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Reducing children's psychological distance from climate change via eco-feedback technologies

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ABSTRACT

Empirical environment and behavior research has found that empathy improves environmental attitudes and behaviors. Emotionally persuasive icons (EPIs) show promise for creating empathy and for the design of effective eco-feedback technologies, particularly among children. Yet studies using these icons have focused on adults, with little research devoted to eco-feedback design for children. We explore the affective reactions to EPIs among children ages 9–11. To understand which types of EPIs generate the most empathy, we vary them in two dimensions: (1) metaphorical versus literal representations and (2) animal scenes versus environmental scenes. Our findings suggest that the impact of EPIs extends beyond metaphorical or literal images; to improve eco-feedback technologies that employ EPIs, designers must link the causes and effects of climate change to concrete, tangible actions that are associated with personal experiences, which could lead to stronger engagement and emotional responses among children. These results are consistent with the construal level theory of psychological distance, which is the cognitive and affective perception of how close or far something is. We extend this theory to sustainable HCI and contribute a space for future eco-feedback design among children.

1. Introduction

Over the last decade, we have seen an increased interest in eco-feedback technologies, or technologies that increase an individual or group's awareness of energy consumption (e.g., electricity, gas, water) or waste disposal (see [1] for a review). Researchers find that few of these technologies target the various stakeholders involved in the context of household energy consumption [1–3] and within these targeted groups, children as stakeholders have been somewhat excluded. There is some pertinent work that investigates children as stakeholders in this space [4–9], but only Banerjee [4] and Froehlich et al. [7] explore eco-feedback design for children. Children will have to deal with key issues around sustainability in the future and will ultimately carry the burden of our collective decisions around sustainability and our unsustainable choices. Furthermore, depending on age and culture, children are often involved in family decisions at home. They are active energy consumers in the home and, as the next generation, could be influential in shaping a family's environmental attitudes [10]. As a result, there is an opportunity for research to advance the understanding, design and experience of successful eco-feedback technologies among children.

Currently, graphical imagery is an important aspect of feedback that is used extensively in sustainable HCI [1], but our understanding is limited about which eco-feedback technology designs are most effective. The main objective of this work is to examine eco-feedback technologies among children and to explore the emotions and empathy evoked through specific EPIs.

Empirical research on the environment and behavior has found that empathy improves environmental attitudes and behaviors (e.g., [11,12]). Therefore, a promising direction for the design of eco-feedback technologies for children is the use of *emotionally persuasive icons, or EPIs* (Fig. 1). We liken these icons to what Slovic et al. describe as *affective imagery*, or the engagement with mental representations that "include sights, sounds, smells, ideas, and words, to which positive and negative affect or feeling states have become attached through learning and experience" [13, p. 3]. Such affective images have been shown to induce empathy and strong emotional reactions and to provide vivid information that has a greater influence on individuals' perceptions and attitudes than "pallid" (e.g., abstract and technical) information [14].

Yet, while EPIs appear to be a promising direction when designing eco-feedback technologies for children, they have been employed in technologies made primarily for adults [1,7]. We explore

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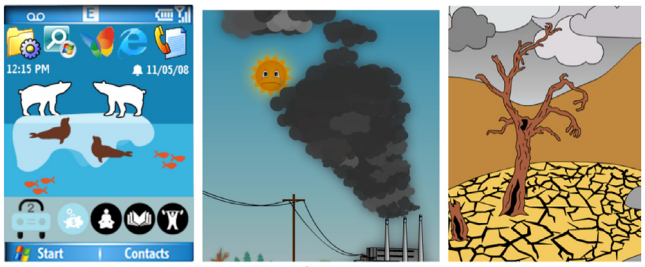

Fig. 1. Emotionally persuasive icons (EPIs) (a. example from Fig. 2; b and c our own work) induce *affective imagery*, or the engagement with emotionally charged mental representations.

this topic further because there is limited knowledge in this space. We draw from the literature on sustainable HCI and interaction design and children [4,6,7,10,15,16], empathy and moral development [17], ecology [18,19] and environmental psychology [20], and we identify two critical dimensions in which EPIs can vary. We then seek to understand differences in children's empathy and engagement levels within these dimensions. These dimensions enable us to explore the design space in terms of the *focus* (environmental scenes versus pets) and the *form* (metaphorical versus literal images). Note that in our study description, we refer to animals (e.g., virtual cats and polar bears) as pets.

Dimension 1—*Environmental scenes versus Pets:* On the one hand, environmental representations may have a direct influence on children's feelings of connectedness to nature, which is a predictor of environmentally responsible behavior [20]. On the other hand, animals may have greater potential for evoking emotions in children because we naturally develop a sense of caring, empathy and emotional relationship with animals. The moral socialization theory proposes that human beings are born with a predisposition to experience empathy [17]. In fact, research has suggested that individuals' affection for *pets* may be a key to encouraging resource conservation and environmental protection [19].

Dimension 2—*Metaphorical versus Literal:* Literal representations have greater educational power because they present accurate information, while metaphorical representations open the design space, potentially leading to more evocative solutions [16]. Children younger than 10 years, for example, show greater proclivity toward fantasy [6]. Because of young children's belief in fantasy, they are more likely to accept the validity of a metaphorical representation such as the effects of how certain behaviors (e.g., turning off lights) could lead to better weather. Moreover, the use of metaphors has been found to be particularly effective in communicating pro-environmental concepts [18].

In this study, we focus on empathy and extend the care and nurture aspects of this concept as it relates to animals and pets and the environment in metaphorical and literal representations. The goal of the study is to understand the emotions and empathy evoked through EPIs used in eco-feedback displays for children. We ask the following research questions:

1. Which graphical representation of eco-feedback, the *environment* (E) or *pets* (P), evokes the most empathy in children?
2. Which graphical representation of eco-feedback, *metaphorical* (M) or *literal* (L), evokes the most empathy in children?

We found that the children in our study understood EPIs that made the impact of climate change more concrete to them and that familiar pets (e.g., cats) evoked the most empathy, which we explain using the construal level theory of psychological distance. Psychological distance is the cognitive and affective perception of how close or far something is [21]. We also found that metaphorical images were stronger in evoking emotions and feelings of empathy. This work extends prior eco-feedback research by investigating children, a relatively unexplored population in sustainable human–computer interaction (SHCI); extends social psychology theory to the design of eco-feedback technologies; and proposes new directions for SHCI.

In the remainder of the paper, we review aspects related to eco-feedback technologies and families and generating empathy, and we describe four game-like interfaces (see Fig. 2) created to represent the two design dimensions. We then report on a study of 14 children ages 9–11 and present our findings. These findings inform the design for eco-feedback displays for children, which we conclude in our discussion.

2. Related work

We provide a review of eco-feedback designs among children and families in HCI, a review of known factors contributing to the success of eco-feedback designs among adults, factors generating empathy, a summary of this related research, and the primary research questions to be explored in this study.

2.1. HCI review of eco-feedback among children and families

There have been efforts in sustainable HCI literature to make eco-feedback designs more engaging to families overall (i.e. both children and parents). For instance, the *aquatic ecosystem* is a display that portrays life in the water with the aim of motivating families to save water [7]. The display is abstract and uses fish and plant life to represent water usage in an ambient and artistic way. Parents and children described this display as a game because the ecosystem evolved in a positive way when specific goals were met, and they liked this display because of the game-like elements and its ambient nature [7].

Researchers have questioned whether eco-feedback for children should be more artistic and mysterious, or more practical and utilitarian [6]. Recently, researchers have questioned the effectiveness of utilitarian displays in sustaining users' engagement and having a long-term effect on their behaviors [22–24]. These investigators, however, did not focus on children's perspectives.

In one such study exploring how children (ages 9–13) perceive sustainability in the home, Desjardins and Wakkary [6] sought to investigate opportunities for creating eco-feedback displays for them. The authors concluded that the children in their study had a very wide and holistic understanding of environmental sustainability and sustainable solutions. For example, children were aware of sustainable technological innovations such as electric vehicles, windmills, and solar panels and understood more natural ways of being sustainable, such as living on a farm. Despite the fact that children seem to understand sustainable practices [6], their parents do not communicate energy-consumption information to them [25] and often have difficulty engaging children to contribute to household conservation [2,26].

2.2. Factors contributing to successful eco-feedback designs

Many studies address specific factors contributing to successful eco-feedback designs; however, this research primarily targets adults. For example, Froehlich et al. [1] found in their review of eco-feedback research in HCI in 2007–2012 that the best-performing eco-feedback designs, or those resulting in the greatest change in energy consumption, were interactive, could provide an appliance-specific breakdown of energy use, provided multiple feedback options (e.g., for comparisons or time periods), and were

Fig. 2. The four eco-feedback interfaces employing different types of EPIs (from top to bottom): (EM) Environment scene-metaphorical (variability in weather conditions such as cloud density, presence of thunderstorms, night/day and the facial expressions of the sun), (EL) Environment scene-literal (communicates the impact of global warming on the environment via deforestation), (PM) Pet-metaphorical (children's behaviors influence the cat's affective state), (PL) Pet-literal (communicates the impact of global warming on the survival chances of the polar bear).

frequently updated. Others [27] emphasized the need for eco-feedback designs to connect users' lived experiences to sustainable actions. Kim et al. [28] built on this work and found that iconic representations of metaphors that were scientifically related to the real environment were more likely to stimulate emotions than numerical data.

2.3. Empathy and emotional attachment to animals and pets, and the environment

To extend Kim et al. [28] work and to understand how iconic representations of metaphors that are scientifically related to the real environment [28] could stimulate emotions, we reflected on empirical research in environment and behavior, which finds that empathy improves environmental attitudes and behaviors (e.g., [11]). Using a factorial design (2×2), Berenguer [11] manipulated empathy level (high or low) and harmed the natural object viewed (bird or tree). He found that those induced to empathy showed stronger empathetic feelings and attitudes toward the natural object and toward nature as a whole [11]. Past studies and models have also shown that environmental behavior and attitudes and feelings of empathy can emerge when someone takes on the perspective of a person or animal in plight [12].

The use of affective imagery to generate empathy by connecting individuals with nature [29,30] is a promising direction and could lead to environmentally responsible behavior. Dillahunt et al. [29] used an image of a polar bear on melting blocks and an emotional story to study the impact of emotional attachment in pro-environmental actions. The findings showed that those in the attachment (or connectedness) condition committed to more actions, followed through with more actions and had higher levels of environmental concern than the control group [29]. In a study to motivate environmentally friendly transportation choices, Froehlich et al. [30] leveraged these findings and created visual representations of environment elements and animals. To engage people, they used a tree that varied in terms of growth and fructification as well as a polar bear embedded in a growing ecosystem, both depending on the people's engagement with eco-friendly transportation habits. However, both of these studies targeted adults (ages 18 and older) and did not explore which elements (animals or the environment) generated the most empathy.

2.4. Summary of related work

In summary, prior research finds that parents often have difficulty engaging children to contribute to household conservation [2,26]. To make eco-feedback designs more engaging to families, past research suggests the use of game-like elements [7] and the use of affective imagery [14] to evoke empathy [17]. The designs that stimulated emotions included iconic representations of metaphors that were scientifically related to the real environment [28]. However, many of these studies target adults [1,27–30]. An open question, and one we seek to address, is whether eco-feedback displays should be more artistic and mysterious, or more practical and utilitarian [6] to generate empathy.

We draw from this past research to create EPIs that are engaging to children. We consider: (a) elements of game play within ambient displays [7] using elements such as animals and aspects of the environment as used in the aquatic ecosystem display, (b) suggestions to focus on iconic representations of scientifically related metaphors to stimulate emotions [28], (c) past research suggesting to connect users' lived experiences to sustainable actions [27] and (d) empathy and affective imageries to connect children with the natural environment via displays. Our study provides a more detailed understanding of the use of metaphors as compared to the more literal representations of the natural environment focused on children ages 9–11, and we contribute findings that identify the most effective factors in our given context.

3. Methodology

3.1. Affective imageries

To study the impact of EPIs varying in the two aforementioned dimensions, the research team commissioned a group of design students to develop three out of the four interfaces, each reflecting a combination of the two dimensions (see Fig. 2). To build from prior work, the researchers used the fourth interface (pet-literal) from Dillahunt et al. [29]. The goal was to create eco-feedback interfaces specifically addressed to children using elements they naturally understood. In addition, we selected and created the specific EPIs from past research [7,27–29] and combined both pet and environment dimensions with metaphorical and literal elements. All four interfaces were interactive. Children could use the mouse to perform a number of interactions and they could see the consequences of their actions immediately. We explain these interactions and consequences in greater detail per each subsection below. After interacting with the EPIs, children responded to a number of questions regarding their behaviors. We tested these EPIs in a pilot study, as discussed in the next subsection, to gauge children's ability to elicit empathy and their understanding of the EPI's interactive elements.

EM. Environment scene—metaphorical interface, or sunny skies to dark clouds. This interface employed a number of metaphors to convey the relationship between sustainable (or unsustainable) behaviors and the positive versus negative influences on the environment. In this interface, children could perform interactions such as switching electronic household appliances on and off. Children's interactions with the EPI led to consequences in the EPI environment. For example, if children turned off light switches (interaction), this would lead to lighter and sunnier skies with clean clouds (consequence). Leaving the lights on (action) led to darker skies with black clouds and smoke (consequence). The game consisted of turning appliances and lights within the household on and off and observing the impact of such actions in the surrounding conditions. For instance, if children switched on multiple appliances and lights, the sky gradually darkened, the sun (with anthropomorphic features) transitioned from a happy to sad state, and the factory polluted the environment, which led to the increased presence of clouds and thunderstorms (see Fig. 2-EM).

EL. Environmental scene—literal interface, or green oasis to deserted land. Here, a direct link was drawn between energy consumption and its environmental impact. Children engaged with a story that demonstrated two environmental states, a green and a deserted state, which represents deforestation. Through the story, children observed how the actions of the main character, a child, directly affected the state of the environment. Similar to the metaphorical interface changes, the environmental scene changed from a pleasant green setting to a deserted and uninviting setting as the child interacted with devices in the house (see Fig. 2-EL). The more devices used, the more deserted the landscape.

PM. Pet—metaphorical interface, or happy cat to sad cat. We employed metaphors to establish a sense of empathy and responsibility for the pet. Like the first two environmental interfaces, children could switch off lights and appliances to save energy and money within the household. Children could see the amount of money saved in the top right corner of the interface as well as the number of devices switched on/off. These features enabled children to associate the number of devices switched on and off with cost, money saved, and quality of life. For example, the interaction with devices and lights affected the quality of life of a cat, named Tobias, in two ways: it enabled owners to save money and buy food for the cat, and it created a dark and peaceful environment for the cat to sleep undisturbed. While no immediate life threat was portrayed, children's behaviors regarding energy consumption were associated with the pet's quality of life (see Fig. 2-PM).

PL. Pet—literal interface, or safe polar bear to threatened polar bear. Here, a direct link was drawn between energy consumption and environmental impact, which in turn affected the life of polar bears to the extent that they could drown. We borrowed images from Dillahunt et al. [29]. Unlike the first three interfaces, we invited children to commit to environmentally friendly actions in a game-like way. Children selected which actions they wished to commit to, which affected the environment. For example, if children committed to turning off the lights at home, a sustainable behavior, this led to increased ice floe and provided a secure environment for the polar bear. In contrast, no commitment or choosing not to commit to such behaviors led to the gradual melting of the ice floe, which caused the polar bear to drown (see Fig. 2-PL).

3.2. Study implementation

Before implementing our study, we conducted a pre-pilot with two children (ages 10 and 11) who were friends. Both children were integrated in similar environmental education programs in a proximate district of the main study participants. Each child had a dog and two cats. We paired the two children and provided them with a laptop to interact with the two metaphorical interfaces (environment and pet). These were interactive game interfaces. We instructed children to interact and to explore each game; we also instructed them to think aloud as they played. Next, we gave the children cardboards (3 per game interface) that represented each image from the game and asked, "What is the first thing in your mind when you see this image?" for each cardboard image. We also asked them to describe how they felt when seeing the image. The researcher used the laddering technique [31], a method to elicit goals and underlying values as a way to probe participants to elaborate on their initial responses. Our pilot results confirmed the benefits of using the cardboards to represent each image and to elicit children's responses. The pre-pilot results also suggested focusing on specific elements from the image landscape as a way to probe responses from children. It was clear after the pre-pilot results that children were able to understand the cause and effects of their actions. For example, in the pet metaphorical interface, children verbalized their understanding that in order to keep the cat nourished, they needed to switch off the lights.

We conducted a three-part study based on our pre-pilot results. We recruited another group of children and conducted the study.

Part 1: The goal of part one was to allow the children to familiarize themselves with the game elements and to observe how children interacted with the interfaces and what kind of verbalizations they made. Children explored each game interface in pairs. We expected the study to be challenging for some children, so we followed the selection recommendation of Hanna et al. [32], and paired children with a good friend to take part in the study. Interacting with friends helps children feel more comfortable. As a result, they are more likely to communicate and engage in deeper

discussions [32]. While teachers took no part in the actual study, they assisted us in pairing the children with their friends.

After a short introduction to the games, children were invited to interact with each of the four interfaces using a 15-inch portable computer. We encouraged them to play the games freely, underlining explicitly that there were no wrong answers and that they were free to interact with each of the interfaces in any way they wished. During this phase, children were encouraged to share their thoughts with each other and to think aloud based on guidelines from Markopoulos et al. [16]. This lasted approximately 10 min for each of the four game interfaces, for a total of 40 min.

Separating interaction (part 1) from feedback (part 2) enabled children to perform comparisons, a practice that has been shown to enhance children's capacity to provide detailed feedback [16]. Taking into account the fact that children would be highly likely to influence and imitate each other, we asked them to take individual notes in the form of single words and short phrases.

Part 2: The goal of part two was to gather children's positive and negative feelings for each game interface image. We gave children one cardboard at a time (3 per interface) in the order from the most pleasant to the least pleasant image specific to each game interface (see Fig. 2). We asked, "What is the first thought that comes to your mind when you think of this image?" We documented responses for each child, and for each response we asked children, "How strong are your negative or positive feelings about X?" Children answered using a smileyometer to rate each word/construct that they gave for each image.

Part 3: The goal of part three was to probe children for their feelings and to elicit children's responses for empathy. We used the laddering technique to elicit and to discuss their responses. Our method relies on the notion of *affective imageries*, which can include sights, sounds, smells, ideas and words. These imageries can be used to create positive and negative affect or feeling states. These states can link to associations with an individual's experiences and attachments [13]. *Affective image analysis* is the systematic study of the associations people make between a given stimuli and words or ideas, and their affective load (i.e. the strength of positive or negative emotions they can invoke in the individual). As Leiserowitz described it, "it is a structured form of word association and content analysis" [33, p. 48]. Using the method of continuous word association, participants were asked, "What is the first thought or image that comes to your mind when you think of X?" For each response, participants were then asked, "How strong are your negative or positive feelings about X?", thus producing a structured dataset of imageries and their affective load. We followed the affective image analysis approach to help describe and categorize the feelings that the EPIs evoked in children. This also allowed us to understand whether certain EPIs induce stronger positive or negative emotional charge, which could affect children's attitudes toward pro-environmental behaviors.

For the final step, the children discussed their notes with the interviewer, a psychologist. The sessions were audio-recorded and fully transcribed and paired with the written forms detailing children's constructs and the researchers' notes.

3.3. Participants

For context, we recruited children from primary schools in a country where environmental education programs were integrated in the curricula and had been since 1996 as a result of federal initiatives. Environmental education programs require schools to develop and implement sustainability-related activities into children's curriculum across all areas. The activities range from recycling, water consumption, and organic farming to energy management. As a result, all children had exposure to a curriculum on environmental education and were capable of understanding how their behaviors could affect the images in our study. While environmental education programs are unlikely to exist worldwide, children are increasingly exposed to them such that these EPIs could be generalized to other regions of the world.

We recruited fourteen children, ages 9–11 (seven female) to participate in the study (see Table 1) using a snowball sampling technique. We chose this age group based on the development of children's specific cognitive skills. In fact, at this age children have developed the capacity for symbolic thinking and can explain mental operations such as logical reasoning and rational interpretations [34]. In addition, their ability for transductive reasoning enables them to better understand cause-and-effect relationships [34]. This understanding allows them to analyze and grasp the associations among actions and consequences in the context of the interfaces.

All children resided in a rural area of Madeira, Portugal—a region characterized to have summer temperatures ranging from 21 °C to 27 °C and winter temperatures from 13 °C to 19 °C. Having pets in rural areas is common and, indeed, all children in our study had pets. We conducted three studies of children pairs in children's homes and the other four in their school. This allowed us to explore the impact of the physical and social contexts on the children's reactions.

3.4. Data and analysis

We analyzed the fully transcribed sessions alongside the children's written forms and researchers' notes. Researchers took notes during the children's interaction game play and the feedback sessions (Parts 2 and 3 as described in Section 3.2). For example, Part 2 data included the feelings reported while asking children about the selected cardboard images, as well as the affective imageries for each EPI. These data were analyzed using a grounded theory approach [35], using open and axial coding, whereby themes emerged from the data and were classified into broader categories. After key themes emerged, we analyzed the elements within the interface that generated specific constructs and further deconstructed children's responses for coding. We avoided duplicate counting by grouping constructs and elements (see Table 2). Note that all children's quotes were translated from their native language (Portuguese) to English.

4. Results

Before presenting the major results, we highlight that our study took place in two different settings: home and school. Conducting this study across two different settings allowed for an exploration of the impact of physical and social contexts on the children's reactions to the game. The teachers' role in the school setting was to help form children pairs since teachers were aware of internal interaction dynamics within their class. Teachers did not play this role in the home setting. Instead, a psychologist, who is a part of the research team, paired children who were either neighbors or classmates who had frequently played together in after school activities. Besides this, the same study was conducted across both settings.

While teachers were not present in either setting, we noticed that children in the school setting tended to behave more formally, with responses richer in educational content. On the other hand, children in the home setting were more spontaneous and their responses were richer in emotional context.

Our main results suggest that familiar pets received more empathetic responses and metaphorical images evoked more responsibility than the other interfaces. The three higher-level themes that emerged from our open and axial coding process included emotions such as (1) fear and happiness, (2) empathy, and (3) responsibility. See Table 2 for a more detailed overview of our results.

Table 1
Subjects' demographic data, research setting, and pet ownership.

User pair	Participant ID	Gender	Age	Interviewing setting	Pet
1	U1	Female	9	Home	1 dog, 1 cat
	U2	Male	9		1 cat
2	U3	Female	10	Home	1 dog
	U4	Female	9		1 dog, 1 cat
3	U5	Male	10	School	1 parakeet
	U6	Male	10		2 dogs, 2 parakeets
4	U7	Female	9	School	1 cat
	U8	Male	9		4 dogs, 1 cat
5	U9	Male	9	School	1 dog, 3 cats
	U10	Female	10		2 dogs, 1 cat
6	U11	Female	9	School	1 dog, 1 parakeet
	U12	Female	9		1 dog
7	U13	Male	11	Home	3 cats, 2 dogs, 2 parakeets
	U14	Male	11		1 dog

Table 2
Results overview.

Affective Imageries (AI)	Constructs/themes	EM	EL	PM	PL
Fear	Safety concerns	29	12	6	13
	Environmental destruction	37	15	2	3
	Personally affected	29	12	1	0
	Extinction	4	0	0	37
Happiness	Positive imageries	39	39	28	16
	Joy	42	46	0	0
Empathy	Feelings	8	5	52	11
	Comparison to pet	0	0	15	5
	Extinction	4	0	0	37
	Actions and consequences	33	0	26	16
Responsibility	Accountability	23	4	39	1
Negative imageries	Negative language	6	1	11	0
Anthropomorphic features	Humanized nature	24	15	21	0
Recommendations	Solutions to improve current situation	6	5	3	4

EM = Environment Metaphorical as shown in Fig. 2-AC; EL = Environment Literal as shown in Fig. 2-AD; PM = Pets Metaphorical as shown in Fig. 2-BC; PL = Pets Literal as shown in Fig. 2-BD.

4.1. Negative visceral reactions evoke fear

We found that several design elements of the metaphorical environmental scenes evoked strong negative visceral reactions. For example, increasing consumption caused the factory to produce thick black smoke, led to thunderstorms and the lack of oxygen—all events that might occur as a result of environmental destruction. Children responded to the potential outcomes of each event: "*The smoke is toxic. If we inhale it, we might get sick or even die because of that pollution*" *[U3]*; "*We can get electric shocks. I am very sad because it is dangerous*" *[U2]*; "*[I am] very scared, because the trees can't give us the oxygen we need*" *[U10]*.

In particular, children found the images of thunderstorms distressing (i.e. sunny skies to dark skies); perhaps they tapped into memories of real-life events for them. Comments included, "*I feel very scared because, when it [a thunderstorm] is happening outside, I run to my mom's room and ask her about what is happening. I get really scared*" *[U1]*; "*I feel very scared and sad because I'm afraid something might happen to us. It [the lightning] might hit and reach the house. And the house might be damaged and we can die*" *[U2]*.

Overall, the sunny skies to dark skies (i.e. the metaphorical representation of the environment scene) evoked more negative responses relating to safety concerns ($N = 29$) than the green oasis to deserted lands representation (i.e. the literal representation of the environment scene, $N = 12$).

Another fear that was repeatedly generated was that of environmental destruction. Interestingly, the literal deforestation representation, which we expected to be the most effective with respect to imageries of environmental destruction, was less effective than the metaphorical representation. Children's concerns were related to the loss of vegetation and its impact on health (e.g., "*We need to have strong and green vegetation and if trees don't have conditions to live we don't have oxygen for ourselves*" *[U7]*) as well as the aesthetics of the landscape (e.g., "*Plants give smells to the environment and make the landscape more joyful*" *[U10]*). Most often, however, these concerns were cued by strong design elements present in the sunny skies to dark clouds metaphorical interface. For instance, the dominance of the sun with the anthropomorphic features and the strong variations in weather conditions (e.g., "*It's awful. The lights, the oven, there is a lot of smoke coming out of the factory, nature is all polluted*" *[U11]*). Overall, the metaphorical representation led to more than twice the number of references to environmental destruction ($N = 37$) than the literal representation ($N = 15$).

4.2. Positive visceral reactions evoke happiness

We found both the metaphorical and literal interfaces to be effective in evoking positive visceral reactions on children. Design elements such as the shining sun, the green landscape and the clear sky evoked personal memories associated with outdoor play and feelings of freedom (e.g., "*I feel very happy, because we can enjoy the day, we can go for a picnic and have fun*" *[U1/U2]*; "*We can come outside to play, because there is good weather*" *[U11]*; "*We feel free, we feel happy, and we have freedom*" *[U9]*). Moreover, all three design elements were associated with good health, the ability to breathe well and living longer (e.g., "*We feel very happy when they do this [save energy], because the sun gives us vitamin D and this makes us even happier*" *[U11]*).

Overall, both the sunny skies to dark clouds (metaphorical, $N = 39$) and the green oasis to deserted land (literal environment, $N = 39$) scenes generated positive affective imageries. The anthropomorphic features of the sun that were present in the metaphorical condition captivated children's interest, resulting in both positive and negative imageries ($N = 21$): "*The sun is*

happy and I feel happy to see it happy" [U10]; "*The sun is becoming sadder and sadder [U3]*; "*The sun is crying" [U9]*. However, positive imageries related to joy were more frequent in the literal condition ($EL = 46$, $EM = 42$). Our assumption is that the representation of a plain green landscape in the literal condition helped children to make associations with their personal lived experiences, thus creating more imagery.

4.3. Familiar pets receive more empathetic responses

While the environmental interfaces were more effective in evoking immediate visceral responses, the cat and polar bear pet interfaces were more effective in evoking feelings of empathy and attachment in children. The metaphorical cat and literal polar bear worked in very different ways. While the literal interface attempted to show the risk that unsustainable consumption posed on the survivability of a polar bear, the metaphorical interface drew arbitrary links between sustainable practices (such as switching off lights and appliances, having enough income to feed the cat, and creating a dark, peaceful environment for the cat to sleep).

Children's concerns for a secure environment were more intense in the literal environment ($N = 13$), where they perceived conditions as an acute life threat. In contrast, deterioration of the cat's quality of life, as reflected in the metaphorical environment ($N = 6$), did not elicit the same level of concern. The differences became apparent in comments such as, "*The bear is almost dying. His paws are squeezed in that small space. I am very sad because he has a worried face, he can't move. If he swam to reach land, he could drown [U5]*"; "*Tobias [cat] is not happy, in this [image] there are more things switched on, they [owners] aren't saving and Tobias can't eat or sleep [U11]*".

However, we noticed that children engaged more with the cat metaphorical interface and often used more emotionally charged language ($N = 11$) when referring to threatening situations for the cat (e.g., "*poor cat" [U9]*; "*they abuse him" [U9]*). In contrast, comments regarding the polar bear appear more descriptive than empathetic (e.g., "*I think the bear is afraid*" [U4]). Children repeatedly showed signs of empathy with the cat's feelings ($N = 52$) (e.g., "*Tobias is suffering, we are wasting money" [U9]*), and made parallels between themselves and the cat ($N = 15$) (e.g., "*If I were the cat I wouldn't like to be treated like that" [U2]*, "*I wouldn't like it if my mother did that to me" [U2]*). Children did not connect in this way with the polar bear, and while they expressed feelings of regret and sadness when the polar bear was at risk ($N = 37$), these feelings were often expressed in terms of generalized knowledge related to the risk of extinction for certain species (e.g., "*It is important to have species and not lose living beings" [U9]*; "*He is almost dying. I feel very sad because we know we have one bear less in his species" [U10]*; "*The bears might be wild, but they don't deserve being mistreated even if they can't get along with people" [U3/U4]*).

In the same vein, we noticed that children often held themselves or the leaders of the household accountable for the threats that the cat faced in the metaphorical condition ($N = 39$) (e.g., "*He doesn't eat, he doesn't sleep, they abuse him" [U9]*). However, they were more likely to attribute the situation to actions of the polar bear reflected in the literal environment (e.g., "*He needs to be squeezed if he wants to survive, there is much less ice" [U7/U8]*).

Moreover, we observed that children grasped the causal relationship among human actions and their impact on the pet's life in the metaphorical condition (e.g., "*Tobias is not very happy, because they are not saving, that way he can't eat or even sleep" [U11]*), whereas they didn't show the same understanding in the literal condition of the polar bear. Instead, they commented on natural phenomena – such as ice melting – as being independent of their actions. We speculate that their general knowledge may have contributed to less emotional bonding with the polar bear.

4.4. Metaphorical and pet interfaces evoke responsibility

Interestingly, all four interfaces evoked not only strong emotional reactions in children but also feelings of responsibility for their own actions, as well as the actions of the household leaders. Overall, we found the metaphorical and pet interfaces to evoke stronger feelings of responsibility than literal interfaces and environment scenes, respectively.

First, by way of explanation, both metaphorical interfaces (i.e. sunny skies to dark clouds and happy cat to sad cat) were stronger than literal interfaces in evoking emotion and feelings of empathy. In the environment scenes, use of anthropomorphic features such as the sun "crying" or "smiling" not only captured children's interest but the images cued feelings of empathy and enabled children to connect the dots between household actions and consequences, both for the environment ($N = 33$) and for their pet's health ($N = 26$). Understandably, children also developed feelings of empathy for the pets, especially in the metaphorical condition (i.e. happy cat to sad cat). In addition, the children often judged their own behaviors: "*The factory is polluting a lot more because we have the lights switched on. It was greener before, now the trees don't have any leaves. [I am] very sad because not only is this bad for the environment it is also bad for us" [U7]*. Children also negatively judged the actions of the household: "*The owners don't know how to care for the animals, they shouldn't have animals at home" [U3]*.

Second, a particularly effective strategy was the metaphorical-environment scene interface (i.e., sunny skies to dark clouds), which accentuated the contrast between good and bad. For instance, the interface attempted to represent the sun as a victim of human overconsumption that led, in turn, to the factory producing more harmful smoke. This representation created a narrative that engaged children in feeling empathy for the sun and threatened by the factory (e.g., "*This is not the way to help the environment. If we keep wasting energy, we are helping the factories to produce more energy and pollute even more" [U4]*). Research in media studies also supports our finding that accentuating the contrast between good and bad leads to heightened involvement of children with the victim [36], which in our case was the sun. In the sections that follow, we discuss implications of our findings for eco-feedback technologies and SHCI and the limitations of this work.

5. Discussion

The overarching goal of this study was to understand the emotions and empathy evoked through EPIs used in eco-feedback displays for children. To fulfill this goal, we conducted a mixed-method study among children ages 9–11 to study the impact of EPIs varying in pet and environmental dimensions to address the following two research questions:

- Which graphical representation of eco-feedback, the *environment* (E) or *pets* (P), evokes the most empathy in children? (RQ1)
- Which graphical representation of eco-feedback, *metaphorical* (M) or *literal* (L), evokes the most empathy in children? (RQ2)

Our images evoked emotions such as fear, happiness and empathy. These images also evoked an unexpected aspect of responsibility. We addressed our research questions and found that:

- RQ1: Pets, specifically familiar pets, evoked the most empathy in the children who participated in this study.
- RQ2: Metaphorical images were stronger than literal images in evoking emotion and feelings of empathy.

We further discuss these findings.

Recent studies [22–24], as called out in the related work, have questioned whether eco-feedback for children should be more artistic and mysterious, or more practical and utilitarian for sustained engagement. Our findings suggest that these displays should be more practical and utilitarian to generate empathy; we did not measure sustained engagement. Many of the children in our study were knowledgeable of sustainable innovations as suggested by Desjardins and Wakkary [6], likely because of their school curricula. Our findings are consistent with those of Brynjarsdóttir et al. [27], who emphasized the need for eco-feedback designs to connect users' lived experiences to sustainable actions, and with those of Kim et al. [28], who found that iconic representations of metaphors that are scientifically related to the real environment are more likely to stimulate emotions than numerical data. Our findings are also complementary to Jones et al.'s survey results, which suggest that communications of climate change created to reduce psychological distance could be effective for increasing public engagement with climate change [37]. We discuss these insights and use the construal theory of psychological distance and past literature as a lens to interpret our findings.

Psychological distance is defined as the cognitive and affective perception of how close or far something is [21]. Direct experience, or what's right here and now, is considered the lowest psychological distance possible. There is a high level of psychological distance with environmental sustainability issues such as climate change [38]. One way to traverse psychological distance is perspective taking, which is understanding another object's or subject's perspective [39]. Research has found that taking the perspective of a subject in need and imagining how that person is affected by his or her plight can stimulate feelings of empathy [12]. Our study results show that affective imagery, or EPIs, when used to reduce psychological distance, show promise in terms of generating empathy and emotions in children.

5.1. Use metaphorical imagery from personal experiences

Our results suggest that metaphorical images (i.e. sunny skies to dark clouds and happy cat to sad cat) helped overcome children's psychological distance in sustainability and the abstract nature of climate change [38]. Because we do not directly experience climate change, it is difficult to assess the extent of change. Therefore, removing the distance – temporal, spatial, social and hypothetical (which we discuss later) – between individuals and climate change helps to make the concept more concrete.

Yet our results suggest looking beyond the type of representation (metaphorical versus literal) and into children's experiences as a predictor of evoking feelings of empathy. Children's personal experiences were important in portraying empathy and emotions. Images that tapped into children's personal experiences led to stronger engagement and feelings of empathy than those that did not. Yet, we found in our study that the metaphorical rather than literal images tapped into children's experiences to a greater degree.

5.2. Pets: metaphorical (Cat) evoked more empathy than literal (Bear)

For our metaphorical pet image, we anthropomorphized the cat by giving it a name (Tobias), which we did not do for the polar bear. Use of anthropomorphism has been correlated with increased empathy and social competence [34]. All students we interviewed happened to have pets at home—8 of the 14 children had cats.

In contrast to the pet as a cat metaphorical imagery, the pet as a polar bear literal interface was less engaging, and the children viewed the result of their own actions as more detached from the outcome. While children could observe the impact of their actions on the polar bear's habitat, they did not engage with their role of improving these conditions (and thus saving the polar bear's life) to the extent they did in the metaphorical condition with the cat.

We hypothesize that the pet as a cat metaphorical imagery was more effective because it better related to children's experiences and exposure to cats as opposed to their limited prior engagement with polar bears. We posit that their personal experiences enabled them to take on the perspective of Tobias [12] and thereby overcome their psychological distance regarding sustainability issues and generate empathy [12].

5.3. Environment: metaphorical (sun/lightning) increased sense of responsibility more than literal (green/desert)

Although children showed evidence of responsibility when exposed to the pet as a cat metaphorical imagery, the responsibility component was more pronounced in the metaphorical environment, or sunny skies to dark clouds condition. However, drawing from our main argument, children were less engaged with certain aspects of this condition because they were not able to relate it to their experiences.

Prior literature suggests that negative information signals a need for change, and humans may respond more quickly to and show heightened awareness of this form of information [40]. Similarly, we found that accentuating the contrast between good and bad in our environment metaphorical imagery increased children's involvement with the victim. For example, the sun was anthropomorphized with smile and frown expressions and could be portrayed as a victim of the factory's toxic smoke. Children feared the lightning bolt and thunderstorms based on their experiences in these weather conditions—in fact, children had likely experienced the severe weather conditions that occurred in the region in 2010, which caused environmental destruction including the deaths of more than 40 people and more than 100 injuries [41]. Additionally, the environment metaphorical condition evoked a deeper understanding of responsibility among children.

Although these children played outside and could relate to the greenery and the sun as presented in the environment literal condition (i.e. the green oasis to deserted land), the sun was not anthropomorphized, and the negative effect of the deserted land did not resonate with children. The children in this study had no prior exposure to deserted land. Although an absence of green vegetation and trees may be a familiar environment, specific discussions about that environment had been peripheral rather than personal.

To summarize our discussion, the literal imagery used in this study was too abstract to overcome the children's psychological distance in sustainability. As a result, the children's language was more detached. In the case of both the polar bear (pet) and the deserted land (environment), our children had no prior exposure to or personal experience with either. In addition, while some of the actions children selected in the literal pet image were actions that children could do alone (e.g. "*During the day, I'll open the curtains and avoid turning on the lights*"), their parents would normally perform many of the actions themselves (e.g., "*I'll help my parents hang the washed clothes outside so that they dry in the sun*"). This might explain why it was harder for children to identify feelings of responsibility in the literal polar bear imagery. Finally, the lack of an evident causal relationship between their commitment to sustainable behaviors and the impact of their actions on the polar bear might have contributed to a weak emotional connection in the literal condition.

6. Limitations

Our study is not without limitations. First, our sample consists of only fourteen children ages 9–11, located in a specific region of the world. Furthermore, over the past year all of the children in our study had taken part in an educational project to raise children's awareness of sustainability, which may have affected the results of our study. Therefore, we do not claim that our findings generalize to broader populations and regions of the world. In addition, all fourteen children had pets at home. While this was not surprising for the region, this is likely a confounding factor because having pets may have influenced participants' feelings of empathy and attachment in pet interfaces. Our results may not generalize across children who do not have pets at home or who have not interacted with them. Second, while our interfaces were purposefully selected and designed to be similar in their action possibilities, we noticed that the pet-literal interface appeared more static and disengaging to children and involved higher amounts of reading. Some of the results on children's preference for the pet-metaphorical interface might be partly attributed to its more engaging interaction style, leading to higher content understanding and engagement. These limitations present opportunities for future research.

7. Conclusion and future research

Environmental sustainability and climate change are abstract concepts. A key takeaway from our findings is that children can understand EPIs that make the impact of climate change more concrete to them. These EPIs theoretically decrease the psychological distance between our subjects and the impact their actions have on climate change using perspective taking. Again, taking the perspective of a subject in need and imagining how that subject is affected by his or her plight can stimulate feelings of empathy [12]. Because our participants were able to take on the perspective of the cat and understand the negative impact of the thunderstorms on the sun, they showed more empathy and emotion in their image descriptions than they did with the literal imagery. As a result, these findings suggest that designers must link the effects and causes of climate change to concrete, tangible actions that relate to children's personal experiences and prior exposure to generate empathy.

Empathy improves environmental attitudes and behaviors [11,12]. We found that pets, specifically familiar pets, evoked the most empathy in the children who participated in this study. Children in our study had stronger responses to the metaphorical images that better related to their current and past experiences, knowledge and context, and these metaphorical images were stronger in evoking emotion and feelings of empathy.

Future sustainable HCI and eco-feedback research should investigate opportunities to leverage existing connections or relationships that individuals or groups have to aspects of nature and the environment. For example, children understood the metaphorical pet interface interactions and could connect them to tangible situations and concepts; such outcomes are critically important in a successful interface. A key question to be explored is this: How can designers better connect the interactions within an interface to users' experiences? We must first understand whether people exhibit more empathy in EPIs with pets only when they themselves have pets. This could factor into increasing perspective taking and decreasing psychological distance.

Clearly, children's connections to the environment metaphorical conditions stemmed from their exposure to the actual environmental conditions of their climate (e.g., strong weather conditions and vegetation versus deserted land). Future designs of EPIs could explore the impact of linking environment metaphorical images to the actual climate of an area, for example linking images and interactivity to current weather conditions (e.g., selecting natural disasters representative of a person's current climate). Another open question is whether individuals who spend more time outdoors in nature and are exposed to EPIs are more likely to take on perspectives of the natural environment than those who spend less time outdoors. This is consistent with efforts to promote pro-environmental behavior in children by motivating children to interact with nature and exploring how technology could enhance this interaction [42].

One should note, however, that perspective taking is only one component of traversing psychological distance. As SHCI researchers and eco-feedback designers, we should look to extend other techniques from social psychology to reduce psychological distance. In addition to perspective taking, we could build upon the other three dimensions of psychological distance in EPIs: the temporal, spatial and hypothetical. For example, to leverage the temporal dimension, EPIs could show aspects of the future now (e.g., collapse informatics [43]). Leveraging the spatial dimension, or physical space, EPIs could show deforestation occurring in a known area versus how actions contribute to deforestation in a faraway place. Finally, leveraging the hypothetical dimension could evoke an experience of a natural disaster at present instead of imagining future climate change effects. Understanding the effectiveness of these dimensions is an open topic that is ripe for future research.

Our study makes a number of contributions to SHCI:

- We extend prior eco-feedback research by thoroughly investigating visualizations for children, an important yet relatively unexplored population in SHCI. Our results suggest a more practical and utilitarian approach to generating empathy in children, which supports and extends other findings [22–24].
- We complement Jones et al.'s survey results, which suggest that communications of climate change created to reduce psychological distance could be effective for increasing public engagement with climate change among Australian adults [37].
- We extend social psychology theory (i.e. reducing psychological distance via perspective taking) to SHCI and to the design of eco-feedback technologies and provide a set of concrete suggestions for designing empathy-evoking interfaces specifically for children only.
- We propose new directions for SHCI by creating a new perspective on the design of eco-feedback technologies, making practical suggestions for reducing psychological distance in emotionally persuasive icons.

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References

[1] J. Froehlich, L. Findlater, J. Landay, The design of eco-feedback technology, in: CHI 2010, 2010, pp. 1999–2008.
[2] T. Dillahunt, J. Mankoff, Understanding factors of successful engagement around energy consumption between and among households, in: CSCW'14, 2014, pp. 1246–1257.
[3] T. Dillahunt, J. Mankoff, E. Paulos, Understanding conflict between landlords and tenants: implications for energy sensing and feedback, in: UbiComp'10, 2010, pp. 149–158.
[4] A. Banerjee, Eco-buzz: an interactive eco-feedback system based on cultural forms of play, in: TEI'13, 2013.

[5] A. Banerjee, M. Horn, Ghost hunter: parents and children playing together to learn about energy consumption. 2014. http://tidal.northwestern.edu/media/files/pubs/banerjee-tei14-small.pdf (accessed 10.07.16).
[6] A. Desjardins, R. Wakkary, How children represent sustainability in the home, in: IDC'11, 2011, pp. 37–45.
[7] J. Froehlich, L. Findlater, M. Ostergren, S. Ramanathan, J. Peterson, I. Wragg, E. Larson, F. Fu, M. Bai, S. Patel, J.A. Landay, The design and evaluation of prototype eco-feedback displays for fixture-level water usage data, in: CHI'12, 2012, pp. 2367–2376.
[8] G.E. Kara, E.H. Aydos, O. Aydin, Changing preschool children's attitudes into behavior towards selected environmental issues: an action research study, Int. J. Educ. Math. Sci. Tech. 3 (2015) 46–63.
[9] Z. Zhang, P. Shurbsole, M. Janse, Learning environmental factors through playful interaction, in: Interact. Design Child., IDC'10, 2010, pp. 166–173.
[10] R. Ballantyne, S. Connell, J. Fien, Students as catalysts of environmental change: a framework for researching intergenerational influence through environmental education, Environ. Educ. Res. 12 (2006) 413–427.
[11] J. Berenguer, The effect of empathy in environmental moral reasoning, Environ. Behav. 42 (2010) 110–134.
[12] J. Berenguer, The effect of empathy in proenvironmental attitudes and behaviours, Environ. Behav. 39 (2007) 269–283.
[13] P. Slovic, D. MacGregor, E. Peters, Imagery, affect, and decision making, Decision Research. 1998. http://dx.doi.org/10.2139/ssrn.1589800 (accessed 10.07.16).
[14] R.E. Nisbett, L. Ross, Human Inference: Strategies and Shortcomings of Social Judgment, Prentice-Hall, Englewood Cliffs, NJ, 1980, p. 167.
[15] M. Barreto, M. Scott, I. Oakley, E. Karapanos, N. Nunes, S.J. Gomes, Playing for the planet: designing toys that foster sustainable values, in: ECCE 2013, 2013.
[16] P. Markopoulos, J.C. Read, S. MacFarlane, J. Hoysniemi, Evaluating Children'S Interactive Products: Principles and Practices for Interaction Designers, Morgan Kaufmann, Burlington, MA, 2008.
[17] M. Hoffman, Empathy and Moral Development, Cambridge University Press, Cambridge, UK, 2000.
[18] A.R. Kearney, Understanding global change: a cognitive perspective on communicating through stories, Clim. Change 27 (1994) 419–441.
[19] J. Vining, The connection to other animals and caring for nature, Hum. Ecol. Rev. 10 (2003) 87–99.
[20] F.S. Mayer, C.M. Frantz, The connectedness to nature scale: a measure of individuals' feeling in community with nature, J. Environ. Psychol. 24 (2004) 503–515.
[21] N. Liberman, Y. Trope, Traversing psychological distance, Trends Cogn. Sci. 18 (2014) 364–369.
[22] R. Gouveia, E. Karapanos, M. Hassenzahl, How do we engage with activity trackers? A longitudinal study of Habito, in: Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing, ACM, New York, 2015, pp. 1305–1316.
[23] E. Karapanos, Sustaining user engagement with behavior-change tools, Interactions 22 (2015) 48–52.
[24] P. Klasnja, S. Consolvo, W. Pratt, How to evaluate technologies for health behavior change in HCI research, in: Proceedings of CHI'11, 2011, pp. 3063–3072.
[25] C. Neustaedter, L. Bartram, A. Mah, Everyday activities and energy consumption: how families understand the relationship, in: CHI 2013, 2013, pp. 1183–1192.
[26] M. Barreto, E. Karapanos, N. Nunes, Why don't families get along with eco-feedback technologies? A longitudinal inquiry, in: CHITALY'13, 2013.
[27] H. Brynjarsdóttir, M. Håkansson, J. Pierce, E.P.S. Baumer, C. DiSalvo, P. Sengers, Sustainability unpersuaded: how persuasion narrows our vision of sustainability, in: CHI'12, 2012.
[28] T. Kim, H. Hong, B. Magerko, Design requirements for ambient display that supports sustainable lifestyle, in: DIS'10, 2010.
[29] T. Dillahunt, G. Becker, J. Mankoff, R. Kraut, Motivating environmentally sustainable behavior changes with a virtual polar bear, in: Pervasive 2008 Workshop Proceedings, 2008.
[30] J. Froehlich, T. Dillahunt, P. Klasnja, J. Mankoff, S. Consolvo, B. Harrison, J.A. Landay, UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits, in: CHI'09, 2009, pp. 1043–1052.
[31] T.J. Reynolds, J. Gutman, Laddering theory, method, analysis, and interpretation, J. Adv. Res. 28 (1988) 11–31.
[32] L. Hanna, D. Neapolitan, K. Risden, Evaluating computer game concepts with children, in: Proceedings of the 2004 Conference on Interaction Design and Children: Building a Community, 2004, pp. 49–56.
[33] A. Leiserowitz, Climate change risk perception and policy preferences: the role of affect, imagery, and values, Clim. Change 77 (2006) 45–72.
[34] J. Piaget, B. Inhelder, Memory and Intelligence, Routledge and Kegan Paul, London, 1973.
[35] A. Adams, P. Lunt, P. Cairns, A qualitative approach to HCI research, in: P. Cairns, A. Cox (Eds.), Research Methods for Human-Computer Interaction, Cambridge University Press, Cambridge, UK, 2008, pp. 138–157.
[36] A.I. Nathanson, J. Cantor, Reducing the aggression-promoting effect of violent cartoons by increasing children's fictional involvement with the victim: a study of active mediation, J. Broadcast. Electron. Media 44 (2000) 125–142.
[37] C. Jones, D.W. Hine, A.D.G. Marks, The future is now: reducing psychological distance to increase public engagement with climate change, Risk Anal. (2016). http://dx.doi.org/10.1111/risa.12601.
[38] S. Pahl, E. Ashurst, Overcoming psychological distance in sustainability through explaining climate change and visualising proenvironmental behaviours, in: Vulnerability, Risk and Complexity: Impacts of Global Change on Human Habitats, IAPS 21 Abstracts, IAPS, 2010.
[39] F.C. Leeming, B.E. Porter, W.O. Dwyer, M.K. Cobern, D.P. Oliver, Effects of participation in class activities on children's environmental attitudes and knowledge, J. Environ. Educ. 28 (1997) 33–42.
[40] R.F. Baumeister, E. Bratslavsky, C. Finkenauer, K. Vohs, Bad is stronger than good, Rev. Gen. Psychol. 5 (2001) 323–370.
[41] Sobe para 43 o número de mortos, já se contam mais de 100 feridos, Público (in Portuguese), 2010.
[42] B. Cumbo, J. Paay, J. Kjeldskov, B. Jacobs, Connecting children to nature with technology: sowing the seeds for pro-environmental behavior, in: IDC'14, 2014, pp. 189–192.
[43] B. Tomlinson, M.S. Silberman, D. Patterson, Y. Pay, E. Blevis, Collapse informatics: augmenting the sustainability & ICT4D discourse in HCI, in: TOCHI 2012, 2012.