time. We used the MOA-model as a guiding framework to cover the various aspects of behaviour change. To exemplify the proposed

framework MOA-model and its guidelines, we described how we put them into practice in Velix. In the following paragraphs we discuss the guidelines we derived from the findings of the first 6 months of Velix usage and give directions for future research. Table 1 summarizes the findings in what socio-psychological concepts where effective in promoting energy conservation in the form of guidelines. Figure 6 shows to which elements of the MOA-model the different guidelines belong.

3.1 Discussion

The usage data and the experiments showed that socio-psychological concepts are effective in supporting energy conservation behaviour in regard to influencing the choices users make, making users come back more often, and having an impact on energy consumption itself. Rewards like welcome presents, lotteries and bonus points were simultaneously employed in the Velix application. All these reward systems did not reward energy savings directly but aimed at influencing the belief and attitude of users towards actively using the system and as a consequence conserving energy. We found that the activity of the users did not decrease after the users were rewarded. Thus rewards seem to be an appropriate means to convert long-term and vague outcomes, like saving money over a longer period of time or doing *something* good for the environment into near term and more direct benefits. Therefore, our first guideline for persuasive applications to foster energy conservation can be stated as: "Influence the evaluation of perceived benefits through giving rewards". Future research should detangle the effects each reward system has on the decision of initial participation, on continued participation behaviour, and on energy conservation.

We found that employing personal and emotional communication like the usage of the cartoon character Velix and the story around him, helped to reduce perceived complexity of the topic of energy efficiency and therefore to address an audience that is not as familiar with energy conservation topics as more technically oriented users. However, there are some users who do not appreciate the informal way of communication. The effectiveness of emotional communication could be increased through tailoring it for the different users. Thus, we formulate guideline 2: "Use tailored emotional communication to motivate different user groups". Possible future research would be on how to distinguish different user groups and their preferred way of communication early in the behavioural change process.

Influencing the attitude of people towards a specific behaviour can also be done by framing it as desirable goals. Through the Velix website we found an effective way in how to motivate users to set themselves specific and hard to reach goals (Guideline 3) which is usually a premise for high savings. Specifically we found that defaults are effective in nudging consumers toward higher saving goals. What we are investigating further is the relation between goal height, goal feasibility, repetitive goal setting, and the effect on energy conservation in the short and long run.

The social norms are an effective way to influence behaviour. Never the less, we found that social norms in the form of descriptive feedback, i.e. showing what others do, can also have a negative influence on energy conservation for some user groups. To prevent this boomerang effect one should either tailor feedback according to the group or combine it with injunctive feedback, i.e. what people appreciate (Guideline 4). Here future research should investigate the direct effect of injunctive feedback on energy conservation.

Guideline 5, using public commitment to keep the motivation high, is based on the finding that some users actively share their achievements with friends or even publicly. Public commitment and public sharing of one's status and activities a means to involve users that already do conserve energy in persuading others to follow their example. What needs to be investigated is when public commitment should be asked from users. Asking early in the behaviour change process might shy away some more privacy minded users. Thus the right balance has to be found to motivate continued participation and to not discourage initial participation. Here different strategies of how to foster community growth need should be evaluated.

In the context of energy conservation changing habits is an essential aspect. In order to do so it is necessary to provide user with easy how-to instructions (Guideline 6) in combination with prompts and reminders (Guideline 7). In Velix we employed weekly reminders, in order to get people into new routines. Here a trade-off between being not too intrusive and not having users lose focus and interest between actions has to be found. Further research should deal with how frequently reminder should be sent out to users in order to support in long-term behaviour chance and energy conservation. When does it make sense to switch from weekly to monthly reminders? Or is an approach that alternates high intensity phases with phases of lower activity useful?

Guideline 8 "Learning by doing through immediate feedback" is based on the fact that users responded positively to getting information in return for every data they entered. We also found that the "doing" component, reading your electricity meter manually every week, was also an important part to stimulate learning. Thus systems that do automate behaviours, e.g. smart meters that provided real-time feedback continuously, can be enhanced by linking them to the real world to do's in order to support behavioural change. A task for research is here to develop approaches that actively involve users and do support behaviour change through technology.

With regard to energy consumption contextual factors play an important role. Guideline 9 "Simplify actions and personalize behaviours" tries to formalize this. The different situational conditions have to be taken into account by persuasive systems. This can be done by breaking processes down into actionable tasks and letting either the user choose the appropriate action themselves or having a recommendation mechanism that selects actions according to the user's context. Future research should find a way to identify and address the context factors of energy related behaviour and related actions.

3.2 Limitations

There are two major limitations of the studies we conducted with the persuasive website Velix. First, the great opportunity of testing socio-psychological concepts in a real world setting comes at a price. In order to make the website a coherent campaign that makes sense to the user a multitude of contents, persuasive elements and reward systems were employed simultaneously. This has the disadvantage that not all effects can be attributed to a single persuasive element. Also, it is difficult to have complete experimental designs for some essential aspects of the website. In some cases it is just not possible to have control groups that do not get a specific feature, because it was already communicated in the accompanying advertisement campaigns.

A second limitation is that Velix was built in cooperation with an Austrian utility company and users were mainly customer of that utility company. We did not investigate if our findings are equally valid for other user groups. We will implement Velix with other utility companies in different countries. This will allow us to assess the external validity.

4 Conclusion

Persuasive information systems which provide insights into personal energy consumption together with action-guiding advice and suitable incentives can lead to actual energy savings – if the information system succeeds in engaging people in the topic. With our work, we aimed at probing concepts that strengthen this engagement. Therefore, we developed an online platform that simultaneously served as a part of a sustainability campaign run by an utility company and that allowed us to conduct field experiments with a large and relevant user group (N=6'921). Using the system, we showed, among other findings, to what extent email and SMS reminders significantly increased user engagement, that descriptive feedback lead to significant savings for above average consumers but to an higher consumption for those how already consumed less than average, and how additional injunctive feedback can buffer this negative effects of its normative counterpart. Moreover,

we developed a behavioural change framework which builds upon Ölander's and J. Thøgersen's (1995) motivation – ability – opportunity model.

The findings and descriptions provide guidance for both system designers and energy efficiency program managers when developing user-centric smart grid systems and IS-enabled saving campaigns. Moreover, the research approach itself – implementing experiments in scalable and operative IS-infrastructure – was found to be very useful to gain new insights in adjacent research disciplines. The IS-enabled approach rendered possible to combine the substantial body of work from behavioural science with powerful, flexible, and far-reaching information and communication technology. Doing so, the project allowed us to discover even small effects (due to the large N) within a relevant user group. Moreover, it became possible to conduct experiments in a relatively short timeframe and thus quickly move from lab research to field studies. For other researchers, we can emphasise the recommendation of Allcott and Mullainathan (2010) in a recent publication in Science, namely to use engineering approaches to translate "behavioural science insights into scaled interventions, moving continuously from the laboratory to the field to practice".

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