Two Actors: Providers and Consumers inform the Design of an Ambient Energy Saving Display with Persuasive Strategies

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Abstract. Ambient persuasive displays could be a potential way to raise awareness and lower the energy consumption in private households. There already exist a range of products in this direction. However, none of them seem to have any long-term persuasive effects. We argue that this effect could only be enabled by involving providers and potential users in the design process of an ambient persuasive display, which aims to lower energy consumption. In this paper, we present the results of five expert interviews with energy consultants and a participatory design workshop with six potential consumers. We focused on the ideal persuasive strategies as the requirement. In here, we show the commonalities and differences between these two stakeholders, demonstrating the relevance of taking both sides into account in the design to support behavior change systems.

1 Introduction and Motivation

In the domain of behavior change or attitude influence persuasive technologies are designed with intent to modify humans habits [2]. As it is possible to provide private household consumers with various forms of information related to their energy consumption behavior, an ambient persuasive display should have the potential to persuade users to sustainably reduce their energy consumption. Different ambient devices already exist which aim at increasing the users' awareness to save energy and/or change their consumption behavior (e.g., Wattson [9] or Energy Orb [5]). Research has been done on how much and in what way these systems manage to have a long-term effect on users' sustainable behavior (e.g., [6], [12], [13], [14], [15], [16]). Fröhlich et al. [15] outlined common misconceptions of energy usage in the home, established the potential of feedback to change energy consumption behavior, and introduced ten design dimensions of feedback technology with which to build and evaluate future systems. They presented four patterns of design for ambient information systems. As He et al. [13] explained not every individual is motivated at the same way. They presented a motivational framework, which is based on the Transtheoretical Model (TTM – Stages of Change) for energy feedback technology design. Each individual has different stages of readiness, willingness, and ability to change their current behavior.

McCalley et al. [28] discussed a research framework for developing in-depth knowledge of eco-feedback by exploring different forms of immediate product feedback within the contexts of cognitive and social psychology models. It is suggested that by understanding the fundamental principles of how, when, and why, a user's conservation behavior will be enhanced by eco-feedback and should enable designers and engineers to broaden their control of the environmental impact of a product.

But what is unknown is people's basic perception of electricity. An analysis of this aspect was made by Chisik [16] and showed that people do not have a clear mental model of electricity; consumers tend to associate the size of the device and the duration of use with higher rates of consumption regardless of the type of device, the type of use it has, and its actual consumption level. Riche et al. [27] conducted a study to understand consumers' awareness of home-based energy consumption and to determine the requirements for an interface showing data to increase awareness of home energy consumption. They described a three-stage approach to support electricity conservation routines: raise awareness, inform complex changes, and maintain sustainable routines. Fitzpatrick et al. [26] articulated a set of design concerns that focus on research into user experience and better feedback strategies for saving energy. Mankoff et al. [25] explored the use of social networking websites to support the reduction of energy consumption. They proposed to integrate feedback about ones' ecological footprint into existing social networking sites to allow frequent feedback on performance.

On the topic effectiveness of different types of feedback for domestic consumers a literature review can be found in [24]. The review concluded that feedback on energy consumption behavior has great potential for raising energy awareness. Abrahamse et al. [23] reviewed the effectiveness of interventions aiming to reduce energy consumption in households. They summarized the findings of thirty-eight studies and categorized them into antecedent strategies or consequence strategies. In conclusion they showed that several studies investigated commitment and found long-term effects on reducing energy use in households. However, one study contradicted these results and reported only short-term effects. Furthermore, goal setting turned out to be more effective when combined with feedback strategies than goal setting alone. Information led to higher knowledge levels, but did not necessarily induce behavioral changes. It was more effective when combined with other strategies. Rewards only provided short-term effects on energy conservation. Feedback successfully induced behavioral changes, in particular when provided frequently. Studies on comparative feedback showed that it led to the same effects as individual feedback. Combinations of these strategies are especially effective in reducing energy consumption.

Therefore, we assume that identifying the ideal mix of persuasive strategies should optimize the design of such systems. We further argue how it is necessary to include both view points in this process: The one of experts (energy providers) who have knowledge in what technical possibilities and constraints there are and the one of potential users, who are the only ones who can provide knowledge in what expectations they have on these kinds of systems and what they would be willing to use or reject. We were interested in the best way to present information in an ambient persuasive manner and what strategies that are considered most useful by both stakeholders.

We are convinced that a solely user-centered view would not offer an ideal design solution, as users cannot estimate the possibilities of provided information and the potential ways how they could save energy. However, only a provider-centered

perspective would not work either, as the providers need consumers to be willing to change and in a pace that also does not make it too demanding.

In the following section, we present our approach, which involves both providers and consumers to identify the pilot requirements for the development of an ambient persuasive display that should sustainably change energy consumption behavior in private households through stimulating and positively influencing people's awareness. The data collection was done with two different methods: expert interviews with the providers (energy consultants) and a participatory design workshop with potential consumers. We intentionally chose these approaches as we assumed we would need a different quality of information from both parties (technology potentials, constraints and thoughts about the desire of potential consumers from the providers; expectations and wishes from the potential consumers). Both methods enabled us to gain interesting insights for designing an interactive persuasive ambient display for private households.

Furthermore, in this paper we will explain why these two audiences are essential for the design of an ambient persuasive interface and we will briefly summarize our design solution and outline the long-term in-situ study that has followed on the work presented in here. Moreover, we allocate our findings to persuasive strategies to define, which persuasive strategy is essential for which audience and to identify the ideal mix of persuasive strategies for an ambient display. The paper is structured as follows: We start discussing the background and related work on ambient displays for energy saving; next the expert interviews and the participatory design workshop are presented in terms of procedure and results. The paper closes with a comparison and discussion of the results from both studies and presents the display, which we used in our six-month household study.

2 Background

In principle, all cooling and heating devices in the home (e.g., the freezer, the refrigerator, the washing machine, the dryer, the electric stove, the dishwasher, and the air conditioning unit) consume a lot of energy. It should be noted that cooling requires more energy than keeping the same area warm. Also, all devices that are left in stand-by mode (like the TV) contribute significantly to the overall energy consumption. As previously stated, there are already a number of both commercial products and research tools aimed at persuading people to save energy of which we just want to mention a few in the following (those we also referred to in the expert interviews and the participatory design workshop). The *Energy Orb* [5] is an energy-monitoring device that visualizes the household's current energy consumption in real-time. It displays the best (and cheapest) times to use energy by the means of different colors that are set according to the current price band. It can also flash in advance for a period of "critical peak" pricing. Another device for electricity saving and load shifting is the *Wattson* [9]. The information is given as numerical watts, or extrapolated £/year, plus an ambient light that changes color and brightness to support the information for the various levels of energy consumption. Similarly, there are a number of different research prototypes, such as the *Power-Aware Cord* [3] and the *Wilting Flower* [10], aimed at making users more aware of their energy consumption. The *Power-Aware*

Cord is an electrical power strip that displays the amount of energy passing through it by electroluminescent wires, which produce glowing patterns. The *Wilting Flower* is a metal flower in a vase that illustrates the increasing energy consumption by wilting. The petals consist of different colored LED lights, which represents the wilting status.

As noted above, there are no success stories that any of theses systems led to a sustainable behavior change in terms of energy consumption. Our assumption is that technical constraints and user requirements were not considered well enough that these ambient persuasive systems succeed. There is very little research in the direction of what potential consumers want from these systems, and also of what energy providers believe should be there. Therefore, we conducted five interviews with experts from the energy provider sector. We worked with this audience and its enormous knowledge as a proxy of potential consumers. First, we gathered information about their work in general and second, we had the intent to use their advice and thoughts for designing an interface. Further, we invited six potential consumers for a participatory design workshop to gather information from the user perspective on these devices. Both activities aimed at exploring the ideal mix of persuasive strategies and information visualization to inform the design of an ambient display that should sustainably change the energy consumption behavior of its' users.

3 Expert Interviews

In order to explore reasonable persuasive strategies for ambient energy saving systems in private households, we decided to conduct expert interviews with energy consultants from a local power supply company. Trained in energy saving, these consultants daily talk with end-users, who are willing to save costs and energy. Moreover, they have a broad knowledge on the future development of the power supply market (also from a technological point of view) and thus have a notion of how future persuasive ambient displays also could look like in terms of displayed information.

We used the proxy-method (e.g., [17], [29]) as a new method of "persuasive proxy interviews"; therefore we were able to take into account the users' desires while using a third person, the group of energy experts.

Due to the energy consultants' enormous amount of knowledge about end-users' ideas and desires gathered during their work, we interviewed five energy consultants (5 male) in October 2010 for about 1½ hours each. We had no exclusion criteria. The sessions followed a semi-structured interview approach with 19 questions structured after the following research interests (1) barriers and inhibition factors for energy saving, (2) strategies for using an ambient display in the home, (3) ideas for how such display should look like, and what it should provide.

The open-ended interview questions allowed an exploratory approach to identify key-expert knowledge on end-user behavior, as the interviewees had the possibility to provide additional details on topics they had special experience in. As we focused on behavior change we additionally involved the aspect on long-term persuasive. This offered the possibility to identify reoccurring answering patterns (AP), which can be summed up in the following six categories.

- AP1: What are the common questions end-users ask consultants in terms of energy saving?
- AP2: What energy saving strategies could be reasonable for private households?
- AP3: Which appraisal techniques could be reasonable to motivate end-users to save energy?
- AP4: Which kind of persuasive ambient interface could be feasible for supporting end-users in energy saving?
- AP5: Which information should be displayed on this interface?
- AP6: Which innovations will shape the power supply market in future?

We used audio recording to gather the data. The recording was transcribed and then annotated the data using NVivo [11] software for qualitative data analysis. All interviewed experts had worked a long time (9.4 ± 5.3 years; range = 3 - 17 years) as energy saving consultants for private households. According to them, the main questions asked by end-users in terms of energy saving are questions on how to lower the energy consumption, energy costs, and questions concerning renovations and changes in the home.

For an ambient display, the experts stated how consumers need to be aware of the background factors for energy use in the home, such as how devices in stand-by mode consumes a lot of energy even when unused. Also, the experts listed how consumers need to be aware of how the energy price changes throughout the day and over a longer period of time. They suggested separating the costs for the household in gross, net price, and taxes. Similarly, they assumed it would be a good idea to allow consumers to get the predicted savings they could get from potential changes in terms of energy use. Furthermore, the experts stated how it should be possible for consumers to get information on a general level and in more detail on their energy consumption. Therefore, they suggested that a detailed level of information could change over time into an overall information visualization for a specific timeframe, e.g. months, quartiles, etc. Moreover, the experts had the feeling that consumers, in contrast to how they are aware of what it costs to drive their car a certain distance, do not have the same understanding for kilowatt per hour and for the costs per household. The experts believed it would be a good idea to allow consumers to relate their own consumption to the consumption of their neighbors and friends in order to increase this awareness for the home and for energy consumption in general.

4 User-centered Design Workshop with Potential Consumers

As a follow-up activity, we conducted a participatory design workshop with potential consumers, to identify the right persuasive strategies for an ambient display that should sustainably change energy consumption behavior. In the workshop we collaborated with students and had no exclusion criteria besides that participants do not work in the energy sector. The reason for the choice of this sample was that students, more than the general population, are seen as critical, open-minded, and generally interested and informed about new issues, ideas, and actual facts and especially on issues of environmental changes and energy consumption. Also, students are very interested to

save energy due to their generally low income. We are aware that our sample is not representative for the total population, but we accepted this to generate creative design ideas for multi-person households.

In total, six students (1 male; 21-34 years; 24.2 ± 5.1 years) participated in our 3½ hours long workshop in April 2011. Three of them lived in a shared apartment of four, one with a colleague, one as a couple, and one alone. It is worth mentioning that the workshop took place about two weeks after the nuclear accident in Fukushima, Japan, an event that might have had an effect on the results presented here.

The students got 52 colored cards that were created from the inspiration cards technique (e.g., [1], [21], [22]) and the Design with Intent Method [4]. The cards consisted of images and short descriptions, e.g. existing devices, cards with different level of detail, images of places, motivational phrases, or specific term cards. The cards were also prepared on the basis of known persuasive strategies (e.g., [2, 8]), such as reduction and tunneling. These strategies were also used for a set of goal-directed questions (discussion guidelines) that were asked during the group presentations and discussed at the end of the workshop.

The research interests were grouped into three main topics: (1) Ambient Device Feedback. The idea was to get information about which ambient device, like the Wattson, and at which area at home the ambient device and the display should be placed. It is defined as a feedback variation, which is less complex, have a simulative nature, is easy to understand, and an object in the house. (2) Information for Energy Saving, which was the part to include questions, which indicates persuasive strategies, and (3) Luxury Devices, which were based on the "power cards", which imply advices, which use energy and are in the flat as nice to have, like computer, DVD-Player, Laptop, etc., but they are not necessary. Necessary devices are the refrigerator or light. In the following we present the detailed questions:

- 1a: Which type of visualization as feedback do you prefer?
- 1b: Where should the information be placed in the household?
- 2a: Which information do you need in order to save energy?
- 2b: At which level of detail should the information be presented?
- 2c: When is feedback interesting?
- 2d: After a period of time: Which kind of feedback is interesting?
- 3: Which of these luxury devices is seen as the one with the most potential to save energy?

In order to analyze the data collected in the workshop, the posters (see Fig. 1) and transcripts from the discussion were categorized according to the following aspects: (1) placement of the information, (2) type of information, (3) level of information detail, (4) timing of the information, (5) preferred feedback visualization, and (6) luxury devices with highest energy saving potential.

During the poster presentation, it became apparent that the participants wanted a simple way to create a personalized view of the complete household; a place where they could combine overview perspectives with more detailed information on specific elements different from long-term usage. They wanted the system to automatically change into an overview mode. They preferred saving advice for their specific

household, but not general advice, like “to remove stand-by devices”. For such things they believe an expensive ambient display would be unnecessary. The participants also wanted timely feedback to see how a behavior change actually changed their energy consumption. They did not want a novel “electric device” (e.g., the *Energy Orb* or the *Wattson*) as these devices also consume energy. They preferred an attractive device, an App or something they could hide. Moreover, the participants did not want to be compared to their neighbors and friends, as they did not see the long-term effects of such comparisons, this in contrast to what the experts had stated. However, they wanted their consumption in relation to price and costs. Similarly to the experts, the participants affirmed wanting several options for how to save energy.

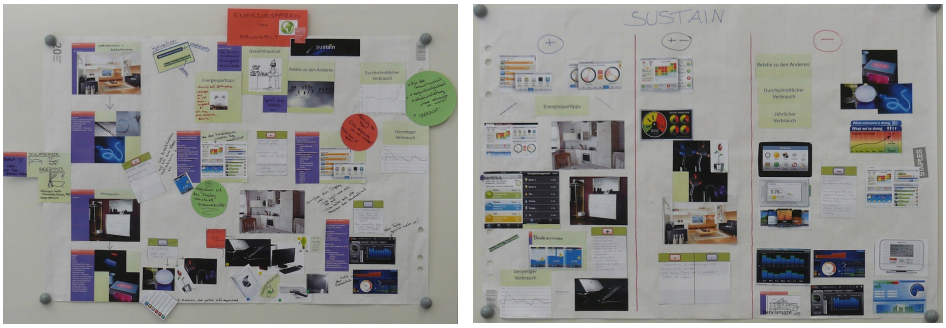

Fig. 1. Example of the final posters: colored cards, which involve persuasive strategies. Group one *(left)* named their poster “Energy saving in the household” with the subtitle “Sustain”. The main points were the general budget, the personalizing overview, and the detailed view. Group three *(right)* titled the poster “Sustain” and divided it into three areas: Positive aspects, need for improvement, and negative aspects to support energy reduction.

Analyzing implicitly used persuasive strategies by the participants, and answering the question how to persuade, we can mention six persuasive strategies: (1) reduction/simplicity, (2) tailoring, (3) suggestions-kairos, (4) self-monitoring, (5) cause-and-effect, (6) social comparison, (7) competition, (8) conditioning-reinforcement, and (9) placement. For detailed background information about strategies, see also [7].

(1) Reduction/simplicity: An overview on consumption behavior (e.g. separated for electricity, water and gas) was preferred. Two of three groups did not want an additional object like Orb, or Wattson. Reduction was considered as minimizing the elements of the display, but maximizing the information. The first impression was in all groups the current consumption should always be visible. The display should show an overview at the beginning and then the possibility for detail views, which were going from the point of showing each floor too each room. The display should be clear, easy to use, understandable, and decorative/attractive.

(2) Tailoring: Tailoring was very important for the whole group. They wanted to create their own views. The possibility for personalization and individualization was essential for changing behavior and to turn into real action by reducing energy consumption. Changing views and information based on their needs was important.

(3) Suggestions-kairos: Saving tips and detail view were two aspects, which should be given at the right time.

(4) Self-monitoring: An acoustic or light signal could be helpful to modify behavior, because graphics or diagrams on displays were often complicated, therefore a signal could led to more attention.

(5) Cause-and-effect: The monitoring via the tachometer gave direct feedback on the actual energy consumption. Users would like to have timely feedback to see that a behavior change changed their energy consumption.

(6) Social comparison was for two of the three groups undesired, because they did not want to feel in a competition. Thus, it is difficult to compare different family constellations with different numbers of devices.

(7) Competition: They did not want to have a direct competition in energy saving between household members or neighborhood.

(8) Conditioning-reinforcement: Incentives and rewards had potential to support behavior change.

(9) Placement: They mentioned the kitchen area as the perfect place and the foyer as a good location for a display.

5 Results

Comparing the findings from the two groups in terms of suitable persuasive strategies for the design of the ambient display, commonalities and differences could be found. As described in Table 1, we allocate our findings to persuasive strategies (identified by the means of literature review) to define, which persuasive strategy is essential for what audience, and to identify the ideal mix of persuasive strategies for an ambient display.

Table 1. Comparison of results of interviews with experts and the participatory design workshop with potential users for designing an interface including persuasive features. The phrases of argumentations are depicted with difference (D) as different argumentation between the groups, and commonality (C) as same comments between the groups. The letter x represents the group who mentioned the comment; stated by experts about user's desires or referred by potential user.

Phrases of Argumentation		Experts	Potential User	Fogg (2003)	Tornig, Oinas-Kukkonen (2009)
D1	Comparision to others	x		Social Comparison	Social support
D2	Being in groups	x		Competition	
D3	Personalized data		x	Tailoring	Primary task support
D4	Detailed bill, costs	x			
C1	Display kWh in Euro	x	x	Tailoring	Primary task support
C2	Detailed view	x	x		
C3	Overview, cumulate power	x	x	Reduction-Simplifying	
C4	Data history (days, weeks, months)	x	x	Self-monitoring	
C5	Individual energy saving tips	x	x	Suggestion, Kairos	Dialogue support
C6	Trendy and smart	x	x	Attractiveness	
C7	Incentive, reward	x	x	Conditioning-Reinforcement	
C8	Action, result	x	x	Cause-and-effect	

Suggestions for social comparisons differed between the experts and consumers; experts believed in this as a motivational factor while the users did not see that this would have any long-term effects on their behavior. Additionally, participants had different suggestions for how the data should be personalized; the experts assumed it would be enough with the two options of an overview or detailed level. Users wanted the possibility to create personalized combinations of these two. Moreover, experts thought it useful to show very detailed information of costs for single positions (such as specific devices or rooms), while users just wanted the overall costs and the forecasts of various savings they could do. Users simply wanted the overall costs and the forecasts of various savings they could do. In terms of commonalities, experts and consumers believed in price as the most motivational factor instead of other incentives or rewards. The interaction between action and effect is an essential factor, which is needed to understand and to reproduce or change the outcome.

In depth, we identified nine strategies [2], i.e. tailoring, reduction-simplifying, self-monitoring, suggestion, kairos, attractiveness, conditioning-reinforcement, and finally cause-and-effect, which were commonalities of both viewpoints are essential for the success of ambient persuasive displays in general. Group differences were found by the strategies, social comparison and competition by the potential consumer group, which were not confirm with the literature, e.g. [25], [30]. The persuasive strategy, tailoring, had special importance as it was seen as essential element in general and as necessary only in the expert group. Regarding to Tornig et al. [20], who developed a Persuasive Systems Design (PSD) model, our results led to three of their four dimensions, the primary task support, the dialogue support, and the social support. We could not find any hint for the last dimension, the system credibility support, which could be interpreted as condition for the usage itself.

We can summarize our results gained from both stakeholders according to persuasive strategies, which have the highest potential, like the commonalities to lead to a sustainable behavior-change.

In conclusion, our findings suggest being careful and attentive in the selection of persuasive strategies. The main message is that consumers know what they want, we just have to involve them in the development and design process of products, and then they will buy and integrate it in their daily life. Therefore, it is important to know before the design process starts how information should be presented in an ambient persuasive manner and what strategies all involved stakeholders consider most useful. The ideal mix of persuasive strategies encourages a sustainable behavior change. Thus, involving different audiences for designing an ambient persuasive interface is a benefit for the success of the product in general and finally, for the value of an interface in the long-term perspective of behavior change.

6 Discussion and Outlook

The aim of our approach was to gain insight from two perspectives, experts and users, for a persuasive ambient display that should support long-term changes in energy consumption in private households. The experts provided valuable knowledge of users'

needs and habits, including their years of knowledge of the energy market. The consumers gave insights in how they were willing to integrate such an interface into their daily life.

As part of the Persuasive End-user Energy Management (PEEM-) project we want to develop such an innovative ambient system with the potential to persuade users to engage in a more energy-positive behavior by utilizing approaches to maximize user acceptance by minimum intrusiveness, as well as examine its effect on sustainability. We have decided to develop a system that we not only want to consult the user, but also a energy provider in the requirement phase to develop the optimum system, which gives output of the right message, at the right time, in the right way in order to be able to be effective.

Based on these results, we get input how we should design our interface and we have developed an ambient persuasive display [7], which was deployed in 24 households for a six-month study to investigate its persuasive effects. We want to investigate if "visual conditioning" supports users' decisions to reduce consumption. Visual conditioning refers to the conditioning/reinforcement strategy of persuasion. Our interface (see Fig. 2.) considers two factors to support behavior change without coercion and deception. First, the users get ambient information about the current state of the grid status/green power, and the future state i.e., 24 hour forecast. Integrating a forecast is a novel persuasive strategy for ambient energy saving devices, which we consider an effective element for a long-term sustainable behavior change. Second, a feedback system that provides three kinds of information: information about users consumption behavior presented in kilowatt per hour, graphical information on their overall usage as a tool for self-monitoring their behavior, and reinforcement of behavior in the form of rewarded trophies.

Fig. 2. The grid status of the FORE-Watch at the end of the study (September 2013): the forecast *(left)* and the feedback *(right)*

We have investigated the way to use two different perspectives of the actors to show the common potential of gaining information about a defined "consumer" group. We combined our identified and discovered effective persuasive strategies for an ambient display and used the already implicit knowledge about the traffic light system (red, yellow, green) for viewing the power load to motivate user's to support or inhibit their

action. We developed the FORE-Watch for testing the persuasive effect in a long-term study (see mockup of the watch in [7]; and an excerpt of the procedure of the long-term study, inclusive the pre- and post phase of the PEEM- Project in [18]).

The household study gives us insights if our design decisions, based on the expert interviews and the participatory design workshops, were of value to find the right persuasive strategies.

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