

ECOBARS: DECREASING APPLIANCE WASTE USING AMBIENT FEEDBACK

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ABSTRACT

This paper presents the EcoBear concept and describes the purpose of the project, which is to help creating awareness of appliance waste. Then, we explain the design process and design choices as well as discuss the preliminary evaluations and findings. Based on our findings, we highlight future work that has to be taken into account for the next iterations of our project.

INTRODUCTION

We have recently introduced the EcoBears concept (Nielsen et al. 2015). In this paper the concept will be briefly summarized and then we further elaborate our concept in regards to the iterative design process and the preliminary user evaluations. Based on our findings, we discuss the opportunities of EcoBears to create awareness of appliance waste and highlight potential future work.

The EcoBear (See Fig. 1) project is aiming to raise awareness of appliance waste and incorrect appliance use. As described in (Nielsen et al. 2015), appliance waste has become a big problem around the world. A recent report from the City of San Diego's Environmental Services Department in the U.S. (San Diego Environmental Services Department, 2012) states that the city's overall disposed waste during 2012 included 7,909 estimated tons of electronics (e.g. video displays, computer electronics, etc.) and 1,028 estimated tons of major appliances (e.g. washing machines, refrigerators, etc.). Similarly, the Middelfart recycling station in Denmark reported that flat-screens and refrigerators are their most common appliance waste during 2014 (René Poulsen – DR, 2014).

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Figure 1: (a) The polar cub; (b) the mother bear.

The EcoBears are designed to raise awareness of this problem, while also helping to correctly calibrate and use the household fridge to conserve power and avoid sickness caused by food deterioration (FDA, 2011). With the increased focus on the environment, EcoBears' goal is to enhance existing appliances using ambient peripheral feedback and additional functionality to add value to old fridges to prevent premature disposal. EcoBears use symbolic features in regards to the polar bear avatars to create awareness of appliance waste, and the environmental effect of this, since polar bears are one of the most well-known animals whose habitat is affected by global warming. The EcoBears concept consists of two polar bears, a polar bear cub (Fig. 1a) and a mother polar bear (Fig. 1b). The cub is equipped with a temperature and light (photoresistor) sensors, a display, a radio transmitter and 3 LEDs and is designed to be placed inside the fridge. The adult bear is equipped with a light sensor, a radio receiver and 3 LEDs. The cub collects temperature data when it stands in the fridge and sends it to the adult bear that can be placed anywhere in the home e.g., the living room. If the cub detects that the temperature is too cold, it will start flashing blue, send the data to the mother bear, which also starts flashing blue. If the fridge is too warm the bears will flash red instead and when the temperature is in the correct range (4-6 degrees Celsius) the bears will have a constant, dimmed white light.

The EcoBears convey their state through ambient lighting. This is done as an attempt to make the EcoBears unobtrusive so the user may continue with their primary activity. When the EcoBears are in a neutral state, the bears will be in the user's peripheral attention, but as soon as the state changes from neutral to too warm or too cold the artifacts will require more

attention and will move into the users focus of attention. The EcoBears are designed to be transparent in everyday use, and only require attention when there is a problem with the fridge.

For a more in-depth explanation of the EcoBears see (Nielsen et al. 2015).

In the following sections, we present the related work and the evaluations of the concept together with the findings. Then, we discuss the challenges and opportunities of the EcoBears concept as well as its relation to embodiment and the benefits of ambient interaction.

RELATED WORK

The idea of augmenting home appliances with technology is not new. For instance, the KitchenSense architecture has been proposed to connect various kitchen appliances through the use of input sensors, attentive digitally-augmented projections and a reasoning engine aiming to enhance appliance interactions to simplify control interfaces (Lee, C.- H. J., et al, 2006). In addition, more and more eco-feedback technology is being implemented to address sustainability challenges by augmenting everyday objects to support behavior change, aiming to reduce environmental impact (Arroyo, E., et al, 2005, Froehlich, J., et al., 2010, Heller, F., and Borchers, J., 2012). These technologies often use lighting mechanisms as attentive feedback and inform users about their water (Arroyo, E., et al, 2005) or power (Heller, F., & Borchers, J., 2012) consumption.

However, most of these technologies have been designed to be the focus of the user's attention, neglecting the fact that many interactions in people's everyday lives take place in the periphery of attention (Bakker, S., et al., 2012). As such, there is a need not only to design for the center but also for the periphery of attention (Weiser, M. & Brown, J., 1997) when augmenting human activities (Rogers, Y., 2009).

PRELIMINARY EVALUATIONS

The evaluation of the concept has been done in four sessions. The first one was a concept validation to get feedback regarding the design of the polar bear avatars, interaction and semantics of the lighting mechanisms. It was an informal interview with three potential users (2 male, 1 female - average age 27). They were asked to identify the avatars, articulate how the avatars differ from each other, and provide first impressions regarding functionality. Three additional sessions were conducted with eight potential users (6 female, 2 male - average age 53) to evaluate functionalities and get further feedback in the home setting. Two of these ended with semi-structured interviews and the last one was a focus group with a family (5 participants). All interviews and discussions were recorded, transcribed, and analyzed through an affinity diagram.

IDENTIFICATION AND SEMANTIC REPRESENTATION OF AVATARS

Overall, participants were able to immediately identify the symbolic abstraction of the avatars even making a

distinction between the adult polar bear and her cub. A participant described the adult bear as *"dangerous, at least the mother"* and the cub avatar as *"A polar bear cub, sitting on a chunk of ice because it is blue"*. Participants also perceived the relationship between the avatars as a bear family. For example, a participant stated by pointing to the avatars *"this one is definitely a polar bear, and this is probably its polar bear cub"*. Another participant expressed why she thought it was appropriate to make the avatars look like a mother and a cub and place them on different positions: *"the cub is usually in the cave while the mother is outside making sure everything is okay before the cub can come out"*. A further comment was given on why paying attention to the cub in the fridge is important: *"when it is small you think that you have to treat it well and pay attention to the temperature so the cub is feeling well"*. Additional meanings were attached to the avatar's form. A participant expressed *"you think about temperature as soon as you see the avatars, or I do anyway, I wouldn't do that if the avatar was a monkey or a donkey"*.

SEMANTIC ASSOCIATION OF COLOURS AND PASSIVE INTERACTION

Regarding the semantic association of colors, lighting and interaction, all participants were able to decode the color scheme and attach meaning to it. For instance, a participant stated *"red would be when you forgot to close the fridge... and blue would be when it is set for a lower temperature than it should"*. Similarly, another participant mentioned *"When the polar bear cub flashes red it is too hot, and when it is blue it is too cold"*. Besides the color semantic, participants were able to recognize the pulsating feedback while varying the intensity of light. A participant stated *"When it pulsates like it does, it is because you have to pay attention"*. Furthermore, participants also differentiate between the flashing (red/blue) LEDs and the stable white LED. A participant said if *"it doesn't flash so it's something neutral"*. The communication between the bears was also well perceived. For instance, a participant stated *"if the little bear flashes red and the big bear flashes red, then it is because the big bear tries to tell that there is something wrong with the little bear"*.

THE POLAR BEARS AS AN EDUCATIONAL TOOL

Participants highlighted the potential of the avatars to support the communication of sustainability issues and to make people aware and do something about it. For instance, a participant confirmed this giving a valuable comment *"I have children and I might like to buy one of these because the children would have something they could put a face on like, I have to remember to shut the refrigerator door and remember to shut it properly because there will be a sound of some crying baby bear with red lights and stuff"*. Another participant stated that *"There are many places it could be fun to have one. At the daycare... that is a good place to teach the kids about this stuff and to keep the fridge door closed"*.

THE HOME SETTING AND BEYOND

Some participants also suggested the possible use of EcoBears in different settings and situations. For instance, A participants said: *“If you have the possibility to have more polar bear cubs, in more units, and then a central unit to supervise all the other, eh, chiller refrigerator where there is 10 °C in the vegetable drawer, and 3/4 °C in the fridge and then the freezer that has to be -18 °C, and then that you have one central to keep an eye on the other ones”*. Additional settings such as supermarkets and restaurants were suggested as well as other locations inside the home. A participant mentioned *“it would be smart to have one in the bedroom during a thunderstorm so you know that your fridge is still working”*.

TECHNICAL CHALLENGES AND OBSERVATIONS IN THE HOME

We initially wanted to investigate if the ambient lights have the desired effect in the home even if a person might be performing a different primary activity. However, we experienced issues in all three home evaluations, since all refrigerators were too hot, and needed adjustment, which is an important finding in relation to possible food waste and deterioration issues. A technical issue that appeared during the second evaluation showed that the insulating material of the fridge and the 3D-printed models (See Fig. 1) blocked out the wireless signal. This issue was not unique to the second test as we experienced a similar issue with connectivity due to the walls in the participant's home that partly blocked the signal during the last test. We also observed that one of the fridges came from a respected brand, and was marked as A+ for energy efficiency. However, it did not have any smart features, making it a good candidate for the concept.

DISCUSSION

The preliminary evaluations showed that the participants were indeed able to understand the symbolic features of the bears and figure out the meaning of the ambient lights. Additionally the participants came up with more uses of the EcoBears, e.g. use of the polar bears in kindergartens, restaurants and supermarkets. The evaluations also gave important insight in how the electronics in the bears at times were not sufficient in the home settings and that participants had ‘non-smart’ refrigerators that were energy efficient, though lacking the smart features that the EcoBears are going to bring. While the evaluation determined that the participants were able to identify with and figure out the meaning of the polar bears, it is still hard to tell if the ambient and peripheral feedback of the bears are going to have the desired effect. Since the electronics were insufficient for conducting long term evaluations of the concept, it cannot be determined at this time if the EcoBears are going to have the desired effect in the long term.

In light of the Embodied Interaction topic at SIDeR15, it is relevant to present our discussions of what degree of embodiment was relevant for the EcoBear concept.

As it is clear from our introduction, the EcoBear system is not an embodied system with direct interaction, and this is due to two main factors, which were very important when choosing the best design for our system. These are introduced and discussed in the following subsections.

DOES THE PROBLEM SPACE AFFORD EMBODIMENT?

The problem space for a regular fridge with an notification system using sound is the kitchen, and perhaps rooms nearby (depending on the intensity of the alarm). The EcoBear project extends the radius of specific rooms to include the entire house or flat, giving the users the option to place the mother bear wherever they find it most useful. It is not hard to define an embodied scenario, where the users could be notified of the temperature in the refrigerator, this could be done using e.g., vibrations in a smartwatch. This embodied interaction would expand the problem space beyond the home and the authors questioned if this was desirable. A simple scenario was discussed, and partially led to an exclusion of embodied interactions of this kind. Imagine that you are at a sports game with your friends, and you receive a notification from your refrigerator via your smartwatch. How do you respond? It could be that your flat mate/partner is simply restocking the fridge with new groceries, or perhaps the fridge is actually broken? You have no way of telling, because you are not near the refrigerator, and it would require further interactions to investigate the matter. This is one argument that goes against using direct embodied interaction for the EcoBear project.

SOCIAL VS. NON-SOCIAL AWARENESS

Another aspect that was discussed when it came to the bears, was how they could be used to afford social interaction. There are two obvious scenarios that would socially engage people with the current system. The first could be that visitors in the home would enquire about the mother bear, thus leading to a conversation of the system and perhaps even an opportunity for waste management. The second scenario could be the parent to child interaction, where a parent could use the bears to engage in a conversation with their children about waste management. Would these two scenarios be possible if an embodied interaction is used? Notifications and alarm systems used in e.g. smartphones and smart watches are examples of embodied technology that neither encourages social engagement and foster antisocial experiences

FUTURE WORK

The future work of the system could be broken into two different types of work, one should focus on the technical aspect of the project, and the second on the design. The two different aspects are discussed in the sections below.

Another aspect that could be tested is how the EcoBears add value to the old appliances, and if they could affect the awareness of the users in regards to

appliance waste, and perhaps even add enough value, to enable extended life of old appliances. This subject is not described further in this paper.

FUTURE TECHNICAL WORK

As discussed earlier, the EcoBears project failed to achieve proper test results in a real life setting and it still needs long term evaluations to determine if the bears will have the desired effect. The long term evaluations are especially important, to enable more accurate conclusions on what effect the polar bears will have, in regards to how the ambient peripheral feedback will work in practice. To enable these evaluations in the real home setting, a different technical setup would be needed, since the components used in the first version proved insufficient. A new system would need to achieve two primary goals. The first would be to enable a signal to pass through all different types of refrigerators, and the second would be to keep the system energy efficient in order to execute long term evaluation. In regards to logging data over longer periods, the system could be expanded to include a Wi-Fi module that could send user data to the cloud. This data could be used in conjunction with different techniques such as user-diaries etc. to further evaluate the use of the system.

Based on the evaluations using XBees as radios during the initial evaluations it was concluded that this type of communication would not be sufficient if the bears are to reliably communicate through multiple variations of refrigerator doors and interior walls. For further tests bluetooth low energy was discussed and an RFduino was tested. The RFduino is a low power, Arduino compatible platform for rapid development that features bluetooth low energy. Preliminary tests show that the RFduino is indeed able to communicate in refrigerators that the XBee modules were not able to communicate. The RFduino module would be suitable for further tests.

FUTURE DESIGN WORK

Two immediate design flaws were discovered during the first evaluations. The first was the lighting in the polar bears that was created using only a single LED for each color. This resulted in only a small part of the polar bears being lit up. In the next design iteration more LEDs should be added to strengthen the light and thus enhancing the pulsating effect in the bears. The second part concerns the physical size of the polar bear cub. It became clear that the cub might be too tall to fit in between the shelves and also too wide to fit into the shelves in the door of most regular fridges. This could be fixed by making the cub smaller. It might also make the cub more suitable for everyday long term use, if its footprint in the refrigerator was smaller, thus it might be an improvement to the overall design to have a smaller cub in the next iteration of the design.

CONCLUSION

The EcoBear project proposes the use of ambient lighting and symbolic representation to augment

everyday appliances. The overall concept was validated through iterative short evaluations, but technical difficulties hampered long term evaluation in a real home setting. In the final part of the paper, a brief discussion of the concept and future work, which includes suggestions for a revamp of the technical system for the project, was described.

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