

DESIGNING PERSUASIVE AMBIENT MIRRORS TO MOTIVATE DESIRABLE LIFESTYLE

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Abstract: Our daily lives are recently very busy and stressful, and our time spending to keep desirable lifestyle is cut down although we know that high quality lifestyle is very important for maintaining the health of both our body and mind. One of reasons that we tend to lead a sloppy lifestyle is that there is no adequate feedback to us about our current behavior, and it is not easy to motivate us to keep desirable lifestyle in stressful everyday lives. These are especially becoming serious social problems in many urban cities. We are demonstrating a couple of persuasive ambient mirrors whose expression evokes our emotion to motivate to change our current undesirable behavior. In the systems, persuasive ambient mirrors represent adequate feedback to reflect our current behavior to boost our positive emotion to motivate desirable lifestyle and change undesirable behavior by evoking our negative emotion. The paper presents two case studies that motivate desirable lifestyle, and extracts some design issues based on the experiences with the case studies.

1 INTRODUCTION

Our urban daily lives are extremely busy and stressful due to dramatic economic changes as shown in Figure 1. In Tokyo, for example, commuter trains are very crowded in the early morning and late night everyday, and people access a variety of information through mobile phones. Most of people do not have enough time to keep desirable lifestyle. We know that a variety of daily activities such as cooking, cleaning, exercising and saving energy and money are very important for our health, well-being, and environmental sustainability. These activities are very useful for desirable lifestyle, but it is not easy to change the current sloppy behavior in a stressful daily life. One of solutions of the problem is to return adequate feedback that reflects people's current behavior through computer mediated persuasive technologies (Jafarinaimi, 2005); (Lin, 2006); (Consolvo, 2008); (Toscos, 2008). These previous studies show the effectiveness of some case studies, but do not discuss general design issues for developing persuasive ambient mirrors to change human behavior and attitude systematically.

In our daily lives, a mirror reflects our figure to show our appearance. Using a mirror allows us to know whether we are well or not, and whether our makeup and clothes are fit or not. A mirror has a power to make what are invisible from us visible. In

a past work, Fujinami et. al. have developed a mirror to superimpose useful information in an ambient form (Fujinami, 2005). We believe that mirrors are adequate devices to reflect our current behavior to return feedback because we sometimes remind ourselves in front of a mirror. Future smart mirrors can be used to persuade people to change their lazy behavior to motivate desirable lifestyle. We believe that the pervasive installation of these mirrors presenting persuasive visual information is promising to improve our daily lives.



Figure 1: Busy and Stressful Urban Life.

We have developed two case studies to develop persuasive ambient mirrors presenting visual information to motivate desirable lifestyle, and show some technical details behind the case studies. These persuasive ambient mirrors sense the current

behavior of the user and reflect the behavior in on peripheral displays as ambient information. In our approach, these peripheral mirrors embedded pervasively in our surrounding environments present feedback information in an ambient style not to increase our cognitive overload.

In this paper, we discuss how persuasive ambient mirrors are effective in motivating the user to change his/her undesirable behavior. The emotional engagement is very useful in making the user to keep desirable behavior although he/she considers it to be hard and challenging. For example, “quit meters” provide smokers with constant feedback on how much money is wasted and how many minutes of life are lost. But the feedback they provide lacks the engagement and fun that the games provide, lessening their emotional impact to change undesirable behavior.

Section 2 shows the first case study called Mona Lisa Bookshelf. In Section 3, our second case study called EcoIsland is described. We show some design issues to develop persuasive ambient mirrors in Section 4. The design issues includes how to attach the meaning to ambient information to persuade the user, how to design the feedback loop between human behavior and the ambient information, and how to manage the interaction between the user and the persuasive ambient mirrors. We finally conclude the paper by showing future directions in Section 5.

2 MONA LISA BOOKSHELF

Resources shared by a number of people, such as a public toilet or a bookshelf in a research laboratory, tend to deteriorate quickly in a process called the tragedy of the commons. This happens because each individual derives a personal benefit from using the resource, while any costs are shared between all the users, leading to reckless use. Garret Hardin, the ecologist who popularized the concept, noted that this belongs to the category of problems that cannot be solved by technology alone, requiring instead a change in human behavior (Hardin, 1968). Mona Lisa Bookshelf, is aimed at keeping a bookshelf organized. It tries to encourage users to keep books in order and to return missing books, but also to take books out every now and then for reading. Each book in the shelf is linked with a piece of a digital image of the Mona Lisa. Like a picture puzzle, the image changes according to how the books are positioned. A high-quality flat display placed near the bookshelf shows the image to the users.

The tracking of a user's behavior is based on optically detecting books in the shelf. In the prototype system, visual tags are attached to the spines of the books to facilitate their detection and identification. Visual tags are also attached to the corners of the shelf to determine its dimensions (Figure 2 (Left)). The detection system (Figure 2 (Middle)) comprises the following hardware: a digital video camera (iSight by Apple), a high-resolution digital camera (D50 by Nikon) and two infrared distance detectors (GP2D12 by SHARP). The distance sensors and the digital video camera are used to detect whether the user is manipulating books in the shelf. OpenCV, a real-time computer vision software library, is used to analyze the video signal. As soon as the user is seen leaving the shelf, the high-resolution still camera takes a picture of it and all the books contained within it. Images captured by the still camera are analyzed by the VisualCodes software library, which recognizes the visual tags attached to the books. The system is shown installed in Figure 2 (Right). Each visual code yields data regarding its position, alignment and identity. This is then translated into context information that describes the bookshelf's width and height, which books are currently contained in shelf, and how they are aligned and ordered. This information is then passed to the feedback logic component. The above approach is able to observe how the user uses her bookshelf passively without requesting extra actions to play the game.



Figure 2: Mona Lisa Bookshelf prototype installation.

In this system, the feedback logic aims to encourage the following ideal behavior: 1) books should be arranged correctly and aligned neatly; and 2) at least one of the books should be read at least once per week. The correct arrangement of the books is pre-programmed, and could be e.g. alphabetical. User behavior is compared to this ideal, and translated to feedback as described below.

Mona Lisa Bookshelf also offers two expression styles to return feedback to the user to encourage cleaning his/her bookshelf or reading books in the following ways. When a book is removed from the shelf, the corresponding piece of the Mona Lisa image also disappears. If books are lying on their

face or otherwise misaligned, the pieces of the image also become misaligned, distorting the picture. When the books are arranged neatly, Mona Lisa smiles contently. The assumption is that users are aware of how da Vinci's Mona Lisa is supposed to look like, and as when completing a picture puzzle, inherently prefer the correct solution to a distorted image. The feedback thus provides clues and motivation for keeping the bookshelf organized. The left picture shown in Figure 3 is an example of a distorted image. Also, if none of the books are removed from the shelf for over a week, Mona Lisa starts getting visibly older. The right picture shows and example of an aged portrait. As soon as one of the books is removed from the shelf, she regains her youth.

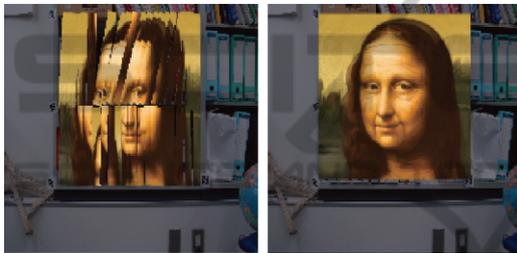


Figure 3: Two example outputs of the Mona Lisa Bookshelf. The image on the left shows that some books are tilted and in the wrong order. Some books are also missing. The image on the right side indicates that none of books have been picked up for a long time.

3 ECOISLAND

Global warming caused by greenhouse gases released into the atmosphere through the actions of man is believed to be a major threat to the earth's ecology (IPCC 2007). Efforts to reduce greenhouse gas emissions come in two forms: technological solutions and changes in human behavior. Technological solutions broadly include improving energy efficiency and developing cleaner energy sources. Dramatic changes in human behavior will be necessary if catastrophic climate change is to be avoided.

Public and private efforts to change individual behavior towards more environmentally friendly practices usually rely on education, but there are psychological limits to the ability of education alone to effect behavioral change. Even when a person full-well knows that a particular behavior is detrimental enough to their long-term well-being to offset any possible short-term benefits, they may still irrationally choose the short-term indulgence. Future

consequences, while widely known, are easily ignored in the present.

EcoIsland is a game-like application intended to be used as a background activity by an ecologically minded family in the course of their normal daily activities. A display installed in the kitchen or another prominent place in the household presents a virtual island. Each family member is represented on the island by an avatar (Figure 4). The family sets a target CO₂ emission level (e.g. national average minus 20%) and the system tracks their approximate current emissions using sensors and self-reported data. If the emissions exceed the target level, the water around the island begins to rise, eventually sweeping away the avatars' possessions and resulting in a game over.



Figure 4: Some Screenshots of EcoIsland.

On their mobile phones, the participants have a list of actions that they may take to reduce the emissions: turning down the air conditioning by one degree, taking the train instead of the car, et cetera. Upon completing an action, a participant reports using the phone, and the water level reacts accordingly. Reported activities are also shown in speech bubbles above the corresponding avatars. A lack of activity causes the avatars to suggest actions. Participants can also see neighboring islands and their activities in the display, and can list buy and sell offers for emission rights on a marketplace. Trading is conducted using a virtual currency obtained from a regular allowance. The credits are also used to buy improvements and decorations to the island, so successful sellers can afford to decorate their island more, while heavy emitters have to spend their allowance on emission rights.

The general approach from ambient lifestyle feedback systems is to provide a feedback loop for user behavior. The virtual island shown in the display acts as a metaphor and makes the

participants conscious of the ecological consequences of their choices and activities. We also tap into social psychology, attempting to exploit social facilitation and conforming behavior to encourage the desired behavior. Social facilitation is the phenomenon where a person performs better at a task when someone else, e.g. a colleague or a supervisor, is watching (Zajonc, 1965). Conforming behavior is the desire not to act against group consensus (Asch, 1955). EcoIsland's design facilitates these by involving the whole family, and by presenting the participants' activity reports in the speech bubbles and providing contribution charts and activity histories. On the other hand, the fact that the game is played by a family unit instead of an individual means that participants can also agree to assign tasks to certain members.

Lastly, there is the trading system, which is based on the same principle as industry level emissions trading systems: reductions should be carried out in places where it is easiest to do so. A family that finds it easy to make significant reductions can sell emission rights to households that find it difficult due to e.g. location or job. This should make it possible to attain the same amount of total reductions with a lower total cost (measured in disutility), promoting use of the system.

4 EXPERIENCES WITH PERSUASIVE AMBIENT MIRRORS

In this section, we describe how to design persuasive ambient mirrors to motivate desirable lifestyle based on our experiences with building case studies described in previous sections. We found that three issues are important in our experiences. The first issue is how to design persuasive ambient mirrors and how to attach the meaning to the expressions on the mirrors. The second issue is how to control the timing of feedback to users. Finally, the third issue is how to manage the interaction between the mirrors and users. In the following sections, we show our findings while conducting user studies of our case studies.

4.1 Persuasive Information

In our experiences, we found that human preferred the Mona Lisa over the abstract and the still life paintings. The reason given was that more figurative paintings were considered to be more "intuitive".

While any visual representation can be used to relay information, shapes that come with pre-attached meanings (e.g. "a tree withering is a negative thing") are more capable of evoking emotional engagement. The meaning attached to an expression on a mirror is essential to design the persuasiveness in our approach.

When designing persuasive ambient mirrors, two meanings need to be attached to expressions on the mirrors. The first meaning is the metaphor visualizing the user's lifestyle. Also, the metaphor shows the goal of the user's desirable lifestyle. In our case studies, the goals are represented in ambient information shown in the mirrors. In Mona Lisa Bookshelf, beautiful Mona Lisa is a metaphor of a well-organized bookshelf, and a sinking island is a metaphor of the effect of global warming. The user sometimes mistakes to make the meaning of an expression in an aquarium, and this is one of the serious problems to rely on metaphor. The user tends to define the non intentional meaning in information (Suri, 2005). For example, an ugly picture may be used to discourage to keep the current undesirable behavior, but the picture may encourage to keep the current undesirable behavior for some avant-garde people. This is highly depending on the cultures and personalities of the users. It is not easy for a designer to attach a single meaning to a specific expression by all people. There are alternatives to represent lifestyle goals in expression shown on a mirror more directly. Some information may represent numbers showing goals in an art form, or a portrait photo that a user expects to become in the near future. We believe that art thinking will help to design effective persuasive ambient mirrors that offer more stimulative experiences to consider the important of desirable lifestyle.

The second meaning is the incentive to satisfy human needs and desires that control the user's behavior. In our case studies, we have considered following four incentives: physical incentive, psychological incentive, social incentive, and economical incentive. The physical incentive uses physical comfort and discomfort to change the user's behavior. Our current case studies did not use the physical incentive, but there are many opportunities to use the incentive in smart spaces by embedding several actuators in our surrounding spaces. The psychological incentive evokes the user's emotion to change his/her behavior. Mona Lisa Bookshelf use positive reinforcement and negative punishment to engage the user's emotion. Ugly Mona Lisa tends to change the user's current sloppy behavior. The social incentive uses other persons' eyes to change the

user's current undesirable behavior. Competition with other people is a typical social incentive to motivate the user. Also, sympathy with friends and family members is a strong social incentive. In EcoIsland, we use the incentive to motivate activities that reduce CO₂ emission. A family member's anxious look has a power to motivate to change the user's current undesirable behavior. The economical incentive is to give rewards to the user when changing his/her undesirable behavior. In EcoIsland, users get virtual money to buy virtual interiors to decorate their islands when their activities to reduce CO₂ emission are more than expected.

There are many approaches to attach the meanings to products and services (Krippendorff, 2005) (Schifferstein, 2007). Slow technologies are effective technique to attach information to artful expressions in an ambient way (Hallnas, 2001). The emotional engagement evoked by persuasive ambient mirrors develops some feeling to like or dislike on the expressions on the mirrors. The feeling is essential to make the effect of persuasive expressions valid. This means that the user needs to feel empathy on the expressions. In product design, the user feels empathy when his/her belongings can be personalized gradually like a pet's growing. The aspect is important to use products for a long time, and it is effective for maintaining environmental sustainability. In the near future, we may use various daily smart objects to motivate to change the user's undesirable behavior. We believe that the expressions showing some virtual creatures are more acceptable to most of the people. Of course, each person may love different creatures. Also, what the user evokes empathy on is varied according to cultural differences. In general, human evokes empathy when a creature is growing by his care.

4.2 Feedback Control

A key issue to design persuasive ambient mirrors is when and how feedback is returned to the user. In our case studies, we have considered two types of feedbacks. The first type is immediate feedback and the second type is accumulated feedback. Immediate feedback is returned immediately according to the user's current behavior, and the feedback information visualizes his current behavior. For immediate feedback, we adopt a basic technique in operand conditioning to encourage or discourage the user's behavior using positive reinforcement and negative punishment (Reeve, 2005). In most of our case studies, the user's behavior is changed due to

positive reinforcement and negative punishment caused by the expression reflecting the user's current behavior. When Mona Lisa is getting old, the negative emotion is increased and they feel anxious. Emotional engagement is a very powerful tool to change the user's undesirable behavior and to keep desirable behavior (Fredrikson, 2003). The balance between evoking positive and negative emotion is a key to control the user's behavior. If an expression gives too much positive reinforcement, users feel boring eventually, but too much negative punishment are given, they feel helplessness, and the effect will become ineffective eventually. The adequate combination makes it possible to maintain the effectiveness of persuasive ambient mirrors over the long duration.

Even if the combination of positive reinforcement and negative punishment is well designed, only immediate feedback is inadequate to motivate the user over the long duration. The interval of accumulated feedback is usually a few days or a week. Sinking an island in EcoIsland is also accumulated feedback to reflect family members' lazy activities. We believe that it is more effective to incorporate a long-term goal in accumulated feedback. A long-term goal makes the user to aware of the merit of a target desirable behavior, and to develop intrinsic motivation to keep the desirable behavior.

The feedback information needs to be changed according to the stage in which the user is changing his undesirable behavior. The transtheoretical model proposes the five stages as a process involving the progress to change the user's undesirable behavior (Zajonc, 1965). In earlier stages, the user prefers positive reinforcement not to give up to change his/her undesirable behavior. On the other hand, for the user who is in the latter stage, weak negative punishment is effective to remind that his/her current behavior is not enough to achieve the short-term goal. In our experiences with our case studies, understanding the current stage of the user's behavior changing is necessary for designing a successful persuasive ambient mirror.

4.3 Interaction Management

Virtual Aquarium uses a 3D accelerometer to recognize the movement of the user's toothbrush to observe his/her behavior without interacting explicitly. Our experiences show that recognizing the user's behavior with sensors implicitly has the limitation in reliability. In Mona Lisa Bookshelf, we chose to analyze a very simple context that can be

implemented in a reliable way. However, it is very difficult to analyze the user's complex behavior correctly even if using heavy-weighted learning-based algorithms. Thus, EcoIsland uses a self-reporting method to input what kind of actions the user takes in order to avoid complex behavior analysis. EcoIsland encourages users to input their actions to reduce CO₂ emission since they are recognized as eco-conscious persons. A self-reporting method requires the user to motivate to input their activities explicitly. The user may use a mobile phone and gesture to input his/her activities with a minimum cognitive effort. Using incentive is also effective to motivate self-reporting. For example, EcoIsland uses social incentive and economic incentive to encourage the self-reporting.

One of the problems in the current case studies is that the user may cheat the analysis of the sensors consciously. There are two approaches to solve this problem. The first approach is to prohibit cheating by increasing the accuracy of the movement analysis. The second approach is to encourage the user not to cheat to use sensors. From our experiences, the user is encouraged to keep desirable behavior if he/she deeply thinks about the merit behind the desirable lifestyle. As described in the previous subsection, incorporating a long-term goal to develop intrinsic motivation is promising to solve the problem.

5 FUTURE DIRECTIONS

Persuasive ambient mirrors are strongly effective to encourage users to change their current undesirable behavior. In our short-term case studies, the user could enjoy to be encouraged to change his/her behavior through persuasive expressions shown on the mirrors. However, it is not easy to motivate him/her to keep desirable behavior over the long duration even if accumulated feedback is well designed. If the user changes and customizes persuasive visual information, feedback control and interaction management are gradually changed according to his/her changing preferences. He/she can enjoy personalizing the interaction of persuasive ambient mirrors. When the expression on a persuasive ambient mirror is growing up like a pet, the user feels empathy and feels the attachment to the expression (Ruth, 2007). In our research group, we are interested in making every daily artifact intelligent. In (Kawsar, 2008), they reported to develop a system to customize intelligent artifacts by end-users. In the current Internet, many persons

eager to publish their photos, music, programs, picture, and idea on the Internet, and any other persons can enhance them cooperatively. This kind of co-design or co-creation will be commonly applied to daily artifacts in the near future to develop more attractive daily artifacts. We are currently developing a toolkit to develop smart artifacts to add and personalize persuasive ambient mirrors by end-users in a tangible way.

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