

JOANA FERREIRA HIPÓLITO

EMOTION-ORIENTED INTERVENTIONS FOR ENVIRONMENT
AND THE FACILITATION OF PRO-ENVIRONMENTAL BEHAVIOR

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Orientador: Professor Doutor António N. S. Câmara

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Autor: Joana Ferreira Hipólito

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To my parents and to my daughter

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Almost approaching the end of this work, I feel I strongly need to acknowledge for the affective images I keep in my mind of many shared moments and places.

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Finally – Obrigada! – to my closest family, always my enlightening top.

Abstract

This research aimed at studying the facilitating pro-environmental behavior problem by approaching new pro-environmental interventions. The following elements make this study particularly relevant: a) the actual debate concerning the impact of scientific and technological innovations and b) the consideration of new emotional research findings, which stress that emotion is an essential part of information processing. However, the role of emotions is still largely absent from most pro-environmental studies. This situation highlights the importance of conceiving personal and professional initiatives aimed at encouraging reflection and supporting pro-environmental behaviors research while focusing on emotional issues.

The study involved an interpretative approach of a qualitative nature, organized in two complementary phases. The first phase evaluated the possible impact of the purposed research. It involved different collaborations and the first experimental research study was implemented as a proof-of-concept approach. In addition, this phase research advanced a new model of pro-environmental behavior and a design framework. The second phase of the study, motivated by the results of the first phase, led to advancing emotion-oriented interventions scenarios and also planning and implementing their evaluation. This initiative showed two technological opportunities to consider for future developments: Affective images rewarding systems using digital material and sensorial feedback tools using non-digital material. The planned qualitative research included questionnaires, semi-structured interviews, panels, observation and the analysis of documents.

The results of this study have several implications. Among the most relevant are: a) the potential of combined research methods in investigating individuals conceptions and perceptions about environmental behavior; b) the importance of discussions about new pro-environmental interventions for facilitating pro-environmental behavior; c) the importance of multi-disciplinary research approaches for advancing new technological options; and d) the relevance of considering an emotion-oriented approach.

Keywords: Pro-environmental behavior, positive emotions, environmental interventions, affective images, qualitative research.

Sumário

A presente investigação pretendeu estudar a forma como o problema de facilitar comportamentos pró-ambiente pode ser abordado através de novas intervenções pró-ambiente. Este estudo tem particular relevância num período marcado simultaneamente pela actual discussão relativa ao impacto de inovações científicas e tecnológicas e pela consideração de novos resultados de estudos sobre emoções, que realçam a importância da emoção no processamento de informação. No entanto, o papel das emoções está ainda muito ausente da maioria dos estudos de comportamento pró-ambiental. Esta situação destaca a importância do desenvolvimento de iniciativas pessoais e profissionais que, estimulando reflexão, habilitem o desenvolvimento de investigação em comportamentos pró-ambiente, focando em aspectos relativos às emoções.

Optou-se por uma abordagem interpretativa, de tipo qualitativo, que decorreu em duas fases complementares. Numa primeira fase, procurou-se basicamente avaliar o impacto da investigação proposta. Envolveu diferentes colaborações e a realização do primeiro estudo experimental sob a forma de prova-de-conceito. Foram ainda desenvolvidos o novo modelo de comportamento pró-ambiente e o quadro de desenho de intervenções. A segunda fase do estudo, suscitada pelos resultados obtidos na primeira fase, conduziu ao desenvolvimento de cenários aplicados a intervenções orientadas às emoções e ao planeamento e implementação da sua avaliação. Esta iniciativa permitiu constatar as potencialidades tecnológicas de duas vertentes: Sistemas de recompensa com imagens afectivas utilizando meios digitais e aplicações de feedback sensorial utilizando meios não digitais. A investigação experimental planeada incluiu diferentes métodos e amostragem propositada. Como métodos de recolha de dados aplicaram-se questionários, realizaram-se entrevistas semi-estruturadas, realizaram-se painéis de discussão e observação de participantes e analisaram-se documentos.

Os resultados obtidos neste estudo têm diferentes implicações. Entre as mais significativas destacam-se: a) as potencialidades da utilização combinada de métodos de investigação no estudo das concepções e percepções individuais sobre comportamento ambiental; b) a importância de discussões sobre novas intervenções que facilitem o comportamento pró-ambiente; c) a pertinência de abordagens inter-disciplinares de investigação na consideração de novas opções tecnológicas aplicadas ao ambiente; e d) a relevância de considerar uma abordagem orientada à emoção.

Palavras-chave: Comportamento pró-ambiente, emoções positivas, intervenções ambientais, imagens afectivas, investigação qualitativa.

Glossary of Acronyms

AESAM	Affectively Evocative Smart Ambient Media
AI	Artificial Intelligence
ART	Attention Restoration Theory
CENSE	Center for Environmental and Sustainability Research
CENTRIA	Centro de Inteligência Artificial
CITI	Centro de Investigação para Tecnologias Interactivas
DCEA	Departamento de Ciências e Engenharia do Ambiente
DEAP	Developing Environmental Awareness with Persuasive systems
DESD	Decade of Education for Sustainable Development
DFE	Design for Environment
DIY	Do-it-yourself
ECOS	Environmental Consumer Observation System
EFD-E	Emotion-focused Design for Environment
EIS	Environmental Information System
EnvCom	Environmental Communication
EPI	Environmental Persuasive Interfaces
ESB	Environmentally Significant Behaviors
FCT/MCTES	Fundação para a Ciência e a Tecnologia/Ministério da Ciência, Tecnologia e Ensino Superior
HCI	Human-Computer Interaction
IAPS	International Affective Picture System
ICT	Information and Communication Technologies
LED	Light Emitting Diode
MMS	Multimedia Mobile Services
NFEE	Non-Formal Environmental Education
PC	Personal Computers
PT	Persuasive Technology
SAM	Self-Assessment Manikin
SAMAL	Smart Ambience for Affective Learning
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization

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CHAPTER 1. INTRODUCTION

Environmentally significant behaviors (ESB) in the private sphere are the behaviors of interest to this dissertation. Inadequate ESB include incorrect household waste disposal, irresponsible water use or wasting energy.

To handle this, environmental communication strategies are making appeals to individuals' pro-environmental behavior for decades. However, inadequate behaviors remain as very common. Hence, it is important to research new ways of supporting and facilitating pro-environmental behaviors.

A number of problems concerning environmental behavior have deserved special attention by the scientific community. In particular, interactivity and design for the sustainable development have established several research opportunities, for which many worldwide initiatives have contributed. The use of interactivity and design has known a great development and it is now present everywhere.

The study of problems concerning environmental behavior reflects the social relevance of this sustainability area and is still the goal of active research, with a variety of approaches. However, the role of emotions is still largely absent from most pro-environmental behavior studies.

This dissertation addresses the facilitating pro-environmental problem. A new model for understanding pro-environmental behaviors supported the emotion-oriented approach used to propose new pro-environmental interventions.

A qualitative research approach enabled to collect knowledge and research data from study participants about the facilitation of pro-environmental behavior through emotion-oriented interventions.

Relevant issues that guided this research include:

- What inadequate behaviors should be subject to intervention?
- What technology should implement new interventions?
- What testing approach should address the results of those interventions?

1.1 Why is environmental behavior related to “One”?

In 2005, “One”, a one-minute television ad became visible as part of a sustainable development and energy campaign for the Australian Sustainable Energy Authority Victoria.

This ad features a series of Victorians in everyday activities and places, while several questions emerge for concluding with one answer. It has this narration: “Q: How many joggers does it take?; Q: How many mothers does it take?; Q: How many golfers does it take?; Q: How many architects?; Q: How many students?; Q: How many teachers?; Q: How many dreamers?; Q: How many Victorians does it take to change a power station? A: One. – When you switch to a credited green power, you are changing the way your electricity is sourced. You are investing in the power of the sun, water and wind for a cleaner, brighter future. [Pause] Green Power, the power of every one.”¹

This ad is one of the 1243 existing ads in the United Nations Environmental Program (UNEP) creative gallery on sustainability communications (UNEP 2010). Although based in the light bulb joke that tends to be offensive in tone, this creators’ ad have reevaluated it intending to show that everyone can make a difference to the environment.

It proposes viewers to change their environmental behavior, namely their electricity consumption behaviors, to switch to more green energies, to invest in alternative energies, contributing to a brighter future. It gives emphasis to an emotive and creative suggestive format, emphasizing lifestyles and personal images. Evoking enthusiasm, and values such as altruism, familiarity leads to its emotional quality. The ad purposefully stimulates viewers’ senses by displaying Victorians’ activities and places of affective and valued attachment, while using music and aesthetical images. In addition, it combines a story line and a dialogue.

In fact, an essential part of information processing is emotional (Damásio 1994). In addition, action dispositions include emotions (Bradley and Lang 2000). Along with these advances in affective literature, emotion or affect may be a motivational factor influencing environmental behavior (Steg 2009). However, the role of emotion is largely absent from most pro-environmental behavior studies (Searles 2010). Exceptions include the work of Steg (2005) and Gaterleben (2007) which relates to car use, or the work of (Searles 2010) which points to the use of emotional appeals in pro-environmental behavior.

¹ Transcribed from video found on the UNEP creative gallery on sustainability communications website: <http://www.unep.fr/scp/communications/ad/details.asp?id=50283&cat=20>

The evidence presented by this particular study offers support for including emotional appeals in pro-environmental public service announcements as a means to influence the viewer. The study results suggest that enthusiasm reinforces an individual's positivity towards efforts to protect the environment, reinforcing prior beliefs, leading individuals to report an overall positive orientation, while anxiety appeals prove to be counterproductive with a significant and negative effect on participants' views towards the environment.

Drawing on these suggestions, this dissertation proposes that new interventions that make individuals evoke positive emotions while receiving behavior feedback may facilitate pro-environmental behaviors.

1.2 The facilitating pro-environmental behavior problem

The facilitating pro-environmental behavior problem as treated in this dissertation relates with studying the role of new emotion-oriented interventions for facilitating individual pro-environmental behavior.

The relation of the two, intervention and individual, consists in innovative interactions. Through interaction, individuals evoke positive emotions that lead to adequate moods for facilitating pro-environmental behavior.

Handling this problem considers a multi-disciplinary research approach. The approach includes finding out if pervasive and invisible computing techniques may apply into the development of new emotion-oriented interventions. These interventions consider behavior feedback, technology that fits peoples' lives and persuasion by reward.

This is a study within science and environmental engineering, aiming at innovation within pro-environmental behavior modeling, design for the environment and communication for sustainability. In fact, methods of this engineering and environmental systems analysis are used, but also needs to address environmental science knowledge.

This study gives emphasis to emotional perceptions and responses, as a way to contribute to the advancement of new interventions for environment aimed at facilitating pro-environment behavior. Thus, this study contributes to a new multi-disciplinary research area that is expanding.

Furthermore, this study has goals framed by interaction design, enabling to apply insights from interface design and user experience evaluation. It includes, for instance, contributions from the research field of persuasive technology (PT) or emotions and HCI.

This study is important as a contribution to many environmental related areas such as environmental communication, environmental psychology, environmental education and education for sustainable development.

1.3 Research process

This section begins with the definition of certain words and expressions used in this study.

Damásio (2001) writes about “emotions” in a very meaningful way to this work: “emotions are complicated collections of chemical and neural responses that form a pattern” (p. 72). This author explains that emotions play a regulatory role leading to the creation of circumstances advantageous to the organism that express that phenomenon. The various emotional responses are responsible for profound changes in both brain and body.

This work focuses on positive emotions, like joy, which is a primary emotion. In addition, approaching background emotions, such as well-being (Damásio 2001), is fundamental, once this is a concept related to environmental behaviors. Happiness is another relevant concept. To some people happiness relates to joy, while to others it means, for instance, peace of mind (Averill and More 2000). Nevertheless, happiness is always positive.

This study uses the expressions within emotion (for instance, emotional dispositions, mood, affective considerations, and emotional episodes) more or less interchangeably. However, specific related literature certainly addresses that variation (see for instance Russell and Snodgrass 1987).

Another expression, “pro-environmental behavior”, assumes different meanings in different contexts. In this work, pro-environment behavior is:

“behavior that consciously seeks to minimize the negative impact of one’s actions on the natural and built world” (Kollmuss and Agyeman 2002, p.240).

The expression “interventions for environment” refers to interactions between the environment and behavior such as for providing behavior feedback.

“Emotion-oriented intervention for environment” refers to integrating in the interventions different emotional appeals and different behavior feedback representations. Affectively evocative smart ambient media (AESAM) are advanced.

“Facilitating pro-environmental behavior” deals with a multi-disciplinary effort to help individuals minimize the environmental negative impact of their actions.

“Behavior feedback” refers to a stimuli intended to reinforce positive behavior. It considers affective images or other sensorial stimulus. This is the heart of the AESAM.

1.3.1 *Motivations and research goals*

The work presented in this dissertation started in 2005 with the conviction that the role of environmental information systems (EIS) in the transition towards sustainability may be fundamentally changed. At the heart of this idea was the hypothesis that one-way to facilitate everyday pro-environmental behaviors in individuals is to surround them with environmental argumentation in alternative sensorial forms.

The study started by focusing on persuasive technologies and interfaces for changing environmental behaviors. *Environmental Persuasive Interfaces*² (EPI) was the expression called to the new class of interfaces. At that time, the possibility of using new forms of computing emerged, such as photo-chemical computing, considering their low-cost and innovative computing methods³.

Changing environmental behaviors is important⁴, and the research and development of non-coercive persuasive strategies for supporting it may be considered. Technological means can trigger (and sustain) that changing process.

From the six sources of power that people can access to persuade other people, the coercive power (as the ability to give threaten punishment for non-compliance, see Hogg and Vaughan 2002, p. 239) is completely excluded within this work.

² “Environmental Persuasive Interfaces” was an expression first used in 2005 in the submission for the Ph.D. scholarship.

³ This particular method considered invisible inks to use over surfaces representing environmental information that would become visible by external inputs (such as light); considering it resulted from an academic link with the photochemical group (FCT/UNL).

⁴ See, for instance, the perspective of Vandenberg (2004): “Changes in environmental behavior are needed because as regulation has reduced the impact of large firms, the proportional role of individuals of pollution sources has increased”.

The reward power (the ability to give or promise rewards for compliance) and the informational power (the target's belief that the influencer has more information than oneself) are relevant.

The expert power (the target's belief that the influencer has generally greater expertise and knowledge than oneself) and the referent power (identification with, attraction to or respect for the source or influence) are also relevant. Finally, the legitimate power (the target's belief that a recognized power structure to command and make decisions authorizes the influencer) is not so relevant.

However, at that time, there was a need to develop new approaches within how to conceptualize and assess new persuasive technologies for environment. Many research challenges emerged while linking environmental behaviors and new technological approaches for pro-environmental behavior. Those challenges certainly framed the motivations for this study.

The general goal of this research⁵ was to define academic challenges and real life problems concerning access to environmental information in a citizenship framework. Then, express concrete research questions, which answer would enable knowledge advancement in this area.

The methodology should enable to, when applied to evidence, provide answers to the following research questions: are new forms of computing (such as photochemical computing) valuable within ubiquitous computing? Is ubiquitous computing fruitful for environmental info-inclusion? Are new interfaces effective for changing citizens' behaviors leading them to be more environmentally responsible?

Designing, analyzing, implementing, and testing innovative products for different scenarios were phases to consider within achieving the research goal. Research should also address new products use by special needs citizens and promoting info-inclusive social spaces while converging to environmental awareness campaigns.

This study considers a multidisciplinary approach. For instance, studying persuasive communication through technology involved finding information on behaviors and persuasion, social influence and communication.

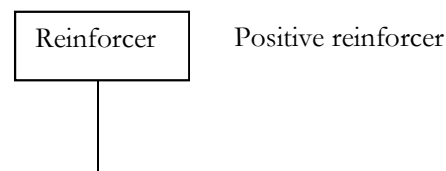
In fact, communication is the essence of social interaction (Hogg and Vaughan 2002) involving interrelationships between people and requiring that people acquire a shared

⁵ As proposed in FCT/MCTES scholarship application.

understanding of what particular sounds, words, signs and gestures means. People influence others and are in turn influenced by them through communication.

At this point, non-verbal communication and cues take an important space. In non-verbal communication between two people, means other than written or spoken language enable to transfer meaningful information. Gaze, facial expression, posture and touch are options to consider. Then, the interaction between people and an interface that provide non-verbal communication about behavior, such as behavior feedback is a strategy to consider.

This strategy of providing behavior feedback takes a “reward system” psychological approach. Rewarding is a process that reinforces behavior. It is something that when offered causes an increase in a behavior intensity (see Figure 1-1).



- Any stimulus, event, or condition
- whose presentation immediately follows a response
- and increases the frequency of that response

Figure 1-1 Defining reinforce
(According to Suarez 2004)

Rewards (and reinforcement will be used similarly) are considered an operational concept used to describe the positive value given by an individual to an object, behavior act or other inner state. Most important is to consider that rewards apply to behavioral choices that maximize them. In positive reinforcement, a stimulus follows behavior and, as a result, the rate of that behavior increases.

Intrinsic motivation studies (Pierce and Cheney 2008) show that in general rewards effectively enhance or maintain an individual’s intrinsic interest in activities. Specifically, verbal rewards (positive feedback) increase people’s performance and interest on tasks, while tangible rewards increase performance and interest for activities that were initially boring or uninteresting.

In addition, rewards serve as incentives by attracting goal pursuit. Values, such as altruism, can be rewarding, but these do not cause sensation; other rewards, positive emotions-based cause sensations.

In the case of considering positive emotions-based rewards, three main challenges are pointed: 1) how to select stimuli that act as positive emotions prompts while being behavior feedback, 2) when to provide the reward and 3) how to integrate those stimuli in new pro-environmental behavior tools.

In particular, the emotional reaction to affective images and to other sensorial visual stimuli while being behavior feedback emerged as important to this study.

In order to address these challenges, the following considerations arise:

- Emotional reactions to pictures affect behavior, in this case, pro-environmental behavior, enabling to model new emotional-oriented approaches generating new research insights.
- Behavior feedback should be real time, as would be a human-to-human-communication process. Non-verbal pictorial cues (grounded on pictures and color) are a communication priority.
- If the reinforcer is to strengthen a particular behavior response, it must immediately follow that response. According to Suarez (2004) 60-second is the limit. The direct effect of reinforcers, drops off quickly as the delay is increased.

Emotions in particular emotional reactions to pictures⁶ enable consider new studies within pro-environmental behavior. However, those were still almost inexistent⁷. This constituted both a motivation and a challenge.

Thus, it was possible to propose that the interactive exploration of an emotional dimension within pro-environmental behavior could draw new cases and interventions, extending environmental communication. The role of *emotion-oriented interventions* emerged.

Beyond interfaces that mostly relate to computer screens, many other interventions may be considered. Also, due to the changing environmental behavior practical research complexity (it

⁶ Damásio (2010) was an important information source.

⁷ As referred by Searles (2010).

would have been another research to prove that the interventions really change behaviors, involving different goals and methodology), it was first updated from changing to shaping environmental behavior and then further simplified, in this dissertation, to facilitating pro-environmental behavior. In other words, the facilitation of pro-environmental behavior may influence behavior shaping and further changing process.

Facilitating pro-environmental behaviors in this dissertation is, then, a problem that involves the design of affectively evocative smart ambient media (AESAM) that provide behavior feedback, fit people's lives and intend to persuade through a reward system approach.

The research goal was, in some way reorganized, as to also contribute to a design framework that supports the design of emotion-oriented interventions for environment, having still a persuasive communicative intent. Such a design framework is not a replacement for existing approaches; rather, it is a contribution to the discussion and analysis of environmental information and communication strategies.

The subsequent creation of a collection of concepts and examples of how such interventions may become integral parts of everyday environments, enabled discussion and reflection about this research.

This study involved a qualitative research approach (Maxwell 1998; Holstein and Gubrium 1998; Denzin and Lincoln 2000; Savenye and Robinson 2001; Flick 2007; Bowen 2009). Several individuals participated in the overall research that involved survey studies using questionnaires specifically created for this research, discussion meetings, interviews and a final discussion panel.

Overall, this research has an interpretative approach, seeking participants' accounts of how they make sense of the environment, environmental behaviors and emotions, and of technology. It takes a processes perspective, namely about facilitating pro-environmental behaviors (also considers shaping and changing behaviors).

This study addressed the research topics in a very open manner, letting new conceptual frameworks emerge from both the work within the literature review and the collected and analyzed research material.

1.3.2 *Research questions of the qualitative research*

The central elements of this study and heart of the qualitative research design are the research questions. Research questions main functions were to help focusing the study and give guidance for how to conduct it.

This involved the selection of questions (see Table 1-1) that suited the process approach, namely about:

- the meaning of pro-environmental behaviors to participants involved in those;
- the influence of physical, social and technological context on those events and activities;
- the importance of emotional perceptions about environmental issues and technology.

This dissertation includes the following studies:

- First study “Survey study” goals: examine the representations of the impact of automatic systems and just-in-time sensorial feedback on individuals’ environmental behavior awareness for facilitating pro-environmental behavior.
- Second study “Early proof-of-concept meetings” goals: understand if participants welcome environmental behavior feedback tools and if participants understand the concept of having tools that express interactive sensorial arguments as behavior feedback.
- Third study “Analyzing affective images from IAPS” goals: this study aimed at understanding the emotional impact of pictures of environmental landscapes and related elements.
- Fourth study “Interviews” goals: this study intended to understand if affective pictures are part of participants’ environmental actions plans and behaviors and if participants were interested in the theme “emotion-oriented interventions”.
- Fifth study “An approach to the AESAM evaluation” goals: this study was developed with the intent of supporting the exploration of the new interventions scenarios that integrate an emotional orientation for facilitating pro-environmental behavior.
- Sixth study “Document analysis: scientific-fiction and pro-environmental behavior” goals: assess participants perceptions and notions about science and technology possibilities within environmental behavior; values and emotions; affective images.

Table 1-1 Summary of research questions

	<i>Relationship</i>	
RQ1	Can automatic systems and behavioral sensorial just-in-time feedback facilitate pro-environmental behavior?	Chapter 3
RQ2	Can automatic systems and behavioral sensorial just-in-time feedback positively influence environmental behavior awareness perceived by individuals?	Questionnaire “My Environmental Behavior and ICT”
RQ3	Does the effect of automatic systems and behavioral sensorial just-in-time feedback on facilitating pro-environmental behavior mediate the environmental behavior awareness perceived by individuals?	
RQ4	Can facilitated pro-environmental behavior positively influence individuals’ behavior changes?	
RQ5	Are environmental behavior feedback tools welcome?	
RQ6	Is the concept of expressing interactive sensorial arguments understandable?	Chapter 6, 6.2 Proof-of-concept Meetings
RQ7	Do photographs of environmental landscapes and related elements have emotional impact?	Chapter 6, 6.3 IAPS interpretative study
RQ8	Have affective images a positive effect on increasing motivation for adequate environmental behavior?	Chapter 6, 6.5 Interviews
RQ9	Have affective images a positive effect on happiness and enthusiasm?	
RQ10	Have affective images a positive effect on playfulness?	
RQ11	Have increased motivation a positive effect on pro-environment behavior achievement?	
RQ12	Can environmental episodes influence emotional experiences?	Chapter 6, 6.6 AESAM evaluation
RQ13	Are environmental episodes related to the proposed emotion-oriented interventions for environment?	
RQ14	Do emotion-oriented interventions impact emotional experiences?	
RQ15	Is facilitated pro-environmental behavior positively influenced by individuals’ emotional experience?	
RQ16	What kind of affective images do participants select?	Chapter 6, 6.7 Scientific-fiction
RQ17	What kind of social images of science and technology do participants advance?	

Interviews, questionnaires and panels, many times combining methods, enabled collecting research material. Visual materials supported the data collection. The dissertation includes the results and discusses the research questions, supported when appropriate by literature links.

The participants in the several study phases are strongly familiarized with the technological and/or environmental knowledge domains. Therefore, they represent a skilled and knowledgeable minority, different from the majority of environmental systems everyday user.

This experimental research involved a total of fifty-five volunteers' participants within:

- FCT/UNL students
- Environmental experts
- Project DEAP⁸ members
- Other, included interested family and friends

Due to the possibility of developing new knowledge and meaning, extendable to other cases and contexts, talking about research “transferability” instead of “generalizability” seems acceptable in this study.

However, as the participants represent a minority, it is therefore important to clarify how the results can be transferable to other contexts. The qualitative research conclusions (see section 6.8) address this issue.

The qualitative studies required an open-ended strategy with the goals of generating results that are understandable and experimentally sound and engage in collaborative research with environmental and technological practitioners.

Next section provides a synthesis of the research phases.

⁸ Teresa Romão from CITI-DI-FCT/UNL coordinates the DEAP project –Developing Environmental Awareness with Persuasive systems project (2010-2012).

⁹ Guba and Lincoln (1989) in Maxwell (1998) advance this transferability idea.

1.3.3 *Synthesis of the research phases*

The research work involved two complementary phases that intended to answer specific goals through distinct approaches.

Within the first phase, the goal was to study if and how EPI could be conceptualized and further developed by using pervasive and invisible computing. It has involved different collaborations, namely within the SEEK¹⁰ and YInvisible¹¹ projects. In addition, an effort of collaboration with the electronics department started. This effort reflected an opportunity for a joint project relating electronics and environment.

This phase included the first experimental study as a proof-of-concept approach and advanced the first model of pro-environmental behavior and design framework. The author of this dissertation presented results of this phase in two international conferences (in Oulu, Finland and in Torino, Italy).

The overall analysis of the information gathered within the first phase suggested and motivated the implementation of the second phase. This had a re-orientation, by detecting initially unsuspected but relevant issues to the study.

The limitations relate mainly to the unanticipated restrictions of technology development and use that would limit prototype developments.

In fact, within the YInvisible projects, the access to developments was completely restricted due to patents submissions. The electronic student interested in developing a prototype as his final degree project started to work outside the faculty and in relation to the SEEK project, uncertainty was related with how students would handle project themes for further practical developments.

This strongly led to the wish of focusing, for the second research phase, on an interpretative approach, based on qualitative research. This initiative focused on 1) advancing technological scenarios that could support discussion, 2) select study participants, and 3) design qualitative studies that could contribute to the research goal.

¹⁰ SEEK project, Strategic Experiences for Environmental Knowledge, coordinated by Teresa Romão (CITI-DI-FCT/UNL), preceded the Developing Environmental Awareness with Persuasive Systems (DEAP) project.

¹¹ YInvisible project was an YDreams project involving academia and industrial links.

It has involved the study of affective images from IAPS, but also involved environmental experts within the interviews study, and project DEAP members, both in a panel discussion and in the exercise of writing a scientific-fiction story related to pro-environmental behavior.

This phase included the design of four different questionnaires to collected research data: “My Environmental Behavior and ICT”, “Enthusiasm and Playfulness for Pro-Environmental Behavior”, “Emotional Pro-environmental episode” and “Evaluation of AESAM”.

In this second phase, the different research approaches enabled to stimulate reflection about: 1) environmental behavioral aspects, 2) related emotional issues, 3) science and technology potentialities for developing interventions for facilitating environmental behavior and 4) related issues that may limit or be an incentive to pro-environmental behavior.

Simultaneously, it was a constant goal to support the research activities within the DEAP project, namely by sharing environmental insights needed to conceptualize and implement new interventions.

Next section presents the study main contributions.

1.4 Contributions

The contributions of this dissertation are not restricted to a single domain but rather aim at different aspects of environmental sciences, and pro-environmental behavior studies in particular. The areas potentially benefited involve environmental communication, ESB modeling, design for sustainability and education for sustainable development.

This dissertation considers emotion-oriented interventions that support the facilitation of pro-environmental behavior. It introduces automatic systems and real time behavior feedback. Each proposed intervention addresses a particular pro-environmental behavior problem.

In addition to the modeling and design approaches, this dissertation presents a qualitative research and discusses results. The research results analysis enable to discuss the usefulness of integrating emotional appeals within affectively evocative interventions for facilitating pro-environmental behavior.

In summary, the main contributions include:

- Development of a new model of facilitating pro-environmental behaviors;
- Development of an EFD-E framework;
- Definition of requirements and needs of new interventions on the environment;
- Proposal of affectively evocative interventions for environment, namely affective images rewarding systems and sensorial feedback tools;
- Presentation of interventions for different pro-environmental behaviors, describing the design of sensorial stimulations, namely visual and interactivity;
- Implementation of qualitative research studies.

1.5 Overview

Beyond this introductory chapter, Chapter 2 discusses environmental behavior interventions. Chapter 3 formulates the new model of pro-environmental behavior and discusses the approach using a research model. Chapter 4 considers the design of new emotion-oriented interventions. Such design framework supports the proposal of the interventions presented in Chapter 5. Chapter 6 presents the qualitative research and discusses results. Finally, Chapter 7 discusses the overall work together with possible future research directions, and presents some conclusions.

This dissertation presents the research in successive chapters, including the model and the design framework, before presenting the interventions. Therefore, chapters should be read sequentially, although each chapter was kept with a reasonable amount of autonomy, by having clear distinctive objectives.

This organization also intends to facilitate the analysis of not only the decisions taken along the research process, but also of the limitations, achievements, and curiosities involved in such a doctoral process.

The added appendices comprise experimental research materials, reported work and research links. Appendix A includes the questionnaire used to analyze the model of pro-

environmental behavior (Chapter 3). Appendix B describes the study materials of the interviews. Appendix C includes the final study research tools. Appendix D presents the scientific-fiction story prototype. Appendix E, presents the reported work and, finally, Appendix F presents the research links (teams and places).

CHAPTER 2. ENVIRONMENTAL BEHAVIOR INTERVENTIONS

This chapter addresses new pro-environmental behavior interventions, starting with an emotional approach to pro-environmental behavior in section 2.1. Section 2.2 discusses pro-environmental transitions. Section 2.3 focuses on environmental behavior and technology. Section 2.4 concludes this chapter.

2.1 An emotional approach to pro-environmental behavior

This work handles the emotional engagement of individuals two ways: it considers the emotional aspect within the person's relationship to an environment and the emotional reaction to images of the environment (and other visual sensorial options).

A person's relationship to such an entity as an environment is complex and difficult to understand, but a key aspect of this relationship is emotional (Russell and Snodgrass 1987). According to these authors, the relationship between an individual and the environment is such that the affective quality of an environment (estimated, perceived, or remembered) influences behaviors, rather than by its objective properties directly. For them, affective quality is a guide for much of individuals' relationship with a place (what to do there, how well it is done, how soon to leave, whether or not to return). Afterwards, individuals' remember little more about a place than its emotional quality. This emotional quality is also important for the cumulative influence of the environment on mood, subjective well-being and health.

According to Russell and Snodgrass an individuals' encounter with an environment involve three steps, which distinction is also relevant for the present research: 1) Before entering the environment, 2) Effects of the environment, 3) Activity in the environment and the effects of mood.

- Step 1: Before entering the environment – In this step, highlight is given to the importance of plans which may be seen as an intended sequence of acts leading to a goal; this provides a perspective from which individuals attempts to control emotional states by choosing what to do and where to go. There are also emotional consequences to failures of the plan, disruptions and unexpected events. In fact, planning requires affective consideration of the events planned. Also important is to consider that the best prediction of a person's mood in a particular place may be the prior mood (persons in a more pleasant prior mood rated settings as more pleasant). In addition, expectations play

a role in how elements of a place are affectively considered. Indeed, even before a certain event happens, expectations alter mood.

- Step 2: Effects of the environment – beyond the imperceptible, sensory experiences within an environment are affectively charged. Pleasantness and arousal quality ratings of sound, temperature, color, or other single sensory dimensions may be collected leading to evidence about their potentiality for mood altering. Examples include comfortableness of different temperatures, the actual mood altering of noise, or the improved mood by sunlight or the consistency in the affective appraisal of colors. The meaning of a place is also relevant, this is, the places and objects of the physical world are meaningful. They are located in a familiar 3D world enabling interpretation. Another relevant effect of the environment on the individuals is the physical presence of another person, which makes vary the perceived arousal (that increases with presence). Interpersonal closeness and spatial density also have influence on pro-social and antisocial behaviors.
- Step 3: Activity in the environment and the effects of mood – The fundamental fact of the last step is that an environment alters mood. This change in mood and emotional state, influence what individuals think in that place. For instance, once being in a place, the mood created may affect the length of time spent there. Regarding behavior, creating a pleasant mood appears to increase the positive or pro-social quality of behavior. An unpleasant mood increases antisocial behavior. Increasing the pleasantness of mood by, for example, providing a gift, food, drink, or pleasant surroundings increases the rated liking for the present environment, acceptability of sociopolitical slogans, and attractiveness of consumer products, for instance.

In addition, the aftereffects are relevant to consider, meaning that leaving a place does not end its influence. The mood created by a place can continue to influence behavior even after leaving.

At this point, after these initial considerations about ones relation to a place or environment, it is relevant to consider what activates emotions. Damásio (2010)¹² explains that emotions work:

“(…) de uma forma muito simples, por imagens de objectos ou acontecimentos que estão realmente a ter lugar no momento ou que, tendo ocorrido no passado, estão

¹² Damásio current research topics include “The neurobiology of mind and behavior, with an emphasis on emotion, decision-making, memory, communication, and creativity”. (<http://www.usc.edu/programs/neuroscience/faculty/profile.php?fid=27>).

agora a ser evocadas. A situação em que nos encontramos é importante para o aparelho emocional. Podemos estar a viver uma cena da nossa vida e a reagir a uma situação musical, ou à presença de um amigo; ou podemos estar sozinhos e a recordar uma conversa que nos deixou perturbados na véspera. Quer sejam <<ao vivo>>, reconstruídas a partir da memória, ou criadas de raiz na imaginação, as imagens iniciam uma cadeia de fenómenos.” (Damásio 2010, p.145).

In fact, emotions evolved from simple reflexive actions, many of each are still part of human response repertoire (e.g. among the very primitive and general responses are movements toward positive, appetitive things and movements away from negative, unpleasant things). Humans support more responses, organizing them in a variety of combinations, better facilitating adaptation to the environment (Bradley and Land 2000).

Stimuli evoke a limited menu of specific behaviors, though not always immediately nor automatically. Natural language facilitates selective control of responses and helps organizing behavior in the service of long-term goals. Thus, not only has behavior more variations, but also the functional apprehension of time itself – as a dimension of behavioral organizations – has expanded (Bradley and Land 2000).

Table 2-1 includes a list of emotion representative responses (Bradley and Lang 2000).

Table 2-1 Events and representative responses description (Bradley and Lang 2000)

Event	Responses description
Physiological events	
Viscera	Cardiovascular system, sweat glands, tear ducts, pilo-motor response, gut mobility, genitals
Facial muscle patterns	Corrugator, temporalis, masseter, zygomaticus
Other somatic muscle	Head and neck, action muscles of the limbs, overall tension (general activation of the motor pool)
Respiration	Rate, depth, variability; expired CO ₂ , airway resistance
Endocrine and immune system	Antibodies; circulating epinephrine, norepinephrine, testosterone, cortisol
Brain	Bioelectric events, regional blood flow, neurochemistry (synaptic transmitter systems – dopamine, glutamate)
Language events	
Expressive language	Distress cries, prosody, changes in voice intensity and frequency
Evaluative reports	Expressed feelings, attitudes, interests
Social communication	Facilitated or disrupted communication, instrumental emotion: placating, “mobbing”, verbal aggression, inhibition
Behavioral events	
Direct actions	Approach, avoidance, escape, attack, defensive reflexes, appetitive, reflexes, consummation, nurturance
Task enhancement and deficits	State-mediated effects on response latency, amplitude, and organization, reflex modulation

Emotion works when images processed in the brain activate a series of regions that drive emotions and consequent outputs (Damásio 2010).

Damásio explains that another important fact in humans is to consider the coming to mind of ideas and plans. For instance, a negative emotion like sadness leads to the invocation of ideas about negative facts; while a positive emotion does the opposite; action plans represented in the mind are in line with the general emotional tone.

The combination of all those reactions constitutes the emotional state that develops in a relatively fast way and then starts to fade until new stimuli that are able to drive emotions are introduced in the mind leading to a new cascade of emotional reactions.

Feelings of emotion constitute the next phase: the emotion-feeling cycle starts in the brain with the perception and evaluation of a potential stimulus for causing emotion, and the subsequent initiation of an emotion. Then, the process spreads by the brain and body, intensifying the emotional state. In the final phase, the process returns to the brain to the cycle part related to feeling (in different brain regions, though, from the ones that have initiated the cycle).

Feelings are then generated by emotions (Damásio 2001) and it is through feelings (that are private) that emotions (that are public) start to impact the mind. Damásio identifies three phases on this process: emotional state (can be triggered and executed in a non-conscious way); feeling state (can be represented in a non-conscious way); and being aware of a feeling state (known by the organism that have experienced the emotion and the feeling). Thus, conscience needs to be present in order to feelings influence the subject that has those. Therefore, the ultimate consequences of emotions and feelings depend on conscience.

Emotion's outputs in behavior, language and physiology can be constructed three dimensionally (Figure 2-1, Bradley and Lang 2000). Locations within this space define affective states, specified by internal coordinates of the three data systems.

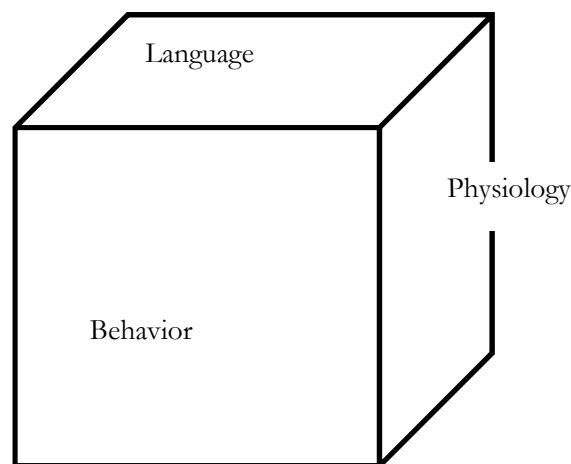


Figure 2-1 The data of emotion

In the view of Bradley and Lang (2000), emotions work as activation in a motive system and the consequent actions enable indexing them.

According to Damásio (2010) emotions are initiated by object images or events that are happening in the moment or that, having occurred in the past are being evoked in the present. Live images, rebuilt images from memory, or built images from imagination - images trigger a series of phenomena.

Then a very important research line to consider is the affective reactions to pictures and other stimuli like sounds. To study emotion in the laboratory, stimuli that reliably evoke psychological and physiological responses are required. Stimulus collections (see the work of the Center for the Study of Emotion and Attention; Lang *et al.* 2008) including color photographs (e.g. IAPS – International Affective Picture System) and digitized sounds (e.g. IADS – International Affective Digitized Sounds System) and verbal stimuli (e.g. ANEW – Affective Norms for English Words) have been developed.

At this point, it is important to highlight that real environmental scenery and landscapes and their representations such as through color photographs (or video) certainly constitute emotional stimuli. Environmental communication uses those for different mixed-media approaches (see 4.1.3).

Visual communication is a rapidly evolving field, many works have been approaching all the involved processes, dominant theories, and different media (see Smith 2005). Aesthetics, perception, representation, narrative and cultural studies are just a few of the involved disciplinary areas.

Studies within visual communication relate to a wide scope of different media, ranging from content analysis of representation of newspapers, to children's comprehension of visual images in TV or analysis of political TV ads.

An area that seems to be able to add value within the visual communication field is the one that relates environmental photographic images to individual emotional reaction as to impact individual behavior perceptions in a certain place.

As told in the beginning of this section, sensory experiences within an environment have affective charge affecting the pleasantness of the perceived local. Then, using images in places, as part of behavior feedback, may affect the emotional state of observers.

While analyzing how to impact emotionally individuals (as observers) through pictorial characteristics, important differences may be pointed in the development of emotional reactions, between positive visual environments and negative visual environments:

- Positive visual environments are mostly related to natural environment, encompassing all living and non-living things that occur naturally on Earth (such as ecological units working as natural systems, including vegetation, soil, atmosphere, water (oceans, rivers, lakes) and the all visible phenomena that occur within their interfaces (e.g. tides). These natural elements transmit quietness, happiness, many times excitement. In contrast with the natural environment, humans strongly influence the built environment, but may also provide positive visual environments.
- Negative visual environments are essentially linked to natural disasters, or other natural catastrophes and hazards (such as floods, fires, tornados, hurricanes, volcanic eruptions, earthquakes or landslides), many times associated with the climate change and the global warming problem. They lead to losses, environmental, financial or human. Vulnerability, stress, pain, terror, and anxiety are expected reactions.

Figure 2-2 and Figure 2-3 illustrate this difference.



Polar bear and cub sleeping



Coastline



Leaves



Cumulus cloud



Agricultural field



Falls

Figure 2-2 Stimuli for positive emotions

(Images are Corbis)



Forest fire



Polar bears on melting ice



Hurricane



Quake and tsunami



Tornado



Eruption

Figure 2-3 Stimuli for negative emotions

(Images are Corbis)

What emotions have these images caused in the reader? Which images provide a sense of joy, happiness; relax? Which images provide excitement? Sadness? Fear? Anxiety? Which images would make the reader trigger pro-environmental behavior?

Laboratory settings study the emotional reactions to images, and that is relevant to this study. In the laboratory, emotions are measured within affective valence (ranging from pleasant to unpleasant) and arousal (ranging from calm to excited). A third dimension is dominance or control.

To assess the three dimensions of valence, arousal and dominance, the Self-Assessment Manikin (SAM), an affective rating system, may be used (Lang *et al.* 2008). In this system, a graphic figure (see Figure 2-4) depicting values along each of the three dimensions on a continuously varying scale indicates emotional reactions.

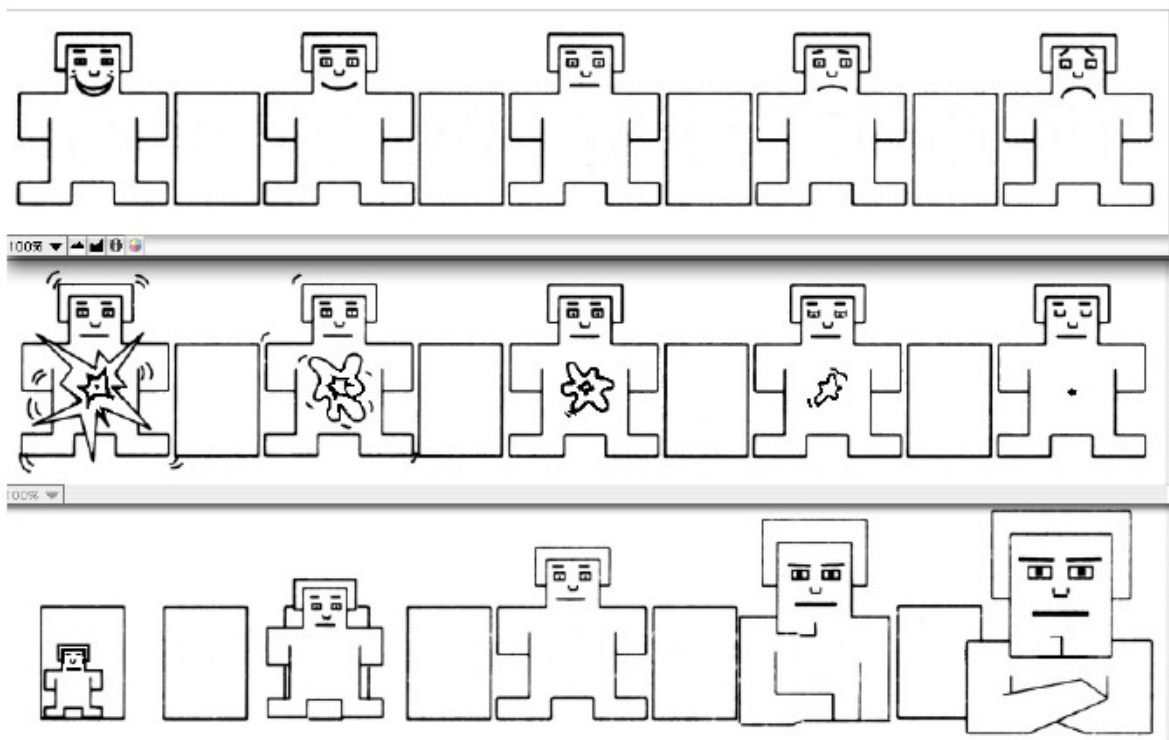


Figure 2-4 Paper-and pencil SAM booklet

Different studies used SAM, including the study of the emotional responses to color across media; in particular, Suk and Irtle 2010 studied the relationship between color attributes and emotional dimensions (valence, arousal and dominance).

2.2 Pro-environmental behavior transitions

There is evidence that behavior transitions have important functions for environmental sustainability. The transitions to more adequate environmental behaviors address both an environmental communication (EnvCom) and environmental psychology views. The first intent is to reach individuals and communities, the second tries to develop understanding on the processes behind behaviors.

Regarding environmental communications strategies, the effectiveness of a communication strategy largely depends on the ability of its messages to catch attention and understanding by an audience. Therefore, messages design should suit specific audiences' characteristics (such as education horizon and aspirations). In addition, they should fit the media selected.

For the message to be successful, the information should be accessible, verifiable, timely, accurate, complete and relevant. Most importantly, the positioning of a message should enable to identify a message focus or theme according to the strategy's objective. The message should be attractive and persuasive by using psychological or social appeals such as incentives/rewards. Carefully pre-test visual messages, per media and groups of beneficiaries, save time and money, and have an educational value.

EnvCom relates closely to non-formal environmental education (NFEE) defined by OECD (1999) as:

“learning processes encompassing knowledge, values, socio-economic and technical skills related to procedures that facilitate the change of norms and practices towards sustainable development through problem-solving action” (p.8)

Research on environmental behaviors should focus on the relationship between interventions and individuals. Environmental psychology, by recognizing that the physical context of human behavior is important (Gifford 2007), has a major role in studying those relationships.

The origins and scope of environmental psychology may be found for instance in the Handbook of Environmental Psychology by Stokols and Altman (1987) which also refers processes of person-environment transaction, including the “Emotion and the Environment” transaction which general ideas have been introduced in the previous section.

Psychological research gave attention to proximate levels, and mostly to resource management; more recently, it addresses larger issues, such as the perception of landscapes, traffic management or urban design. A collection of works highlights this trend (see Gifford 2007 for a review).

According to Gifford (2007) the following seven articles in environmental psychology have been developed in recent years: (1) interest in public policy, (2) a concern with technology, (3) connection with other disciplines, (4) multilevel analyses, (5) the incorporation of new ideas, (6) a focus on sustainability, and (7) scientific interest in the biotic and ecological world.

First, the perspectives and involvement of citizens must be an essential part of policymaking, thus understanding public participation process and to facilitate it is important (e.g. recycling motivators, urban traffic management).

Second, assuming that individuals are motivated and skilled, technology can contribute to environmental sustainability. As many new technologies appear every year, research on understanding its receptivity or not by citizens is relevant.

Third, there is a need for pioneering multi-collaboration between different disciplines.

Fourth, fruitful results can emerge in a multi-level analysis, from the proximate level with a focus on individuals and small groups (often in lab environments) to the consideration of larger level sustainability analysis (beyond resource management), expanding concepts to urban level, for instance, increasing green urban designs, improving transportation efficiency and providing affordable housing. At even a larger scale, scholars have gone further, researching psychological aspects of global warming or the global water shortages.

Fifth, incorporating perspectives from other disciplines brings new ideas. Social and economic perspectives are important sources of sustainability understanding. This dissertation further suggests that studies on emotion processing may also start contributing to understanding environmental behaviors.

Sixth, also important is to consider that the concept of sustainability in environmental psychology has evolved from resource management applications to other constructs such as quality of life.

Seventh, another trend is to expand research to the non-human biological world, because sustainability includes issues related to fauna and flora.

In a proximate level, achieving sustainable development involves changes in individual environmental behavior. Individuals' environmentally significant behavior remains a front line area in research. ESB in the private sphere—those behaviors that directly affect resource consumption or cause pollution—are receiving attention as targets of change (Stern 2005).

Individuals' ESB may be at least of four types (Stern 2005):

- Committed activism – this corresponds to active involvement in organizations and political demonstrations, supporting public policies that affect the environment.
- Non-activist support of environmentally relevant public policies – financial contributions to organizations and support for policies that affect the environment.
- Influences of individuals on the environment by affecting the actions of organizations to which they belong.
- Personal, private-sphere – this relates to the purchase, use, and disposal of personal and household products that have environmental impact. This is the type relevant to this thesis and it is useful to make finer distinctions among these behaviors according to types of decisions:
 - the purchase of major personal goods and services that have significant environmental impact in their manufacture or use, e.g., automobiles, home heating and cooling systems, recreational travel;
 - the use and maintenance of environmentally important goods, e.g., driving cars, setting home thermostats;
 - household waste disposal;
 - and everyday “green” consumerism (purchasing practices that consider the environmental impact of production processes, e.g., purchasing recycled products or organically grown foods).

Scholars tried to model pro-environmental behaviors. An early linear model of pro-environmental behavior (Kollmuss and Agyeman 2002) considered the idea that environmental knowledge leads to environmental awareness and consequently to pro-environmental behavior.

The model considered that informing and educating people about environmental issues would automatically result in more pro-environmental behavior. As this would not happen directly,

those early models identified environmental information distribution deficits but also deficient public understanding of environmental matters.

In most cases, increases in knowledge and awareness do not lead to pro-environmental behavior. Research tried to explain this gap. An important issue to consider is direct versus indirect experiences. Direct experiences have stronger influences on people's behavior than indirect experiences.

Attitudes do not determine behavior directly; rather they influence behavioral intentions, which in turn shape people's actions. Additionally, social (or normative) pressures also influence intentions.

It is recurrent in pro-environmental research that holding pro-environmental attitudes does not lead to pro-environmental behaviors. This is called the "value-action" gap. This reported gap existence challenges environmental communications activity, although there is slowness in abandoning a dependence on information-led interventions.

According to Stern (2005) not only self-will shapes individual ESB, but also a variety of other factors (Table 2-2) including contextual factors, personal capabilities, habit and routine and attitudinal factors.

However, this author does not point explicitly emotion as a variable that influences ESB. His contribution is relevant in the sense of its consideration of the fact that the stronger the contextual influences, the less important are the personal factors on individuals' ESB (Stern 2005).

Table 2-2 Variables influencing ESB (Stern 2005)

Contextual factors (constraint and facilitation)
<ul style="list-style-type: none">• Available technology• Embodied environmental impact• Legal and regulatory requirements• Material costs and rewards• Convenience• Social norms
Personal Capabilities
<ul style="list-style-type: none">• Financial resources• Literacy• Social status• Behavior-specific knowledge and skills
Habit and routine
Attitudinal factors
<ul style="list-style-type: none">• Personal values• General environmentalist predisposition• Behavior-specific norms and beliefs• Non-environmental attitudes, e.g. about product attributes• Perceived costs and benefits of action

This pattern of influences implies that control over irresistible technology means control over behavior. Behavior feedback, as a technological possibility, can then influence behavior.

Grob's (1995) model of environmental behavior already includes an emotion component. Its emotion component includes the emotional value, placed by an individual on aspects of the environment and the disturbance resulting from his or her perception of the discrepancy between ideal and actual environmental conditions.

This model includes the assumption that the more intense the emotions with which individuals react to a worsening state of the environment, the more appropriately they will behave. In addition, the model assumes that the more disturbed a person is by discrepancies between ideal and actual actions, the more appropriately she or he will behave. However, the author points to the scarcity of empirical evidence for his hypothesis.

Another model of pro-environmental behavior includes an "Emotional involvement" component, and further it considers negative or insufficient feedback about behavior as barrier to pro-environmental behavior (Kollmuss and Agyeman 2002).

Steg (2009) and Geller (2002) considered affect as a key issue for the effectiveness of promoting pro-environmental behavior. Table 2-3 includes this and their other pointed key issues for encouraging pro-environmental behavior.

Table 2-3 Key issues for encouraging pro-environmental behavior (Steg and Vlek 2009)

<p>Which behaviors should be changed to improve environmental quality?</p> <ul style="list-style-type: none"> • Select behaviors having significant negative environmental impacts • Assess the feasibility of behavior changes • Assess baseline levels of target behaviors • Identify groups to be targeted
<p>Which factors determine the relevant behavior?</p> <ul style="list-style-type: none"> • Perceived costs and benefits • Moral and normative concerns • Affect • Contextual factors • Habits
<p>Which interventions could best be applied to encourage pro-environmental behavior?</p> <ul style="list-style-type: none"> • Informational strategies (information, persuasion, social support and role models, public participation) • Structural strategies (availability of products and services, legal regulation, financial strategies)
<p>What are the effects of interventions?</p> <ul style="list-style-type: none"> • Changes in behavioral determinants • Changes in behaviors • Changes in environmental quality • Changes in individuals' quality of life • Structural strategies

An important conclusion from this literature is that although the concept of sustainable development is such an emotive one (it evokes future generation's needs¹³) one could expect that

¹³ Rauschmayer *et al.* (2010) proposed recently a theory about refocusing on sustainable development needs, capabilities and well-being for sustainability transitions. The concept of needs (of present and future generations) is central to the sustainable development Brundtland definition. However, as pointed by Rauschmayer *et al.* (2010) it has rarely been explored within sustainability science and policy making. Discussion focuses frequently on goods and services, economic capital, decision making and many other frameworks and models; and so far, it seems that there was not an active transition towards sustainable development. Rauschmayer *et al.* (2010) propose then a refocusing on needs, capabilities and quality of life, and they refer that an awareness of needs being met is accompanied by positive emotions (and a decrease in negative emotions). Therefore, beyond the commonly used division between environmental, economic and social concerns, in their research, they look for developing a more appealing concept of SD by creating robust links to notions such as quality of life and wellbeing.

environmental psychology studies would have been giving large attention to human emotions over the last decades.

Although psychological studies refer to emotions and the environment on theoretical models, emotions are largely absent from most pro-environmental behavior studies (Searles 2010).

Particularly, which emotional stimuli would be more adequate to facilitate pro-environmental behavior? Moreover, how new interventions may create new stimuli for emotional impact?

Studying how to provide behavior feedback by using current and future technology is part of this research. Next section accomplishes a review about ubiquitous computing for environment.

2.3 Ubiquitous computing for environment

In many ways, ubiquitous computing has already entered individuals everyday lives (consider for instance ATM machines, mobile phones and Internet). New technological tools fit more naturally and continuously into individuals' lives. Obviously, the developments are also having an impact in the environmental field (see Hipólito 2007, Woodruff and Mankoff 2009).

In a technology forecasting exercise, by 2020 the computing era of ubiquitous computing (Weiser 1991), with several devices seamlessly integrated in the world and almost disappearing from individuals' attention, should be in full flower (Kaku 1998). Invisible microprocessors that sense human presence anticipate wishes and even read emotions and moods will surround individuals (Saffo 1997).

In Saffo's future version, the interaction with invisible computers includes using gestures, voice, body heat, electric field or motions. In fact, much of these future propositions are already taking shape. In the case of using sensors, interpreting sensors' output provides ground for context-aware computing (Selker 2000).

Research within ubiquitous computing (see Abowd 2000 for a past, present and future research review) embraces many areas such as pervasive computing, responsive environments (Elrod 1993; Paradiso 2005; Kuzmanovic 2005) or reactive environments (Cooperstock 1995), leading to the ambient intelligence discipline.

In this field, innovative works cover public ambient displays (Vogel 2004), attention aware systems (Thomas 2006) and designing for human values such as privacy (see Friedman 2006 for the theory of value sensitiveness in information systems).

Merging the concept of ubiquitous computing with captology that considers the overlapping area between computing technology and persuasion (Fogg 1998a; Fogg 1998b; Fogg 2003; Fogg and Eckles 2007), enables thinking of new systems that use sensors to guide individuals through appropriate actions and even contribute to shape or change behaviors.

According to Intille (2004) an effective strategy to motivate behavior change is to present a simple message that is easy to understand, at just the right time, the right place, and in a non-annoying way.

Regarding environmental behaviors, for instance energy efficiency behaviors, improved feedback on electricity consumption may provide a tool for costumers to better control their consumption and ultimately save energy (Fischer 2008).

For a review concerning the application of information-feedback methods for saving energy in the home, see Wood (2003). Designing for domestic sustainability (Chetty *et al.* 2008) turns on improving the visibility of consumption costs as well as supports individual and collective behavior changes.

Abrahamse *et al.* (2005) carried out other review on studies aimed at household energy conservation. These authors address consequence interventions and strategies, which consider that the presence of positive and negative consequences will influence behavior. For them pro-environmental behavior becomes a more attractive alternative while linking positive consequences to it. Environmentally unsound behavior will become less attractive when linked to negative consequences. They discuss feedback (continuous feedback, daily feedback, weekly, comparative feedback), and rewards (such as monetary rewards) as possible strategies. Other strategies addressed in their review include antecedent interventions and incorporate commitment, goal setting, informational strategies (e.g. workshops, mass media campaigns and home audits), and modeling.

Eco-feedback technology (Froehlich *et al.* 2009; Froehlich *et al.* 2010) provides feedback on individual or group behaviors with a goal of reducing environmental impact. Most people lack awareness and understanding about how their everyday behaviors affect the environment. Thus, eco-feedback technology may bridge this gap by automatically sensing individual activities and

feeding related information back through computing means (e.g. mobile phones, ambient displays, online visualizations).

Due to the multidisciplinary nature of eco-feedback technology, researchers have developed different research applications for a variety of domains including energy consumption, water usage, transportation and waste disposal practices.

For example, Holmes (2007) created an eco-visualization approach by combining art and technology. Arroyo *et al.* (2005) developed Waterbot that provides ambient feedback information about water usage. Investigating mobile tools for tracking and supporting green transportation, Froehlich *et al.* (2009) developed UbiGreen. Holstius *et al.* (2004) advanced Infotropism as living and robotic plants as interactive displays that uses sensors and living plants to provide feedback about recycling and waste disposal.

Another research area covers educational games and simulations (Gredler 2001) that are experiential exercises and enable learners to interact with specific knowledge domains. Regarding the environment, developments include for instance applications that link games and persuasion (for instance see Bang *et al.* 2007; Gustafsson and Bang 2008; Lobo *et al.* 2009b, Centieiro 2011). Centieiro (2011) further explores linking an environmental game to interpersonal persuasion via Facebook (see also Fogg 2008 and Liu 2008).

While many researchers used the availability of sensing systems for environmentally related activities, some have chosen to focus on the next generation of resource measurement systems, often called “smart meters” that can provide real time (or almost) data on resources consumption.

Applications related to HCI and emotions still do not include environmental behaviors. Research topics include health care, education, social life and supporting relationships (Peter *et al.* 2008). Examples include using emotionally expressive avatars (Fabri 2007), improving emotional communication within the classroom (Alsmeyer *et al.* 2007), and designing technologies that encourage the sharing of positive emotions (Kanis *et al.* 2007).

In fact, the study area of HCI and emotions may be enlarged if designing for environmental behavior, namely for facilitating pro-environmental behavior, starts to be a topic, as advanced in this dissertation.

A series of annual international workshops on “Emotion in HCI” started in 2005, reflecting the interest HCI-emotion related topic have within academic communities. Themes such

as emotion theory, significance of emotion in HCI, sensing emotions, current applications related to health care, education, social life and supporting relationships (important is to note that environmental topics were not considered) and further ethical issues started to be discussed and documented within those workshops (see Peter *et al.* 2008 for a retrospective about HCI, affect and emotion).

Scholars also consider the relationship between emotions and the acquisition of knowledge and learning. For example, see Kay (2008) for emotions and the acquisition of computer knowledge or see Kort (2001) for emotions and learning. In addition, Kwok *et al.* (2011) propose a teaching and research initiative named smart ambience for affective learning (SAMAL) that includes affective experiences to enhance learning and influence creativity.

The ability to develop interventions for facilitating pro-environmental behaviors using embedded computational interfaces has also the following application: objects surfaces that become expressive.

From static borders, surfaces become interfaces, privileged places for information exchange (Manzini 1993). These new computational architectures involve sensorial stimulation, by making visible the invisible, supporting reflection on behaviors over time. They also may promote sustainable consumption by product design (Sousa 2008) and stimulate the design of everyday computational things (Redström 2001).

One inspiring example of these new computation architectures is the Static! Project (Backlund *et al.* 2006) by the Swedish experimental media research institute, the Interactive Institute. This project developed different prototypes including the Power-Aware Cord¹⁴ tool (Gyllensward and Gustafsson 2005) for increasing energy awareness.

This prototype intended to support awareness of energy use and efficiency, by showing the amount of electricity that flows through to the connected appliances, in order to be an educational as well as functional product. The Time Magazine (Dyk 2010) recognized the Power-Aware cord as one of the 50 best inventions of 2010.

Senses were considered perceptual systems more than forty years ago (Gibson 1966) and have been reconsidered in light of environmental information exploration (Camara 2002).

¹⁴ The Power-Aware Cord is available at the Static! project homepage: <http://www.tii.se/static/index.htm>

More recently, Camara (2005) forecasts computing efforts in non-electronic low cost substrates such as textiles, wood and paper as representing innovative applications that are limited to pictorial calculus formulations.

Senses appear in research regarding information visualization (Camara 2002), collaborative monitoring (Silva *et al.* 2003), new media proposes (Chang 2006), or multimedia learning (Schnotz 2005) but were still not explicitly used in the context of new pro-environmental interventions for facilitating pro-environmental behavior.

This work suggests that in the context of facilitating pro-environmental behaviors, sensorial effects provided as behavior feedback in a ubiquitous way, embedded within the environment where people live, work and play, may act as emotional stimuli having a positive effect, encouraging people to adopt environmentally significant behaviors.

2.4 Concluding notes

In the last decades, there have been major progresses in environmental communication research. There are still many challenges in the search for innovative environmental interventions.

This chapter presented relevant information for the development of new pro-environmental interventions, in particular, emotion-oriented interventions. The information reflects contributions of disciplines associated to environmental communication research.

The role of emotion is largely absent from most pro-environmental studies. Objects images or events initiate emotions that trigger a series of responses that may affect environmental behaviors of viewers. Environmental scenery and landscapes provide emotional stimuli that may affect the definition of new interventions.

Environmental psychology identified two types of questions. The first one covers the fact of being important to consider a proximate level analysis, namely ESB. The other type consists in the possibility of updating existing behavior models supporting the design of technological interventions.

Future interactive computing forms are appropriate to the development of the emotion-oriented interventions for environment. Observing ubiquitous computing and captology applications brings great insights for the interventions conceptualization. This also considers the

possibility of objects surfaces to become interactive, involving sensorial stimulation and enabling making visible the invisible.

Furthermore, this study is contributing to the UNESCO Decade of Education for Sustainable Development (DESD) 2005-2014¹⁵. Linking learning and happiness (UNESCO 2007) brings many development opportunities that may be considered.

The literature review did not find relevant research issues. These include 1) linking technological prototypes to behavior models and 2) associating design frameworks to pro-environmental behavior models.

Thus, the overall presented analysis enabled to make the decision of considering the following directions for the research, as a way to contribute to some of the reported gaps, as well as to innovate in a useful way:

- Propose a new model for facilitating pro-environmental behaviors and analyze it with real data (see Chapter 3).
- Within a new design framework, see Chapter 4; conceptualize new interventions (see Chapter 5).
- Develop qualitative research studies (see Chapter 6).
- Summarize contributions.

¹⁵ DESD website: <http://www.desd.org/>

CHAPTER 3. MODEL OF PRO-ENVIRONMENTAL BEHAVIOR

To support the stages of the design of new interventions for facilitating pro-environmental behavior, it is convenient to have a model of pro-environmental behavior. The model allows incorporating issues involved in the process, to verify their relationships and generate the ground for new approaches. Hence, the way pro-environmental is modeled may influence the design of interventions.

This chapter presents a new model of pro-environmental behavior. It starts by referring the general lines associated with the new emotion-oriented interventions. Then it presents and defines the model. The analysis of the model enabled to present guidelines for future studies, before the final summary.

3.1 Facilitating pro-environmental behaviors with new interventions

Individuals' environmentally significant behaviors in the private sphere—those that directly affect resource consumption or cause pollution—are receiving attention as targets of change (Stern 2005). Creative approaches involving influences on behavior have potential for change.

It is then well worth seeking innovative ways of changing the context of behavior. By providing feedback, fit people's lives and persuading by reward, the emotion-oriented interventions are likely to have practical utility in the future as facilitators of pro-environmental behaviors.

The pursuit of an emotion-oriented interventions conceptualization follows the following general lines.

- **The development of interventions lies upon appropriate behavior feedback.**

Emotion-oriented intervention for facilitating pro-environmental behavior should provide sensorial feedback real time. Feedback, as behavior reinforcer, consists of affective images or other sensorial visual stimuli.

Emphasis on dynamic behavior sensorial feedback real time is different from the classic "environmental information" emphasis of many information systems. Provided according to action, not because of information finding, the feedback may facilitate changes.

- **The development of interventions considers technology that fits peoples' lives.**

Technology that fits people's lives uses a combination of useful, playful and non-intrusive components. Traditional supports such as mobile phones, but also common objects transformed to become expressive, enable interventions to be technological fit for individuals.

- **The development of interventions includes a persuasive intent.**

The ideal intervention should be persuasive¹⁶, linked to its users, meaningful to them, aware of time, of place and of its function. Its persuasive power covers the ability to reward adequate behavior (reward power), coming from a credible source.

From these generalizations, together with a vision about individual-interventions interaction, a more concrete emotion-orientation for the interventions emerges.

This is fundamental to the creation of the new model for facilitating pro-environmental behaviors. Next section presents this study modeling approach.

¹⁶ Again, the persuasive power of the ideal intervention is not coercive; it is a reward approach (section 1.3.1).

3.2 Modeling approach

Developing a model that tries to incorporate all factors involved in facilitating pro-environmental behaviors is not feasible, but new contributions may illuminate this multifaceted field. Accordingly, Figure 3-1 presents the new model for facilitating pro-environmental behavior.

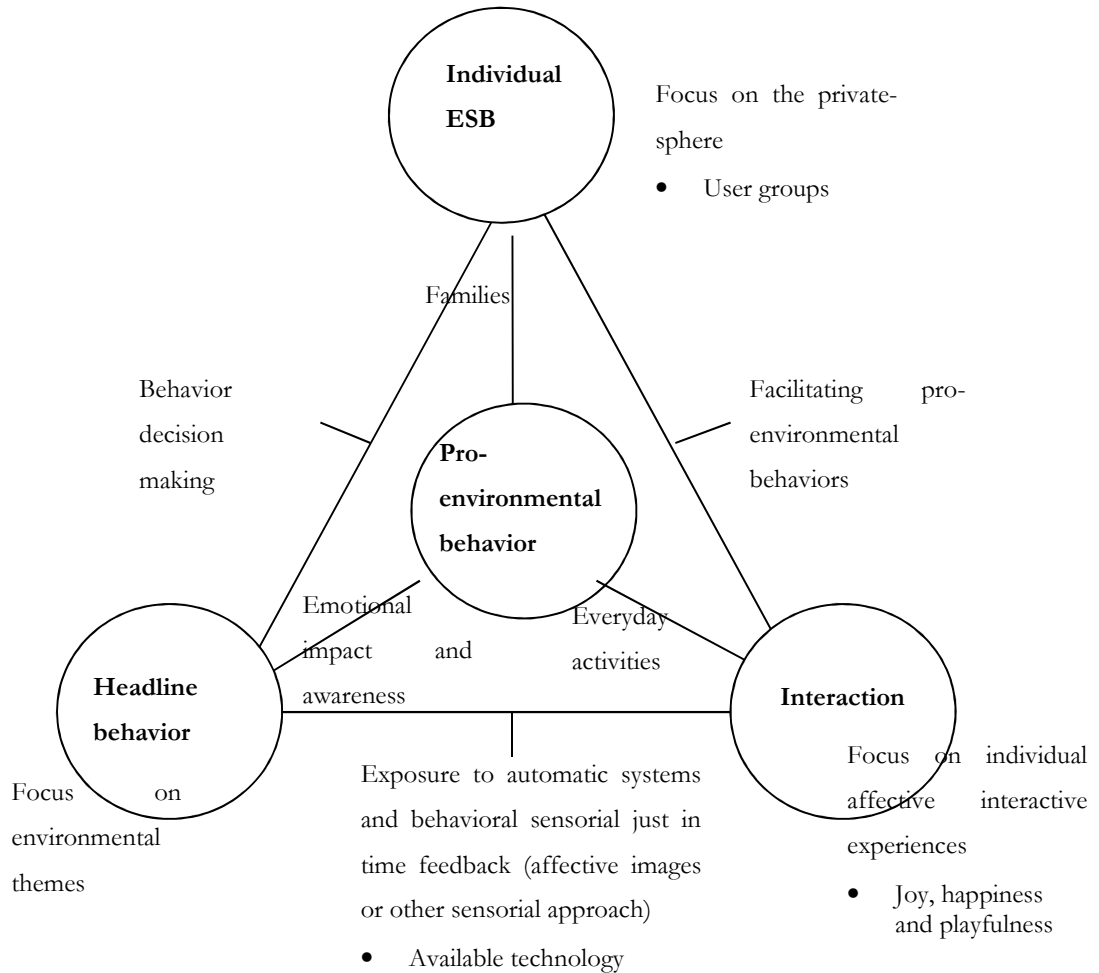


Figure 3-1 Model for facilitating pro-environmental behavior

The model is placed within dimensions, fields and actions that are mapped all together.

Each field is included according to three dimensions: headline behavior, individual ESB and interaction. The fields are emotional impact and awareness, families, everyday activities. The actions that fit the dimensions within augmenting families' emotional impact and awareness during everyday activities are behavior decision making, facilitating pro-environmental behavior and exposure to automatic systems and sensorial feedback just in time.

Furthermore, the model shows focus on pro-environmental behavior regarding three issues: private sphere, individual affective interactive experiences, and environmental themes. Extending the interaction vertice of the model, pro-environmental behavior adopts interactive techniques and places more emphasis on behavior sensorial just-in-time feedback on everyday activities. This way, facilitating pro-environmental behavior employs techniques from both ubiquitous computing and captology.

Two perspectives define the model, sensorial feedback and fitness technique.

Sensorial feedback focus is determined by observing how sensorial appeals promote pro-environmental behavior. Feedback focus ranges from emotional-evocative to informative.

Fitness technique is determined through observations made in terms of what technologies may embed the interventions in the real world. It ranges from digital media to non-digital media solutions.

Figure 3-2 presents the model defining factors.

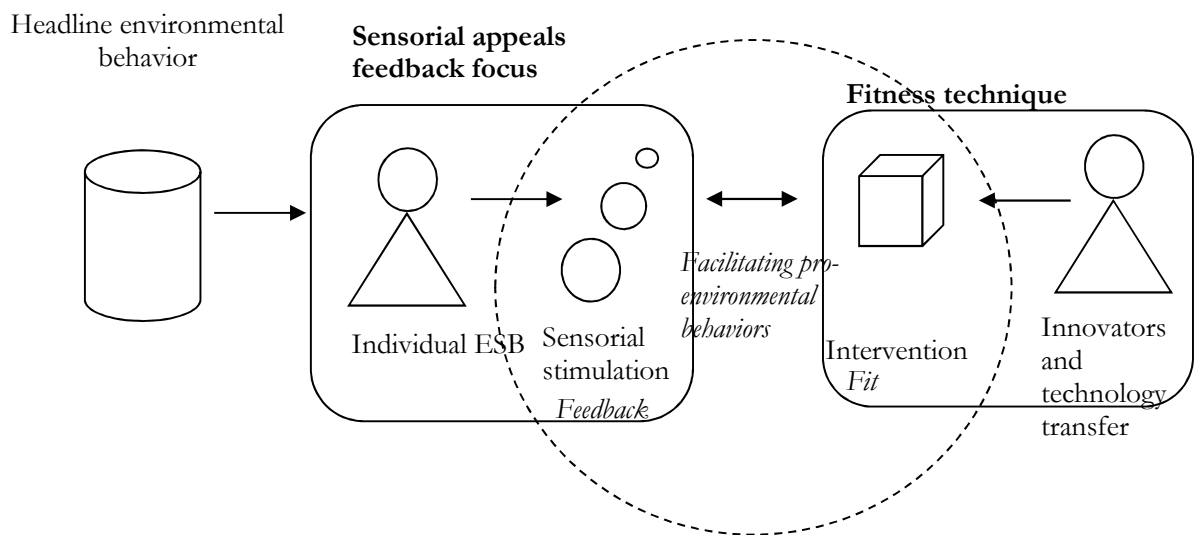


Figure 3-2 Model-defining factors: feedback focus and fitness technique

3.3 Model Analysis

3.3.1 Assumptions and research questions

This section discusses the research model of this study (as shown in Figure 3-3). Research on environmental behaviors models and surveys studies (e.g. see Defra 2008, Research New Zealand 2008, Leiserowitz *et al.* 2008) supported its definition.

This research model has the following assumptions:

- there isn't a direct relationship between environmental knowledge and information and pro-environmental behavior;
- contextual changes by the use of innovative interventions for supporting behavior decision making facilitate pro-environmental behaviors;
- pervasive and invisible computing are key inputs towards facilitating pro-environmental behavior.

Grounded in these assumptions, four research questions emerge:

RQ1: Can automatic systems and behavioral sensorial just-in-time feedback facilitate pro-environmental behavior?

RQ2: Can automatic systems and behavioral sensorial just-in-time feedback positively influence environmental behavior awareness perceived by individuals?

RQ3: Does the effect of automatic systems and behavioral sensorial just-in-time feedback on facilitating pro-environmental behavior mediate the environmental behavior awareness perceived by individuals?

RQ4: Can facilitated pro-environmental behavior positively influence individuals' behavior changes?

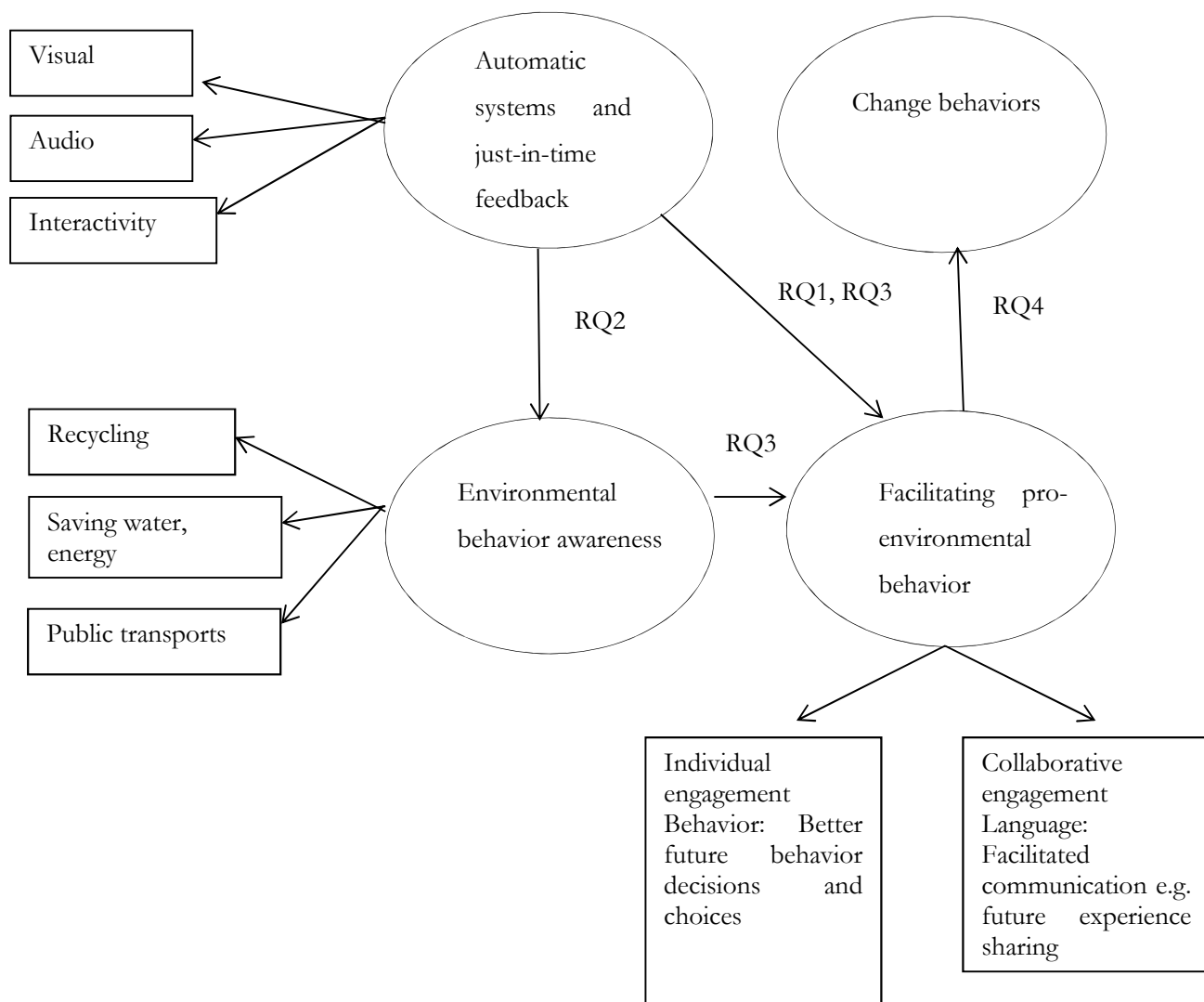


Figure 3-3 Research model

3.3.2 *Method*

To examine the representations of the impact of automatic systems and just-in-time sensorial feedback on individuals' environmental behavior awareness for facilitating pro-environmental behavior (and possibly change behaviors), a "My Environmental Behavior and ICT" questionnaire was created (Appendix A).

3.3.2.1 *Objectives of the survey study*

The objectives of the survey study were to:

- Provide a snapshot of respondents' current behavior with regard to their information and communication technologies (ICT) adoption levels, ESB, expectations, and future tools and ideas.
- Analyze the overall results and identify main key findings.
- Provide guidelines for future studies.

3.3.2.2 *Survey information requirements*

The survey collected the following information:

- Demographic/classification information
- Information about ICT
- Behavioral information
- Expectations, future tools receptivity and participants ideas

To become part of the survey questions, automatic systems and behavioral sensorial just-in-time feedback possibilities were included in the following questions:

- Would you acquire habits more pro-environment if you had an automatic system that would maintain you informed about environmental conditions and the changes created by your actions?

- Would you more easily change your environmental behaviors in order to benefit the environment if after each action you would have information on the consequences (benefits or damages for the environment) of that same action?

Additionally, another question assessed the respondents' receptivity to one particular application –smart recycling bins – to increase recycling actions:

- Would you recycle more materials if you had an intelligent recycling bin that would inform you of the environmental benefits obtained by your recycling actions?

The emotional-evocative side of this process was present in other dimensions. For example, the question about “reasons to act pro-environmentally” included conscience that relates to emotions such as Damásio (2010, p. 200) explains: “conscientious mental states have a mandatory aspect of feeling, and they make us feel something”. Thus, the selection of conscience included a sense of feeling and emotional affect.

In addition, emotional aspects should appear in the free text answers about incentives and barriers. However, answers did not include emotions directly, although reported “lack of conscience”.

Nevertheless, this study did not include explicitly reference to emotional reactions and affective involvement through technological experiences and behavior facilitation¹⁷.

Respondents' demographic data, current ICT and environmental behavior data were relevant to provide ground for analysis and expectations understanding.

3.3.2.3 Survey methodology

3.3.2.3.1 Overview

¹⁷ Chapter 6, section 6.6, addresses this issue.

Figure 3-4 characterizes the study participants. The reasons for choosing these participants included their known interest in ICT issues and easiness of getting answers.

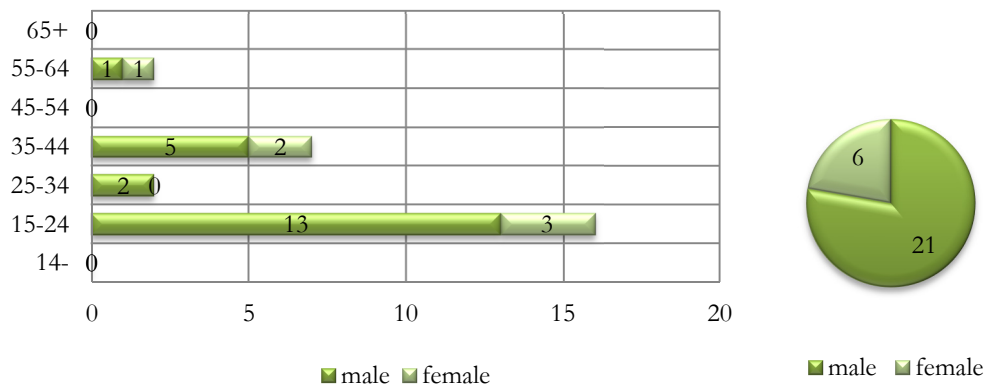


Figure 3-4 Survey study participants age groups and genders (Q 1-2)

The twenty-seven individuals (21M, 6F) responded our survey in a volunteer basis (6 sent by e-mail, 2 by hand and 19 replied online).

Within the sample, all had university formation ranging from undergraduate (the biggest group, ages 15-24) to PhD, including professors (Q 3). The areas of formation included engineering mostly informatics, but also natural sciences such as environmental, civil, chemistry, and materials (Q 4).

Due to the small sample size, it became unimportant to analyze results by gender. However, the study includes results structured by male and female, whenever convenient.

3.3.2.3.2 Survey design

The design of the questionnaire for the survey took into account the research questions. Table 3-1 includes the selected variables.

The general issues considered when designing the questionnaire were keeping the questionnaire short; giving the questions a logical and sequential structure; and structuring the questionnaire.

Question formats included dichotomous questions, multiple-choice questions, checklists, rating scales, including Likert scales and hypothetical questions, and open questions.

Table 3-1 includes the questionnaire structure. The first part contained individual background questions (Q: 1-4). The second part included questions about ICT (Q: 5-6). The third part included questions about environmental behaviors (Q: 7-11). The fourth and final part was about expectations, future tools and ideas (Q: 12-20).

Table 3-1 Environmental behavior and ICT evaluation check

Environmental behavior and ICT evaluation check	Question number
Individual background	
Age	1
Gender	2
Education	3
Formation topic	4
ICT convenience	
ICT everyday	5
ICT adoption	6
Environmental behavior general features	
Habitual good behaviors	7
Reasons to act pro environmentally	8
Sources of adequate behaviors	9
Information about behavior	10
Recycling bins at home	11
Expectations, future tools and ideas	
Smart recycling bins	12
Environmental themes	13
Changing behaviors	14
Current environmental behavior	15
Current actions to preserve	16
Changing behaviors motivators	17
Feedback	18
Automatic systems	19
Ideas	20

Google Docs technology enabled to upload the survey to the Internet. The web page held the questionnaire and the majority of respondents completed the questionnaire on the screen. The submit button linked their response to an electronic database in a remote server.

Within this approach, an Excel Spreadsheet with export capabilities enabled data analysis offline. All the responses were included offline on that Excel Spreadsheet for data analysis purposes.

3.3.3 Analysis and reporting

3.3.3.1 ICT presence and adoption

As detailed in Figure 3-5, all respondents reported access to Internet at school/work. Considerably lower is the Internet access via mobile phones or GPS access.

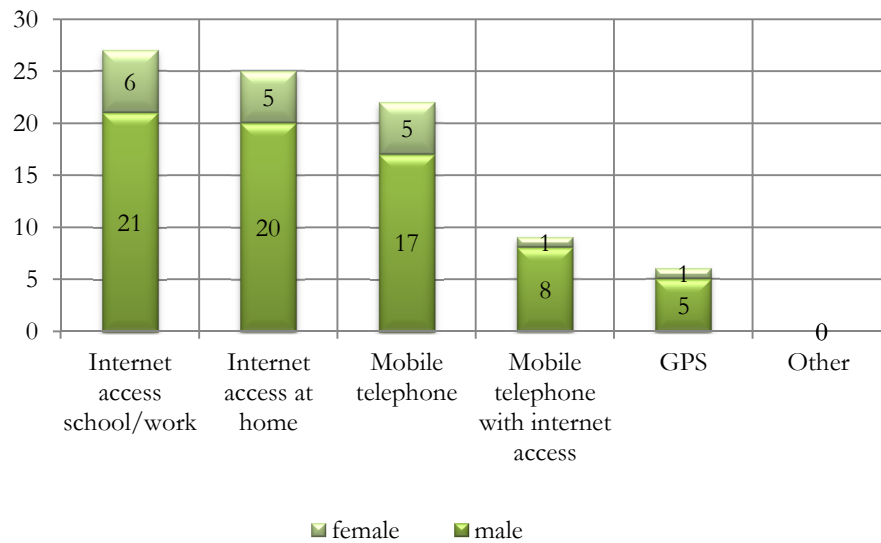


Figure 3-5 Levels regarding the ICT presence in respondents' everyday life (Q 5)

In relation to attitudes related to the adoption of new and innovative ICT, 17 respondents agree having the interest that technology may facilitate life tasks, and 14 say enjoying the modern design and functions of the equipment (Figure 3-6).

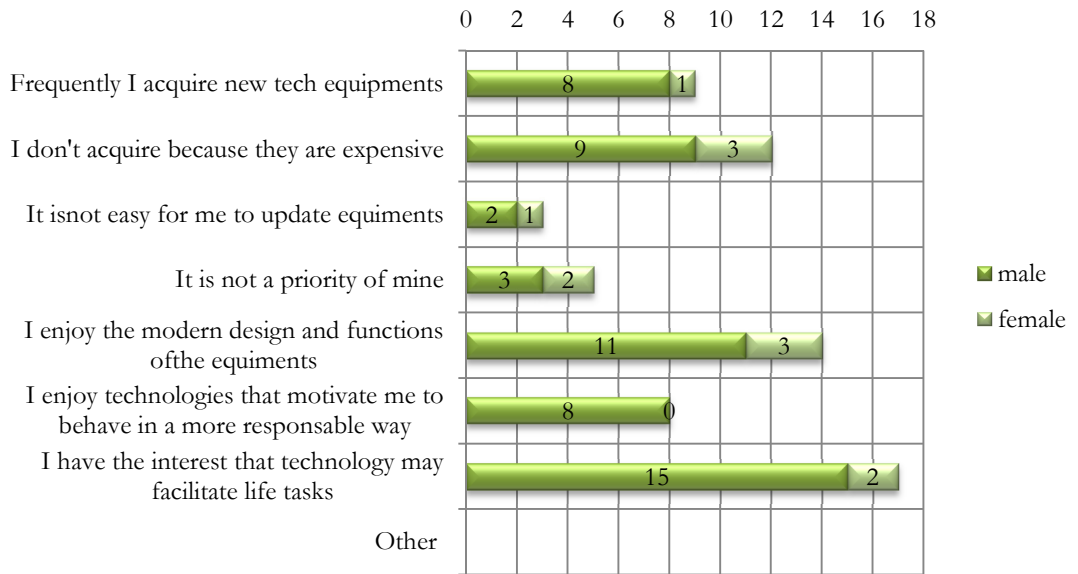


Figure 3-6 Levels of agreement facing the adoption of new and innovative ICT (Q 6)

3.3.3.2 Environmental behaviors general features

Overall, saving energy, water and recycling were the most picked habitual behaviors namely with 23, 21 and 20 responses. While using public transportation and learning about nature received both 11 answers (Figure 3-7).

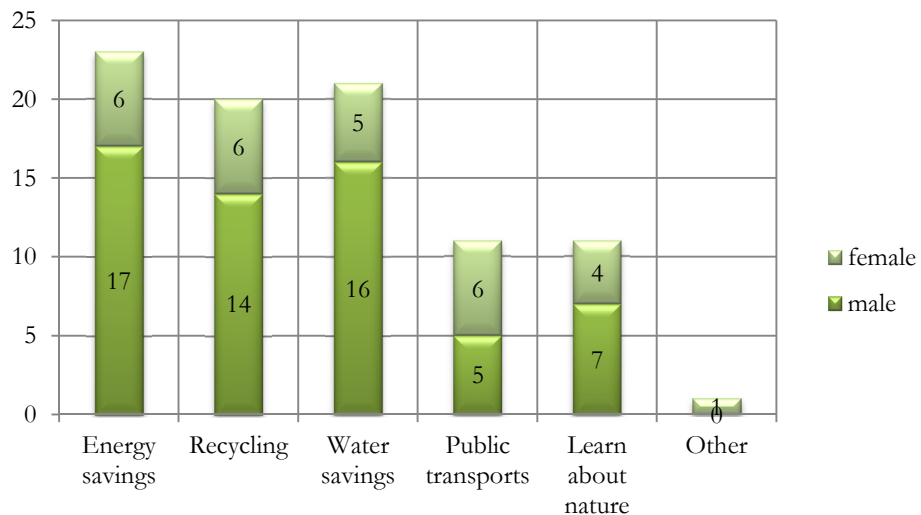


Figure 3-7 Levels of habitual good behaviors (Q 7)

The majority of respondents (24) reported that conscience was a reason to act pro-environmentally. A further 21 respondents selected personal values, while 15 report economic savings (Figure 3-8).

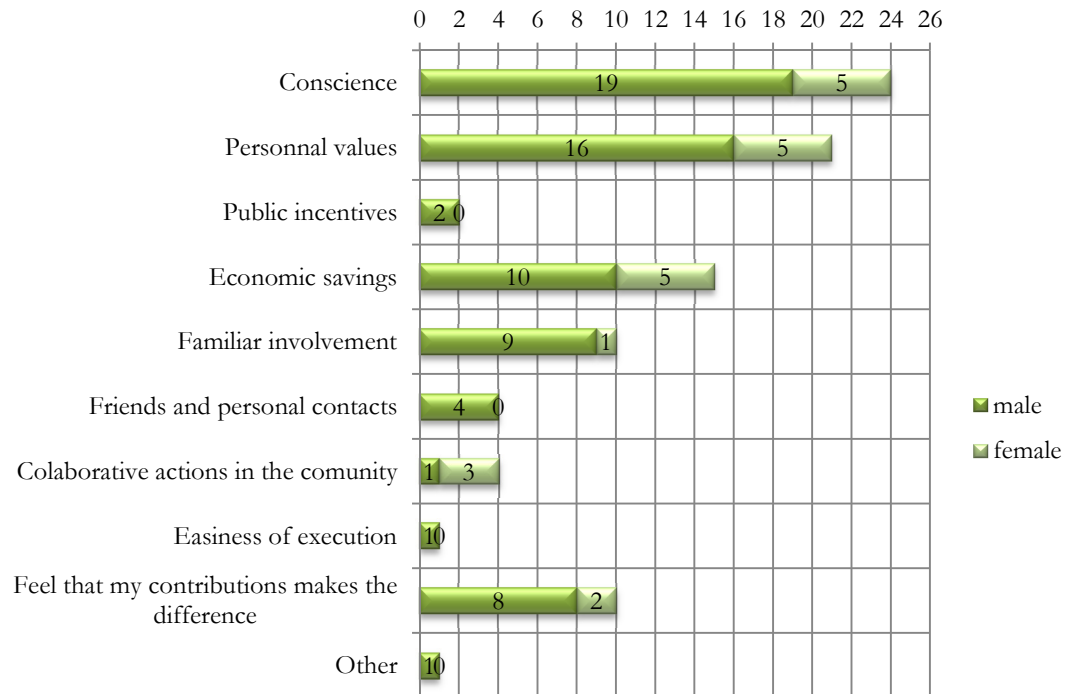


Figure 3-8 Reasons to act pro-environmentally (Q 8)

The easiness of execution was not a selected reason to act pro-environmentally (only 1 answer). *Note:* Sub-sample of 19 for Friends and personal contacts, easiness of execution, feel that my contribution makes the difference.

Most commonly (23) respondents reported social communication as a source of adequate behaviors (Figure 3-9). Collaborative actions in the community received the smallest amount of answers (7).

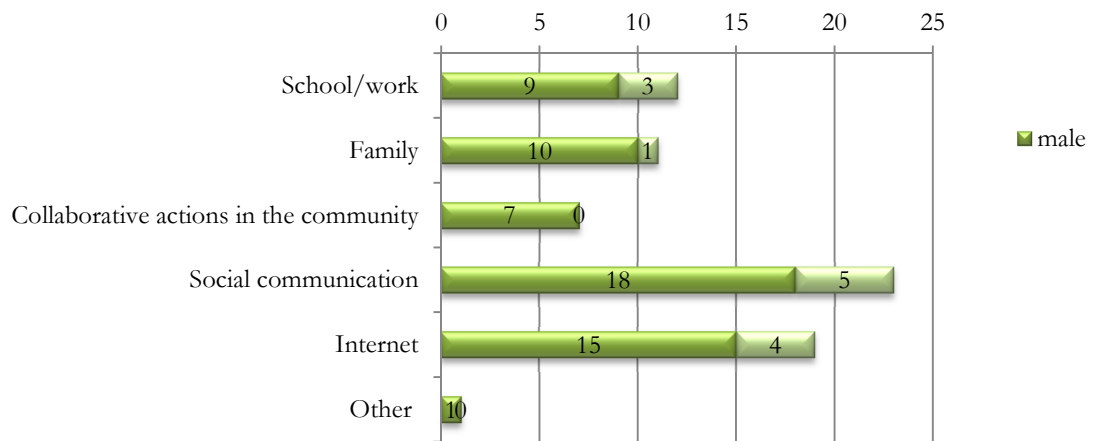


Figure 3-9 Sources of adequate behaviors (Q 9)

Regarding Q 10, about receiving information about the consequences for the environment of one's actions and behaviors, 10 answered Yes, while 16 answered No. The referred ways were campaigns, newsletters, social communication (TV, radio, newspapers, magazines), and ecological footprint estimation. One participant didn't answer.

About having a recycling bin at home (Q 11), 19 answered Yes, while 8 replied No.

3.3.3.3 *Expectations, future tools receptivity and participants ideas*

Q 12 results about the smart recycling bins are included in Figure 3-12.

Q 13 questioned participants about the preferred environmental themes and reasons why. This enabled to collect a heterogeneous set of semantic units: substantives, adjectives, expressions. The analysis of the answers addressed grouping identical words, synonyms or related words (following Reis 2004, p. 204). Then reading those significance units in a repetitive way enabled to create classification categories (knowledge areas and activities). Table 3-2 presents the words associated with environmental themes and reasons why.

Table 3-2 Words associated with environmental themes and reasons why

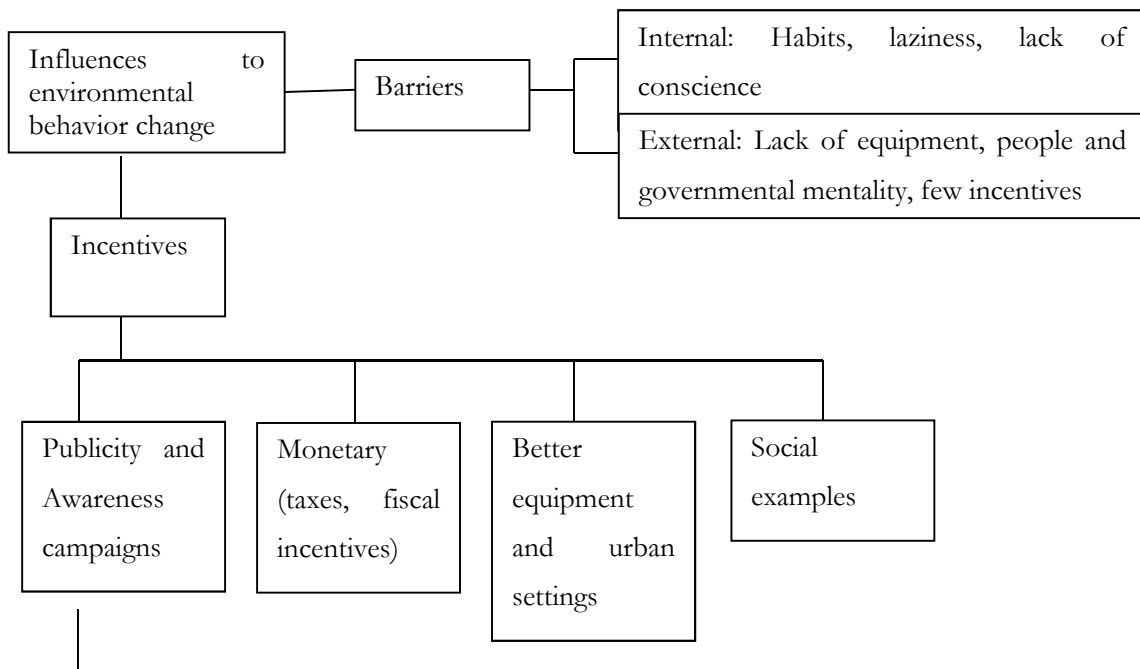
	Knowledge areas	Activities
Environmental themes	Renewable energies Resource management Pollution Global heating Dimming effect Electrical engines Micro-generation Climate change Loss of biodiversity Soil erosion Urban planning Public transportation	Use Save Manage Change
	Knowledge area	Why
Reasons why	Renewable energies	<i>a promising way of facing environmental problems; save the environment than reduces pollution and saves resources once these are limited; enable better quality of life and costs management</i>
	Resource management Recycling and saving resources	<i>one of the simplest ways of contributing to change environmental habits</i> <i>Conscience about depleting planet resources; the most important challenge is reducing, more than recycling, message should be about use less and make them long last (avoid disposables)</i>
	Pollution	<i>Pollution – it is the main problem and the main reason of environmental problems</i>

The analysis of the table enables to identify the following:

- Respondents have selected 12 knowledge areas, mostly related to renewable energies, resource management and pollution (water, air).
- Activities are mainly associated with using, saving, managing and changing environmental resources.
- Reasons why mainly relate to the conceptions of: 1) contributing to a better world, 2) avoid environmental destruction, 3) enable reducing costs.

All respondents said that they would like to change their environmental behaviors (Q 14).

Figure 3-10 presents the influences to environmental behavior change (incentives and barriers).



namely for

|

- *Enlighten about the problems created*
- *Motivate the younger generations (up to 10 years old)*
- *Augment conscience on the auto-destruction course humanity is taking*
- *Provide correct explanations on what will happen if we continue acting the same way*

Figure 3-10 Influences to environmental behavior change (Q 14)

Reflecting their current environmental behavior classification (Q 15), 16 respondents feel it is good, 6 weak and 4 very good. None replied “optimum”.

The respondents’ habitual actions to preserve the environment (Q 16) relate to recycling, saving resources and public transportation use. Other references include the reduction of the unnecessary consumption of goods and resources, avoiding disposable products, segregate, recycling and the use of economical products. Curiously some answers were about the very primitive behavior of do not litter ground or water or more generally do not pollute. Another remark included turning off standby equipment.

Regarding motivators for changing behaviors (Q 17) 19 respondents' reported "TV and radio news and programs", 18 reported "Good practices exposure in public environments" and 16 reported having "Information about consequences for the environment of actions and behaviors" (Figure 3-11).

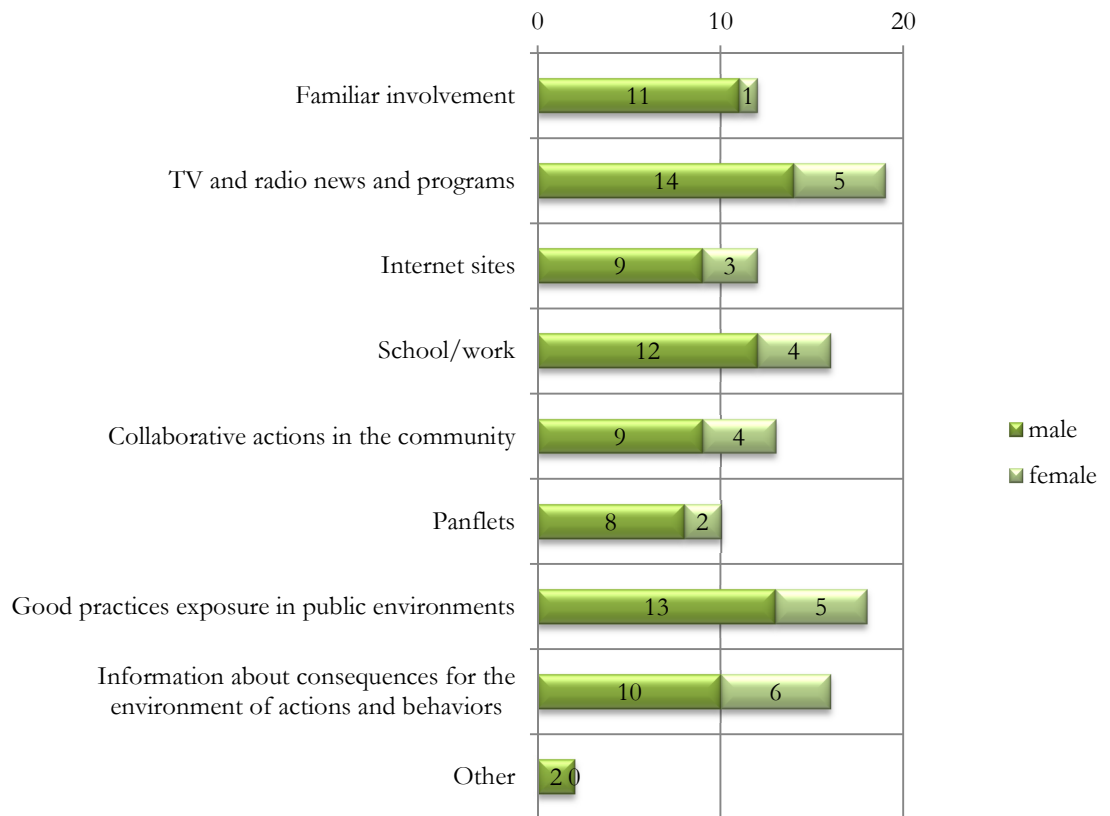


Figure 3-11 Changing behavior motivators (Q 17)

In relation to future tools, two specific questions addressed the following topics:

- Q 18 – Feedback
- Q 19 – Automatic systems

As detailed in Figure 3-12, the respondents tend to be positively receptive to the description of concepts and special recycling application (Q 12).

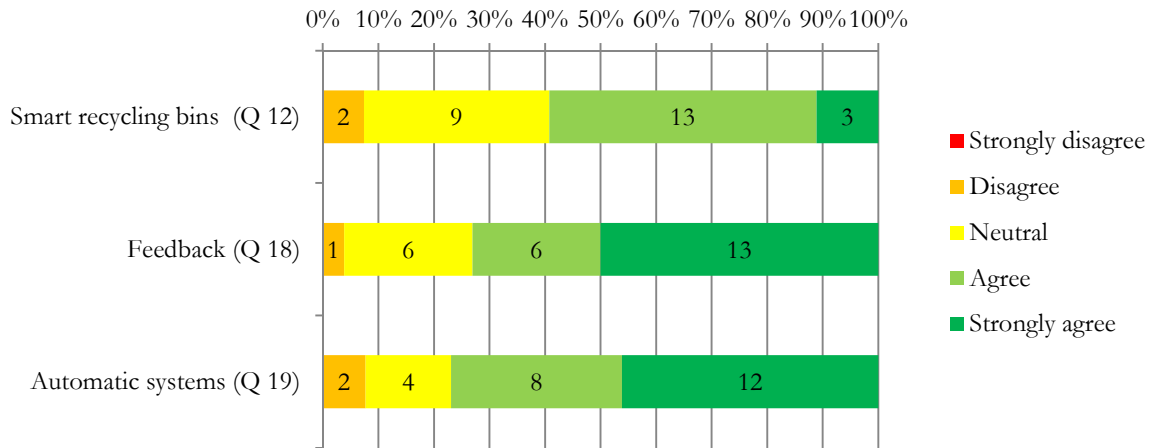


Figure 3-12 Levels of agreement regarding future tools concepts

As for the feedback, 19 said that would prefer to receive it just in time after the action and just in place in an object transformed for that effect. Eight participants said to prefer to consult later an Internet site and six said to that would prefer to receive in the personal mobile phone an SMS or MMS with the information.

As regarding the aspect of the information, 14 said to prefer a visually simple feedback, while 10 said to prefer visual and 4 said to prefer with sound alerts. One participant picked the option without sound.

Respondents answered the survey last question (Q 20) freely. This question had the objective of collecting their ideas about what would help them to change their environmental behaviors. Several ideas emerged, enabling grouping them as:

- Build alerts on one's actions consequences;
- build renewable and alternative solutions;
- improve access to recycling bins and augment their availability;
- improve and integrate metering equipment;
- better public transportation network;
- more authorities' supervision and appealing incentives;
- urban planning.

The first set of ideas, build alerts on one's actions consequences, includes the following variations:

- smart metering with sound alerts or mobile texting messages (also about the damage to nature as a consequence of one's behavior);
- behavior consequences visualization and their environmental benefits;
- more information on one's actions benefits and problems;
- receive suggestions to improve environmental behaviors;
- appealing implementation of friendly behaviors in public spaces;
- informative recycling bins;
- eco-friendly activities;
- information about the impact of decisions on points of decision locals;
- use social networks to spread and share information about daily gestures and their consequences.

3.3.3.4 *Key findings*

The previous section presented the collected research data and results. From its analysis, the following list of key findings emerges:

- The presence of mobile Internet is still not significant;
- The adoption of new and innovative ICT is important as facilitator of life tasks;
- Saving energy is on top of good behaviors;
- The notion of self-conscience and personal values is pointed by many respondents as reasons to act pro-environmentally;
- Social communication is most participant's source of adequate behaviors;
- Accordingly TV and radio news and programs are pointed as motivators for changing behaviors;
- All agree in the wish of changing environmental behaviors in order to contribute more actively to environmental and natural resources preservation;
- There is a tendency to accept positively the future tools for shaping pro-environmental behaviors.

The summary of these key findings is as follows.

1. *The presence of mobile Internet is still not significant.*

While all respondents (27) have Internet access at school/work, and 25 have Internet access at home, levels of mobile Internet and GPS are significantly lower. This can probably be explained by the communication costs, but it is our belief that mobile internet tends to augment in the future. For applications of multimedia mobile internet in environment, see (Hipólito 2007).

2. *The adoption of new and innovative ICT is important as facilitator of life tasks.*

The most responses were to "I have the interest that technology may facilitate life tasks" (17) and to "I enjoy the modern design and functions of the equipments", followed by "I don't acquire because they are expensive"(12). These points to the importance of technology utility or technology with a purpose, to issues related to the interaction design of applications and, again, to the costs both, of equipment, and data communications.

Only 3 respondents reported difficulties related to the easiness of updating equipment and only 5 said that the adoption of new and innovative ICT would not be a priority. Also relevant is to consider the 12 responses on "I don't acquire because they are expensive" once a very important

factor to stop technology adoption is the cost. End of the line tech has still high costs, blocking its dissemination.

3. *Saving energy is on top of current good behaviors.*

When asked about habitual good behaviors, energy savings (23), water savings (21) and recycling (20) are common behaviors. This relates probably to the economic savings respondents' will. The use of public transports and the effort for learning more about nature are not reported as so common.

4. *The notion of self-conscience and personal values is pointed by many respondents as reasons to act pro-environmentally.*

Also relevant are the reasons "economic savings" (15), "familiar involvement" and "feel that my contributions makes the difference" (both with 10 responses). These results support, thus, our intention to develop tools that touch people awareness and having at the same the practical result of helping to reduce the costs of resources use.

5. *Social communication is most participants' source of adequate behaviors.*

Other sources of adequate behaviors include internet and family. Collaborative actions in the community are still not a common source of adequate behaviors within our sample. This alerts us to the importance of developing technology that reaches out people with messages containing information about adequate behaviors.

6. *Accordingly, TV and radio news and programs are pointed as motivators for changing behaviors.*

Also relevant is the selection of "Good practices exposure in public environments" (18) and "School/work" (16) and "Information about consequences for the environment of actions and behaviors" (16). Considering future multimedia interaction forms are then central to produce innovative ways to shape pro-environmental behaviors.

7. *All agree in the wish of changing environmental behaviors in order to contribute more actively to environmental and natural resources preservation.*

When asked about the barriers that delay the change and incentives that may speed up the change, the general participants' reported issues are mixed.

Regarding the barriers, while some refer that the problems are in the population, other are more self-focused, thus more aware of their role as making change happen. Another reported barrier was the need for better equipment (e.g. better recycling bins).

Reported incentives included awareness and publicity campaigns (or in other viewpoints the need to self-clarification about the problems created), economic incentives or other fiscal instruments.

Additionally, many respondents reported as part of common actions headline behaviors such as recycling, saving water and energy.

8. There is a tendency to accept positively the future tools for shaping pro-environmental behaviors.

None of the respondents referred to the possibility of having the new technological tools as an incentive for change. However, when asked about those, the tendency to accept it was positive. As for an interaction design of the future tools point of view, the feedback is most welcomed if provided just-in-time and just-in-place in a visually simple form.

Additionally, participants reported the following ideas:

- alerting to possible consequences of one's actions,
- exact resources consumption metering with sound or SMS alerts,
- visualizations of environmental behaviors results and of practical benefits of those in an everyday basis,
- behavior informative recycling bins,
- metering nature damage due to the consumed electricity,
- information in point of decision locals (shopping, transport interfaces, products labels)

Innovative tools for shaping pro-environmental behavior may integrate these ideas, as this dissertation proposes.

3.3.4 Discussion

This section presents the research questions discussion, based on the information collected from the participants through the questionnaire “My Environmental Behavior and ICT”, and complemented with Chapter 2 information.

This global analysis intends to detect the tendencies of those participants mainly about technology for pro-environmental behavior and awareness.

The questionnaire collected evidence in relation to a) ICT convenience, b) environmental behavior general features and also c) expectations, future tools and ideas. Several questions formats were included.

The questionnaire delivery approaches included hand, e-mail, and an online form. The answers to the different items were read in a repetitive way and their analysis allowed to, in a first phase, identify key findings and to, in a second phase, discuss the research questions.

The study provided an opportunity to combine two major approaches to understanding the behavior-technology relationship, the behavior based approach and the technology ICT approach.

The behavior approach focused on how individuals relate with environmental behaviors. The technology ICT approach focused on the current use and expectations of future tools for environment. These two approaches assess the behavior-technology relationship from a different and integrated perspective.

The new model for facilitating pro-environmental behavior guided this study. This model considers pro-environmental behavior within individual ESB, headline behavior and interaction. In addition, it also proposes technological solutions that provide behavior feedback, fit people's lives and persuades by reward.

This model presents an adequate framework for combining the behavior and technological perspectives of research. The following goal guided this study: examining the enabling effects of automatic systems and sensorial feedback on facilitating pro-environmental behaviors. A conceptual research model and four related research questions tested that goal.

RQ1: Can automatic systems and behavioral sensorial just-in-time feedback facilitate pro-environmental behavior?

The model for facilitating pro-environmental behavior suggests placing the facilitation of pro-environmental behavior within everyday activities through interaction and exposure to automatic systems and behavior sensorial feedback, focusing on affective experiences for increasing emotions such as joy, happiness and playfulness.

In fact, the following result supports this; overall, participants show a positive interest about technology that may facilitate life tasks. From the 27 participants 17 indicate that. This is consistent with the views of Stern (2005) when he suggests that the available technology affects ESB, although this author does not focus on the facilitation issue.

Another result suggests that conscience is an important issue within the reasons to act pro-environmentally. Because developing conscious states to environmental matters requires time and interaction within those matters, it is likely that respondents in this study would express receptivity to the proposed future tools for behavior feedback, as they would enable to augment conscience, facilitating then pro-environmental behaviors. The result of having respondents positively receptive to the concepts description and special recycling application supports this.

Reasons to act pro-environmentally included personal values and economic savings, thus having automatic systems and behavior feedback that help people reach those goals, may also facilitate pro-environmental behavior. For example, having a system that makes people evocate feelings of altruism or help to reduce consumption and consequently costs may facilitate adequate environmental behaviors. In order words, thinking on the variables proposed by Stern (2005) as influencers of ESB, the respondents' preference are consistent with the variables personal capabilities, namely financial resources, and attitudinal factors, namely personal values.

The process of environmental behavior as suggested by Grob (1995) or Kollmuss and Agyeman (2002) involves emotional bounds. Thus, developing affective experiences through interactive experiences that make people evoke positive emotions can well become facilitators of pro-environmental behavior.

RQ2: Can automatic systems and behavioral sensorial just-in-time feedback positively influence environmental behavior awareness perceived by individuals?

The model for facilitating pro-environmental behavior suggests that environmental behavior decision making relates to emotional impact and awareness for each headline behavior, while focusing on environmental themes.

Results show that headline behaviors integrated in current lifestyle of respondents included saving energy and water, and recycling. According to the results, social communication is a source of adequate behaviors, followed by Internet. In fact, these sources are rich in images that according to Damásio (2010) are responsible to initiate emotions. Thus, this supports that behavior decision making and awareness have emotional impact. According to Searles (2010), enthusiasm would reinforce individual positivity towards efforts to protect the environment, while anxiety would have a negative effect on individual view toward the environment.

One innovative way of augmenting environmental awareness was proposed by the authors of the Power Aware Cord (Gyllensward and Gustafsson, 2005), as they suggest that showing the amount of electricity that flows through the connected appliances would be and both functional and educational. The study findings provide support for those authors research direction on augmenting awareness. In fact, when asked about future tools that provide feedback on individual actions, this would be preferably over objects transformed for that effect and the feedback should be visually simple. Then, a research line would be to provide “information about consequences for the environment of actions and behaviors” once this was an issue pointed out as motivator for change if available.

According to the study, exploring “Good practices exposure in public environments” (18 responses) can support perceiving environmental awareness, once these interventions are supposed also to be available in public spaces.

Many research efforts, namely within persuasive technology and captology for environment, use public spaces and environmental settings as ground for their applications. Examples include developments for public ambient displays, but also mobile persuasion applications.

RQ3: Does the effect of automatic systems and behavioral sensorial just-in-time feedback on facilitating pro-environmental behavior mediate the environmental behavior awareness perceived by individuals?

Human senses support perceiving environmental behaviors awareness. Gibson (1966) considered the senses as perceptual systems and Camara (2002) have reconsidered those in light of environmental information exploration.

In fact, automatic systems and feedback to be effective in facilitating environmental behaviors should consider a sensorial format, interactivity or visual cues that senses could perceive. Moreover, the feedback, taking a reward approach and working as a behavior reinforce, just in time, until 60s according to Suarez (2004).

Results show that preferences within the interaction design of the future tools welcome the feedback provided just in time and just in place in a visually simple form. Thus, sensorial stimulations (visual and interaction) made from digital or non-digital material, used to create emotional-evocative ambience based on behavior, will have effect on facilitating pro-environmental behavior if it helps individuals to become aware of their behaviors.

The model suggests that the behavior decision-making processes are related both to headline behaviors but also to individual ESB focusing on the private sphere. Stern 2005 describe these as the purchase, use and disposal of personal and household products that have environmental impact. Thus, the systems and feedback development should consider those activities.

Ubiquitous computing and related technologies (Weiser 1991, Saffo 1997, Kaku 1998) enable the creation of such systems with feedback sensorial capabilities, while fitting people's lives and persuading them to have adequate behaviors by rewarding adequate behaviors. This reward approach is based on positive reinforce that according to Suarez (2004) correspond to any stimulus, event or condition whose presentation immediately follows a response increasing the frequency of that response.

RQ4: Can facilitated pro-environmental behavior positively influence individuals' behavior changes?

This study addressed a final relationship, although being beyond the model, relating the facilitation of pro-environmental behavior and behavior changes. Results show that there is a strong willingness to change environmental behaviors within the participants as all have reported that.

There is evidence that working on the following incentives could facilitate environmental behavioral change: create awareness campaigns, provide better equipment and urban settings and define social examples. That is, people will recall emotional memories of when they interacted with experiences perceived as incentives or when they had particular behaviors facilitated, and partially transfer those emotional bonds to further behavior changing processes. This transferred emotional bond will further increase their preference for further environmental friendly activities.

As Russell and Snodgrass (1987) noted, the relationship between individuals and the environment is such that behavior may be influenced by the affective quality of the environment (estimated, perceived or remembered), rather than by its objective properties directly. In addition, encouraging pro-environmental behavior in effective ways, as suggested Steg and Vlek (2009), should consider affect as a key issue.

Thus, creating individual interactive affective experiences aimed at facilitating behaviors could well suit changing behaviors processes. Results report several ideas as helpers of behavior changes. For example: 1) build alerts on one's actions consequences, 2) build renewable and alternative solutions, and 3) improve and integrate metering equipment.

This last point is consistent with the studies developed by Fischer (2008), Wood and Newborough (2003) as they provide a revision of different tools for consumers to better control their consumption and other information-feedback methods for saving energy.

3.3.5 Guidelines for future studies

The presented data analysis, derived key findings and research questions discussion enable to select guidelines for future studies (Figure 3-13).

Particularly, it seems important to study the development of interventions that 1) touches ones' conscience, 2) enable to increase awareness, 3) allow making life tasks easier and 4) help to reduce costs.

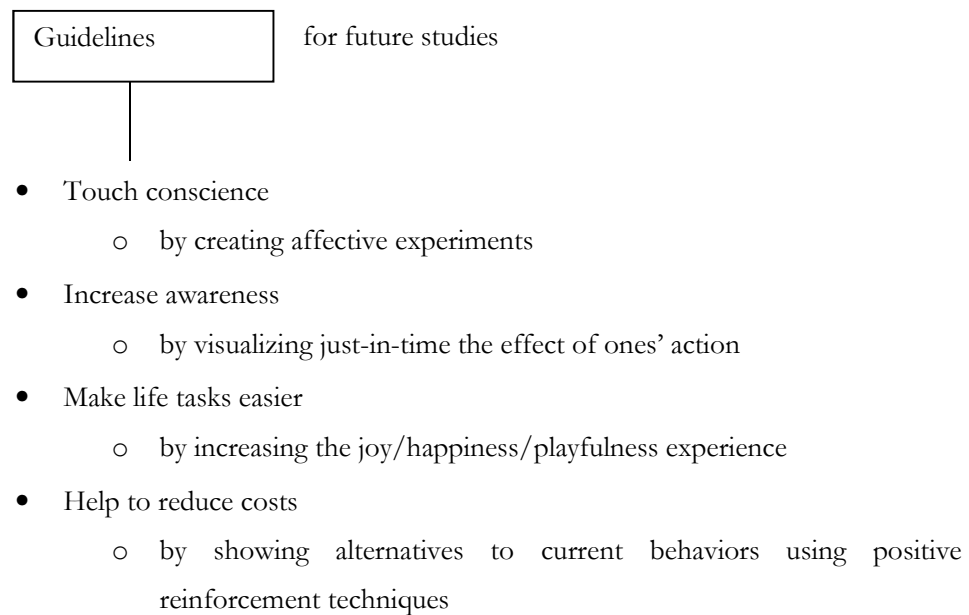


Figure 3-13 Guidelines for future studies

3.4 Summary

This chapter highlighted the importance of pro-environmental behavior modeling in promoting environmental behavior understanding.

Results from the survey research emphasize the technological potentialities for developing automatic systems for behavior feedback. However, discussing those issues is still far from most pro-environmental studies.

Many communication approaches are still giving priority to traditional informative. New interventions for environment should involve new technological approaches but also individuals conceptions about environmental behaviors and technology.

Environmental research and design for environment may have then a special role in building new interventions for facilitating pro-environmental behaviors.

Designing new interventions requires addressing: a) knowledge about environmental behavior and related processes; b) critical thinking and decision making about communicative approaches for new interventions; and c) willingness to handle innovative technological approaches.

However, this achievement depends on building research experiences that provide an interdisciplinary structure that promotes a) a reflexive approach about environmental behaviors, technology and emotions; b) knowledge about approaches, methods and activities that are adequate to study those issues; and c) knowledge about facilitating behavior problems and related environmental topics.

CHAPTER 4. EMOTION-FOCUSED DESIGN FOR ENVIRONMENT

An adequate ESB as expected by the model for a given headline behavior may be facilitated through creative interaction forms. Innovative interactive interventions should address input (sensorial stimulations)-output (behavior reactions) patterns. New interventions may be designed handling dedicated design frameworks.

Choosing such a design framework is the subject of this chapter where after an introduction in section 4.1, section 4.2 addresses the design framework for facilitating pro-environmental behaviors. Section 4.3 defines the requirements of new emotion-oriented interventions. Section 4.4 addresses future research. Finally, section 4.5 concludes this chapter.

4.1 Introduction

The previous chapter showed that automatic systems and just-in-time behavior feedback facilitates pro-environmental behavior if targeted to augment individual conscience, increase awareness, make life tasks easier and help to reduce costs. Behavior feedback would be most welcomed if provided just in time and place in a visually simple form.

Moreover, Chapter 2 referred that this study handles emotions two ways. Links to places are emotional (Russell and Snodgrass 1987) and images initiate emotions that trigger a series of phenomena and outputs in behavior, language and physiology (Damásio 2010); also, Damásio explains that action plans represented in the mind are in line with the general emotional tone.

Thus, the development of interventions that provide in a given place, as behavior feedback, affective images or other sensorial stimuli for creating an adequate emotional tone, will echo on the individual action plan, promoting adequate behavior decision making and facilitating pro-environmental behavior.

This effect can influence even after the place where the experience have occurred. The mood created by a place and the activities can continue to influence behavior even after leaving that place.

4.1.1 *Extending design for environment*

According to Fiksel (1996) the concept of design for environment (DFE) originated in 1992, through the efforts of electronics firms that were attempting to build environmental awareness into their product development efforts.

According to Fiksel (1996):

“Design for environment is defined here as systematic consideration of design performance with respect to environmental, health, and safety objectives over the full product and process life cycle.” (p.3)

This author also considers the following shorter definition:

“DFE is the design of safe and eco-efficient products” (p. 51)

The scope of DFE encompasses, then, a variety of disciplines, including environmental risk management, product safety, ecology and resource conservation and waste management. The integration of DFE-related disciplines is crucial to the successful development of eco-efficient products. The approaches to eco-efficiency include three broader categories: cleaner processes, cleaner products and sustainable resource use.

The practice of DFE is becoming essential in industrial environmental, as firms recognize the importance of environmental responsibility to their long-term success. Thus, DFE has been used mostly in the production and development sector, and at the same time individuals have becoming increasingly concerned about the environmental “friendliness” of the products to purchase and about the consumption habits.

In fact, consumer demands for “green” innovation and products may encourage eco-innovation and wider use of eco-efficient techniques. This may improve environmental performance, but also can raise economic productivity, making business more competitive (OECD 2008).

Design may play a major role in the in the transition towards a sustainable knowledge society. Discussion on design (visions, proposals, and tools) have been made within the Changing the Change Conference (Cipola and Peruccio 2008), where the design framework presented in section 4.2 was introduced (Hipólito and Câmara 2008).

That work, led to the exploration of a new dimension for DFE, named Emotion-Focused Design for Environment (EFD-E), related to the citizenship sector and in particular personal ESB.

Within EFD-E interventions should be designed aiming at facilitate pro-environmental behavior following if possible the guidelines of Figure 3-13. It promotes the design of affectively evocative smart ambient media (AESAM) for facilitating pro-environmental behavior. It considers design of emotion-oriented interventions that provide just-in-time behavior feedback, while fitting peoples' lives and persuading through rewards.

In EFD-E task enhancement in environmental behavior and facilitated environmental communication in language are desired outputs after exposure to emotional stimulus provided by the AESAM. Emotion starts by exposure to affective images or other sensorial stimuli within interactive events in a given moment and place.

4.1.2 *Approaching emotion in HCI*

The previous section introduced EFD-E as a new dimension within DFE, having a different application scope, directed to personal ESB. This study does not intend to explore the interventions production lifecycle (this constitutes a completely different study); rather it studies how new interventions relate to facilitating pro-environmental behaviors.

The new interventions use interactivity and visual stimulations through automatic systems and just-in-time feedback. Pervasive and invisible computing techniques are the means selected for the development of new interventions.

The proposal of the design framework discussed in this dissertation gathered insights from the discipline of HCI design. However, the interventions go far beyond traditional interfaces design for personal computers (PC) or mobile devices.

In particular, the discipline HCI may contribute to the design of the new interventions by considering the development of applications and systems that use affective information (see Peter et al. 2008) linking emotions and HCI.

One important dimension in the interface design activity is the idea generation. Several techniques such as scenario development support idea generation. The most creative ideas may be developed and adapted to the simulations and prototypes that follow them.

An emerging area for HCI explores the concept of playful photography (Petersen *et al.*, 2009). This investigates new ways of engaging with digital photography relating to playfulness and experience-centered design.

From the perspective of multimedia learning (Mayer 1997), pictures comprehension play an important role (Schnotz 2005). Many studies have shown that for instance students learn generally better from words and pictures than from words alone. Mayer (1997) called this multimedia effect.

In fact, combining texts and pictures, with coherence and spatial contiguity, have positive effects. The closeness of pictures and related written words reduce visual search processes, enhancing simultaneously availability of pictorial and verbal information (Schnotz 2005).

Overall, interface evaluation regards the receptivity upon a certain system. The overall receptivity is a mixed between social receptivity and practical receptivity. Factors like cost, compatibility, utility and usability may be considered.

Usability, as a multi-dimensional property of the interfaces (easiness of learning, efficiency, easiness of remembering, low errors and user satisfaction), is then just one of the things to consider when evaluating computational systems. However, usability testing has gained significant relevance in interface design. Another relevant perspective is user experience

Interaction design requires many skills conceptual, technical, behavioral and aesthetical. The interdisciplinary teams that work in this domain reflect this.

To create successful projects, communication efforts bridging all the disciplines are indispensable. Regarding the environmental domain, see for instance, Flemming *et al.* (2008) for the need of considering human factors in the sustainability domain; Lockton *et al.* (2008) addressing design for sustainable behavior; Steinfeld and Mino (2009) handling the challenge of trans-disciplinarily in education for sustainable development.

4.1.3 *Reinforcing environmental communication*

Approaches to the promotion of pro-environmental behavior cover efforts within environmental communication that can have the following definition and goals:

“the planned and strategic use of communication processes and media products to support effective policy making, public participation and project implementation geared

towards environmental sustainability. (...) Environmental communication aims not so much at information dissemination as at a shared vision of a sustainable future and at capacity building in social groups to solve or prevent environmental problems.” (OECD 1999, p.8)

This definition and goals setting does not highlight a dimension of pro-environmental behavior that relates to a possible emotional approach considered particularly relevant at an individual level. However, it considers that environmental communication has personal impacts by enabling triggering reactions in non-rational (e.g. emotional) dimensions of human behavior and practices (OECD 1999).

Along with the iterative design approach, a systematic and comprehensive environmental communication strategy may support a design framework. OECD (1999) proposes the following four stages (and 10 steps) environmental communications strategy:

- Stage 1 – Assessment, including 1) situation analysis and problem identification; 2) actors and knowledge, attitude, practices analysis; and 3) communication objectives.
- Stage 2 – Planning, comprising 4) communication strategy development; 5) participation of strategic groups; 6) media selection and mix.
- Stage 3 – Production, covering 7) message design; 8) media production and pre-testing.
- Stage 4 – Action and reflection, involving 9) media performances and field implementation; and finally 10) process documentation, monitoring and evaluation.

This strategy considers the development of an appropriate multimedia mix. The selection of media should be appropriate to individuals’ information-seeking habits, preferred information sources, media access, media consumption patterns, communication networks and group communication behavior.

This way, coherent and reinforcing systems of communication should be able to address specific but also diverse information and behavior problems, and needs of intended beneficiaries (OECD 1999).

Also according to this source, is important to assume that:

- No medium is effective for all purposes or target beneficiaries.
- A communication strategy usually has various information, educational and communication objectives.
- Different media and communication channels complement and reinforce each other.
- Strategic planning means to select which medium or combination of media should be used for what purpose by whom in order to deliver which specific messages to whom.

General approaches to multimedia selection include select a medium:

- for a single or specific rather than for different goals;
- that has a unique characteristic or particular advantage which is useful to accomplish a specific purpose;
- which the target audience is already familiar with and has access to;
- which can easily accommodate 'localized' messages;
- that can be locally developed, produced and operationally supported;
- that complements and reinforces others used in the same strategy, while offering distinct functional strengths and emphases.

4.2 Design framework for facilitating pro-environmental behaviors

The proposal of a design research framework that explores the development of new interventions resulted from considering notions from extending design for environment (see section 4.1.1), approaching emotions in HCI (see section 4.1.2) and reinforcing environmental communication strategies (see section 4.1.3).

Such a design framework consists of four major stages: analysis, conceptualization, fabrication and evaluation (see Hipólito and Câmara 2008 for a previous version of the design framework).

An iterative process is considered, meaning that design and evaluation should be constantly integrated through the process. The process is interdisciplinary in nature and involves skills related to environmental systems analysis, environmental psychology and communication, computing techniques, and to further design and aesthetics aspects.

4.2.1 Analysis

In a first stage, analysing the issues involved in facilitating pro-environmental behaviors and problems identification should be accomplished. This refers to principles related to individuals' relationship with nature and environment (e.g. resources conservation, recycling actions) and to further social and economic issues (e.g. education, community promotion, and people involvement). In this study this was completed during the model proposition (see section 3.2).

The analysis phase should consider studying emotional aspects for design and evaluation of the interventions. New methods of emotional assessment should be considered.

After this analysis phase, new concepts can be developed. This is described in the next section.

4.2.2 *Conceptualization*

The conceptualization phase relates to the proposition of new concepts that explore the potential of innovative interventions. This refers to advancing innovative sustainable concepts such as the ones related with automatic systems and just-in-time feedback while being emotion-oriented.

An emotion-oriented approach aimed at facilitating pro-environmental behavior promotes individuals' environmental awareness, involvement and participation. It also contributes to well-being and sustainable life-styles.

It is relevant to stress that the senses support directly the individuals' reaction to the provided feedback. Sensations are absorbed and used to interpret the sensorial message. This intuitive approach possibly motivates reflection upon resources consumption leading to environmental behavior facilitation.

The design challenge involves the issues considered in Figure 3-13, namely: touch conscience by creating affective experiments; increase awareness by visualizing real time the effect of ones' action; make life tasks easier by increasing the joy/happiness/playfulness experience; and help to reduce costs by showing alternatives to current behaviors using positive reinforcement techniques.

A focus upon feedback for controlling behavior as dynamic indicator of consumption (see 2.3) is not a novel approach. Fisher (2008) provides an overview of types of feedback. Different characteristics may be relevant including frequency and duration, content, medium and mode of presentation, comparisons and additional information and other instruments.

Another important feature for successful feedback within this research work is the one of creating affective experiences, and its ability to create individual positive emotions such as joy/happiness/enthusiasm or even playfulness. These emotions will affect viewer's mood that will affect making future behavior choices, facilitating pro-environmental behavior.

At this point, is important to consider that this should address the following (Figure 4-1): embed computational systems in everyday places of affective and value attachments, while using sensorial attributes (visual, aural, touch and interactivity) for purposefully stimulate viewer's senses.

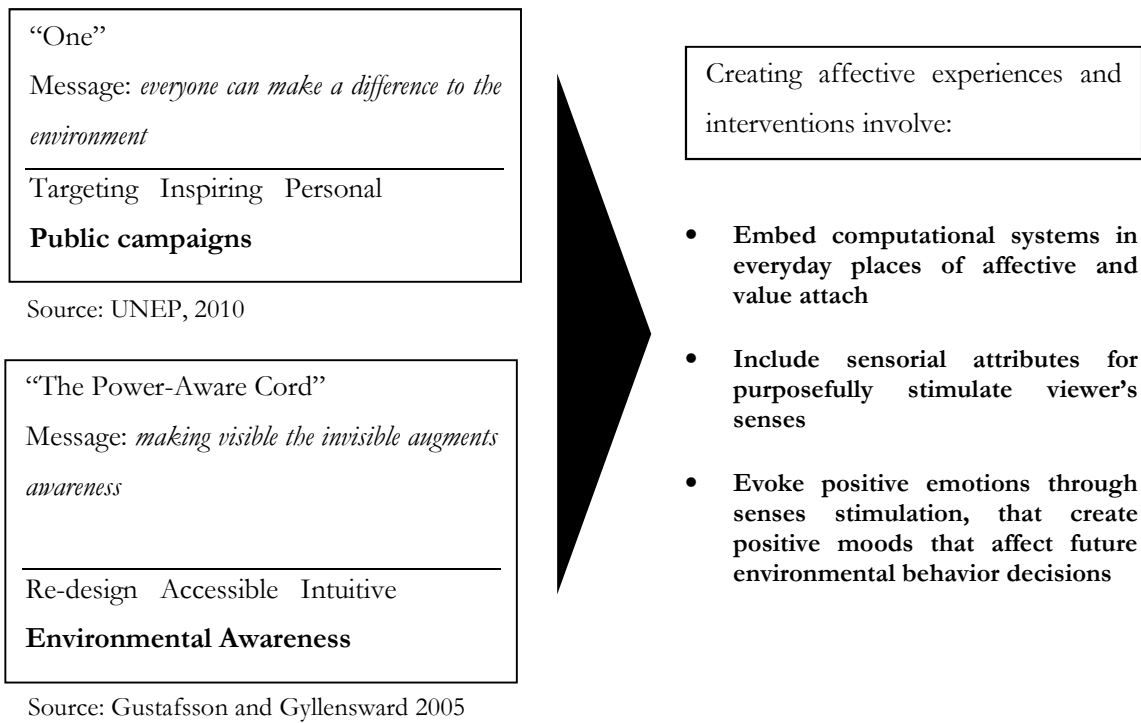


Figure 4-1 Creating affective experiences and interventions

The design should follow the guidelines included in Figure 3-13 and further consider the following issues:

- Sensorial appeals are more effective, the more directly after an individual's action it is given. However, emotional responses (either behavior, language or physiologic) can be delayed or seemingly inhibited entirely, or responses can be retained in storage for later use in a very new setting. Furthermore, cues previously observed can be reviewed, reevaluated and alternative behaviors formulated to fit changing circumstances (Bradley and Lang 2000).

- Sensorial appeals design considers ESB on the private sphere, behaviors that directly affect resource consumption or cause pollution. The appeals may refer to resources consumption alone, on cost, on environmental impact of consumption, or for supporting moral values.
- Sensorial appeals design considers two media: Digital media and non-digital material. For both, human senses support the individuals' reaction to the sensorial appeal. Sensations are absorbed and used to interpret the sensorial appeal. This intuitive approach possibly motivates reflection upon self-ESB leading to facilitate pro-environmental behaviors.
 - Digital media allow integration of electronic displays and appliances on other place elements, while using Internet as interactive tool. Advantages of this approach may be flexibility of reaction to users demands (showing different types of appeal upon request), and the ability to process and present data. However, interactive digital tools require substantial user involvement. In addition, users not used to the digital world, may have problems to understand the applications.
 - Non-digital material goes further beyond written material (e.g. direct mailings, brochures). Environmental behavior sensorial feedback tools (Hipólito 2008; Hipólito and Câmara 2008) design consists on developing environmentally conscious tools based on a desire to embody in the look of products the high importance given to environmental matters such as reducing resources consumption. Its design focuses on multi-purpose adaptability once interactive sensorial feedback (e.g. visual, sonic) works as a response to resources consumption, with a minimal use of materials to increase simplicity. The designed sensorial argumentation becomes products' added intelligence and intends to promote sustainable consumption augmenting consumers' awareness, involvement and participation.

The support of different behavior decisions usually used passive experiences involving environmental campaigns, information systems and specific learning tools, which were inadequate, in practice, for a large set of behaviors.

The approach presented in this dissertation, however, requires the consideration of direct experiences, as an alternative to ICT. In particular, AESAM intend to support the facilitation pro-environmental behavior problem, by introducing automatic systems and real time feedback.

This behavior feedback works as a reinforce behavior-image format¹⁸, where the adequate behavior is given special qualities by means of a symbolic relationship. A symbolic context surrounds the behavior, impairing meaning to the behavior beyond its constituent elements or benefits. The reinforce behavior-image interventions work by fusing two systems of codes within a single message, a behavior and a symbolic code.

In generating the overall meaning in the intervention, some narrative approach links those codes. The symbolic association thus established brings the behavior into a meaningful relationship signified by a natural setting such as a landscape or a recognizable visual and sensorial metaphor. The increasing use of photography, providing ubiquitous imaging, encourages the symbolic rewarding of appropriate environmental behaviors.

These emotion-oriented interventions reward adequate behaviors with beautiful environmental landscapes or its individual elements (e.g. fauna, flora), helping individuals' to imagine places where they would be wishing to be or a moment when the behavior could be contributing for the preservation of such landscapes.

In all cases, the predominant interpretation results from the transfer of the symbolic quality associated with a particular image to the adequate behavior. Figure 4-2 represents the reward behavior-image format.



Figure 4-2 Reward behavior-image format

According to Abrahamse *et al.* (2005) this approach applies to consequence interventions approaches, once it is assumed that the presence of consequences will affect behavior. However, instead of considering as those authors do, two approaches separately (feedback or rewards) the emotion-oriented approach considers simultaneously feedback and reward. The nature of reward is different from previous options that relate with monetary rewards.

¹⁸ This description was based in the description found in Leiss *et al.* (1990, p. 244) of the basic advertising format called “Product-image format”.

After conceptualization, next section addresses the fabrication step.

4.2.3 *Fabrication*

The fabrication step includes an assessment of prototype fabrication feasibility since the concept idea. Planning the prototypes development includes the following phases: conceptual, sketch, artefact, fully operational.

Furthermore it also includes gathering, information regarding systems and tools specifications. This is certainly a multidisciplinary approach, once beyond the environmental analysis and conceptualization of solutions, specific development skills need to be involved.

In fact, the proposed use of pervasive and invisible computing techniques that enables dynamic visualizations, also embedded on common surfaces such as textiles, boards or paper (Camara 2005) is encouraged and need specific and skilled development support. These led to considering partnership projects that involve different interested collaborators.

Research developments linked to the following groups (see also Appendix F):

- YDreams and its YInvisible opening activities, for developing non-digital material applications;
- Electronics Department of FCT/UNL, for developing a new prototype;
- Informatics Department of FCT/UNL, for developing digital media applications.

The collaboration within the Informatics Department resulted in the development of the academic research projects SEEK and DEAP, that led to the development of several successful applications and prototypes that were fabricated by Master students within their own projects, mixing digital media and technological approaches (e.g. Lobo 2009 and Centieiro 2011).

The former two attempts efforts did not resulted in the fabrication of tangible applications, and were then more useful for supporting the conceptualization phase.

Thus, the interventions that are advanced in the next chapter remain in a scenario level and their sketches are introduced. The scenarios were used for evaluative purposes.

The evaluation phase is described in the next section.

4.2.4 *Evaluation*

The evaluation phase should include qualitative research methods (both on environment-behavior research, but also approaching the interventions), enabling gathering real data from individuals regarding initial conceptual perception studies to later hands-on prototype testing, if the prototypes are to be developed.

As an iterative process is considered, the results of the different evaluation phases have impact in the design process. The results can support shifts in the interventions design or support the evaluated approach.

In this EFD-E framework, the evaluation phase intends to provide fundamentals for the new ideas and concepts regarding the new pro-environmental behavior interventions that are the subject of the next chapter.

To achieve this goal, the suggested approach must include environment-behavior research but also problem detection regarding the integration of sensorial appeals in the emotion-oriented interventions for environment. The defined evaluative approach had the following properties:

- Adoption of an exploratory environmental-behavior qualitative perspective;
- Focus on visual and interactivity sensorial stimulation and the behavior reaction;
- Include an analysis to a set of interventions for facilitating pro-environmental behaviors.

This way, different criteria assures evaluating the integration of sensorial stimulation and detecting associated relevant problems.

The evaluation of the sensorial stimulation integration should be a part of the global interventions evaluation, including their goals and strategies. This means that the evaluation phase is a complex process that needs to combine the principles that have guided the development of the interventions.

The diversity of methods of evaluation, led to the selection of different approaches to support the study of new interventions for facilitating pro-environmental behaviors.

4.3 Definition of requirements of new emotion-oriented interventions

Individual's creativity, entrepreneurship, knowledge and skills are generating new and sustainable ways of living. Facing these social innovation processes, research upon design should also support it. That includes the generation of new ideas to conceive enabling solutions and further prototype developments.

In this context, this dissertation proposes a design framework that addresses the challenges of facilitating pro-environmental behavior and, at the same time, explores the opportunities that arise from the present technological and cultural evolution. New emotion-oriented interventions provide feedback upon environmental behavior, focusing on positive emotions such as joy, happiness, enthusiasm or playfulness.

The development of new emotion-oriented interventions addresses the following requirements:

- Focus on ESB, noting that many times these behaviors lead to emotional episodes. For instance, observing a beautiful landscape provide positive emotions and recycling in dirty recycling bins provide negative emotions. These emotions that are place related and that interfere with individuals' mood will have an effect in the interventions use. This should also be taken in account when reflecting about the interventions development.
- Select the environmental resource associated with a headline behavior. Focusing on personal ESB the following set of possibilities emerges:
 - Nature conservation - Learning about nature
 - Homes: waste - Increase recycling; Waste less
 - Homes: energy/electricity- Better energy management
 - Homes: water - More responsible water usage
- Focusing on affective experiences and emotions, namely the positive, like joy, happiness, enthusiasm and playfulness. Designing for these emotions while using symbolic settings is a requirement. Another topic is to integrate emotional aspects of the individual experience into the interventions evaluation process, namely how to assess emotional individual reactions. The selected approach uses the self-assessment manikin scale (SAM) included in the IAPS research materials (Lang *et al.* 2008).

- Another important requirement relates to contextual factors such as available technology to create feedback. Feedback is more effective, the more directly after an action it is given. Moreover, the feedback characteristics discriminated in section 4.2 should be considered: frequency and duration, content and medium and mode of presentation.
- User characterization (in terms of age, gender, and education, but also further technology acquaintance or emotional features) should be pointed as another requirement once previous motivation and environmental awareness influence the results. In this sense, feedback has a learning function when individuals learn about the link between a certain pro-environmental problem and their behavior or as habit formation when individuals put the new awareness into practice, facilitating the formation of new environmental habits.

4.4 Future research

The previous section addressed the requirements for new emotion-oriented interventions, by attaching emotional-orientation to a set of headline behaviors and personal ESB.

In the future, extensions to EFD-E include consider emotional elements of a pro-environmental problem.

An interesting result of the work presented in this chapter covers the possibility of extending the designing approach to many environmental problems, such as the pro-environmental behaviors problems described in the next chapter.

4.5 Conclusion

This chapter proposed to create positive emotions (e.g. enthusiasm, happiness, and playfulness) through feedback to facilitate pro-environmental behaviors by an emotion-focused design for environment framework.

The potential of the design framework is its simplicity, having four main steps. The use of such a design approach supported the proposition of new interventions.

Next chapter describes the new interventions.

CHAPTER 5. NEW PRO-ENVIRONMENTAL BEHAVIOR INTERVENTIONS

The previous chapters covered:

- Identifying the topic of this dissertation, motivation and research goals;
- Reviewing the literature;
- Laying down the foundations of research by approaching a new model; and
- Showing how new emotion-oriented interventions for facilitating pro-environmental behaviors could be handled by using steps of an EFD-E framework approach.

This chapter addresses the issue of facilitating pro-environmental behaviors with pervasive and invisible techniques. This chapter places focus in the affective experiences design for future environmental behavior adequate decisions.

This study does not include prototype development. The scenarios, as central concepts for the forthcoming analysis, are a rich and detailed portrait of a plausible future world¹⁹. They are descriptions of what might occur. In this sense, the scenarios describe pro-environmental interventions and trends as they can occur in the future.

The definition of the interventions considered the following options:

- Integrate individuals reactions since the beginning;
- Focus on sensorial stimulations (visual and interactivity) also related with environmental landscapes and scenes;
- Develop an iterative design process that by combining qualitative studies with reality enables to increment the usefulness and convenience of the intervention.

A systematic approach presents the interventions scenarios with the goal of comparing the involved work.

This chapter focuses on a number of pro-environmental behavior problems, adopting AESAM. The first section describes such problems. Section 5.2 describes a general approach of AESAM in order to distinguish the examples. Section 5.3 presents affective images rewarding systems and section 5.4 presents sensorial feedback tools. Section 5.5 summarizes the conclusions.

¹⁹ For scenario-building methods see Moniz (2006, p. 185).

5.1 Pro-environmental behavior problems

This section defines four pro-environmental problems.

In this scope, there are three parameters involved: Sensorial stimulus, output behavior reactions and possible interactivity.

Problems consist of finding and proposing sensorial stimulus and possible interactivity given a desired output pro-environmental behavior.

5.1.1 *Learning about nature*

The learning about nature problem consists of obtaining the output behavior of encouraging visits to urban parks, when subject to a set of park scenes and landscapes.

5.1.2 *Recycling*

A relevant pro-environmental behavior problem is the problem of recycling. This consists in supporting recycling activities by providing better recycling equipment with dynamic feedback functions.

5.1.3 *Saving energy*

The saving energy problem consists in augmenting consumption awareness while helping to reduce costs, when exposed to dynamic consumption sensorial feedback.

5.1.4 *Responsible water use*

Visualize real time the heat water use is the interactivity designed to obtain the output behavior of more responsible water use.

5.2 Affectively evocative smart ambient media

The defined set of interventions shares a common property: the intention of facilitating pro-environmental behavior using innovative technology. The interventions are naturally distinct and resulted from the proposed EFD-E framework.

Their development considered the following requirements:

- Focus on ESB personal, private sphere;
- Focus on headline behaviors
- Focus on creating affective experiences
- Focus on contextual factors, namely available technology, as variables that influence ESB; and provide feedback in a pictorial away;
- Focus on specific user groups, specifically on those that may use feedback as a learning function or as further habit formation.

Two approaches are considered:

- Affective pictures rewarding systems – are about sending to devices (mobile phones or public ambient displays) affective images related to behavior. It contains two scenarios for further evaluation: The Happy park photo and the KnowY scenarios.
- Sensorial feedback tools – designed to support increased awareness in the area of resources consumptions. It contains two scenarios for further discussion: The Wall illuminated light switcher tools and the Affective minute-by-minute scenarios.

Table 5-1 includes the interventions used in the emotion-oriented interventions study.

Table 5-1 Interventions

Concept and scenarios	Headline behavior and ESB	Affective experience	Guideline
Affective pictures rewarding systems			
Happy park photo	Nature conservation: linking learning and happiness	Share positive emotions through mobile media	Increase awareness by visualizing just-in-time the effect of ones' action
KnowY	Recycling: Garbage disposable	Dialogue and contextual interaction through better equipment	Make like tasks easier by increasing the emotional experience
Sensorial feedback tools			
The Wall Illuminated Light Switcher	Electricity: Save energy	Sensorial feedback made of a well-known metaphor	Augment conscience and awareness and help to reduce costs and consumption
Minute-by-minute	Water: Responsible water use	Framing an affective image	Increase awareness by visualizing just-in-time the effect of ones' actions

The main goal of creating these examples was to enable discussion around interventions aimed at facilitating pro-environmental behaviors. This central goal promoted the definition of the following specific objectives:

- Offer the possibility to explore different pervasive and invisible techniques for different pro-environmental problems;
- Integrate different approaches for facilitating understanding on how emotion-oriented interventions may positively influence pro-environmental behavior;
- Offer an approach that is adequate to individuals' prior experiences regarding their ESB.

The development of the interventions included the following phases:

- Definition of the interventions goals;
- Design of a concept that integrates multiple techniques;
- Development of the intervention sketch;
- Development of a “simulation” activity;
- Evaluation.

The development of the interventions scenarios considered support from experts on environmental related areas, namely environmental sciences, education and design.

Also relevant to the scenarios development was the experience of the project DEAP members on interactivity issues and most particularly on persuasive technology for environment.

Each intervention relies on specific inspiration provided by related researches, mostly performed at FCT/UNL in different moments, some simultaneously. Their diversity inspired the interventions definition.

Table 5-2 includes related research.

Research collaborations had different approaches, commitment and involvement. However, all have provided insightful moments that have greatly enriched the research (see also Appendix F).

The participation in several work meetings enabled to explore related ideas within interdisciplinary environments, thus aligning to the proposed interdisciplinary design process.

Table 5-2 Related research, goals and the main discipline

Intervention	Related research	Goals of the research	Main discipline
Happy Park Photo	“Sharing positive emotions” (Kanis and Brinkman 2008)	Provide insights into the design and development of technologies that aim to encourage the sharing of positive emotions	Emotions and HCI
KnowY	SEEK project (2007) and later DEAP project (2009-2012)	Develop environment applications using captology.	Persuasive technology HCI
The Wall illuminated light Switcher	Yinvisible projects opening activities (2006-2007)	Study and conceive new forms of computing, namely expressive surfaces and define future possible applications.	Applied Chemistry and Materials together with YLabs
ECOS- Minute-by-minute	Electronics internship definition (2008) and STATIC prototypes analysis (2010)	Reflect on consumption observation applications and find new ways to express that.	Smart materials and design

Supporting all the interventions development is the collaboration within CENTRIA-DI/FCT/UNL that provided access to the IAPS gallery. Studying the IAPS materials supported the research of affective images and emotional reaction to pictures.

This certainly contributed to the advancement of EFD-E that extends the traditional DFE. Bridging IAPS research and environmental behavior studies, new contributions arise for the research field of emotion and reaction to affective images.

In the next sections the Affective images rewarding systems (section 5.3) and the sensorial feedback tools (section 5.4) are presented.

5.3 Affective images rewarding systems

The concept of affective images rewarding systems (Figure 5-1) consists in creating interventions that send to devices (mobile phones or public ambient displays) affective images related to behavior.

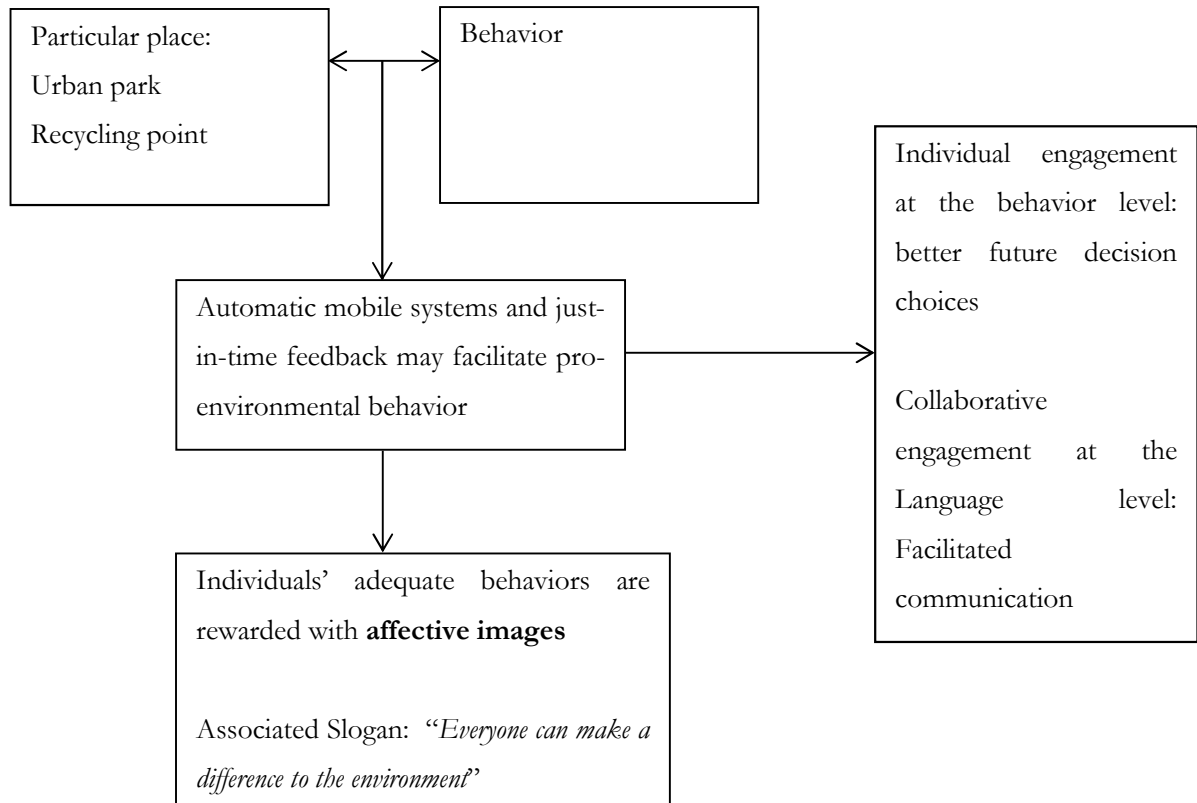


Figure 5-1 Concept of a rewarding messaging system

In the Happy park photo intervention (section 5.3.1) a stimulus collection selects randomly a photo of an urban park and sends it to that park visitor.

In the KnowY intervention (section 5.3.2) a public ambient displays act as smart displays, embedded nonintrusive in the ambient that can perceive users proximity and recycling behavior and react accordingly.

5.3.1 *Happy park photo*

This intervention has the general goal of sharing positive emotions through affective images delivered within mobile environments. This leads to increasing enthusiasm about learning more about the ecology of urban parks²⁰. The intervention design included specifying the following phases:

- Sketch of the intervention approach;
- Development of the simulation;
- Evaluation.

Research efforts link emotion and HCI. However, examples of how designers and developers can provide social interactive experiences that actively communicate positive emotions are still scarce (Kanis and Brinkman 2007).

One problem to address this way is the learning about nature problem (see section 5.1.1) that consists in obtaining the output behavior of encouraging visits to urban parks, while rewarding visitors with park scenes and landscapes positive images.

Different data about the urban park supported its exploration with the intention of designing a new pro-environmental intervention strategy and a simulation.

Parque Eduardo VII has several points of interest including diverse visual landscapes and sportive infrastructures. Available data and walking around in the park enabled to select the visual sensorial stimulations to include in the simulation.

The three park areas selected were upper pond, lower pond and children playground area (Figure 5-2). Photos included a collection of pictures representing different ecologic systems and their natural and artificial elements. Table 5-3 includes the pre-selected pictures that represent those areas.

²⁰ This is inspired in the design of an interface that explores soundscapes in environmental education and the correspondent “Sons de Serralves” prototype developed in the scope of a Ph.D. thesis work (Silva, M.J 1999, and Silva *et al.* 1998).



Figure 5-2 Park selected locals

Table 5-3 Pictures themes

Upper pond	Lower pond	Children playground
Ducks and geese	Birds	Flowers
Water	Trees	Sky

5.3.1.1 *Sketch of the intervention approach*

The following principles were the basis for the simulation draft:

- Affective pictures of natural elements must represent park natural elements of interest;
- In the simulation, the affective pictures integrate a stimulus collection;
- Pictures are sent to mobile phones that are in the area as a reward;
- Additional information may also be associated with the picture.

The association of these principles guided the development of the intervention that could be seen as a Municipality service (free for the intervention beneficiary). By capturing the location of the device, real-time affective pictorial feedback would be provided accordingly to its spatial location (Figure 5-3).



Figure 5-3 Rewarding urban park visitors with affective images

This service could be available within urban parks aiming at increasing environmental related enthusiasm among park visitors, as well to encourage future visits and contribute to new sustainable lifestyles.

5.3.1.2 Development of the scenario

The main characteristics of this intervention are related with design of sensorial stimulations, visual and interactivity (Table 5-4). In this phase of the intervention development it was decided to consider pictures from three park locals, namely the upper pond, the lower pond and the children playground area. For each zone two pictures were selected making a collection of six pictures. To each picture, additional information was added.

Table 5-4 The Happy park photo intervention

Design of sensorial stimulations	Description
Visual	<ul style="list-style-type: none"> • Collection of park photos. • One Park natural scene photo is delivered to the point of interest nearby mobile device. • One photo per mobile device.
Interactivity	<ul style="list-style-type: none"> • Visiting the Park will interact with the Happy Park Photo dynamically. • The closer to a point of interest, the more the correspondent photo will be sent; the more distant to a point of interest, a randomly photo will be sent. • Photo is given just-in-time and just-in-place. • A new use of digital media enables the creation of an emotional-evocative intervention.

5.3.2 KnowY

This intervention has the general goal of increasing recycling activities.

The intervention design included specifying the following phases:

- Sketch of the intervention approach
- Development
- Evaluation

The initial work had Teresa Romão²¹ contributions, with collaboration of Nuno Correia²² and José Danado²³, enabling to define the SEEK project ideas. The initial project ideas were presented in the Second Persuasive Technology conference as a poster that included the following description in the submitted abstract:

“We introduce KnowY system, a just-in-time environmental “know-why” messaging system to inspire people to engage themselves in environmental friendly activities. Such system presents environmental persuasive messages in the form of know-why questions, before jumping to the know-how answers. This KnowY interaction dialog allows users to become conscientious regarding environmental issues and guides them into convenient procedures towards the environment.” (Romão *et al.* 2007).

²¹ FCT/UNL Assistant Professor.

²² FCT/UNL Professor with “Agregação”.

²³ At that time YDreams collaborator and U.Évora Ph.D. candidate.

The collaboration and experience of Teresa Romão regarding projects proposals enabled to submit the SEEK project and later approval of the DEAP project²⁴ FCT/MCTES financial support. Within these projects, the Master students Pedro Lobo²⁵ and Pedro Centieiro²⁶ (with Teresa Romão supervision) have developed and tested successfully their own applications for the environmental headline behavior of recycling.

Recycling is today's environmentally preferred method of solid waste management and is an environmentally friendly desirable behavior. However, although most people understand the relatively simple tasks required, many still do not do so.

The general public's perception of what recycling is remains largely limited to those visible urban elements including recycling bins and recycling centers, and that recycling is good for the environment because those materials do not go to landfills or incinerators.

Also part of the perception is a misunderstanding about what can or cannot be recycled. One of the reasons to recycling are altruistic reasons, as protecting the environment and conserving resources have become self-evident as being in everyone's general interest.

Recycling bins programs often serve families' residential units requiring residents to use one or more containers to separate and store recyclable materials separated from the normal waste stream. The design, capacity and construction of the containers can also vary. However, containers never include an interactive display for additional information. Specific labeling included in the container adds information. Newsletters may give residents further procedures information.

Involving the community is essential for a successful recycling program and this KnowY intervention support individual behavior.

5.3.2.1 *Sketch of the intervention approach*

The following principles were the basis for this intervention design approach:

- Appealing messages should be produced and conveyed to individuals through multimodal interfaces;

²⁴ Project DEAP: <http://deaproject.com/> (last accessed February 2011)

²⁵ See Lobo (2009).

²⁶ A first "persuasive location-based multiplayer mobile game" was conceptualized, developed and tested (Centieiro 2011).

- In the simulation, visual stimulation includes an affective image and a “Thank you” message;
- Consider public ambient display interaction.

As in the previous intervention, the equation of these principles led to the development of the intervention. KnowY system’s public ambient displays act as smart displays, embedded non intrusively in the ambient, that can perceive users proximity and attitude and react accordingly, and aims to promote recycling (Figure 5-4, Figure 5-5).



Figure 5-4 The KnowY intervention
(In Romão *et al.* 2007)



Figure 5-5 Dialogue (output)

5.3.2.2 *Development of scenario*

In Romão *et al.* (2007) this scenario is described as follows. Touchable displays are used for data input, allowing users to easily reply to system's requests. Electronic sensors, such as light, temperature and proximity sensors or video cameras provide the system with contextual awareness and help it to perceive users behavior.

According to the data gathered by the system, appealing messages are produced and conveyed to users through multimodal interfaces that combine text, audio, still images and video. Demonstration videos or sound effects highlight provide text messages that are short, simple and seductive.

To establish communication between the system and the nearby users' mobile electronic devices, such as mobile phones and PDAs, the system uses wireless communication technologies. Data exchange uses Wi-Fi and Bluetooth and presence detection uses object recognition and motion-sensors.

A KnowY system may promote recycling daily activities, using public ambient displays located outdoors near recycling bins. During the neutral ambient phase, the screen attractive presents animated images to create emotional responses and activate the will for exploring the system.

As people walk by, a motion sensor detects their presence and the initial system state shifts to the next interaction phase with peripheral multimedia add-ons such as sound alerts. Then the short duration dialogue between the display and the user starts.

Questions such as "Do you know why it is important to recycle?" appear on the display. The users may select one of the available on-screen know-why questions, using the touch screen, and the system provides the correspondent "know-how" answer. The system can also help users to take the correct behavior, providing instructions on how to perform right objects' disposal, through an explanation video.

The use of RFID or image recognition techniques to validate object disposal is also part of this scenario. This allows the system to identify the object near a specific bin and immediately provide audio alerts when anticipated wrong disposal. The system can also maintain information on the amount of collected recyclable material along with the correspondent environmental benefits.

This information appears on the display each time users perform a disposal. It can also appear in the user’s mobile device. Table 5-5 describes the sensorial stimulations of the KnowY intervention.

Table 5-5 The KnowY intervention

Design of sensorial stimulations	Description
Visual	<ul style="list-style-type: none"> • A scene of a paper recycling bin is designed to represent behavior • The words “Thank you” appear like paper falling • When the bin is emptied the words fade our gradually
Interactivity	<ul style="list-style-type: none"> • The amount of recycled paper interacts with the “Paper recycling bin” scene • The frequency of the words “Thank you” is sensitive to the amount of recycled paper • Words appear in a simple way just-in-time and just-in-place • Digital media is used to create a new emotional-evocative ambience for environment

5.3.3 Evaluation

Beyond seeking feedback about understandability, aesthetics, and perceived usefulness of the interventions, it is also important to evaluate its effects on behavior in field studies. Froehlich *et al.* (2010) address this issue and conduct a comparative survey of feedback technology including papers from environmental psychology and papers from the HCI literature. A long-term evaluation strategy would be required to study the impact that the interventions have on individuals’ future behavior, whether as private-sphere behavior related or part of a wider community effect.

For studying feedback interventions in laboratory, HCI evaluative approaches can be considered, once laboratory studies enables to define low-costs means of receiving reactions to early design ideas or preliminary prototypes. Long-term field studies should include baseline data and control groups not exposed to the feedback interventions.

This research work considers qualitative studies (following e.g. Maxwell 1998) involving study participants aiming to seek their reactions to the concepts, environmental behavior understandability issues and perceived interventions usefulness.

This evaluation approach considered concept understanding, perceived interventions usefulness and feelings towards the interventions.

5.4 Sensorial feedback tools

Figure 5-6 illustrates the concept of sensorial feedback tools. Environmental behavior sensorial feedback tools are environmentally conscious tools that embody in their look the high importance given to environmental matters such as reducing resources consumption.

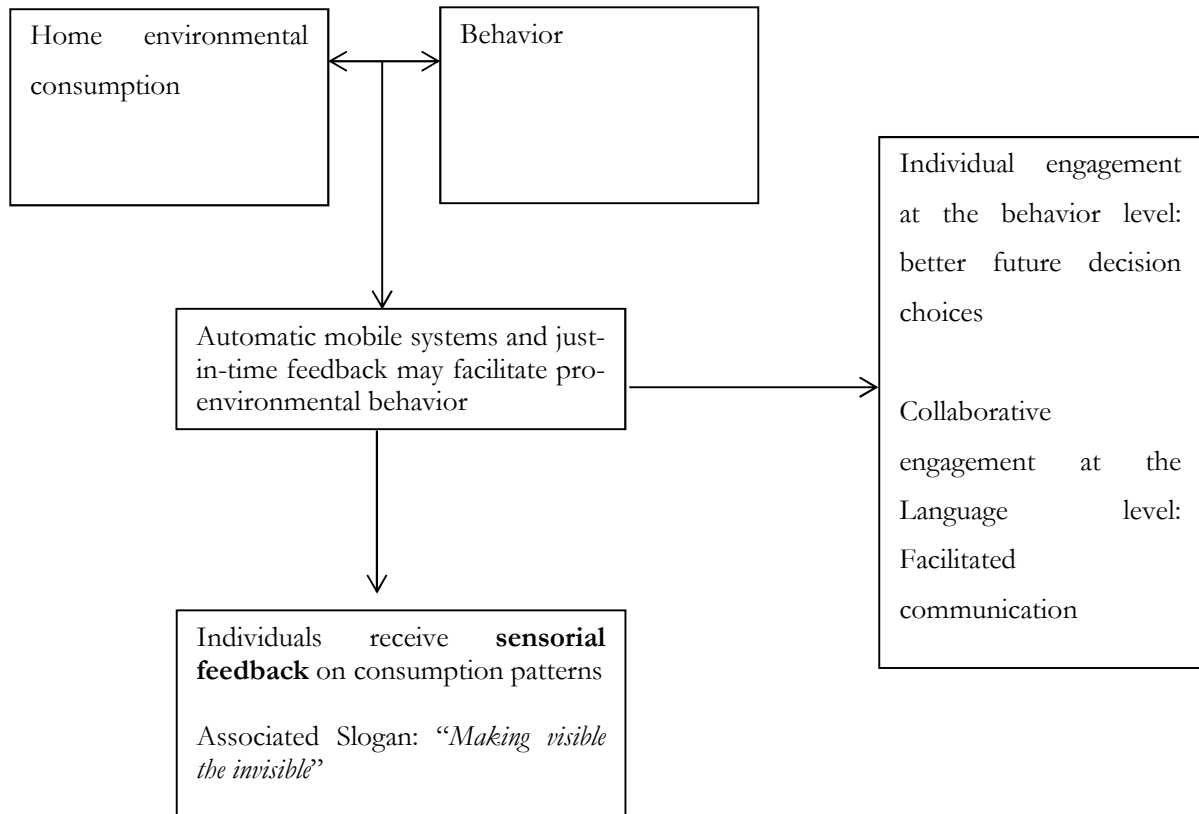


Figure 5-6 Concept of sensorial feedback tools

Its design focuses on multi-purpose adaptability. Interactive sensorial feedback (e.g. visual, sonic) appears as a response of resources consumption with minimal use of materials to increase simplicity.

The designed sensorial argumentation becomes products' added intelligence and intends to promote sustainable consumption augmenting consumers' awareness, involvement and participation.

Consumers' senses support their reaction to the sensorial feedback. Sensations are absorbed and used to interpret the sensorial message. This intuitive approach possibly motivates reflection upon energy consumption (Hipolito 2008).

5.4.1 *Wall illuminated light switcher*

This intervention has the general goal of augment conscience and awareness and help to reduce costs and energy consumption.

The intervention design included specifying the following phases:

- Sketch of the intervention approach
- Development of the simulation
- Evaluation

The first phase of this intervention has been greatly enriched by the collaboration within YDreams YInvisible project opening activities. In fact, the collaboration had two main approaches:

- Support the definition of scenarios for computing over boards, textiles and paper.
- Support the quality control activity of the documentation produced within the YInvisible projects development²⁷.

The observation of YDreams production methodologies and practices constituted a source of inspiration. In fact, collaborators working on interactive materials, designed interactive furniture, ergonomic testing, and many interactive related topics, were nearby and many times open to informally answer development related questions.

These surroundings supported the creative process of the definition of the Wall Illuminated Light Switcher Tool that was presented both in Finland (Hipólito, 2008) and Italy (Hipólito and Câmara 2008).

5.4.1.1 *Sketch of the intervention approach*

The sketch of this intervention considered the following principles:

- Feedback upon consumption should be given over a light switcher
- LED should be used as visual stimulation
- A ring display may be used to represent consumption over time

²⁷ This led to a formal consultancy contract with YDreams-YLabs, having produced deliverables related to quality control. Data was confidential, under the ongoing patents submission procedures. The methodology included internal quality reports (based on a model provided by Eng. Natália Feitor) that were delivered to Dr. Mónica Pedro (Ynvisible projects Manager).

The intervention development considered these principles, illustrating the use of new expressive surfaces to support energy conservation.

The first mock-up design simulates energy consumption sensorial feedback using commercially available green-yellow-red LED as actuators forming a ring display (Figure 5-7). It intends to express consumption time by starting to emit light, clockwise, when a room light is on and after a period of time.



Figure 5-7 Wall illuminated light switcher prototype
(a) drawing and (b) LED functionality experimentation
(In Hipolito 2008)

5.4.1.2 Development of the scenario

Illuminated apparatus for enabling persons to readily locate a wall mounted light switch when entering a dark room are not new. Additionally, visual dynamics such as automatically emitting light when the room is dark and ceasing emitting light when the room is well lit or flashing in the dark to provide eye catching signals are already available.

However, creating an illuminated light switcher tool for enabling consumers to become aware of the energy consumption when lights are lit is novel and represents its adaptability to a different purpose.

Wall light switchers are used every day, their face plate act as displays and incorporate the needed electricity to activate sensorial and expressive visualizations. Expressing on the apparatus surface consumption time or energy quantity in an intuitive way (visual or sonic) may contribute to augment energy awareness and possibly change behaviors.

The added sensorial feedback expression is disabled once the room light is turned off. In order to experiment LED functionality a 9V battery activates LED embodied in a common light switcher.

The light switcher adopts a revitalized look, communicating sustainability just-in-time with simplicity. By representing the consumption time in a sensorial way it makes consumers react inviting them to reflect upon energy consumption. This may promote sustainable consumption behavior.

Further prototype developments include electronics design for adjusting adequate voltage in real settings (batteries are not the best solution) and feedback design for expressing, for instance, energy consumption quantity depending on the light bulb.

Table 5-6 includes the sensorial stimulation of this scenario.

Table 5-6 The Wall illuminated light switcher intervention

Design of sensorial stimulations	Description
Visual	<ul style="list-style-type: none"> • The light traffic metaphor is used to promote energy consumption awareness over the light switcher • The Light Switcher helps to make visible the invisible • An extension to this tool considers the appearance of an affective picture on the wall near the light switcher
Interactivity	<ul style="list-style-type: none"> • Energy consumption interacts with the “Wall illuminated light switcher” • The energy consumption level triggers the change of color of the led display • The visually simple form was selected for interaction, just-in-time and just-in-place • Non-digital materials are used to create emotional evocative setting • A common object is transformed

5.4.2 *Affective minute-by-minute*

This intervention has the general goal of enabling visualizing just in time the effect of ones' water consumption behavior.

The intervention design included specifying the following phases:

- Sketch of the intervention approach
- Development of the simulation
- Evaluation

The first phase of this intervention had the collaboration of Nuno Paulino²⁸ and João Oliveira²⁹, following a first attempt of offering a graduation internship within CENSE for a student from the Electronic Engineering degree.

This enabled to schedule different work meetings for the internship focus definition. In fact, a student started to work on the proposal but it has not completed it due to his needed shift for an out of college work.

However, all the meetings have settled the ground for the proposal of new Environmental consumer observation systems (ECOS)³⁰. The tool presented next is not the one defined in the internship proposal. However, it considers the same goal of developing a new tool for visualizing real time consumption behavior.

This scenario definition considers the STATIC! prototypes and further IAPS analysis.

5.4.2.1 *Sketch of the intervention approach*

The sketch of this intervention considered the following principles:

- Consider chromogenic materials as visual stimulation
- Include an affective image
- Interactivity should promote consumption awareness
- Create an emotion-evocative ambience

²⁸ FCT/UNL Professor

²⁹ FCT/UNL Professor

³⁰ The involved student advanced this title for the system.

This intervention is about the appearance and disappearance of frames of affective images related to environmental scenes and landscapes located in specific locations. This works as an ECOS system, namely an affective minute-by-minute (A-MBM) tool.

The A-MBM tool (Figure 5-8) is a chromogenic system operated by heat inputs used to augment awareness on heat as an energy form that results from electrical appliances use or hot water use.

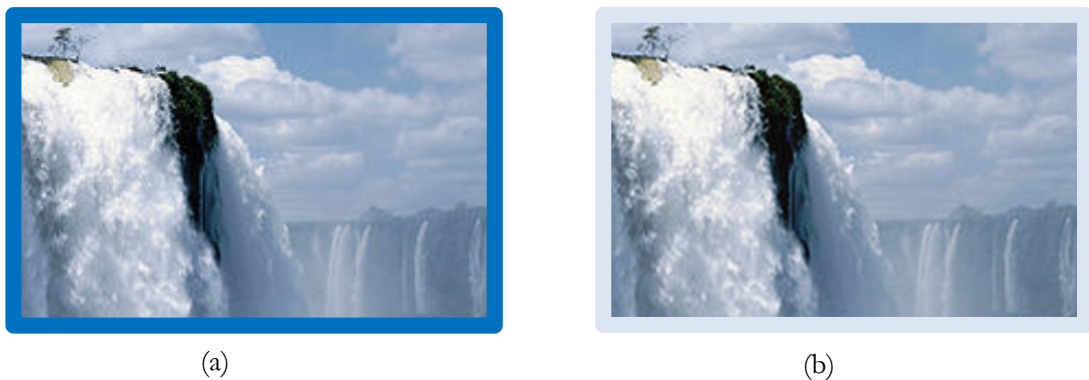


Figure 5-8 ECOS intervention: A-MBM tool – The waterfall frame
(a) no heat condition, (b) with heat the frame stars to disappear.

5.4.2.2 *Development of the scenario*

This scenario development considered the STATIC! “Disappearing-Pattern Tiles” example, which contains bathroom tiles, decorated with patterns in a thermo-chromic ink that reacts to heat, fading away to reflect splashes and intensities of hot water use (the longer the shower, the less decoration on the wall).

Following this example, this scenario proposes a chromogenic frame for an affective image related with an environmental scene or landscape. The purpose of creating an adequate mood for evoking enthusiasm led to chosen images classified with high valence and happiness values. This led to the analysis and evaluation of the IAPS stimulus gallery and to the study described in section 6.3.

The intervention example considers, then, a waterfall image. Associated with the image is a special chromogenic frame that disappears with heat. A heat water source in the bathroom is the

place to locate the picture and its frame. With no heat, the frame is on, in full color; with heat conditions the frames starts to disappear.

Table 5-7 describes the sensorial stimulations of this A-MBM tool.

Table 5-7 The Minute-by-minute intervention

Design of sensorial stimulations	Description
Visual	<ul style="list-style-type: none"> • A chromogenic frame for an affective image related with an environmental scene or landscape is designed • The image has high valence and arousal values
Interactivity	<ul style="list-style-type: none"> • The chromogenic frame disappears with heat • The heat water shower consumption activates the disappearance of the frame pigments • This simple visual cue is presented just-in-time and just-in-place • Non-digital material is used to create emotional-evocative ambience

5.4.3 Evaluation

Sections 4.2.4 and 5.3.3 referred that evaluation should seek reactions about understandability, aesthetics, perceived usefulness and feelings on the design. It should also evaluate the interventions effects on real behaviors in field studies and over time.

Proof-of-concept studies supported interventions early phase definition and other studies (see Chapter 6) enabled to gather participants' reactions to different research aspects.

However, the evaluation did not include studying the effect of the interventions over time, as that would correspond to another research.

5.5 Discussion

The different solutions of AESAM aimed at solving pro-environmental behavior problems based on ESB, headline behaviors, and building individual and affective experiences.

If encouraging visits to urban parks is the problem, than a system that sends affective park scenes and landscapes to an individual mobile phone may be considered. If supporting recycling activities is the goal, than providing modern equipment with feedback functions may be useful.

Another approach regarding the saving energy problem consists in augment consumption awareness through exposition to dynamic sensorial feedback. In addition, the visualization of just-in-time heat water consumption may lead to the adequate behavior of more responsible water use.

To decide what the best solutions are is still an open problem, and perhaps using the combination of the proposed creative approaches is preferable.

5.6 Summary

This chapter presented new pro-environmental behavior interventions, AESAM, aimed to solve pro-environmental behavior problems. Such interventions enable the facilitation of pro-environmental behaviors and are an alternative to existing ICT solutions.

In addition, the goal of these interventions to use different pervasive and invisible techniques on creating direct experiences, rather than passive experiences, showed that many other applications could benefit from this approach, thus allying interactivity with pro-environmental behavior facilitation.

The next chapter presents the qualitative research studies.

CHAPTER 6. QUALITATIVE RESEARCH

This dissertation has so far addressed a number of interventions that expand environmental communication with sensorial stimuli to AESAM for environment (with different stimuli and behavior reactions).

As seen in Chapter 5 new pro-environmental behavior interventions may be of different kinds. This allows the use of different sensorial stimuli by handling different pervasive and invisible techniques. Usually, affective image rewarding systems use digital material while the sensorial feedback tools use non-digital material.

In general, the sensorial stimulations produced by the affectively evocative interventions are visual. For instance, behavior feedback may be a non-digital monochromatic form in the sensorial feedback tools. By contrast, in the affective images rewarding systems, feedback relates with emotional reactions to color photographs.

This chapter applies the notion of emotional-oriented interventions to handle the facilitation of pro-environmental behavior in a qualitative research approach that involved study participants. The new developed meaning can be transferable to other cases and contexts. Thus, talking about research “transferability”³¹ instead of “generalizability” is adequate in this study. The chapter conclusion (see section 6.8) presents how results transferability may occur in the future.

The study considered the following environmental-behavioral-technological research:

- Early proof-of-concept meetings – Interviews and panels included informal conversation with participants especially about the sensorial feedback tools concept.
- Analyzing affective pictures from IAPS – An interpretative approach was used to study the emotional impact of twelve images within the IAPS, considering IAPS data.
- Interviews – A pre-coded interview research method evaluated participants’ expectations, acquaintances, associations and motivation in relation to affective pictures and their environmental behaviors.
- An approach to the AESAM evaluation – A study developed with the goal of supporting the exploration of the proposed scenarios that integrate an emotional orientation for facilitating pro-environmental behaviors. It also considered the study of participants’

³¹ Guba and Lincoln (1989) in Maxwell (1998) advance this transferability idea.

emotional pro-environmental episodes, which enables to identify through recall and verbal report the results of their individual evaluation process in the case of specific emotional environmental episodes.

- Document analysis – This final study intended to complement the information gathered within the previous research approaches. In particular, in the context of creating a scientific-fiction story, participants should reflect and write about technology and pro-environmental behaviors. Most importantly would be the environmental affective images, participants should add to their story.

After describing the qualitative research design (section 6.1) and presenting two different approaches in Section 6.2 (Proof-of-concept) and 6.3 (Affective images from IAPS), Section 6.4 presents their limitations in handling interactivity representations. Section 6.5 presents a qualitative study based on interviews and section 6.6 discusses an approach to the AESAM evaluation. In section 6.7 the document analysis study complements the information gathered in the previous research approaches. Finally, section 6.8 presents conclusions, before a final summary in section 6.9.

6.1 Description

The qualitative research considered the following issues (Maxwell 1998, p. 69):

- Purposes: What are the goals of this research? What issues is it intended to illuminate, and what practices will it influence?
- Conceptual context: What theories, findings and conceptual frameworks will inform the research, and what preliminary research and personal experience will guide the research?
- Research questions: What new understanding this research provide? What questions will the research answer, and how those questions relate to each other?
- Methods: What are the approaches that enable to collect and analyze data?
- Validity: What are the plausible alternative explanations and validity threats to the potential conclusions of the research?

Maxwell highlights the usefulness of its model (Figure 6-1) by including the following reasons:

- It identifies as components of the research design key issues to treat in a systematic manner.

- It emphasizes the interactive nature of design decisions in qualitative and applied research, and the multiple connections among the design components.

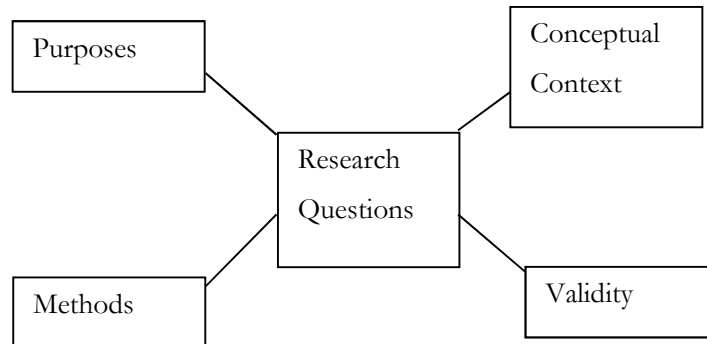


Figure 6-1 Model of research design

This systematization of the research design supported the work done in this doctoral work. Next sections present each model component.

6.1.1.1 Purposes

The main research purpose is to understand the meaning, for the participants in the studies, of their environmental behaviors and emotions, together with technology issues. In addition, it intends to find out the interpretation participants give to their daily environmental experiences and expectations. Another purpose is to understand the context within each particular participant act, and the influence this context has on their actions.

This way, and by considering the open-ended strategy required by the qualitative studies, the research addresses the following goals:

- Generate results that are understandable and experimentally sound.
- Engage in collaborative research with environmental and technological practitioners.

6.1.1.2 *Conceptual context*

The conceptual context of this experimental research was built, it was not found ready-made. The construction of its structure considered existing theory and research found in different published work, doctoral dissertations (Silva 1999, Reis 2004, Cheng 2007), work within the DEAP project and orientation of Professor António Câmara.

Each part contributed to the overall definition of the experimental research in either the selection of methods, definition of research questions, and related research models or in defining questions for the questionnaires or interviews.

6.1.1.3 *Research questions*

The research questions are at the heart of the qualitative research design (see Figure 6-1). In this study, research questions had two main functions: help focusing the study and give guidance for how to conduct it.

Questions addressed environmental behavior processes, focusing on how and why behaviors happen. Three kinds of questions suited the processes approach, namely about:

- Pro-environmental behaviors meanings;
- Influence of physical, social and technological context on environmental activities;
- Feelings and emotional impact of environmental behavior.

6.1.1.4 *Methods*

The study aimed at gathering an understanding of environmental behaviors and of the reasons that rule those behaviors. The selected qualitative research approach used numbers, though, to illuminate the research.

The interpretative research approach taken in this doctoral work, led to considering the following methods, beyond observation of participants:

- Interviews
- Questionnaires
- Panels

Linking different approaches enables extending the knowledge of an issue, by combining methods that focus on the knowledge of participants (everyday, expert or biographical), with methods that are addressing the observable practices of members (individual or interactive) (Flick, 2007).

The study included analysis of visual materials and a panel that use an interactive context for collecting data and thus operate at a different level than single interviews.

Questions format included Likert Scales. The results visual presentation includes the color-coding:

- Strongly agree – strong green
- Agree – Light green
- Undecided – Yellow
- Disagree – Orange
- Strongly disagree – Red

Column or bar charts represent other questions formats.

6.1.1.5 *Validity*

To increase the credibility of the conclusions of the qualitative research, the study addressed the following (from Maxwell 1998):

- Soliciting feedback for identifying own biases and weaknesses in logic, including a variety of people, both familiar and strange to the setting studied. These two groups of individuals gave different sorts of valuable comments.
- Consider the use of simple numerical results readily derived from the data; many results of qualitative studies have an implicit quantitative component.
- Include “rich data” requiring transcripts of the interviews.

6.2 Early proof-of-concept meetings

This study used an open, exploratory or unstructured form as looking for new ideas was a goal. Interviews and panels involved informal conversation with participants about sensorial feedback future tools.

Sessions used research tools created to the effect, including power point slides and material for hand exploration. In addition, observations and picking up cues and themes raised by participants were part of this study open method.

6.2.1 *Method*

Planning this study and setting up the meetings included the following:

- Decide what themes and research questions to discuss.
- Choose participants, research approach (interview or panel) and meeting places.
- Create the research tool for supporting discussion.
- Set the meeting tone.

6.2.1.1 *Themes to be discussed and research questions*

The themes included environmental behavior feedback, sustainable consumption by product design and visual communicative options.

The study addressed two main questions:

RQ5: Are environmental behavior feedback tools welcomed?

RQ6: Is the concept of expressing interactive sensorial arguments understandable?

6.2.1.2 *Participants and meeting places*

Meetings involved 15 adult (4 female, 11 male), all being YDreams related or collaborators. The reason to choose these study participants was their known skills to develop research related with technology linked to ICT, ubiquitous computing and other current technological approaches.

Meetings took place in their workplaces, namely YDreams meeting rooms (at both FCT and Alcantara office) and other FCT spaces.

6.2.1.3 *Research tools*

PowerPoint slides with the research framework and examples of sensorial feedback tools promoted discussion. Material for hand exploration was available supporting the debate.

Rapid prototyping enabled to build a prototype for the early concept meetings related to the Wall Illuminated light switcher tool. See section 5.4.1 for a description of this tool.

6.2.1.4 *Meeting tone*

The meetings took place in a relaxed way and everyone was encouraged to interrupt with questions or comments, while being observed in an unstructured way. Meetings occurred in an informal, flexible way, differing from group to group.

6.2.2 *Results*

The following results were obtained.

Overall, sensorial feedback tools were welcomed and referred to be helpful (and possibly also playful) within family environments with children. Participants demonstrated adequate perception of the proposed behavior feedback.

The ring form was recognized as to be related with consumption over time as intended. Colours availability and contextual visual communication (e.g. using rings, bars, or lines) are topics for further research.

This study results suggest that these innovative tools are powerful sources for augmenting environmental awareness, participation and involvement. However, sensorial visualizations design should be highly considered, once such data is crucial to the application success. Another expressed concern was related to the evaluation method of the tools efficacy, pointing that wouldn't be an easy or straightforward thing to accomplish. These results were discussed at the Changing the Change Conference (2008).

RQ5: Are environmental behavior feedback tools welcomed?

The study discussed behavior feedback tools within the themes of sustainable consumption by product design and visual communication approaches. The results suggested that overall participants welcomed the tools and their usefulness to promote pro-environmental behaviors. This is consistent with environmental psychology studies that show that eco-feedback can reduce consumption (Froehlich *et al.* 2010).

These results are consistent with the results of the model research, when they suggest that automatic systems and feedback relate positively to the facilitation of environmental behavior and may augment the behavior awareness perceived by individuals.

Froehlich *et al.* (2010) noted that understanding why people engage in environmentally responsible behavior is a complex topic ranging many disciplines such as education, economics, sociology and psychology. In fact, debates involved those topics during the meetings, mainly related to environmental related activities, reducing costs, collaborative and cooperative activities and behaviors.

The sessions included debating tools such as the Power-Aware cord (Gyllensward and Gustafsson 2005) and screenshots of its interface illustrated an innovative ambient display tool. Participants' welcomed considering simple sensorial behavior feedback over common objects, supporting those authors' developments.

Regarding the Wall illuminated Light Switcher tool (Hipólito 2008; Hipólito and Câmara 2008) its playful element has been discussed pointing then to the importance of linking playfulness and learning; also the playfulness factor may be relevant as a factor that motivates families' engagement in environmental matters.

RQ6: Is the concept of expressing interactive sensorial arguments understandable?

There are many ways to express behavior feedback, always with the goal of augmenting individuals understanding about how their everyday behaviors affect the environment. Froehlich *et al.* (2010) have reported that automatically sensing individuals environmental related activities and feeding related information back to individuals through computing means is been done in several applications within different technological supports such mobile phones, ambient displays and other online visualizations.

Bio-feedback technology examples include different interactive means that go beyond the computer screen settings such as developing robotics forms or other visualizations. However, results displays may be complex for some user targets.

Thus, the intent of this study was to discuss the usefulness of having simple, sensorial feedback (more similar to the Power-Aware Cord approach). These discussions focused specifically in the Wall illuminated Switcher Tool and on the planned ways to visualize consumption. A possible option considered a ring form.

The preference for having a visually simple feedback real time and just-in-place in an object transformed for that effect was also found in the study of Chapter 3. Therefore, technological elements such as LED can integrate new approaches, similar to the Wall Illuminated light switcher tool approach.

As for the reward approach handling emotions, photographs (affective images) that add to the behavior symbolic meanings can integrate feedback options. These proof-of concept studies did not assess the emotional impact of photographs, but its research is the goal of experimental study described in the next section.

6.3 Analyzing affective images from IAPS

The International Affective Picture System (IAPS) study the emotional impact of images. IAPS developments provide ratings of affect for a large set of emotionally evocative, internationally accessible, color photographs that include contents across a wide range of semantic categories (Lang *et al.* 2008).

The IAPS system includes 1196 images enabling to select a first set of pictures. The goal was to select images of environmental scenes and landscapes and to map those in a two-dimensional space, defined by the judged dimensions of valence and arousal included in Lang *et al.* 2008.

This second research study did not consider collecting new research material as it considers the IAPS sample data and their interpretation in the light of this research.

Planning this study involved:

- Define the main research question;
- Decide what principles may be applied when trying to find out what interpretation may be placed on IAPS research materials;
- Interpret the data;
- Frame recommendations.

Next sections present each of these perspectives.

6.3.1 Method

6.3.1.1 Main research question

The literature review suggests that emotional states research has focused on considering images as activators of emotions (Damásio 2010) and has also focused at the reaction to affective images (Lang *et al.* 2008).

The effects of some images of the IAPS gallery have been identified (e.g. arousal, valence), but none attempts have been made to fit them into pro-environmental behavior explanations. As it was presented in Chapter 4, behavior feedback may work as an reinforce behavior-image format, where the adequate behavior is given special qualities by being embedded in a symbolic context that

impairs further meaning to that behavior. It seems reasonable to suggest that the special qualities added to the behavior would work even better if the image can create in the observer a positive emotional state.

Based on this assumption, the following research question guided the investigation.

RQ7: Do photographs of environmental landscapes and related elements have emotional impact?

6.3.1.2 Principles applied to interpret IAPS research materials

To make sense of IAPS research findings, this study involved reflexive critique, confronting their findings with internal thinking and concerns (self-expectations on affective quality and pictures utility for sensorial feedback).

The study also considered plural principles because interpreting IAPS research findings involved recognizing that different groups of individuals may well have diverse definitions of what is affective or not. This interferes with the usefulness of the design approach.

6.3.1.3 Data interpretation

The data interpretation took the following steps:

- Browse the IAPS gallery. First, the study considered assessing the complete IAPS gallery before focusing on environmental scenes and landscapes. This enabled to select a first set of photographic images, by looking at the pictures³².
- Read the IAPS technical manual. The IAPS technical manual provides information on the method used by the data producers to assess the emotional reaction to images and contains the emotional data itself enabling to understand how to collect and analyze data.
- Select the twelve final environmental affective pictures. The selection took into account positive visual environments. Positive visual environments included isolated or mixed natural elements related to water, soil, sky and living beings. The selected pictures did not include persons. Care was given to the evoking enthusiasm factor, positive emotions triggering while intending to cover different environmental themes and elements, e.g.

³²The display of the selected IAPS pictures is not possible due to the research agreement that prevents the images publication. The twelve pictures used in the study, and the IAPS gallery itself, can be obtained by contacting the authors (IAPS; Lang *et al.* 2008).

biodiversity (living beings), air and water quality (sky and water), farming (land), natural areas management (seaside). This led to consider also images that are not directly related to Portuguese landscapes but that are related with common positive imaginary (e.g. animals from faraway places, waterfall). The selection was free and subjective. The study included two other pictures for comparison effects, namely a lift off image and a galaxy.

Then the selected pictures valence and arousal data (and standard deviations) for all subjects (Lang *et al.* 2008) were gathered (Table 6-1) and the results mapped (Figure 6-2). The obtained results enable to discuss briefly how images trigger emotional pictorial appeals.

6.3.1.4 *Framing recommendations*

This study considered the use of IAPS research materials for interpretation. This way, their results interpretation must be cautious. Moreover, it led to the decision of including a self-evaluation in the following experimental study that included interviews.

6.3.2 *Results*

Results show that all selected images are above the mean in the valence scale (unhappy-happy). However, that does not happen in the arousal scale (relaxed-excited). In other words, all selected images provide a sense of happiness. However, they vary in the excitement they provide.

The Waterfall image has the highest arousal value (most reported excitement) and the Seaside image the highest valence value (most reported happiness). Leaves and Grain images show the lowest arousal (most relaxed) and valence values (most unhappy), namely. The Clouds image follows the images related to land on providing a sense of relax. The case of Polar bears image (showing sweet bear adult with cub over ice is also interesting as the image provides, as expected, a high happiness value; the second after seaside).

The Lift off image provides the highest excitement value, but curiously, the Waterfall image follows it closely.

Table 6-1 Means and standard deviations of each picture in the IAPS

	IAPS Slide n.	Valence (Unhappy - Happy)	SD	Arousal (Relaxed-Excited)	SD
Polar bears	1441	7,97	1,28	3,94	2,38
Elephants	1812	6,83	1,33	3,6	2,11
Seaside	5210	8,03	1,09	4,6	2,48
Waterfall	5260	7,34	1,74	5,71	2,53
Galaxy	5300	6,91	1,80	4,36	2,62
Lift off	5450	7,01	1,60	5,84	2,40
Clouds	5551	7,31	1,63	3,26	2,47
Sky	5594	7,39	1,45	4,15	2,76
Farmland	5720	6,31	1,60	2,79	2,20
Grain	5726	6,23	1,60	2,84	2,04
Leaves	5800	6,36	1,70	2,51	2,01
Earth	5890	6,67	1,75	4,6	2,30

The IAPS slides number orders it, and besides the provided mean, the SD enables to see how broad the consensus about each slide classification is.

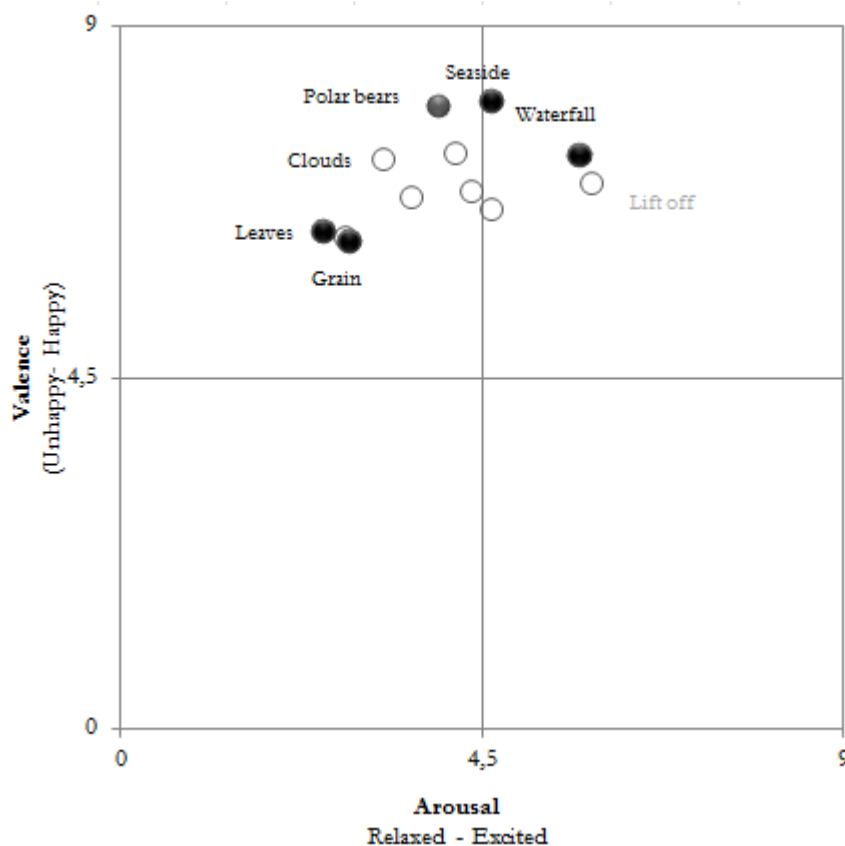


Figure 6-2 Distribution of 12 photographic images from IAPS

RQ7: Do photographs of environmental landscapes and related elements have emotional impact?

Social communication and advertising use images to reinforce messages. The basic advertising format product-image format (Leiss *et al.* 1990) enabled to propose that behavior feedback could work in a reinforce behavior-image format, where the environmental behavior is given special qualities by means of a symbolic relationship with the image.

In other words, a symbolic context that impairs meaning to the behavior embeds the behavior, by considering a natural setting such an environmental landscape or their related elements. Rewarding the behavior with a symbolic setting (rather than utilitarian) allows for new ways of exploring the potentialities of behaviors, and their meanings in the social world.

Lang *et al.* (2008) have been studying the emotional reactions to images in laboratory settings by measuring its affective valence (ranging from pleasant to unpleasant) and arousal (ranging from calm to excited). From the IAPS gallery, images were selected subjectively as to trigger positive emotions (happiness and enthusiasm) that would first be assessed with the Lang *et al.* (2008) data. A reflexive critique confronted their findings. In fact, images emotional impact could create those symbolic contexts that would embed environmental behaviors through interaction.

As regarding the images contents, and for the point of view of creating feedback that provides emotional impact through pictorial stimulus (translated into high values of happiness and excitement while exposed to an image), water related images seem to be more appropriate than sky or land images.

However, drawing further key findings requires more studies. This led to the decision of including a self-assessment of the twelve pictures in the interviews study.

6.4 Limitations

The studies discussed on sections 6.2 and 6.3 certainly supported the development of new environmental interventions concepts and scenarios, namely the sensorial feedback tools and the affective images rewarding systems. However, although both studies had specific research goals, they did not include a research model. The studies were exploratory with characteristics that may limit the research. Namely, the IAPS analysis was made using data from a non-Portuguese sample (Lang *et al.*, 2008) introducing a cultural effect that can biases the results of affective ratings.

Regarding the proof-of-concept study, it only considered the sensorial feedback tools examples and in particular the Wall Illuminated light Switcher Tool, and the emotion-orientation was still not included in the discussion.

Furthermore, the just-in-time feedback used a simple light traffic metaphor, not exploring many other visual stimuli, such as the affective color photographs considered in other affectively evocative interventions.

To handle these main limitations the following qualitative studies were planned: Interviews (section 6.5) and an approach to the AESAM evaluation (section 6.6).

The interviews study was semi-structured, supported by questionnaires and audio taped. It enabled to question environmental related experts about their current environmental behaviors and their relation with affective pictures of environmental scenes and landscape.

The AESAM evaluation was also semi-structured, supported by questionnaires and was audio taped. It explored a research model and used a panel composed by project DEAP members to analyze the four research questions.

Section 6.7 describes the last study that used a document analysis technique.

6.5 Interviews

The emotions of anxiety, fear and sadness are many times included in environmental related appeals or world news. Communication channels present natural disasters images such as floods, hurricanes, earthquakes and fires all over the world. However, as Searles (2010) refers, anxiety appeals prove to be counterproductive with a significant and negative effect on participants' views towards the environment.

Thus, the following questions emerge:

- What benefit to ESB these pictures bring?
- If enthusiasm reinforces an individual's positivity towards efforts to protect the environment, reinforcing prior beliefs, leading individuals to report an overall positive orientation, what images are best for creating emotional stimuli and adequate moods for adequate behavior?

These questions, together with a need to better understand expectations, acquaintances, associations and motivation of participants in relation to positive affective pictures and their environmental behavior, led to a pre-coded interview research method. This enabled to partly quantify research material and compare views and experiences of different subjects.

The interview transforms the subject behind the respondent from a repository of opinions and reasons or a wellspring of emotions into a productive source of knowledge (Holstein and Gubrium 1998). Interviewing is a research project for producing new meaning, and includes the phases of finding the research topic, selecting respondents, questioning and answering, and results interpretation.

6.5.1 *Research method*

The set of interviews had the goal of better understand:

- participants' expectations in relation to the use affective pictures for pro-environmental behavior;
- their acquaintance with the possible affective pictures by environmental elements, particularly water, land, sky and living beings;
- associations made within affective pictures and behaviors (happiness and enthusiasm, and also playfulness);
- their motivation to the theme "emotion-oriented interventions".

An interview guided pre-coded approach intended to ensure collection of the same general areas of information from each interviewee. This provides more focus than a conversational approach, but still allowing a degree of freedom and adaptability in getting the information from the interviewee.

The sessions included two printed questionnaires providing to respondents a change of pace, rhythm and style. The sessions were audio taped for posterior transcription and analysis.

The research interviewing approach planning included the following steps:

- Sort and list areas of questioning, including behaviors, opinions and values, feelings, knowledge, sensorial and background and demographics;
- Edit and prioritize questions;
- Consider methods to analyze the answers;
- Put questions into sequence;
- Check the relevance of questions.

6.5.2 *Participants*

The study participants are all environmental related experts (Table 6-2). The selection took into account criteria such as different environmental specializations, commitment to environmental themes and causes, both genders.

The candidates to the interview knew that the results treatment would be anonymous. All have agreed to participate in a complete volunteer basis, authorizing the audio recording of the interview.

The selection began by using personal contacts to identify respondents that in turn have nominated subjects that they consider who would also be appropriate respondents. The terms of engagement included introducing subjects to the study summary, including the selected research method and meeting duration.

The interviews took place in locals approved by the participants. They usually selected their workplace, either in personal office, meeting room or classroom. If the first had the advantage of having respondents more comfortable in their desk, the latter had the benefit of using a neutral

space that may encourage respondents to open up. One exception, though, led to make the interview in a public space suggested by the participant as to be more convenient.

The participants (4M, 2F) were aged from 30 to 52. Obtained results were very fruitful in terms of better approach understanding and evaluation of associated topics and concerns.

Table 6-2 Subjects

	Formation/Current Profession	Interview local and recorded audio
1	Environmental engineer, Ph. D. candidate (New digital media)	The interview took place in the participants workplace in the University Recorded audio: 7:22 + 9:42
2	Environmental Engineer University Professor	The interview took place in the participant workplace in the University Recorded audio: 30:55
3	Environmental Engineer, Environmental Agent	The interview took place in the participant workplace in the Company Recorded audio: 30:55
4	Environmental Engineer, University Professor	The interview took place in the participant workplace in the University Recorded audio: 35:27
5	Psychologist, University Professor (Environmental Psychology)	The interview took place in a public space Recorded audio: 32:29
6	Psychologist, University Professor (Environmental Psychology)	The interview took place in the participant workplace in the University Recorded audio: 37:28

6.5.3 Research questions

This study focuses on four research questions. Figure 6-3 expresses their relationship.

RQ8 – Have affective images a positive effect on increasing motivation for adequate environmental behavior?

RQ9 – Have affective images a positive effect on happiness and enthusiasm?

RQ10 – Have affective images a positive effect on playfulness?

RQ11 – Have increased motivation a positive effect on pro-environment behavior achievement?

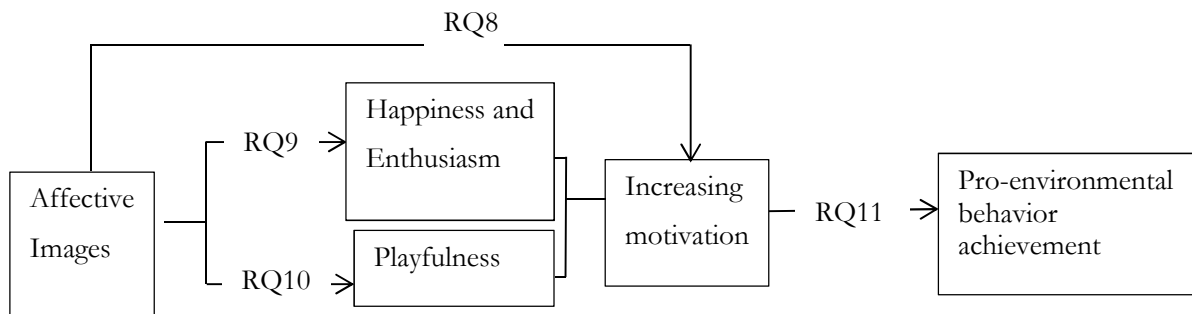


Figure 6-3 Research model

6.5.4 Research tools

Each participant received a printed interview script, including informed consent form and instructions in the interview first minutes (Appendix B1). The script included a prior acknowledgment, study goals, and detailed participant involvement clarification. It also expressed that there are not right or wrong answers, and that responding in the most honest way was the expected.

In addition, it asked authorization for recording the interview. The session program was also included in the script, presenting the exercises and the research tools.

The following research tools were prepared and used within the interview:

- An interview guide ensured to collect the same general areas of information from each interviewee. It was a detailed guide and included a list of questions (Appendix B2) serving as a reminder of all listed topics to cover at some time in the interview. The questions were open-ended questions, respondents could respond freely as their wishes. This had the advantage of letting respondents volunteer whatever information they considered as most appropriate in response; and at the same time, it shows respect and interest by their views and judgments (Jones 1996). Disadvantages relate to the production of more information than needed; although full and detailed responses are expected. Probes (verbal or non-verbal) used to encourage respondents to continue, amplify or clarify an answer when appropriate included direct questions, requests for specific additional information and silence.
- Rating IAPS pictures with the Self-Assessment Manikin. IAPS Affective images (the twelve ones analyzed in section 6.3) supported discussion. Participants could handle the images included in cardboards (A4 size). Participants rated their just-in-time emotional experience with each picture by using the SAM booklet (Appendix B3). The answers by the subjects formed the basis for self-reported emotional state when exposed to such an environmental landscape and scene.
- “Enthusiasm and Playfulness for Pro-Environmental Behavior” questionnaire was used as a survey tool for further qualitative analysis (Appendix B4).

The “Enthusiasm and Playfulness for Pro-Environmental Behavior” questionnaire enabled to explore the relationship among pro-environmental behavior achievement, motivation for behavior and affective images. It includes 12 questions, divided into three sections of four questions each: motivation for behavior, enthusiasm and playfulness for pro-environmental behavior. All questions used the 5-point Likert scales for respondents’ to indicate how they feel ranging from strongly agree to strongly disagree.

6.5.5 Study results

This experimental research focused on environmental related experts and explored the relation among motivation, pro-environmental behavior and affective pictures. A guided interview enabled to understand that relation.

In addition, participants rated IAPS pictures using the SAM scale.

The “Enthusiasm and Playfulness for Pro-Environmental Behavior” questionnaire was done after each interview session.

The use of affective pictures from IAPS, as well as the interview (that was audio recorded) and questionnaire responses, enabled to make an account of participants responses and to compare them.

Next sections present an approach to the interviews obtained results, presenting excerpts of the interviews, translated to English.

6.5.5.1 Expectations

The expectations part of the interview started with a request of current environmental behaviors. When asked about current pro-environmental behavior (Q 1), the followings topics were mostly pointed, all related to frequent behaviors: recycling, water and energy savings, public transportation, and green purchases. Another reported topic was not accepting extra bags.

“(...) I recycle... paper, plastic, metals and glass and I try to, whenever it is possible, to save water, namely during shower, teeth brushing and dish washing... I close the taps (...)” (Interview 1)

“(...) each time I buy something I think if it is a good environmental choice,... each time I drive, I think if I could have a public transportation alternative,... during shower I am always minimizing the tap water or closing it to save water, ... and also energy...” (Interview 2)

“I recycle and separate garbage, I don't want... I accept the minimum extra plastic and paper bags in all the stores, I never accept those... only when I don't have one (...) I buy biologic food...” (Interview 5)

One participant reported as important distinguishing the type of behaviors related with structural changes (one-time events) such as changing home appliances to more energy efficient ones or thermic isolation. These can even have more positive environmental impact than common behaviors activities.

“...There are also two types of behaviors. There are repetitive behaviors and behaviors related with installing things at home, or structural changes... that aren't behaviors, is only one behavior, is not a sequence of behaviors, that can have much more impact. I give you an example: (...) for instance isolating your home, is only one behavior, is not a sequence of behaviors, however, has more impact than a sequence of behaviors. (...) Many time only one behavior may be more efficient than a series of behaviors. (...) I isolated my home, included high definition windows, reduced the energetic impact (...) and use high efficient fireplaces, reducing energetic consumption (...) using timber and reducing electricity” (Interview6)

This participant has also said to have a hybrid automobile:

“...Cars... (...) I have a Toyota hybrid that I have imported from the United States, so I have a high efficient hybrid” (Interview 6)

Then the interviews focused on the values behind pro-environmental behavior (Q 2). Topics reported include sustainability, ethics and next generation needs, environmental conscience and responsibility.

“...Sustainability... and is also an ethical issue, about leaving for next generations a world that is also habitable for them as it is for me.” (Interview 3)

“... Responsibility and sustainability...” (Interview 4)

“...I think it is important (...) environmental conscience...” (Interview 1)

In addition, the following distinction of values emerged:

- selfish values (as considering that “my happiness and survival” depends on the safeguard of many other values);
- solidarity values (what ones make impacts others quality of life);
- intergenerational values (the quality of life of next generations depends on what ones make in the present, e.g. landscape and resources safeguard).

“...I think that some values are more selfish, others more solidary... I think that really... my own happiness depends of safeguarding other values, and that is the selfish part ... happiness and survival (...) I also think that our quality of life and of future generations depend on what we make (...) and these are intergenerational values...” (Interview 2)

Another topic covered related to values was social issues as strong behavior limitation. The social pressure to behavior includes for instance neighbors that promote recycling within the home building leading to limitation in not doing the adequate behavior.

“The problem of environmental behaviors is related to values but also to other questions such as social issues... (...) if everyone makes something we end up doing it (...)” (Interview 5)

Other reported examples that limit adequate behavior includes lack of close equipment, or green products that are typically more expensive, also less attractive, and more difficult to find.

One participant referred to the group minority of “radical ecologists” that intend to take environmental behaviors in all aspects of their lives.

“...there are people that take this too serious and change completely, they have a kind of new environmental paradigm and try to be very systematic ... from the detergents, to the food, they eat meat or not, for example, because they think that meat has more environmental impact. So, there is a group of people that are extreme in terms of radical ideology (...) these are the “radical ecologists” (...).” (Interview 6)

Regarding the emotions behind pro-environmental behavior (Q 3), all agreed that environmental behavior has an emotional component.

“...I think there are different emotions; I think there is personal satisfaction, self-better feeling (...). I think that this is important ... in a first phase (...) we do things with sacrifice, in a second phase we do things naturally, in a third phase we almost hate the ones that don't do those things like us (...). If I see someone sending paper to the floor I have a reaction of certain anger, I think that person is disrespecting the common good...” (Interview 2)

“Emotions are always related with behavior; I do more easily things that are pleasurable (...)” (Interview 5)

“...the relationship with the environment has a strong emotional component...the environment is something that awakes sometimes a very strong and radical ideology... and for obtaining this very strong emotions are needed...” (Interview 6)

Both positive and negative emotions emerged.

Positive emotions relate to the positive feeling of behaving in an adequate way, and positive behavior provides self-satisfaction.

“...the emotions that above all we have in behaviors linked to environmental protection are related with... making me more happy in the sense of helping others and the Planet, I think those let us more satisfied, more joyful, and perhaps this is important, we also feel more responsible.” (Interview 2)

“...I take a positive gain from knowing that I am playing a role having positive behaviors, thus it is satisfactory” (Interview 3)

Stronger positive emotions emerge beyond adequate environmental everyday practices that are instinctive, namely within activities with landscape proximity in natural areas.

“(...) it depends on the action; if it is an everyday action it is almost done instinctively I don't know if there is a feeling or if I can perceive there some emotion (...). But, for instance, all actions related to contacting nature (...) I think that all that is related with enjoying a landscape, natural area proximity awakes stronger emotions.” (Interview 4)

Social positive feedback on adequate habitual behavior may reinforce self-adequate behaviors, also enabling to augment awareness on the audience of that social situation. Social influence through adequate behavior feedback activates positive emotions.

“I think that if I am at a certain place and someone says “Great! You are part of the ones that recycle” (...). That is a way of reinforcing my behavior (...). There is a social influence...that is a positive emotion (...).” (Interview 5)

Negative emotions (like sadness, anger, and revolt) relate with the observations of inadequate environmental behaviors, and disrespect for the common environmental goods. This situation can even become annoying.

Furthermore, negative emotions emerge with observation of places degradation or its transformation in an intense urban area, losing original elements. Negative emotions relate then with the loss of some local environmental quality.

“Sometimes I feel revolted and sad (...) because people don’t change behaviors and life styles... sometimes only small changes are needed... and people don’t take that initiative.” (Interview 1)

“...imagine you know an area for a long time ago and visit it again and suddenly you see that it is totally degraded, in the sense of urbanization... losing some original and characteristics elements, then the emotions are more negative, about losing some environmental quality (...).” (Interview 4)

When asked about the link between affective images and pro-environmental behavior (Q 4), participants reported both positive and negative images as stimulus for adequate behavior.

Negative images may have more impact than positive images; however, these are also strong stimuli. It is important to find an adequate sense of negative, because strong negative images are not useful at all, losing their effect.

“...research knows that (...) if images are slightly scary we look at the image and say (...) we really need to change ... then if the images are really scary we don’t even want to see those (...). I think that images should be slightly scary to activate our attention, but not too much.” (Interview 5)

Furthermore, to be useful images should indicate simple and frequent behavior cues, as alternative behaviors associated with the negative images. This builds a cycle of scared impact-attention to new behavior cue.

“...and then they need to give behavior cues (...).” (Interview 5)

The sensation that images of natural disasters like floods or earthquakes, tsunamis or extreme climate episodes provide is that:

“...when you see those images you have the impression that something is escaping from control... (...).” (Interview 4)

To feel anger and touched by a negative image, it is necessary to have at the same time the perception of the correspondent positive image; this game of contrasts seems to be a key factor for messaging.

“I think that both work... (...) If I see a very beautiful landscape that I like a lot, a natural beach... without construction, if I see a ridge with a fantastic landscape (...) we feel touched (...). ... However, at the same time there are those terrifying images of (...) hunting protected species unnecessarily, or seeing a spectacular valley eviscerated by a road or a tunnel... I think that we need both images... (...) ... for us to feel “anger” and to be touched by a negative image, we need to have at the same time the perception of the positive image. (...) It is the game of contrasts that works in terms of messaging.” (Interview 2)

Positive images may be more stimulating:

“...images of preserved landscapes, of places where you want to be, photographs where you want to be inside the photography...” (Interview 4)

Landscapes that are stimulating in the affective perspective are aesthetically stimulating and balanced. They induce in their viewers a sense of relax, beauty. However, informing adequate specific behaviors needs other approaches.

“...behaviors are specific, environmental images are global. What does this signify? Signifies that an environmental image can introduce a very positive feeling and emotion and I am very positively stimulated with that image; but that image does not tell me (...) the behavior I should infer. This is, when I see the emotion I get excited in relation to the environment, great, and I want to protect the environment in a global perspective. In a specific perspective, the image does not say anything. (...) the image does not say where to protect the environment, in the water, energy, transports, recycling? (...) Landscapes that are affectively stimulating (...) are stimulating, balanced that induce in people a sense of relax, emotion, of aesthetically beauty. What these have to do with my specific behavior? When I am looking to that image, the image does not help me (...) to determine what the most correct behavior is.” (Interview 6)

However, when asked specifically about using images as real time feedback about adequate behavior (the recycling example was used to illustrate adequate behavior), positive feedback was referred as being better.

As examples, participants said the following:

“...of course, if I recycle, I would like to have as feedback... (...), ok, if I recycle I am contributing to a better world, thus, the image would mirror that better world; it would be a positive image,

something that would make me feel good with myself, joyful, happy.(...) The image would transmit that emotion (...)” (Interview 1)

“...in case of a rewarding attitude, this is, if a just recycled (...) I think that it works better (...) using positive images then something like “if you didn’t make that, this would be chaotic...” I think that is more a pro-activity reflection and then is more in a positive way (...)” (Interview 2)

“...definitively I think positive is better... for instance when you put a bottle in the recycling bin it says “with this bottle we are going to make a sweater” or “with this glass we saved sufficient energy to light a lamp for 3 hours” I think it is much more constructive for people to understand that their actions have impact.” (Interview 3)

“I think that I would laugh to the recycling bin (...) I don’t know if I would think that it would be ridiculous, I don’t know... why would it talk?... I don’t know... I don’t know (...) then, if it would smile at me (...) I would think it is funny (...) for kids that would work very good... but then... I don’t know if I would let to pay attention... I don’t know if that would work. ” (Interview 5)

Behavior feedback would be useful, but should be continuous and progressive. Mechanical feedback loses interest.

Behavior changing should be easier when environmental problems link close relatives (children first, ourselves, family, friends and neighbors) with a scary episode and if simple behavior cues are proximately provided.

6.5.5.2 *Acquaintance*

This study considered two directions. First participants should designate images with affective positive value related with natural elements. Then, participants should indicate the most relevant sense used to trigger that emotional experience.

When asked about their acquaintance with possible affective pictures by environmental elements (Q 5), particularly water, land, sky and living beings, participants pointed different features in their image descriptions:

- The natural element is many times included as part of a larger environment.
- Natural dynamics operations and movement emerged when describing images.
- Positive affective experience descriptions included environmental wideness.

Table 6-3 includes the reported affective positive images by natural element.

Table 6-3 Reported affective positive images by natural element

Natural element	Images
Water	Beach Stream running through a mountain or green valley Sea Brook running through a forest Lake Water drops Moving water Transparent water Waterfall
Land	Forest, ridge with a green extension Garden Farming soil (soil with parcels, different colors) “Living land”, brownish, prepared to be cultivated Mediterranean costal landscape
Sky	Top of a mountain looking at the sky in a wide extension Always appear in a landscape, clouds over blue sky Any landscape, for instance sea with sky above Any picture with 2/3 of blue sky, with clouds Blue sky without clouds
Living beings (both vegetable and animal)	Forest with animals Underwater ocean with fishes Big animals Culturally flagship species (e.g. dolphins and otters) Lioness with cub Own pets (cats) African big trees (e.g. baobabs, inverted trees with big roots) Wild animals (horse in natural setting, running free and elegant; genets) Growing cubs; playing with cubs, affective sense

When asked about the most relevant sense that triggers the self-emotional positive experience after exposure to stimulus related with environmental landscapes (Q 6), vision was always reported first, followed by sound (e.g. moving water or birds). Some participants reported smell and tactile experiences related with temperature (wind blowing, sunlight and shadow exposure).

Regarding negative emotions (Q 7), the most important sense to activate the emotional experience was vision (it provided a sense of not clean, disorganized, dead or non-life) followed by smell and sound (noise).

Reported negative images included forest destruction, polluted rivers, dry land or dry vegetation, oil spills and factories settings.

6.5.5.3 Association

This section of the interview had the objective of understanding the environmental related affective pictures role in environmental thoughts construction and behaviors (Q 8).

Respondents reported the role of images as reinforcement:

- Feelings in moral terms by showing that if the behavior is incorrect earth suffers; however, behavior is more related to a sense of duty and values.
- Attitudes, once a set of positive images give adequate moods for the actions to be develop (different images are part of the imaginary related with actions).
- Behavior justification (leading to think about how some individuals still don't have adequate environmental behavior; or to do something that hurts).

Another reported insight was the consideration that thinking works by evoking images, being mostly visual. However, for this interviewee, behaviors are more related with reason and values, although images support emotion and not reasoning, although both are connected.

After the initial gathering of perceptions around this topic, participants classified the twelve IAPS pictures using the SAM scale for the valence (unhappy-happy) and arousal (excited-relaxed) data (Q 9).

The IAPS technical manual (Lang *et al.* 2008) supported the explication of the SAM scale as follows:

“You can see that each SAM figure varies along each scale. In this illustration, the first SAM scale is the happy-unhappy scale, which ranges from a smile to a frown. At left extreme of the happy vs. unhappy scale, the figure is happy. If you felt completely *happy* while viewing the picture, you can indicate this by placing an “X” in the figure at the left, like this (demonstrate with SAM). The other end of the scale is when you felt completely unhappy. You can indicate feeling completely *unhappy* by placing an “X” in the figure at the right, like this (demonstrate with SAM). The figures also allow you to describe intermediate feelings of pleasure, by placing an "X" over any of the other pictures. If you felt completely neutral, neither happy nor unhappy, place an "X" over the figure in the middle. If, in your judgment, your feeling of pleasure or displeasure falls *between* two of the pictures, then place an “X” in the space between the figures, like this (demonstrate with

SAM). This permits you to make more finely graded ratings of how you feel in reaction to the pictures.

The excited vs. calm dimension is the second type of feeling displayed here. At one extreme of the scale you felt stimulated, excited. If you felt completely *excited* while viewing the picture, place an “X” in the figure at the left of the row, like this (demonstrate with SAM). On the other hand, at the other end of the scale, you felt completely relaxed, calm. You can indicate you felt completely *calm* by placing an “X” in the figure at the right of the row, like this (demonstrate with SAM). As with the happy-unhappy scale, you can represent intermediate levels by placing an “X” in any of the other figures. If you are not at all excited nor at all calm, place an “X” in the figure in the middle of the row. Again, if you wish to make a more finely tuned rating of how excited or calm you feel, place an “X” in the spaces *between* the pictures, like this. (Demonstrate with SAM).”

The images classification enabled the following two main analyses:

- Calculate a mean of unhappy-happy, and relaxed-excited by image (Figure 6-4);
- Mapping the images means (participants and IAPS) all together (Figure 6-5).

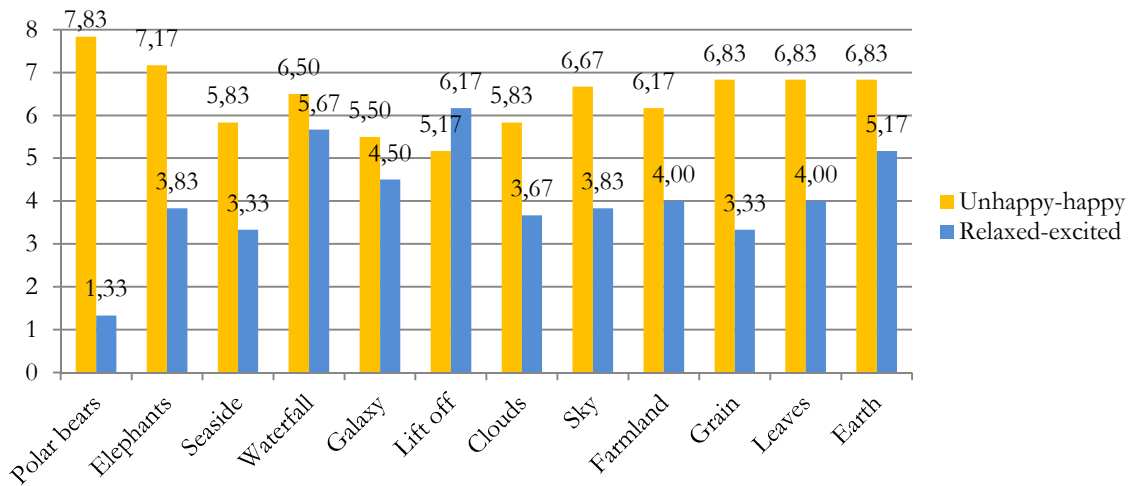


Figure 6-4 Valence and arousal data for the 12 IAPS pictures

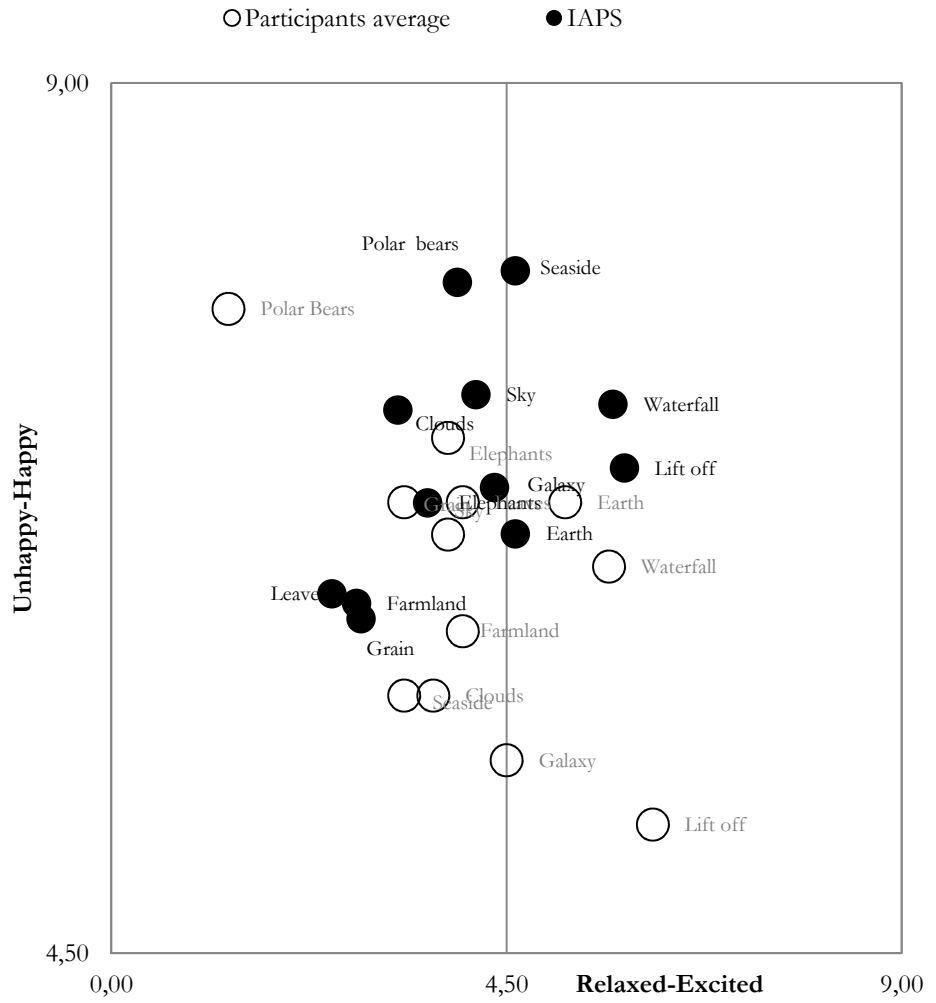


Figure 6-5 Distribution of the 12 IAPS pictures

After the classification, participants picked up the images in order to choose three according to “playfulness” emotions (Q 10). Figure 6-6 shows the results.

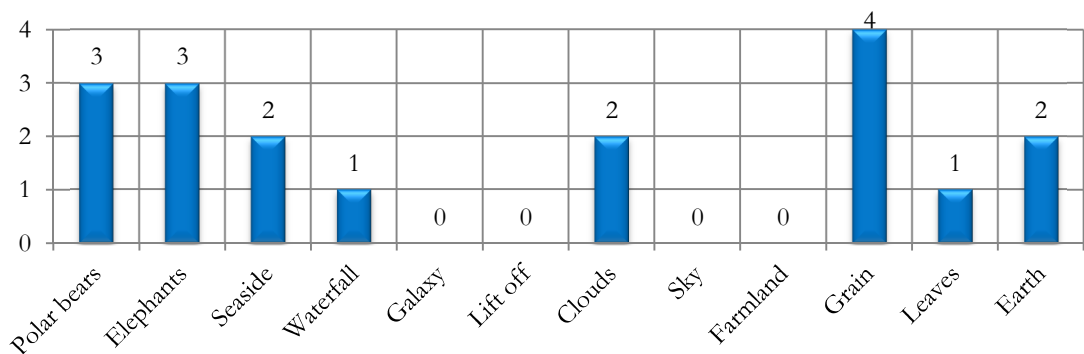


Figure 6-6 Playfulness results

6.5.5.4 *Motivation*

The last interview section, asked about the motivation to the theme “emotion-oriented interventions”. First, a question inquired about what is motivational about the proposed approach (Q 11). Then, the questionnaire “Enthusiasm and Playfulness for Pro-Environmental Behavior” enabled to collect data for comparison.

Overall, participants considered the proposed approach of having emotion-oriented interventions using behavior feedback real time new, interesting and convenient. However, participants expressed concerns on interventions functioning. Participants remained curious about the interventions.

The following main insights were gathered:

- Rewarding individuals with affective positive images by their environmental positive behavior is reinforcing that adequate behavior, so that one can feel that is doing well; if someone already has adequate behavior he should already be motivated, but he could feel even more motivated if he would have that positive feedback.
- Driving individuals through environments implies using proximity approaches. However, it would largely depend on each individual history. The idea of working upon means and not about each person historical may be a problem. To draw automatic schemes of creating emotions through the use of images, and making it “hit” in the observer, this is with the historical of the observer, seems to be the challenge. The proposed technological approach is new, but is important to investigate if there are social and environmental psychology studies upon the theme of using images to reinforce behaviors, namely about the relation of emotions, images and environmental protection. The impact of images through automation systems constitutes an innovative approach.
- Using feedback just-in-time is a new approach, that enables individuals to perceive that the action that are making has importance, is real and concrete and is not in vain. That would shape individuals, letting them know that they are making the difference, and that the action is useful. The approach is useful because emotions shape individuals more than reason. Reinforcing a positive behavior with a positive emotion would lead to behavior repetition. In addition, emotions and emotional experiences make the difference in individuals choices; also applying to the choice of having a more adequate environmental behavior. Reinforcing communication with positive emotion will lead individuals to remember and to choose properly. It would be better to add to the affective image some kind of informative text.

- It is a motivating approach because the images that awake in individuals' well-being sensations are positive raising motivation to preserve what is on each image, to be part of it, or to contribute to preserve and refresh the memory of those elements. The fact of permanently renew and invoke images has a positive effect.
- Two problems emerged, namely 1) inform specific behaviors through global settings and 2) the positivity of pictures and their receptivity is not universal. The selection of pictures in this context is a challenge (what are the best pictures?)

Last question (Q 12) enabled to gather additional information, introducing the following issues (existing or hypothesized tools and research areas):

- Environmental calculators (such as footprint or carbon calculators) provide behavior feedback through computer or mobile phones. It is a different approach because it focuses on information, behavior evaluation and their impacts and feedback is about reducing actions impact. Generally, calculators do not work using affective images or emotions.
- Google logo that changes with environmental day to augment environmental awareness works as a simple and funny environmental cue that is not annoying. This supports the importance of playfulness and non-intrusive approaches.
- Restorative environments as providers of positive emotions lead to wellbeing and calm lifestyles, and recovering from tiredness. Natural environments and landscapes are particularly important as restorative environments (associated with freedom feelings and less social pressures and unbalances) and are being the focus of interesting behavior related American and European Nordic research. According to Bell and colleagues (2001), the restorative effects of nature and natural scenes are related to stress reduction and to the attention restoration theory (ART). According to this theory, to rest and “recharge”, it is necessary a directed attention by finding different and involuntary attention that require little efforts. Fascination provides effortless attention and natural settings are important sources of fascinating things and objects. Even the soft fascinations, such as clouds, sunsets, or leaves flickering in the sunlight, require little effort to capture attention.
- Reinforcing theory of positive behaviors includes commonly rewards such as monetary incentives; using affective pictures as reward is new.

Figure 6-7, Figure 6-8 and Figure 6-9 include the results of the questionnaire “Enthusiasm and Playfulness for Pro-Environmental Behavior”.

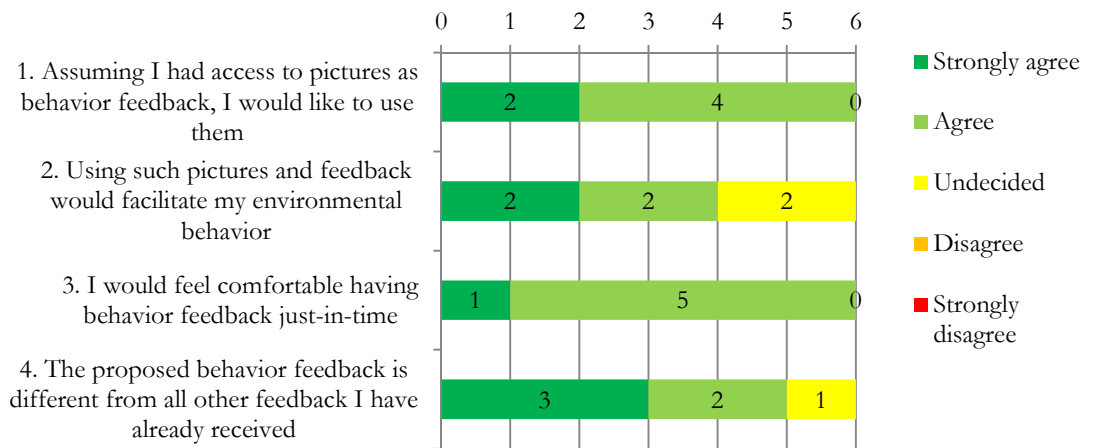


Figure 6-7 Levels of agreement upon the use of behavior feedback as motivation for behavior

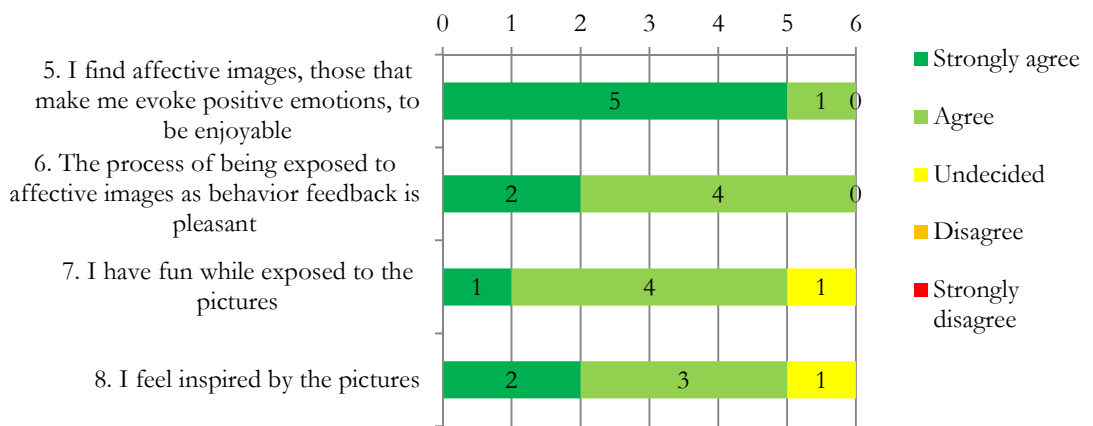


Figure 6-8 Levels of agreement upon enthusiasm for pro-environmental behavior

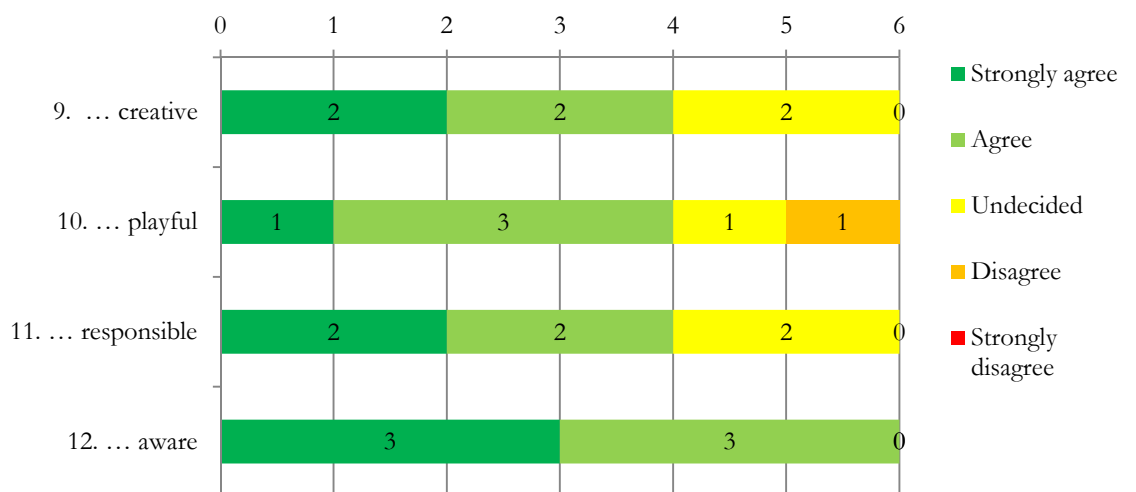


Figure 6-9 Levels of agreement about playfulness

6.5.6 Discussion

This study had the goal of understand expectations, acquaintances, associations and motivation of participants in relation to affective pictures and their environmental behavior, using an interview-guided approach.

The experimental design included the definition of a research model focused on four research questions, the selection of environmentally related subjects to interview, and the creation of research tools, namely an interview guide, IAPS pictures and SAM paper scale and a questionnaire called “Enthusiasm and Playfulness for Pro-Environmental Behavior”.

RQ8: Have affective images a positive effect on increasing motivation for adequate environmental behavior?

This study results suggest that participants understand that affective images have emotional impact and in particular, the presented images have positive emotional impact. This is consistent with the previous study results.

In fact, according to Isen (2000) most people seem to have a sense that affect (feelings, emotion) can influence their decisions and thought processes. This author explains that such influence is assumed to be something irregular or unusual; that frequently only strong and occasional feelings would be perceived as to have such effects; and that most often only negative feelings such as anger, sadness, or fear would have an impact on thinking processes.

Furthermore, most people assume that when affect plays a role in their decision processes, such influences are disruptive and tend to make their decisions “irrational” and less appropriate than otherwise. This author notes, however, that a growing body of research indicates that even mild, and even positive, affective states can markedly influence everyday thought processes, and do so regularly. For example, the presence of positive feelings cue positive material in memory, making access to such thoughts easier, and thus making it more likely that positive material will “come to mind”. This reflects that far from being an infrequent influence on thought processes, common positive feelings are fundamentally involved in cognitive organization and processing.

Positive affect promote creativity and flexibility in problem solving and negotiation, as well as both efficiency and thoroughness in decision-making, and other indicators of improved thinking (Isen 2000). Therefore, under many circumstances the influence of mild positive feelings on

thinking and decision making has been found to be not only substantial, but facilitative, leading to improved decision making and problem solving.

Thus, if behavior feedback uses affective images, it will create positive emotional reactions, echoing on motivation and promoting adequate decision-making processes. Williams (2001) addressed the emotional-motivational aspects of choice and learning. In addition, Froehlich *et al.* (2010) provided a summary of key motivation techniques to promote pro-environmental behaviors. That includes information, goal setting, comparison, commitment, incentives /disincentives and rewards /penalties and finally feedback. However, they do not refer specifically to affective images and their emotional impact as a source of motivation. This study can add to their review another contribution, namely regarding the emotional impact of feedback and future behavior decision making.

RQ9: Have affective images a positive effect on happiness and enthusiasm?

For Averill and More (2000) there is lack of agreement on what it means to be happy. For example, happiness may be to some people a highly aroused state like joy; to others it connotes contentment, tranquility, or peace of mind; still other people are happiest when enrolled in an activity, unaware of their emotional state. Nevertheless, happiness is always positive.

In recent years, research explores “subjective well-being” and its relation to different social and demographic variables. Measures of subjective well-being typically include self-reported happiness as well as measures of satisfaction and morale.

Emerging research in the positive psychology research area (Lyubomirsky *et al.* 2005; Boehm and Lyubomirsky 2009) further reflects the potential of happiness-enhancing interventions (intentional activities for happiness). These interventions within positive psychology enable practicing virtues such as gratitude, forgiveness and thoughtful self-reflection, bringing enhanced well-being. However, this study studied happiness in another sense – namely associated with images visualization.

The central tool to measure the emotional state was the SAM scale (Lang *et al.* 2008) and that enabled to measure participants reactions (Figure 6-5). Results show that visualizing positive affective images have a positive effect on happiness. As for the enthusiasm, many pictures have been reported as more relaxing than exciting.

RQ10: Have affective images a positive effect on playfulness?

Playfulness may provide a critical motivational force for learning. Discussions on this issue address children learning, although its potential should not be neglected in adult learning. For instance, play is likely to motivate for learning if it renders complex experiences and provide immediate feedback; play supports the competence of improvisation; play stimulate novel lines of thinking (Katzeff, 2003). Thus, creating playfulness emotions in observers may well motivate for adequate behaviors.

According to Gredler (2001), educational games and simulations, unlike direct forms of instruction, are experiential exercises, enabling learners to interact with knowledge domains. For her, the increased power and flexibility of computer technology is contributing to renewed interest in games and simulations, being convergent to the perspective of effective instruction which meaningful learning depends on construction of new knowledge by the learner.

Applications related with games and persuasion for environment have been developed (e.g. Band *et al.* 2007; Centieiro 2011) although they do not address and explore how their games affects players emotional states. In his game for environment called “GAEA”, Centieiro (2011) handles the effect of competitiveness characterized by plays and moves of the players. While addressing recycling, the objective is to win following the strategy permitted by the game rules.

When asked for the affective images that relate to playfulness feelings, results show Grain (four times picked), followed by Polar bears and Elephants (both picked three times).

The animals’ photographs of progenitor with cub perhaps make observers remember a play factor associated with human childhood, bringing into mind emotions of playfulness. In fact, the play/joy system is a basic emotional system already addressed in emotional research (e.g. Panksepp 2000).

The Grain photograph perhaps make observers remember open natural places where time was used to play and relax, making it to be associated with playfulness emotions.

Thus, although it remains unclear how affective images activate playfulness feelings, it seems that some pictures have the power to do that. Activating a playfulness feeling through the rewarding behavior approach would be of great importance. This is an issue for future research.

RQ11: Have increased motivation a positive effect on pro-environment behavior achievement?

It seems that, overall, participants considered the emotion-oriented interventions an adequate behavior motivator approach, by awakening in individuals well-being sensations promoting for instance the interest of preserving what is in each affective image.

Another way of motivating adequate behavior is to make observers wish to be in environments such as the ones included in the feedback. Refreshing the observers' memory of those positive environmental elements constitutes a reward for adequate behaviors. This perceived motivation would then facilitate behaviors, especially if they were already established.

The analysis of the qualitative collected information, namely the respondents' verbal spontaneous comments about the proposed approach, enables to consider the following categories for further discussion:

- Strengths of the emotion-oriented interventions approach – behavior feedback just in time is innovative, interesting and convenient to reinforce adequate behavior with affective positive pictures. It would enable individuals to become motivated while making them know that they are making the difference. It also shows the usefulness of the behavior. Using an emotion approach is powerful because emotions have a role on individual decisions, also applying to environmental behavior decisions. The reinforcement of communication with positive emotion would lead individuals to choose properly.
- Concerns about the emotion-oriented interventions approach – drawing an automatic scheme of creating emotions using images, and making it “hit” in the observer was a main concern. The design of the emotion-oriented approach, made upon means may not fit all individuals.
- Selection of affective pictures – to be affective in a positive way pictures may include natural elements as part of a larger landscape (e.g. picture of a river running in a green valley) and may capture the representation of natural dynamics and movement (e.g. clouds over a blue sky). The idea of wideness was reported, including living beings size (e.g. big animals, such as elephants or dolphins, tend to create more positive emotions than smaller ones, such as ants) and landscape extend in the way that environmental landscapes with amplexness create more positive experiences. Some reported affective pictures themes were coincident with the selection of IAPS pictures, namely, seaside and streams (although

waterfalls were not reported), forest and green related images, clouds and sky and big animals with cubs. Cultural and educational imaginary support this.

- Suggestions and recommendations - It could be useful to add to the affective image some kind of informative text. Creating different types of feedback to match different reactions to images and to avoid monotony is relevant.
- Similar approaches - no similar emotion-oriented approach for environment was reported and no other type of feedback was described. The persuasive power of the interventions was never reported.

The analysis of the pictures ratings enabled to understand emotional data after exposure to visual stimulus of environmental affective pictures.

The analysis of the questionnaire “Enthusiasm and Playfulness for Pro-Environmental Behavior” responses enabled to make an account of participants responses and to compare them.

Overall, this study found that affective images could be used in a way that is both happiness and enthusiastic oriented and can be playful, which ultimately contribute to pro-environmental behavior reinforcing.

Approaching the obtained results led to the decision of including an assessment of those in the next experimental study, presented in the next section.

6.6 An approach to the AESAM evaluation

The present evaluation approach intended to support (together with the previous experimental studies) the exploration of the new interventions concepts and scenarios that integrate emotional orientation for facilitating pro-environmental behavior.

This approach should include detecting emotions related with pro-environmental behavior. In this context, the experimental approach should have the following features:

- Include an analysis of emotive pro-environmental behavior episodes for EFD-E, through a critical incident approach.
- Review results obtained in the interviews study. This supports the interpretation of the obtained results and applies the principle of a collaborative resources approach. It considers looking at the results from the perspectives of different participants that are involved as resources in interpreting and understanding research material.
- Highlight sensorial stimulations (visual and interaction) and other related elements of each intervention.
- Adopt a perspective of environmental communication evaluation, centered in the practical strengths and concerns of each intervention and its use.

This approach was useful for providing:

- Orientation to a new research field.
- Participants' interpretations of results from earlier studies.
- Evaluation of different research scenarios.

This way, it is possible to provide several criteria for evaluating the emotional-oriented interventions that can be useful for environmental communication strategists.

6.6.1 *Research model and research questions*

This section discusses the research model of this final study (as shown in Figure 6-10). The research model assumes that emotion-oriented interventions will make participants evoke appropriate affective states of mind, stimulating individual and collaborative engagement in pro-environmental processes.

Based on emotion appeals in pro-environmental theories (e.g. Seales 2010) that assume that enthusiasm reinforces positivity towards environmental efforts, the model hypothesizes that such evocation of emotional experiences will mediate the effect of the emotion-oriented interventions on facilitating pro-environmental behavior.

Specifically, this study considers the following four research questions:

RQ12: Can environmental episodes influence emotional experiences?

RQ13: Are environmental episodes related to the proposed emotion-oriented interventions for environment?

RQ14: Do emotion-oriented interventions impact emotional experiences?

RQ15: Is facilitated pro-environmental behavior positively influenced by individuals' emotional experience?

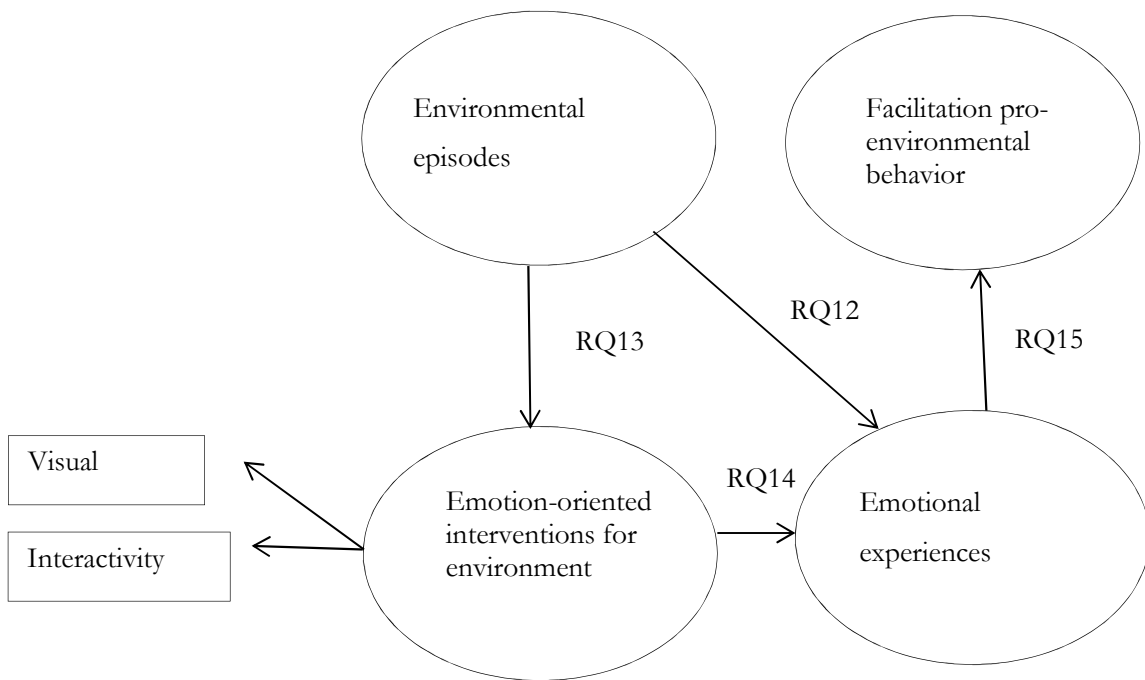


Figure 6-10 Research model

6.6.2 Method

A panel session composed by three exercises explored the four emotion-oriented interventions. The session started with the presentation of the emotion-oriented interventions basic concepts and strategies, reinforced by the visualization of the “One” ad (see section 1.1). A Power Point slides presentation supported the session. The twelve IAPS pictures printed on cardboards were available for observation.

6.6.2.1 Exercises

In the first exercise, participants filled the “Emotional pro-environmental episode” questionnaire (Appendix C1). This research tool adapted from the Geneva Appraisal Questionnaire (GAQ)³³, had the purpose of assess, as much as possible, through recall and verbal report, the

³³ GAQ was developed by the Geneva Emotion Research group. (http://www.affective-sciences.org/system/files/page/2636/GAQ_English.PDF)

results of an individual evaluation process in the case of a specific emotional environmental episode. Table 6-4 includes the stimulus evaluation checks considered in this study.

Table 6-4 Stimulus evaluation checks

Stimulus evaluation checks	Question number
Episode General Description	
Intrinsic Pleasantness	
Pleasant	4.1
Unpleasant	4.2
Episode General Features	
Features	
Suddenness	5.1
Predictability	5.2
Familiarity	5.3
Goal/need importance	5.4
Consequences	
Goal /need significance	6.1
Control	6.2
Imagination	6.3
Sharing	6.4
Reactions	
Emotions activation	7.1
New experience?	7.2
Behavior facilitation	7.3
Behavior changing	7.4
Intensity	
Reducing emotional experience	8.1
Learn more about the episode	8.2
Self-mask the experienced feelings	8.3
Future recalling	8.4

The questionnaire contained questions on the timing and social context of the emotional experience and episode.

It also included questions on verbal description of the emotional experience (one word or short verbal expression) and correspondence of emotion terms (Sadness, Joy, Anxiety, Surprise, Fear, Irritation, Shame, Contempt, Guilt, Disgust, Pleasure, Despair, Pride, and Rage) with the reported emotional experience.

In the second exercise, subjects discussed part of the interviews study. In particular, participants addressed the issue of creating automatic systems that enable to create emotions on the observers through visual and interactivity stimuli, thus trying to hit on each observer's history.

The third phase introduced and described each one of the emotion-oriented interventions in terms of its visual and interactivity sensorial stimulations. Each participant completed a questionnaire called "AESAM" (Appendix C2). This questionnaire intended to collect data on participants' overall perceptions on the concept and each scenario. Finally, a free discussion was encouraged.

Lastly, the readiness of participants to write a science-fiction story was assessed. This corresponds to another experience based on document analysis presented in the coming section 6.7.

6.6.2.2 *Participants*

Seven participants (1F, 6M) were recruited within the ongoing DEAP project, having then an expected acquaintance with the theme of developing "persuasive technology for changing environmental behaviors".

In addition, participants could already know the KnowY scenario concept (Romão *et al.* 2007) and the Wall illuminated light switcher tool (Hipolito 2008, Hipolito and Camara 2008) and the questionnaire study results of Chapter 3.

However, none was familiar with the emotion-oriented interventions approach, namely with the affective pictures and behavior overall research, preserving a surprise factor and requiring participants to look at the research with fresh eyes.

Although being all related to informatics and design (however having environmental interests), the decision of considering project DEAP members as study participants was constrained by the following practicalities:

- Known interest in the topic of using technology for environment
- Easiness of group gathering (both time arrangement and motivated participants)
- Meeting place already known to all
- Established group dynamic that could facilitate the meeting flow
- Possibility to transform the scenarios in prototypes

6.6.3 Results

6.6.3.1 Exercise 1: “Emotional pro-environmental episode”

First, each episode received a title according to the provided description (Table 6-5).

The study collected data on the episode intrinsic pleasantness, and timing and social context of the emotional experience, namely:

- How long ago was this emotional experience?
- Where were you when you experienced this emotion?
- Who was present when you experienced the emotion?

Table 6-5 Episodes titles, occurrence and general evaluation

Emotional pro-environmental episode “Prototypical examples”		Age	Occurrence of the episode			Intrinsic pleasantness
			How long ago was this emotional experience? Some... ago	Where were you when you experienced this emotion?	Who was present when you experienced the emotion?	
E1	“Home” movie visualization	24	Months	In a public urban space	A friend or colleague	Pleasant
E2	Reforestation campaign for Serra da Estrela	26	Months	In a natural setting	An acquainted	Pleasant
E3	Polar bear and ice melting	28	Months	At home	Nobody, I was alone	Unpleasant
E4	Japan’s catastrophe	36	Weeks	At home	An acquainted	Unpleasant
E5	Garbage container near recycling bins	41	Weeks	In a public urban space	Nobody, I was alone	Unpleasant
E6	First visit to lake Eibsee in Germany	41	Years	In a natural setting	An acquainted	Pleasant
E7	Rock climbing near the Portuguese-Spanish border	45	Months	In a natural setting	An acquainted	Pleasant

Episodes description

- E1: “Home” movie visualization

The visualization of the “Home” movie, which I have visualized when I was preparing my Master thesis, also related with current environmental problems. This movie gave me extra motivation for my Thesis, and made me start to recycle more actively.

- E2: Reforestation campaign for Serra da Estrela

During last summer, I was touched by knowing that a movement had been organized with the goal to proceed to the reforestation of burned areas in Serra da Estrela. This movement joined thousands of persons and the several initiatives fruits are already observable. This movement had the cooperation of local school students and has gathered the community around a goal.

- E3: Polar bear and ice melting

The image of a polar bear that intended to return to a semi-melting ice mass and that he couldn't. I have made a metaphor of the mourning of one against all in particular by the scenery of grandiosity in dissolution.

- E4: Japan’s catastrophe

It is related with the catastrophe that is currently occurring in Japan. It is related with the fact of being necessary to study very well the use of nuclear energy. This way, I turn immensely emotional when I see and think of people, animals and goods that are being affected by the Fukushima nuclear case. With an earthquake origin, and consequent tsunami, a very severe emergency state emerged, due to bad environmental behavior related to the decision of choosing energy nuclear. (...) I have been in Japan that I love for many reasons, one of which is the attitude and behavior of people. I turn sad to think about what they are living. Additionally, this episode makes me fear for our future, if we will have nuclear energy in Portugal.

- E5: Garbage container near recycling bins

Garbage container (of big dimensions) in the recycling bins surroundings. Many recycling bins (or garbage containers) live surrounded by garbage (sofas, electro domestic appliances, rubbish ...).

- E6: First visit to lake Eibsee in Germany

First visit to lake Eibsee, Alps, Southern Germany. This first visit to this paradisiac local mainly touched me in two ways: 1) by its natural beauty, a perfect framework within water, vegetation and mountains; 2) by the almost pure local state, despite the thousands of tourists that visit it annually. Without noise, without garbage, without motor vehicles ... Nature is respected in every detail...

- E7: Rock climbing near the Portuguese-Spanish border

Climbing of a rock near the Portuguese-Spanish border. In that local exist vultures and still some wildlife like rabbits, eagles and boars. I could observe the vultures flying within the scarps as we stood in a higher place and also flying over us as if we were their prey. (...) Arriving to the top of the rock with a superb landscape raised a feeling of freedom, harmony with Nature. It made me feel small, but yet big?!?

General description of the Episodes

Episodes sources for the experienced emotions have resulted from exposure to a media channel or by a direct, immersive experience (Figure 6-11). The first group includes episodes E1-E4 while the second group includes the episodes E5-E7.

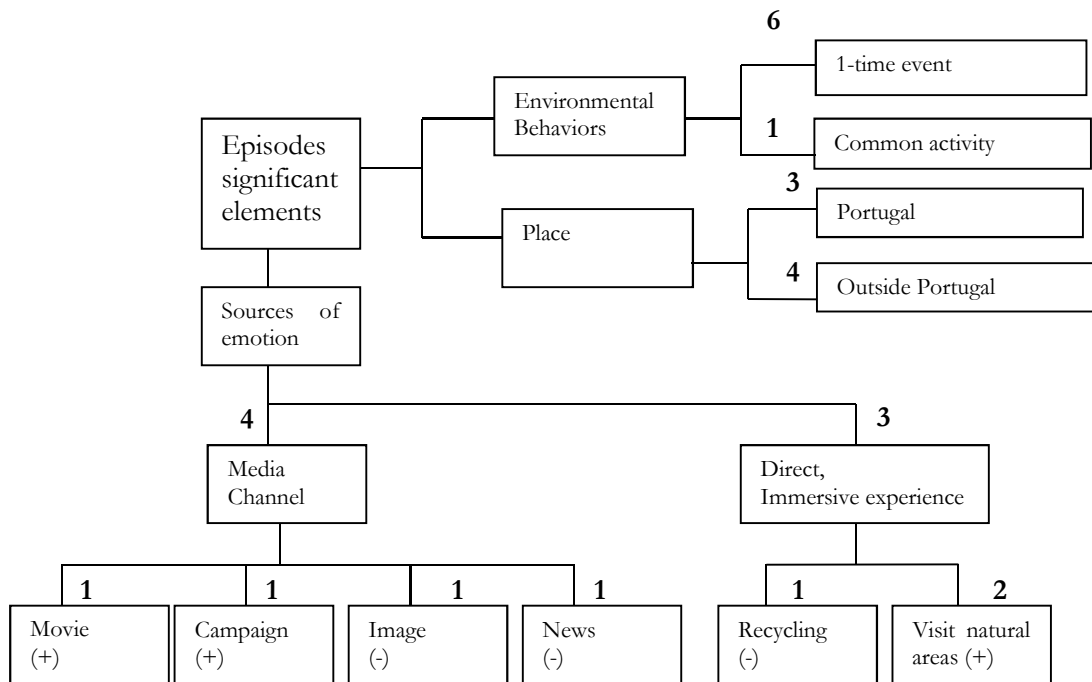


Figure 6-11 Characterization of the emotional pro-environmental episodes

(Note: Numbers correspond to the frequency of each case)

Only one episode was related to a common everyday environmental behavior, namely recycling (E5); two episodes were related with experiencing nature (E6 and E7), E2 was related to an environmental campaign, while E1, E3-E4 were related with images visualization through movies, news or other visual sources.

The emotion starts then, both from direct and close experiences, but also from images visualization of faraway events.

It seems also, that the episodes are related to one-time episode instead of common everyday behaviors. In fact, only E5 seems to be related to an everyday environmental behavior, which is recycling.

Only one time (E1) referred that the sources of emotion have contributed to increase motivation towards a common environmental behavior, namely to increase recycling.

Three episodes are related directly to Portugal (E2, E5 and E7), while the others are related to other countries events (E1, E3, E4, E6). However, E4 refers Portugal in the description. Episode recalling varies from weeks ago (2) to years ago (1), while month ago was the most picked (4).

In relation to the intrinsic pleasantness of the episodes, both positive and negative feelings emerge from media channels or direct experiences:

- Pleasant episodes were related to visualizing positive scenarios both through a movie, forestation campaign, or while visiting natural areas.
- Unpleasant episodes were related to natural catastrophes and also garbage visualization.

The intrinsic pleasantness of the episodes (Figure 6-12) is associated to different themes and words that described the episode.

The episodes that report unpleasant feelings focuses in natural disasters and incorporate disaster scenes that are many times included in news in both TV and papers. In addition, the existing of garbage was also reported as unpleasant.

Regarding a positive dimension, pleasantness relates to different levels involving motivation, public participation and community involvement and nature respect and observation.

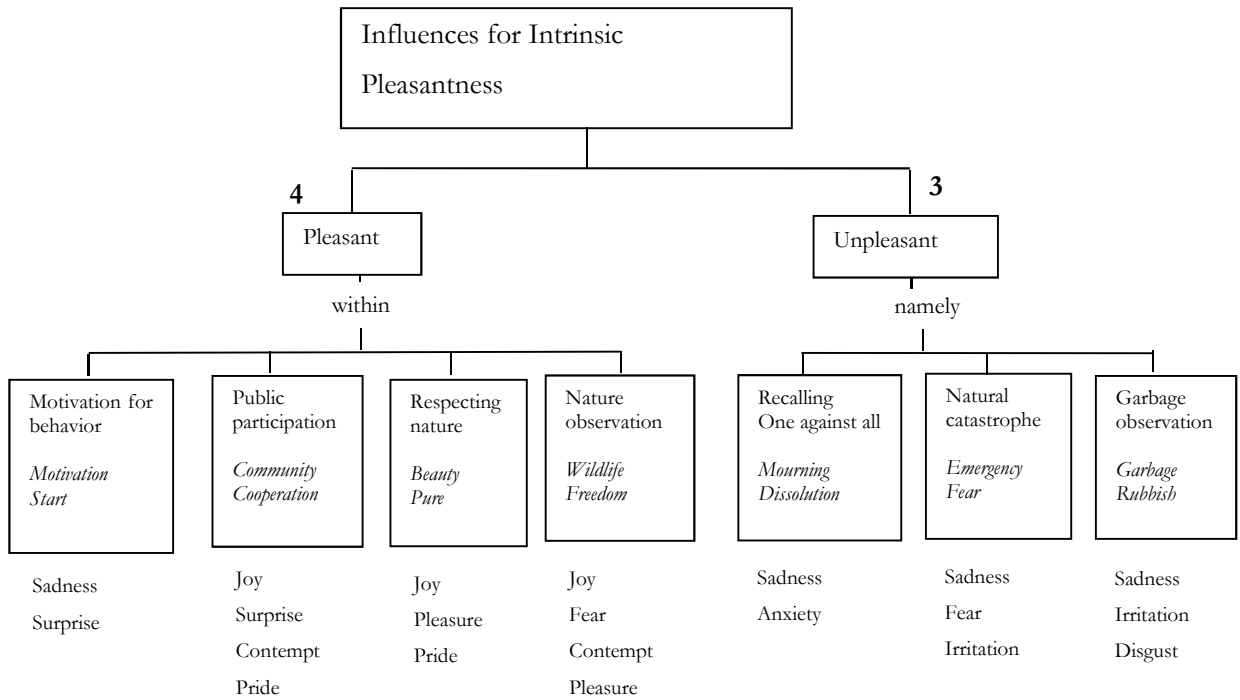


Figure 6-12 Influences for intrinsic pleasantness

In general, the description of pleasant episodes includes positive emotion terms Surprise, Joy, Contempt, Pride, and Pleasure. The inclusion of Sadness and Fear relates possibly to some images content within the movie and to the physical exercise related to climbing the rock.

The description of unpleasant episodes led to the selection of negative emotion terms, namely, Sadness, Anxiety, Fear, Irritation, and Disgust.

The questionnaire also intended to collect evidence in relation to participants' concepts about the episodes regarding its features, consequences, reactions and intensity (see Table 6-4). All questions used the 5-point Likert scales for respondents' to indicate how they feel ranging from strongly agree to strongly disagree.

Figure 6-13, Figure 6-14, Figure 6-15 and Figure 6-16 present the results.

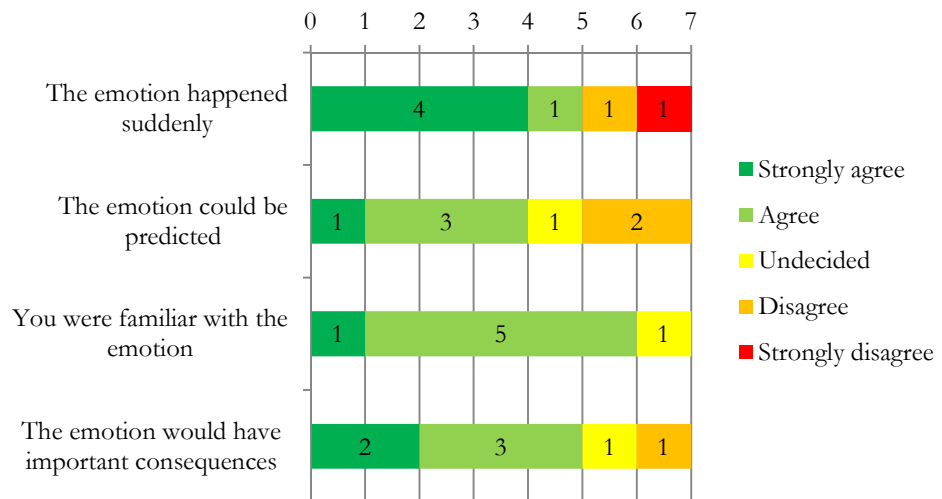


Figure 6-13 Episode features

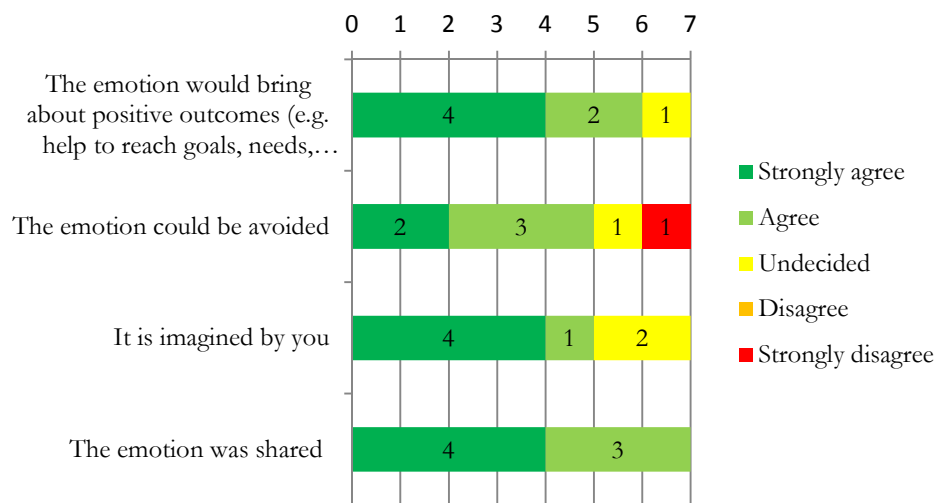


Figure 6-14 Episodes consequences

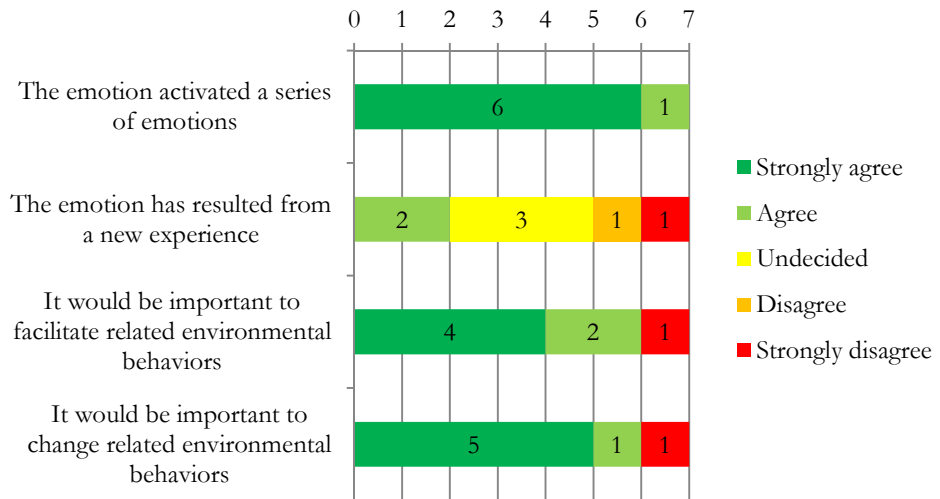


Figure 6-15 Episode reactions

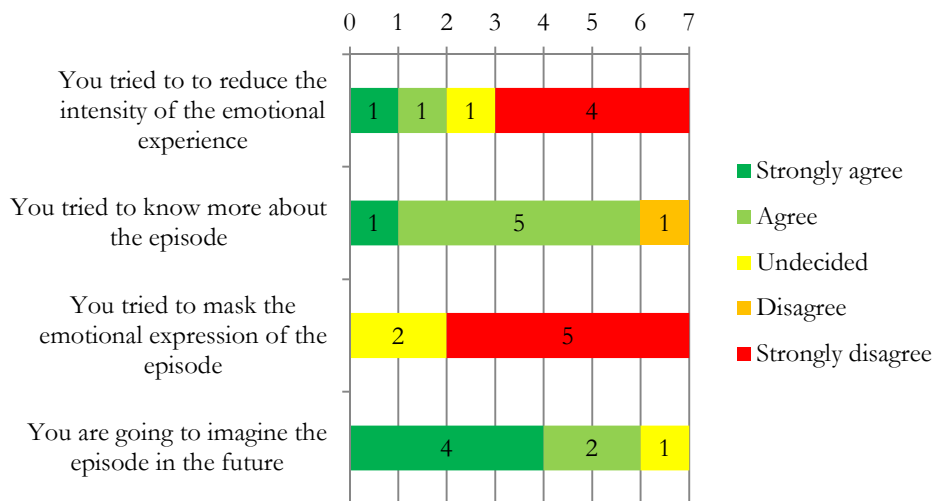


Figure 6-16 Episode intensity

Table 6-6 presents the results for the verbal description of the emotional experience (one word or short verbal expression) and correspondence of emotion terms with the reported emotional experience. Participants were asked in the following way: “How would you describe this emotional experience in your own words? Please write a word or a short expression.”

Table 6-6 Verbal description of the emotional experience

	Episode	One word or short verbal expression	Emotion terms
E1	“Home” movie visualization	<i>It make us think about what our Planet future will be in the next years</i>	Sadness, Surprise
E2	Reforestation campaign for Serra da Estrela	<i>Surprise and contempt</i>	Joy, Surprise, Contempt, Pride
E3	Polar bear and ice melting	<i>Fatalistic</i>	Sadness, Anxiety
E4	Japan’s catastrophe	<i>Profound sadness mixed with fear</i>	Sadness, Fear, Irritation
E5	Garbage container near recycling bins	<i>Irritating, worrying</i>	Sadness, Irritation, Disgust
E6	First visit to lake Eibsee in Germany	<i>Visit to a Paradise on Earth</i>	Joy, Pleasure, Pride
E7	Rock climbing near the Portuguese-Spanish border	<i>Communion with Nature</i>	Joy, Fear, Contempt, Pleasure

6.6.3.2 Exercise 2: Discussion of the interviews results

The second part of the panel included discussion upon the creation of automatic systems and affective pictures and the importance of having informative messages. The 12 IAPS pictures (and their emotional data) supported the discussion.

A summary of the interviews results included:

- Participants considered positive affective pictures as just-in-time feedback for reinforcing adequate behavior an innovative approach.
- The design of automatic systems that create emotions should address user segmentation.
- Also, discussion included the topic of the need of adding informative text to each affective image.

The discussion followed openly, without a guiding script, and the following topics emerged as important:

- User segmentation is important and considering extremes may facilitate developments. The selection of images pleasantness differs according to the users; also, many people may imagine that a larger context around the picture and that may lead to other feelings.
- Reinforcing behavior should use an repetitive approach
- Reinforcing positive behaviors should use positive images although the use of negative images may also be considered. For day-to-day events, positive images are better to reinforce.
- Seems important to have an informative message, beyond the symbolic setting.

6.6.3.3 Exercise 3: “Emotion-oriented interventions for environment”

The last exercise presented the basic version of each intervention concept and participants discussed them openly. The following topics emerged, according to each scenario.

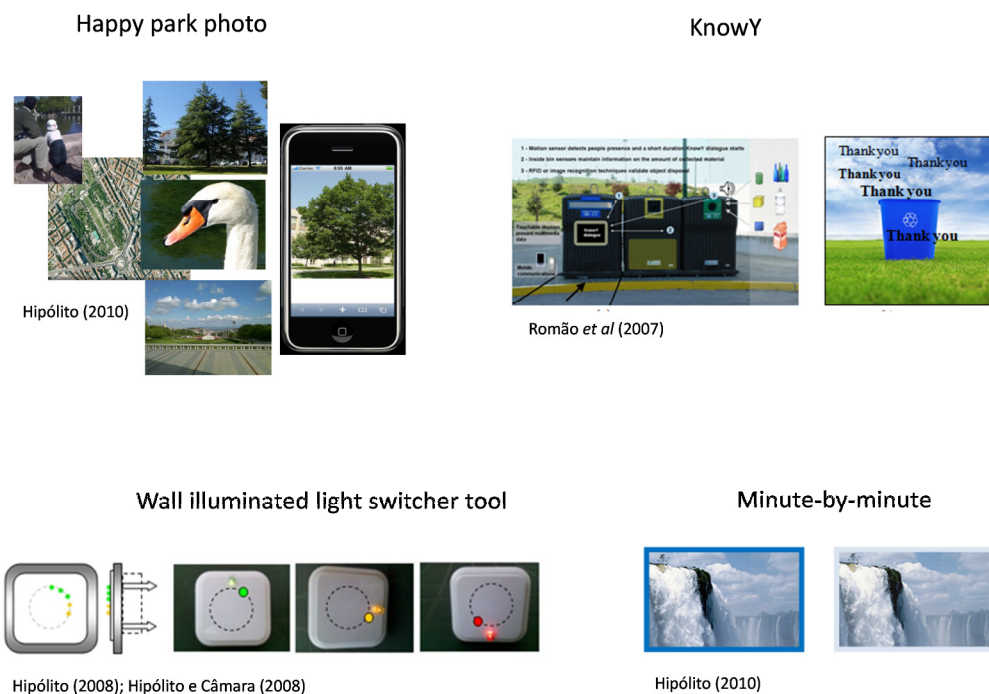


Figure 6-17 Scenarios being discussed

- Happy Park photo – the Happy Park photo scenario generated large discussion. Participants considered it an interesting approach, although it could be intrusive if it is not part of an application. To overcome this, the idea of having posters around the park like “This Park is interactive” or to have special kiosks that would frame the system by pre-register the interested users, or even having areas (e.g. blue areas designed in the ground) in the park where the pictures could be sent to the mobile devices. Bluetooth was a referred enabling technology. As for developing an application, IVO (developed by a project DEAP collaborator) could be used. This would enable to select particular areas and create the associated pictures to include in the application. This application could be part of a municipal service for encourage visits to urban parks. Natural elements information such as their history or season’s details could integrate a gallery stimulus of specific areas.
- KnowY – participants already knew the scenario, constraining its discussion. A main point relates to the need of controlling environments for having public ambient displays near public environmental equipment such as the recycling bins.
- Wall Illuminated Light Switcher Tool – participants considered this scenario interesting. It was extended considering a hybrid approach of smart objects connected with a digital image provided in another channel. This created enthusiasm in another DEAP member that asked if developing the idea would be possible within his work.
- Minute-by-Minute – this scenario originated the possibilities of switching images as feedback.

After the discussion, participants completed a questionnaire including the following items:

- Expectations
- Scenarios classification
- Visual feedback
- Interventions utility
- Emotional potentialities
- Preferred scenario

The questions format included rating scales, including Likert scales and semantic differential, and a final open question. Graphics present the results when appropriate. Firstly, participants were asked about how coincident with their own expectations regarding emotion-oriented interventions for the environment the presented description was. One participant

answered better than expected, five participants answered the second highest answer and one participant did not answer. The scenarios classification obtained the following results.

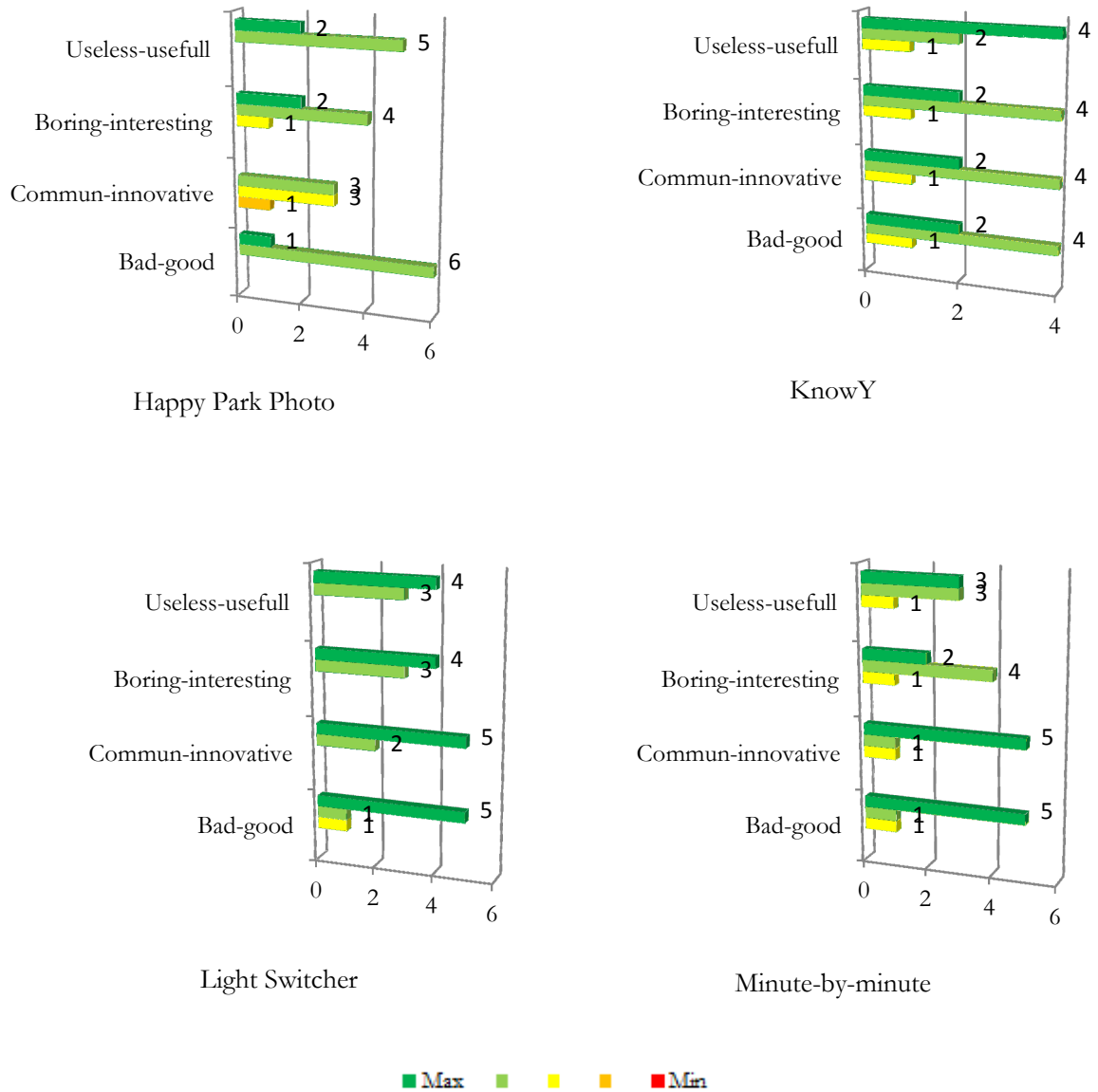


Figure 6-18 Scenarios classification

As regarding the described visual feedback, it was classified in terms of being useful, practical, exciting and encouraging. Figure 6-19 shows the results.

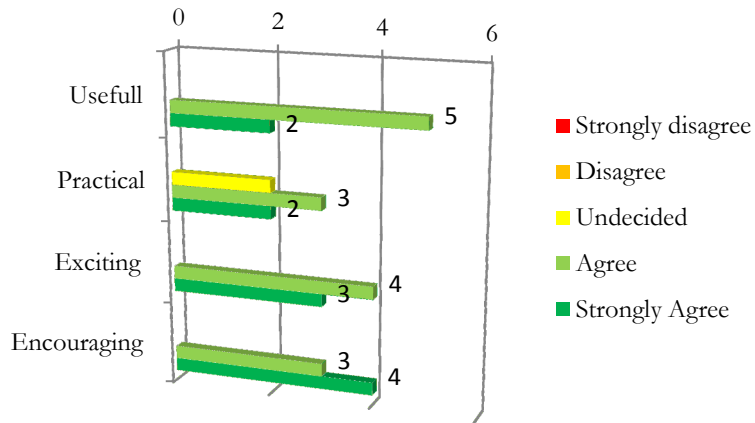


Figure 6-19 Visual feedback is...

The questionnaire also approached the issues included in Figure 6-20 .

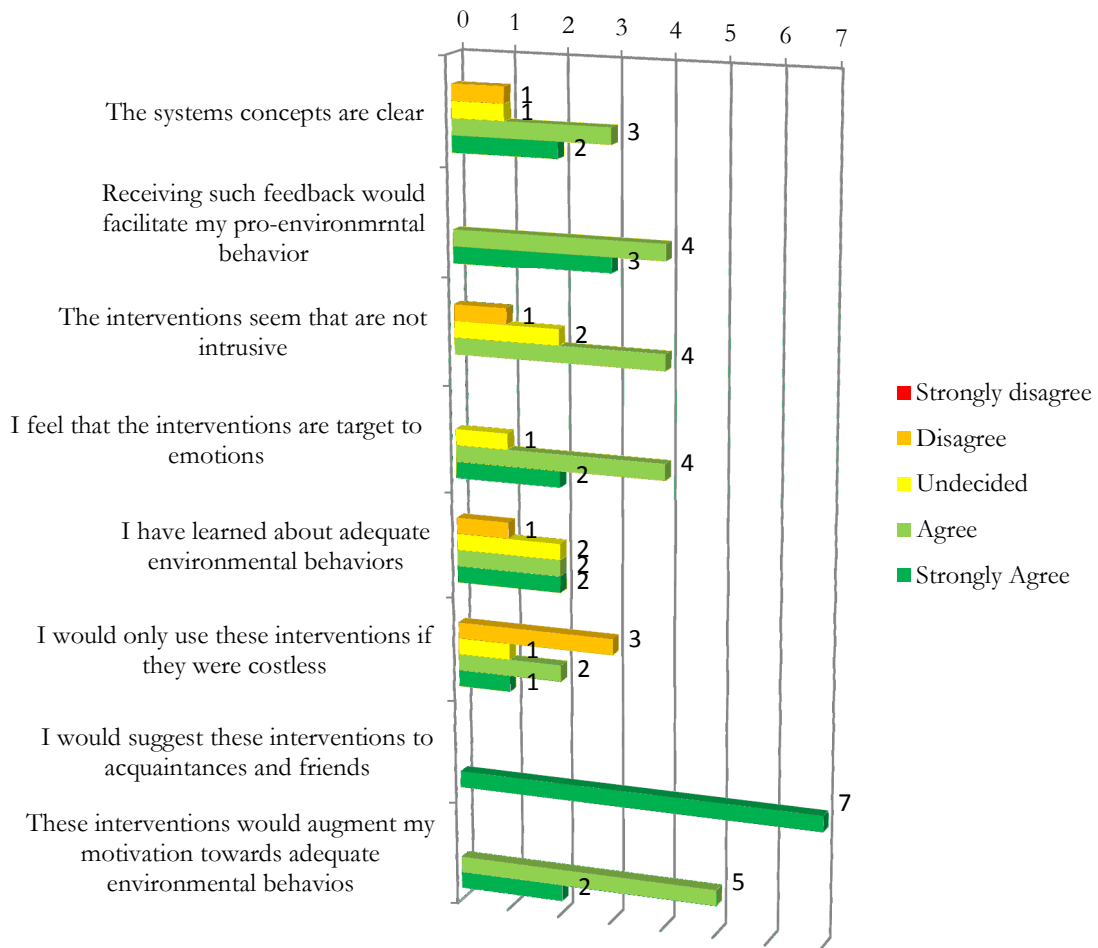


Figure 6-20 Levels of agreement regarding the selected sentences

Before asking participants about their preferred scenario, they were asked to imagine similar interventions for feedback in the future and they were asked to classify their emotional

potentiality in the facilitation of pro-environmental behaviors. Two participants have considered Very high, while five have considered High.

Finally, participants should name their preferred scenario. None as picked the KnowY scenario and the others were picked in the following proportion: Happy Park Photo: 1, Light Switcher: 4, Minute-by-minute: 2. Table 6-7 presents the reasons why.

Table 6-7 Preferred scenario and reasons why

Scenario	Why?
Happy park photo	<ul style="list-style-type: none"> • <i>It seems quite interesting and I see myself using this application in the future. Although it should include the mentioned suggestions (E1).</i>
KnowY	
Light Switcher	<ul style="list-style-type: none"> • <i>This is my favorite due to the impact that it may have in the future and for having commercial viability for current smart houses (E4).</i> • <i>I prefer this because it gives a more direct feedback to the user (consumption-light-cost) (E5).</i> • <i>This, due to simplicity and by using metaphors already known to users (E6).</i> • <i>For having just-in-time practical effects in changing behaviors (E7).</i>
Minute-by-minute	<ul style="list-style-type: none"> • <i>It seems the most innovative and the one that presents the biggest challenges in terms of research (E2).</i> • <i>Has a lot of potential, in the sense that my behavior could be a capital gain to keep the presence of a positive visual stimulus, or to lose it (or reduce beauty, for instance) (E3).</i>

6.6.4 Discussion

RQ12: Can environmental episodes influence emotional experiences?

A person's relationship to such an entity as an environment is difficult to understand and it is complex, but a key aspect of this relationship is emotional (Russell and Snodgrass 1987).

The participants' descriptions of the episodes clearly support answering positively this question once all subjects have quickly identified an emotional environmental episode and characterized it in the selected ways. The results show that some participants selected an episode that have resulted from a personal encounter with an environment (direct and immersive experiences) while others report emotional experience because of exposure to media channels.

The individual encounter with an environment was noted by Russell and Snodgrass (1987) to involve three steps: 1) before entering the environment, 2) effects of the environment; and 3) activity in the environment; all may influence the emotional experience.

In fact, the reported episodes involve planning efforts (to visit natural areas, but also to accomplish recycling) that met expectations differently; visiting natural areas was perceived as a very positive emotional experience, while founding garbage near the recycling bins was perceived as a negative emotional consequence.

The sensory experiences within the environment are also affectively charged, promoting pleasantness (visiting natural areas have abundant natural sensorial stimuli and restorative effects) or unpleasantness (visualizing garbage and perhaps smelling it).

Finally, the activity that is been carried certainly may alter the emotional state both ways, in one way open air activities in natural areas stimulate well-being and freedom while everyday tasks may not be perceived as enthusiastic and happiness triggers.

The exposure to media channels provided emotional impact. This is related to the fact that emotions are initiated from images (Damásio 2010) that are occurring in the present or that having occurred in the past are being evoked in the present. In this study, participants have rebuilt images from memory to support their description of both positive and negative emotional episodes and experiences.

RQ13: Are environmental episodes related to the proposed emotion-oriented interventions for environment?

Emotional episodes are about something in particular typically involving subjective feelings, and including both an affective appraisal and a mood change (Russell and Snodgrass 1987).

In the prototypical case of an emotional episode, there is a change in physiology and a change in behavior, and may consist of components behavioral, physiological and mental. The behavioral component could be expressive (such as smiles, gestures) or instrumental (such as aggression). The physiological component includes changes such as blush. The mental component may include three sorts of events:

- 1) Perceiving external events or objects as pleasant, attractive, likable, disgusting, threatening, and so on (affective appraisal);
- 2) Feeling happy or unhappy, aroused or calm (mood);

3) Perceiving self-emotional episode (emotional experiences).

Creating a positive mood appears to increase the positive and pro-social quality of behavior and that an unpleasant mood increases antisocial behavior (Russell and Snodgrass 1987). For these authors, increasing the pleasantness of mood by providing gifts, food, drink or pleasant surroundings increases the rated liking for a given environment. Thus, the proposed way of increasing one's pleasantness by rewarding environmental behavior applies to this perspective. In addition, it could increase motivation and promote happiness and enthusiastic feelings, and playfulness.

The described episodes relate to the following themes: environmental information, environmental equipment and visit to natural areas, thus, the interventions such as the ones introduced in this work may support all the situations.

RQ14: Do emotion-oriented interventions impact emotional experiences?

Described emotional experiences related to immersive experiences and exposure to media channels. For the study participants that exposure has affected their emotional perception. Thus, it can be expected that the exposure to emotion-oriented interventions that handle affective images and other sensorial ways would also affect individual emotional experiences.

Considering that the interventions are to be delivered ubiquitously in an environment (both outdoors and indoors) it could be expected a summative emotional effect. The equation of resulting emotional experience includes both the environment but also the interactive experience lived there.

The resulting effect will always be subjective, depending on each individual history and perceptions. For instance, a recycling behavior may lead to a sense of well-being thus corresponding to an adequate behavior to reinforce positively through such interventions. However, if the equipment is improperly preserved, the final emotional experience can be unpleasant.

This study did not study specifically how the visual and interactivity really affects the emotional experience perceived by subjects in a given environment. However, in a general way participants perceived the interventions has being targeted to emotions (see Fig. 6-24) and all subjects agreed in the possibility to suggest those to acquaintances and friends.

RQ15: Is facilitated pro-environmental behavior positively influenced by individuals' emotional experience?

Positive mood appears to increase the positive and pro-social quality of behavior and that an unpleasant mood increases antisocial behavior (Russell and Snodgrass 1987). Furthermore, Damásio (2010) explains that negative emotions lead to the invocation of ideas about negative facts; while positive emotions do the opposite; and that action plans represented in the mind are in line with those general emotional tones. Thus, it seems that considering positive emotional experiences regarding environmental issues would promote pro-environmental behaviors and thus its facilitation.

This is in line with Searles (2010) study that advances that enthusiasm (positive) appeals would reinforce positivity towards efforts to protect the environment, leading individuals to report an overall positive orientation; while anxiety (negative) appeals would do the opposite, being counterproductive, and having a negative effect on the participants' views towards the environment.

The study participants have classified as very high (29%) and high (71%) the emotional potentiality of the interventions in the facilitation of pro-environmental behaviors. This reported perception seems to support the idea that the emotional component should be considered when designing the new interventions.

6.7 Document analysis: scientific-fiction and pro-environmental behavior

In many classic science-fiction stories, alien life is based on silicon—the substance at the core of modern electronics technology—rather than on carbon, the fundamental building block of earthly biology. Scientists have even speculated that they might someday create silicon life-forms. Instead the opposite is starting to happen: carbon is serving as the foundation for electronic devices—and in the process is breathing new life into the quest for inexpensive, flexible products that offer a broad range of capabilities. (Gruner 2007)

Document analysis consists of a qualitative research technique appropriate to identify new aspects of a given situation as well as complementing other information gathered with other approaches (Reis 2004).

It is a systematic procedure for reviewing or evaluating documents, requiring data examination and interpretation in order to elicit meaning, gain understanding, and develop knowledge (Bowen 2009).

Documents contain text (words) and images recorded without the researcher's intervention.

6.7.1 Method

In the present study, the document analysis technique focused on personal documents, photographs and writings, made by the previous study participants in the context of producing a scientific-fiction story. This enabled to compare results, namely between the described environmental episode and the written story.

The stories represent another way of trying to assess participants' notions on the research issues. The production of scientific-fiction stories should reflect a combination of different elements such as:

- Participants ideas and feelings about science and technology possibilities and environmental behaviors;
- Participants values and emotions;
- Conceptual images obtained by several sources such as social communication and movies;
- Social images of science and technology advancements towards citizenship issues;

- Other elements identified by participants as important in pro-environmental behaviors.

Also, and most important was the possibility to assess how participants perceive affective images related to the environment, as the previous studies relied on a subjective selection of images from the IAPS collection.

The study addressed the following two research questions:

RQ16: What kind of affective images do participants select?

RQ17: What kind of social images of science and technology do participants advance?

6.7.1.1 Participants

The participants are the ones that have participated in the previous study. After the session described in the previous section participants were assigned to write their story, include the picture, and return it by e-mail.

6.7.1.2 Research tools

Each participant was asked to write a small scientific-fiction story, by imagining a group of multi-disciplinary scientists working on a concrete situation closely related with new technology for environment and if possible with the facilitation of pro-environmental behavior.

Participants should add a related affective image captured by them. Prior contact to the affective pictures topic took place during the panel described in the previous section when participants saw the selected IAPS pictures.

An example of a scientific-fiction story (both text and image) that could serve as an example (Appendix D) was sent by e-mail. In this prototypical story, the image contained a landscape of a coastal zone, mostly sky with white clouds and sea. Renewable energies, specifically the future scenario of using wind and waves' energy, were the story topic, thus not pointing directly to the facilitation of pro-environmental behaviors.

Beyond the affective image (providing a subjective happiness sense) the story approached cues regarding interactions between science, technology and society. It also focused on emotions and environmental affective quality.

Providing this story was important to elucidate participants about what to achieve in this exercise. However, the story could somehow influence the participants' creativity and writing style.

Nevertheless, the stories results intend to, through a creative approach, complement previous results. They do not intend to be a detailed portrait of the participants' conceptions.

6.7.2 *Results*

The stories of science fiction were a complementary source of the participants' conceptions about science and technology ventures regarding technology for environment and if possible the facilitation of pro-environmental behavior problem.

The different stories included elements regarding: 1) Affective images, 2) Science and technology concepts, 3) Interaction within environment, science, technology and society. Another expected element was pro-environmental behaviors and their facilitation.

From the seven enrolled participants six have returned their story (5M, 1F).

The obtained science-fiction stories are:

- The Last Trees
- 19:15
- The Invisible Smoke
- Development of Ubiquitous Systems for Human Body Energy Production
- Giving Nature a Helping Hand
- Green Camouflage

The Green Camouflage story was written in English; the other stories were freely translated from Portuguese by the author of the dissertation.

The six stories are as follows.

The Last Trees

The year is 2054. My name is David and I belong to a research team that intends to save the last trees of our planet.

In recent years, Earth has suffered radical changes due to new technologies that are based more and more in using our planet natural resources, in particular trees wood, to build the comfort Humanity wishes. Trees are decreasing, and parks are less.

The situation is unsustainable. The oxygen is created artificially, but one expects that in the near future it will not be possible to produce more...

Thus, I appeal to ensure that Humanity do not reach this point.

For that, I send this message back to year 2011. I hope you use this information on behalf of our planet.

19:15

I noted the time: 19:15. I pressed "play" and two men voices started to leave, from the laboratory sound system.

- They only think about doing their things but never stop to think in what we have to stand... - said one of the voices. I noted the sentence; the system didn't accused, but I suspected that was another critic. Another.

- It is another coming building, isn't it? Last one has already taken the best pasture we had. - answered its fellow. More notes. The system continued without signaling.

- They keep on building, building, do their things and we end up losing - regardless language issues, the discourse analysis system ended to accuse the conversation negative tone. Perfect. - That building was a research station about the barrage, wasn't it? (...)

-Well, I only know that before I used to wake up with birds singing and now I wake with horns by my window!

I thought briefly in the destinies of those two men that I was listening to (shepherds, apparently). We, while researchers don't have access to biographical data of people whose discourse is analyzed, but only to the time the recording was made: about 8 years before. In fact, my team only uses the recordings that are coming in massive quantities, to study the population alignment with the orientations to development and progress that current science keeps on imposing to the country. All recordings I have listening to came from the same region - the habitants of a small village without a name located near that research building -, and all were critics. Apparently, some interventions in the environment, even if made with good intentions, end to cause population discomfort. After analyzing some demographic data, I noticed that birds weren't the only ones to escape. That village also extinguished and, in a curious turnaround, the research station also ended abandoned.

As I always do, I avoid taking personal conclusions. Much could be said about this, about the distance that separates a plan from its final result, from paper to terrain, from calculus to persons, but I insist not to take conclusions. The study was only in its beginnings and was promising since then: not all population has agreed with the building construction; the majority did not understand its necessity; they have passed by other negative experience related to other constructions (...). It was late, time to go home. I left the laboratory building and head up to the car parked. Trees bordered the way, and by the roots of one of them, above the cement, next to tire marks and dark oil spots, a nest was fallen. Besides some feathers and straw, it was completely empty. I went to the car, searching - again - not to take personal conclusions... birds, all.

The Invisible Smoke

My name is Joaquim and I belong to a research group that works on studying greenhouse effect gases (dioxide carbon, chlorofluorocarbon, nitrogen oxides).

Last February, we had our first positive results by using filters that enable to reduce until 2% the harmful effect created by these gases. The experimental tests were made in a cork factory which foundations go back to the final of century IXX thus having quite old transformation processes. These filters also enable to transform the dense smoke into a mist.

The smoke is still there and can be seen through dark polarized glasses, but the anesthetic effect over the landscape is reduced.

Press has been given more highlight to this fact than to the reduction of 2% of greenhouse effect, and that is raising the interest of several governmental institutions that seek using our technology in other purposes.

All in the group believe that we can achieve even better results, and we are very motivated to pursue the good work.

Development of Ubiquitous Systems for Human Body Energy Production

I am an ultra-secret crazy scientist that investigates energy alternative ways; Alj00x11 is my code name. In the last years I have been working on renewable energies that I explore in super-ultra-secret laboratories in big buildings caves, which headquarters are somewhere in the "alentejano" desert. I should say that I think I come from the Melmac planet, which is located in that X spot of the Universe.

After "landing" (I don't know how) in the planet Earth, I checked that the existing energetic resources were depleting. Thus, I looked forward to dedicate my life to the research about new energy forms, preferably renewable. While observing people I noted that they used much energy in their different activities, especially in the ludic context (oddly, or not, it seems to me that people aren't as energetic in professional activities). This way, I try to develop ubiquitous systems that in a natural way, and non-intrusive, are able to use the energy produced by the human body. The following image represents my main research line. Through an IRUbi vision it is possible to visualize the energy released (with spaces saturation) by bodies in activities, such as, musical activity (as the image illustrates). Thus, it is possible to use the system that captures and stores the energy in ultra-sensitive containers in an abstract way and invisible to human vision. These containers are found in 2-5m above the bodies (it depends on available space and bodies in activity) and communicate through wireless channels of floating energy transmission.

Now it is still not possible to explain in detail the developed systems, once I am still trying to find the best way to publish this crazy invention (...). These systems can have reduced acceptance due to privacy and security issues (...).

Given Nature a Helping Hand

The world is full of desolated and depressing sceneries. Desolated because sceneries are naked of green and depressing due to being shaped more by the human hand than by the Nature hand.

My work is focused on delivering to the hands of the unpredictable and immensely creative Nature, the destiny of these landscapes. Nature always finds a way to reconquering territory, since opportunity is given to Nature; and that is where I work, opening paths and facilitating regeneration.

I am a researcher and my work is focused on the reforestation of big areas, with the goal of producing green surface in areas that have been affected by fires, or that have been victims of mineral explorations. Thus, I try to find new methods of preparing the soil for receiving new life and also methods for delivering seeds to the soil. Currently I am in the Canada, reforesting a large area, which land was dissected due to precious minerals search. For me, nothing is more painful than finding, in the heart of a large forest, a large crater, where it used to be a green surface.

At the end of the day, I know that I have contributed for future generations that won't have to witness all this destruction. However, the truly work is not the one I make; I just give a helping hand.

Green Camouflage

I am an environmental designer and I explore innovative ways to save energy and produce clean energy that minimizes aesthetic environmental impact.

Inspired by palm and pine trees GSM antennas which try to camouflage electronic devices and integrate them in the landscape, we are exploring how to design and produce energy generators that merge into the natural landscape, minimizing their aesthetic impact in the environment. Small photovoltaic cells can be used to cover part of the fake tree trunk and produce clean solar energy.

Other examples that reduce the aesthetic impact of technology in the landscape include solar roofs tiles or flower covered parking car buildings.

Participants included the following images (Figure 6-21) in their stories.



The Last Trees



19:15



The Invisible Smoke



Development of Ubiquitous Systems for Human Body Energy Production



Giving Nature a Helping Hand



Green Camouflage

Figure 6-21 Scientific-fiction stories images

6.7.3 Discussion

This study did not consider observation of participants.

Participants took their time and selected their writing place.

The method for collecting research data on perceptions and conceptions about behaviors, science and technology and affective images consisted on document analysis (Savenye and Robinson 2001; Reis 2004; Bowen 2009).

Participants wrote a short science-fiction story and illustrated it with an affective image. The received stories became artifacts (Savenye and Robinson 2001) of interest to this research as they provide insights of participants understanding of science and technology.

The following four activities were involved in this method application:

- Enrollment of participants in the study – Participants enrollment began on the panel session described in section 6.6. Then, participants received a follow-up e-mail with the main goals and instructions and later a scientific-fiction story prototype called “Sky over Sea” that could be considered as example (see Appendix D).
- Identifying the received material – The stories were received by e-mail and were translated to English to be included in the dissertation (only one story was written in English).
- Analyzing the documents – Text and affective images analysis enabled discussing the defined research questions.
- Evaluating the material – The evaluation of the stories enabled gaining an overall view of the involved issues and context, trying to be sensitive to both what was included as well as what was excluded.

The following discussion emerges.

RQ16: What kind of affective images do participants select?

The six affective images are less emotionally positive than expected. “The Last Trees” story included a park landscape, featuring a healthy small tree. The stories “19:15”, “The Invisible Smoke”, “Giving Nature an Helping Hand”, and “Green Camouflage” included images related with

environmental elements, namely an empty birds nest, a factory, a mountain rural landscape, and a flower covered parking car building.

The story “Development of Ubiquitous Systems for Human Body Energy Production” included an image not related with environmental landscapes, sceneries or their elements, representing instead musicians in a music concert.

The twelve IAPS pictures shown during the panel did not influence this selection of affective pictures. The selected affective pictures are not similar to the image included in the scientific-fiction story prototype, which consisted of a coastal landscape.

RQ17: What social images of science and technology advancement are reported?

Stories arguments included environmental issues focusing on trees preservation, urban planning, industrial pollution reduction, renewable energies and reforestation. Stories action follows in the future or in non-determined time.

The selected themes occurrence is diverse, surprising, and are not similar to the provided prototypical story. However, the story provided as example could have impact the writing stories work, for instance in the sense of these do not refer the facilitation behavior problem that was also not addressed in the provided prototypical story. However, it is not possible to determine the degree of the story influence on each story. Addressing this could be done by considering interviewing each participant in the future.

Another missing element covers that none participant has mentioned links to problems and solutions addressed in the literature or other source.

The stories arguments go far beyond the topics addressed by the project DEAP and not address the interventions introduced in the panel session where the participants have been. However, the stories incorporate informatics knowledge, namely related to information and communication systems and ubiquitous computing:

“For that, I send this message back to year 2011. I hope you use this information on behalf of our planet.” (“The Last Trees”)

“(…) I noted the time: 19:15. I pressed “play” and two men voices started to leave, from the laboratory sound system. (...)The system continued without signaling. (...) the discourse analysis system ended to accuse the conversation negative tone. Perfect.” (“19:15”)

“(...) I try to develop ubiquitous systems that in a natural way, and non-intrusive, are able to use the energy produced by the human body. The following image represents my main research line. Through an IRUbi vision it is possible to visualize the energy released (with spaces saturation) by bodies in activities, such as, musical activity (...)it is possible to use the system that captures and stores the energy in ultra-sensitive containers in an abstract way and invisible to human vision. These containers are found in 2-5m above the bodies (it depends on available space and bodies in activity) and communicate through wireless channels of floating energy transmission.” (“Development of Ubiquitous Systems for Human Body Energy Production”)

“Inspired by palm and pine trees GSM antennas which try to camouflage electronic devices and integrate them in the landscape (...)” (“Green Camouflage”)

The expressed ideas of science and technology and the involved scientists are mainly positive.

According to these artifacts created especially to this research, science purposes are global and humanitarian (e.g. save the Humanity):

“Trees are decreasing, and parks are less. The situation is unsustainable. The oxygen is created artificially, but one expects that in the near future it will not be possible to produce more... Thus, I appeal to ensure that Humanity don't reach this point.” (“The Last Trees”)

Alternatively, science purposes are instrumental and more localized (e.g. pollution reduction, alternative energy production and storage, minimizing technology aesthetic impact).

“(...) using filters that enable to reduce until 2% the harmful effect created by these gases.” (“The Invisible Smoke”)

“While observing people I noted that they used much energy in their different activities, especially in the ludic context (oddly, or not, it seems to me that people aren't as energetic in professional activities). (...)” (“Development of Ubiquitous Systems for Human Body Energy Production”)

“(...) we are exploring how to design and produce energy generators that merge into the natural landscape, minimizing their aesthetic impact in the environment. (...)Other examples that reduce the aesthetic impact of technology in the landscape include solar roofs tiles or flower covered parking car buildings.” (“Green Camouflage”)

Negative ideas were expressed in relation to, for instance, having technology that consume natural resources excessively, or to having discrepancies between technological advancements and population receptivity to those.

“In recent years Earth has suffered radical changes due to new technologies that are based more and more in using our planet natural resources, in particular trees wood, to build the comfort Humanity wishes.” (“The Last Trees”)

“to study the population alignment with the orientations to development and progress that current science keeps on imposing to the country. All recordings I have listening to came from the same region – the habitants of a small village without a name located near that research building -, and all were critics” (“19:15”)

According to the analyzed stories, science and technology are ventures that require persistence and monitoring to achieve the goals and to advance innovations.

Science and technology are related to the artificially production of oxygen, filters to reduce smoke pollution and greenhouse effect as well as the investigation of alternative energies (e.g. *“small photovoltaic cells can be used to cover part of the fake tree trunk and produce clean solar energy”* in the Green Camouflage story).

The scientists integrate research teams that work on saving the last trees of planet Earth, study the alignment of population to the progress science impose to the country, study greenhouse effect gases, alternative energy production, reforestation, or minimize technology aesthetic impact in the environment.

The “Development of Ubiquitous Systems for Human Body Energy Production” story scientist is an alien: *“Alf00x11 is my code name (...). I should say that I think I come from the Melmac planet, which is located in that X spot of the Universe (...). After “landing” (I don’t know how) in the planet Earth”*.

Also, reference to the mandatory publication work within research is only included in this story: *“Now it is still not possible to explain in detail the developed systems, once I am still trying to find the best way to publish this crazy invention (...).”*

Stories do not provide indication from where their research financial support comes.

It seems that research take place in laboratories, although results are to be applied outdoors. Investigation, experimentation, invention and design are related activities.

Generally, stories focus more on experimental and practical aspects of the research process. The research process includes the activities of collecting data, analysis, experimentation and testing and provides recommendations.

“Trees are decreasing, and parks are less.” (The Last Trees”)

“We, while researchers don’t have access to biographical data of people whose discourse is analyzed, but only to the time the recording was made (...) recordings that are coming in massive quantities (...) After analyzing some demographic data, I noticed that birds weren’t the only ones to escape. That village also extinguished and, in a curious turnaround, the research station also ended abandoned” (“19:15”)

“The experimental tests were made in a cork factory which foundations go back to the final of century IXX thus having quite old transformation processes. These filters also enable to transform the dense smoke into a mist.” (“The Invisible Smoke”

“I checked that the existing energetic resources were depleting.” (“Development of Ubiquitous Systems for Human Body Energy Production”)

Scientists work alone or in teams and are presented as persistent and dedicated to their research topics, and that leads to research success and motivation.

“It was late, time to go home. I left the laboratory building and head up to the car parked.” (19:15)

“All in the group believe that we can achieve even better results, and we are very motivated to pursue the good work.” (“The Invisible Smoke”)

Relevant is to consider the implicit interaction between science, technology and society, that places more emphasis on the influence that science and technology over the society, than the opposite. These influences are positive when the goal is to augment Humanity quality of life, for instance.

Although the story should focus on environmental behaviors, none of the stories included pro-environmental behaviors in the private sphere, like recycling. In fact, the stories induce the need of changing behaviors but do not address the use of technology, interfaces or other interventions to achieve that.

In addition, the stories do not refer captology and related persuasive technology (Fogg 1998 and Fogg 2003) or other forms of eco-feedback (Froehlich *et al.* 2010) for environmental behaviors. This was expected once the participants are aware of that research opportunities as well as they are directly involved in the development of such systems within the DEAP project.

Furthermore, participants did not address smart materials potentialities and new forms of computing (see e.g. Camara 2005, Microsoft 2006, Gruner 2007). Also, the science-fiction exercise did not address the research area of low cost electronic applications. This was expected because FCT/UNL colleagues are developing advancements with outstanding results and much deserved media publicity (e.g. Fortunato *et al.* 2008).

During the panel study participants were introduced to the idea of making visible the invisible, namely to design new interventions that enable the visualization of resources consumption, such as the Power-Aware Cord (Gyllensward and Gustafsson 2005) or the Illuminated Light Switcher Tool (Hipólito 2008 and Hipólito and Câmara 2008).

Interesting was to note how the story “The Invisible Smoke” addressed the invisibility issue, in the opposite way, advancing the technological possibility of reducing the visual impact of pollution, namely the smoke visibility, also applying to the slogan “invisible technology, visible impact”:

“These filters also enable to transform the dense smoke into a mist. The smoke is still there and can be seen through dark polarized glasses, but the anesthetic effect over the landscape is reduced. Press has been given more highlight to this fact than to the reduction of 2% of greenhouse effect, and that is raising the interest of several governmental institutions that seek using our technology in other purposes.” (“The Invisible Smoke”)

Another analysis made was to compare by participant, the intrinsic pleasantness reported in the environmental episode with the story tone. The stories are somehow linked to the environmental episode described by the participants. Thus, it seems that an emotional environmental episode affected the mind of some participants (emerging during the last study) tending to inspire future expectations for research.

Table 6-8 includes the correspondence between the science fiction story and the environmental episode.

Table 6-8 Stories and episodes correspondence

Science-fiction story and affective picture		Emotional episode (and intrinsic pleasantness)	Common base summary
Story Title	Affective picture		
The Last Trees	Park landscape, featuring a tree	“Home” movie visualization (Pleasant)	Narrative of environmental problems
19:15	Empty birds nest	Polar bear and ice melting (Unpleasant)	Having a confront between entities
The Invisible Smoke	Factory	Japan’s catastrophe (Unpleasant)	Factories and power plants and their risks
Development of Ubiquitous Systems for Human Body Energy Production	Music concert	Rock climbing near the Portuguese-Spanish border (Pleasant)	Sport, energy and well being
Giving Nature a Helping Hand	Mountain and rural landscape	Reforestation campaign for Serra da Estrela (Pleasant)	Reforestation
Green Camouflage	Green roof	Garbage container near recycling bins (Unpleasant)	Minimizing negative aesthetic impact

Also interesting is to note that the emotional impact of the images selected by the participants seem to be aligned with the general participants' pleasantness tone regarding their selected environmental topics (both story and episode).

Participants' environmental perceptions descriptions involve emotions, although not explicitly used. These emotions relate to the described environmental problem, generally negative, but also with the technological solutions, that tend to be positive.

The perceptions of environmental problems involve anxiety, fear such as when related to the planet degradation: *"The situation is unsustainable. The oxygen is created artificially, but one expects that in the near future it will not be possible to produce more..."* ("The Last Trees")

Alternatively, disappointment and worry when related to urbanization of natural areas:

"- They keep on building, building, do their things and we end up losing – regardless language issues, the discourse analysis system ended to accuse the conversation negative tone." ("19:15")

"The Invisible Smoke" story describes reaching a pollution problem solution using a positive emotional tone, involving optimism and contentment, related with the research successful approach: *"(...) we had our first positive results by using filters that enable to reduce until 2% the harmful effect created by these gases. (...) and we are very motivated to pursue the good work."*

Surprise and playfulness integrate the "Development of Ubiquitous Systems for Human Body Energy Production". The described work involves a creative way of contributing for the development of new alternative energy production forms: *"... I try to develop ubiquitous systems that in a natural way, and non-intrusive, are able to use the energy produced by the human body. The following image represents my main research line. Through an IRUbi vision it is possible to visualize the energy released (with spaces saturation) by bodies in activities, such as, musical activity (...)"*.

Another type of emotions, like hope was found in the "Giving Nature an Helping Hand". Although the story starts with an emotional negative tone related with the participant environmental perceptions: *"The world is full of desolated and depressing sceneries. Desolated because sceneries are naked of green and depressing due to being shaped more by the human hand than by the Nature hand.(...) For me, nothing is more painful than finding, in the heart of a large forest, a large crater, where it used to be a green surface.(...)"*. The approached solution involves hope: *"Nature always finds a way to reconquering territory, since opportunity is given to Nature; and that is where I work, opening paths and facilitating regeneration." and satisfaction:" At the end of the day, I know that I have contributed for future generations that won't have to witness all this destruction. However, the truly work is not the one I make; I just give a helping hand."*

The “Green Camouflage” story does not include an emotional writing style. It does not include an environmental problem perception described in a negative tone. In addition, it handles solutions in a neutral way: *“and I explore innovative ways to save energy and produce clean energy that minimizes aesthetic environmental impact.”*

A future approach within this study considers interviewing the participants to deepen, through that method, their perceptions and feelings about how these emotional perceptions relate to further individual behavior changing intentions.

Regarding this study future research it would also be appropriate to evaluate the emotional impact of the pictures using the SAM scale (Lang *et al.* 2008).

6.8 Conclusions

This chapter has shown that considering different emotional-oriented interventions for environment to solve facilitating pro-environmental behaviors problems may be better than the use of each of the interventions alone. The integration of different techniques improves environmental communication strategies.

Overall, these experimental studies results suggest the use of strategies that enable to:

- Develop knowledge regarding environmental behavior issues, as well as assist interest multidisciplinary researchers while mobilizing that knowledge.
- Consider future technologies in the mediation of media and behavior feedback, in order to augment new media positive possibilities and minimize effects of traditional approaches.
- Promote a multidisciplinary reflection about pro-environmental behavior in order to address the issues detected by this research work and to promote a more real and human approach to environmental issues.

The interventions that were developed are not functioning prototypes. In fact, they remain scenarios, since they relied on rapid definition for conceptual testing purposes.

The approaches could be more elaborated and even fabricated. Nevertheless, the overall described research allows moving from usual communication channels research to more surprising

procedures. In fact, instead of providing passive information about behavior, the interventions provide emotional inputs, enabling to reward behaviors appropriately within each situation.

The qualitative research allowed concluding that the interventions would be alternative ways for facilitating pro-environmental behaviors. Moreover, the exposure to such interventions would increase motivation when facing self-ESB.

A research problem not solved yet is to consider the influence over time of exposure to the interventions, pointing to an environmental psychology approach of long-term field studies (see Froehlich *et al.* 2010). Research questions that remain include:

- Would the interventions really be a motivational source?
- Would they be a source of individual enthusiasm promoting participation and augmenting awareness?
- How frequently should be the interventions updated not to fall into a routine?

Answering these questions was not part of this qualitative research goal. That would involve having full functioning prototypes and specific evaluation methodologies to apply in real contexts over time.

The qualitative research involved study participants that represented a skilled and knowledgeable minority. That enabled to produce new meaning grounded in the participants' current understanding of environmental behaviors and emotions that supported the advancement of new interventions.

It is relevant to highlight the following participants' contributions in the Interviews study, describing its specific strengths:

- Environmental behavior has an emotional component. Participants were consensual regarding their perception about having an emotional component in their environmental behavior. Satisfaction, well-being, happiness, joyfulness were some of the positive emotions linked to adequate environmental behavior. This supports addressing environmental behavior research in an emotion-oriented approach.
- Real time feedback about adequate behavior should be positive. The feedback should make individuals feel good, joyful and happy. It should also reflect their pro-activity, enabling them to understand that their actions have impact.
- Emotional reactions to positive affective images include a sense of happiness, enthusiasm and playfulness. All participants could immediately classify the images according to the SAM scale. This was an easy to do task, reflecting that the images can

rapidly make people evoke happiness and enthusiasm emotions. Furthermore, participants could select the images that provide a sense of playfulness.

- Positive feedback about adequate behavior increases motivation. Several insights support this statement. For instance, rewarding individuals with affective positive images within adequate behavior feedback reinforces that behavior. Positive feedback enables individuals to perceive that the action made is important, real and concrete and is not in vain. That would shape individuals, letting them know that they are making the difference. Furthermore, reinforcing an adequate behavior with a positive emotion would lead to behavior repetition.

In the study that approached the AESAM evaluation, it is relevant to review that participants could easily describe an emotional pro-environmental episode. Participants described both pleasant and unpleasant episodes. Their sources of emotion consider media channels but also immersive experiences.

Regarding the emotion-oriented interventions, participants considered visual feedback encouraging, exciting and useful. The Wall Illuminated Light Switcher was the preferred scenario. Thus, this enables to consider future multi-disciplinary research to address the topics covered in this doctoral work.

Finally, the last study showed participants knowledge and creativity about environmental problems and their solutions perceptions. Emotions were included in stories related to the perceptions of environmental problems (mostly negative emotions) and to the solutions (mostly positive emotions). Anxiety, fear, optimism, contempt, surprise and hope are some of the extracted emotions.

Contextual information description about this overall research (e.g. people who contributed data, number of participants and data collection methods) enables readers to consider results transfer in the future. The readers understanding of this research, enables them to consider comparing the results described in this dissertation with those they expect to see emerge (or have seen emerge) in their situations.

In order to assess the transferability of findings to other environments and settings, similar projects using the same methods would be of great value. This accumulation of findings from studies performed in different settings would enable to gain a more inclusive research picture.

Using multiple environments to study the issues approached in this dissertation would provide a larger research understanding with which the results of subsequent work could be compared. Furthermore, understanding of a research topic increases gradually, through several studies.

These several approaches, could even offer different results, reflecting multiple realities. The reflection on the reasons behind those variations would be as useful as the reported results.

Results transferability within the following contexts may occur in the future:

- Transfer research results within this research future work – The author of this dissertation is engaged in transferring this research results into future multi-disciplinary research opportunities. These include studying prototype interactions and deepen individuals’ perceptions regarding behaviors and emotions. The comparison of the results of those future studies with the ones obtained in the present doctoral work would augment research understanding.
- Transfer research results into other research settings – Researchers interested in this research can develop similar studies or use the results as an input for the development of new interventions. Thus, research on environmental communication and psychology, or HCI specialists may be interested in studying the findings described in this dissertation. It remains their responsibility, though, to assess the research results transferability. Nevertheless, embracing these research results, and comparing them to other studies, would improve understanding on the issues studied in this dissertation.
- Transfer research results into policy and practice – Policy-makers seek closer relationships between research, policy and practice. Research aimed at problem solving and at consolidating knowledge about what works better within “messaging for all” is most welcomed. Thus, practioners can have a role in the process of transferring this research results into interventions that would work in environmental communication. The findings could also be useful to other contexts where communication plays an important role. For example, augment security and reduce risks in behaviors related to health or to civil construction where accidents happen due to lack of correct procedures awareness.

6.9 Summary

Table 6-9 summarizes participants and testing materials of each study.

Table 6-9 Studies summary

Study	Participants Total: 55 plus IAPS sample	Tools		
		New Questionnaires	Power-point Slides	Other
Model analysis	27	Q1: “My Environmental Behavior and ICT”	-	-
Early proof-of -concept meetings	15	-	slides	Material for hand exploration
Analyzing IAPS affective images from IAPS	IAPS sample	-	-	IAPS data
Interviews	6	Q2: “Enthusiasm and Playfulness for Pro- Environmental Behavior”	-	12 IAPS pictures and SAM rating scale
An approach to the AESAM evaluation	7	Q3: “Emotional pro- environmental episode” Q4: “AESAM”	slides	12 IAPS pictures
Document analysis	6	-	-	Story prototype (text and picture)

CHAPTER 7. FINAL CONSIDERATIONS, CONCLUSIONS AND FUTURE WORK

This thesis covered the problem of facilitating pro-environmental behavior, handled with different emotion-oriented interventions scenarios.

Such scenarios were developed supported by a model and a design framework, enabling comparing the different approaches. Qualitative research described different techniques that enabled approaching results in complementary ways.

Three sections constitute this final chapter. The first section presents some final considerations about the new interventions and emotions. In section 7.2 the overall work of this thesis is discussed and it also presents main implications. The third section suggests directions for future research.

7.1 The equilibrium of facilitating environmental behaviors: can new interventions and emotions interact?

Facilitating pro-environmental behavior can be supported by new interventions aimed at dynamically activate emotions. According to this idea, advancing new emotion-oriented interventions takes a major role in the promotion of pro-environmental behaviors.

This way, multi-disciplinary research should stimulate the development of: a) new individual behavior meaning within environmental matters; b) solutions of pro-environmental behavior problems through new communication interventions; c) methods for evaluating new approaches in their social and technological dimensions; and d) willingness to continue to address related scientific and technologic issues.

There are different ways to handle those goals. Within the experimental research, it was perceptible the participants' receptivity to the proposed sensorial feedback, as well as a positivity towards affective images that trigger positive emotions.

These emotions contribute to augment the perception that everyone can make a difference for the environment. Furthermore, making visible the invisible seems to be a powerful emotional way to augment environmental awareness through senses stimulation. The facilitating pro-environmental behaviors problem can then address the design of new interventions aimed at evoking positive emotions.

By introducing new interventions aimed at facilitating pro-environmental behavior, this research is also contributing to DESD goals in an innovative way. Until the end of the UN Decade of Education for Sustainable Development (2005-2014), new interventions design can improve ESB.

Interventions such as the “One” ad and the “Power-Aware cord” are both contributing to support pro-environmental behaviors by emotional stimulus. The collective of creative approaches and experiences developed by researchers all over the world bring positivity to environmental education and communication strategists within the sustainable development arena.

In this study, it became clear the importance of developing research upon multisensory communication channels for promoting pro-environmental behavior. In fact, results from the qualitative research suggest that participants perceive the importance of sensorial approaches to augment their environmental perceptions. For instance, in the interviews study all participants reported vision as the sense used to trigger the self-emotional positive experience after exposure to stimulus related with environmental landscapes.

Furthermore, participants welcomed sensorial interaction within the interventions that by being emotion-oriented while rewarding positive behaviors, would increase well-being and satisfaction.

7.2 Conclusions and implications

This dissertation covered different interventions regarding the facilitation of pro-environmental behavior problem with a set of sensorial stimulations and a set of desirable behavior reactions.

This problem arises from the fact that individuals may have unintended behavior, and theories for pro-environmental behavior should be modeled, generated or updated. Along with this, the formulated model expressed the relationship between ESB, headline behaviors, and interaction within affective experiences. The model analysis included a survey study so that real life data enabled to support the definition of design guidelines.

Chapter 3 described the modeling approach and its analysis. The model supported the creation of the emotion-focused design for environment (EFD-E) framework presented in Chapter 4.

The EFD-E framework, consisting of four steps (analysis, conceptualization, fabrication and evaluation), supported the creation of interventions that create adequate positive moods for facilitating pro-environmental behavior.

The developed pro-environmental behavior interventions scenarios (Chapter 5) included different interaction techniques within pervasive and invisible computing and sensorial stimulations.

In addition, the IAPS gallery enabled to study the affective reaction to color pictures of environmental scenes and landscapes. This study allowed recommending within the AESAM, the affective images rewarding systems. Sensorial feedback tools are the other kind of pro-environmental behavior interventions purposed.

For the affective images rewarding systems, the *Happy park photo* scenario and the *KnowY* scenario were developed. For the sensorial feedback tools, the scenarios *Wall illuminated light switcher tool* and *Affective minute-by-minute* were developed.

All the possible use of innovative computing descriptions, namely within the YInvisible projects or transparent electronics, was restricted due to ongoing protection of intellectual property and patent submissions. That constrained our intended experiences and prototypes developments considerably in the first study phase.

Hence, it became not the main purpose of this thesis to provide new technological solutions and descriptions; rather, it intended to be an interpretative approach, explaining the interest and applicability of the approach by showing its potential through scenarios and qualitative research.

Qualitative research included, beyond the questionnaire study for the model analysis, early concept proof meetings, the analysis of affective images from IAPS, interviews, an approach to the AESAM, and a document analysis. The overall study suggested that new emotion-oriented interventions for environment as an alternative to ICT are likely to have significant practical impact in facilitating pro-environmental behavior towards sustainability in the future.

Overall, the implications of the obtained results include:

- Implications for the research about pro-environmental behaviors – The present study enabled to identify the potentialities of using different collection methods of behavior

data in order to build an understanding about interventions for facilitating pro-environmental behaviors. Combining questionnaires and interviews enabled to gather different evidence on current environmental behaviors, but also on expectations and motivations. It was especially significant the information gathered through the last panel that enabled to discuss scenarios and prior results. The overall approach also enabled to access other aspects of participants such as their emotions, feelings and values related to this research. Another positive feature detected during the analysis was the fiction exercise that enabled to express participants' creativity and inventiveness in different ways (beyond questionnaires, single interviews or group panels).

- Implications for the design of new interventions – The results obtained in this research suggest a set of design implications for emotion oriented-interventions for facilitating pro-environmental behaviors, namely: a) for discussion of new approaches of rewarding positive behaviors through sensorial feedback; and b) for approaching new technological options, namely through ubiquitous and invisible computing possibilities. The creation of an “articulated” multisensory communication system include a collection of distinct yet interconnected approaches, composed of interventions, persuasive and emotional strategies and media channels whose unity is obtained by the accumulated experience of the interdisciplinary research.
- Implications for studies in the HCI research area – Participants contributions in the qualitative research enable to consider the following perspectives for further studies within HCI: a) HCI and emotions perception, b) multimedia and multisensory integration of simple cues for environmental behaviors and c) interventions updating scheme definition. Hypotheses to check within these studies could be H1- Positive feedback may facilitate pro-environmental behavior, H2- Simple behavior cues associated with affective images may positively augment environmental awareness perceived by individuals, H3- Emotion-oriented interventions influence the facilitation of pro-environmental behavior. Whenever possible, those studies should include sessions involving participants' interaction with the systems, or their representations as prototypes, even of low technology.
- Implications for future interdisciplinary research projects – The behavioral and technological understanding diagnosed through this study, resulted especially relevant to the development of new research on technology for environment. In fact, the analysis and discussion of the participants' ideas enables to draw several future

potentialities for stimulating the interest on finding new ways for facilitating pro-environmental behaviors. Building interdisciplinary teams enable to adapt research to a larger reflection about activities, promoting the understanding of aspects from environment and science and technology. It would be pertinent to invest in a double way: 1) build and maintain educational materials about socio-science/technology-environmental issues related to this research for supporting ongoing related research activities as well as future activities; and 2) promote the research beyond the academic world, including searching for both new private and public partnerships.

7.3 Future work

This study has made an effort to fill in research gaps recognized by this researcher. This work represents an important step in the personal and professional dimensions of its author, with consequences in her future activities of environmental research and engineering.

Reflecting about the overall work of this thesis and the results obtained the following future orientations for this research on the environmental sciences area emerge, namely:

- Conception of strategies, methodologies and activities that are appropriate to achieve the goal of finding new ways for facilitating pro-environmental behavior;
- Investigation of the impact of those strategies, methodologies and activities in the conceptions of multidisciplinary teams of researchers and individuals;
- Application and evaluation of the developed approach used in this study to other contexts, namely, initial research activities and research projects financial submission;
- Construction and dissemination of educational materials with suggestion of activities and discussion of socio-scientific-technological issues related with this environmental research.

This dissertation not fully experimentally documents some theoretical statements. However, if its thesis is sound, it will have tangible consequences, particularly for environmental communication, education and research in the future. However, to build the interventions and apply those in real life contexts for testing would have meant to extend in time this research, and book length. Nevertheless, the wish of having touchable prototyping tools and their consequent real life use analysis, not perceivable in these pages, is not remote from future research subjects to treat.

Currently, related research is under way, integrated in the larger DEAP project. This represents, simultaneously, the continuation of the author research efforts as well as a contribution to the development of a more environmentally aware academia, augmenting active involvements in environmental issues.

Part of future research is the effort of moving from the qualitative research results transferability approach into a generalizability approach. That involves studying quantitative research specific methodologies. Nevertheless, participants' contributions enable to draw research perspectives to analyze in future quantitative studies. These consider field studies aimed at looking to the effect of positive feedback on environmental behaviors, including control groups and over time. Another possible research approach considers examining the impact of multiple interventions, collecting baseline, intervention and post-intervention data.

Beyond new experimental work, two other lines of research in the future include considering (1) feedback interventions as mood and facial expressions responses, beyond behavior response, pointing to affective computing (Picard 1997) for environment, and (2) feedforward interventions (Howard 2009, Zhang and Luck 2009) as a design strategy for anticipating undesirable environmental behaviors.

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APPENDICES

These appendices include experimental study materials (Appendices A-D), the reported work (Appendix E) and research links (Appendix F).

- Appendix A: Questionnaire “My Environmental Behavior and ICT”
- Appendix B: Interviews
 - B1: Guião e instruções da entrevista (30 min)
 - B2: Expectativas sobre o uso de imagens afectivas e comportamento pró-ambiente
 - B3: SAM scale
 - B4: Questionnaire “Enthusiasm and Playfulness for Pro-Environmental Behavior”
- Appendix C: AESAM evaluation
 - C1: Questionnaire “Emotional Pro-environmental Episode”
 - C2: Questionnaire AESAM
- Appendix D: Scientific-fiction story prototype
- Appendix E: Reported work
- Appendix F: Research links: places and teams

Appendix A: Questionnaire “My Environmental Behavior and ICT”

QUESTIONÁRIO

Exmo(a) Senhor(a), No âmbito de uma investigação da FCT/UNL, agradecemos o preenchimento do seguinte questionário, que visa a obtenção de dados que permitam compreender de que forma novas interfaces persuasivas poderão impulsionar a mudança de comportamentos ambientais, tornando-os mais positivos. Este questionário destina-se a fins científicos e é confidencial. O sucesso deste estudo depende da sua colaboração no preenchimento do questionário que ocupará sensivelmente 15 minutos. Muito obrigada.

1. Idade

- Menos de 14 anos
- Entre 15 e 24 anos
- Entre 25 e 34 anos
- Entre 35 e 44 anos
- Entre 45 e 54 anos
- Entre 55 e 64 anos
- Mais de 65 anos

2. Sexo

- F
- M

3. Qual a formação académica máxima que possui?

- Estudos primários/secundários
- Licenciatura
- Mestrado
- Doutoramento
- Outra:

4. Área de formação

5. De que forma as tecnologias de informação e comunicação estão presentes no seu dia-a-dia?

- Internet na escola/trabalho
- Internet em casa
- Telefone móvel
- Telefone móvel com acesso a Internet
- GPS
- Outra:

6. Como encara a adopção de novas e inovadoras tecnologias de informação e comunicação?

- Adquiro equipamentos de nova tecnologia com frequência
- Não adquiro porque fica caro
- Custa-me fazer a transição entre equipamentos
- Não é prioritário para mim
- Gosto do design e das funções modernas dos equipamentos
- Gosto de tecnologias que me possam motivar a ser uma pessoa mais responsável
- Tenho o interesse que venham a facilitar tarefas na minha vida
- Outro:

7. Por hábito, que bons comportamentos ambientais tem?

- Poupar energia
- Reciclar
- Poupar água
- Usar transportes públicos
- Procurar aprender sobre a natureza
- Outros:

8. Quais as razões que o fazem agir pró-ambiente?

- Consciência
- Valores pessoais
- Incentivos públicos
- Poupança económica
- Envolvimento familiar
- Contacto pessoal e amigos
- Acções colaborativas na comunidade
- Facilidade de execução das acções
- Aperceber-me que a minha contribuição faz diferença

- Outras:

9. Actualmente, a informação sobre comportamentos ambientais adequados chega-lhe de que fontes?

- Escola/trabalho
- Família
- Acções colaborativas na comunidade
- Comunicação social
- Internet
- Outras

10. Actualmente, recebe informações sobre as consequências para o ambiente das suas acções e comportamentos?

- Sim
- Não

Se sim, de que forma?

11. Utiliza em casa um ecoponto que lhe permite fazer a separação dos lixos? Se fizer parcialmente (vidro, papel, embalagens, pilhas ou lâmpadas) responda Sim

- Sim
- Não

Se respondeu Sim, indique por favor o que recicla (vidro, papel, embalagens, pilhas ou lâmpadas)

12. Pensa que reciclaria maior quantidade de materiais caso possuísse um ecoponto inteligente que o informasse dos benefícios ambientais atingidos devido às quantidades de materiais que já reciclou?

	1	2	3	4	5	
Muito menos						Muito mais

13. Que temas ambientais o preocupam/interessam mais? (Exemplos: reciclagem; poluição do ar ou da água; utilização de energias renováveis e micro-geração; poupar recursos ambientais). Mencione até 3 temas.

Porquê?

14. Gostaria de mudar os seus comportamentos ambientais e contribuir mais activamente para a conservação do ambiente e dos recursos ambientais?

- Sim
- Não

Que barreiras atrasam a mudança?

Que incentivos aceleram a mudança?

15. Actualmente, como classifica o seu comportamento ambiental?

- Ótimo
- Muito bom
- Bom
- Fraco

16. Que acções pratica habitualmente no sentido de preservar o ambiente? Mencione até 3 acções.

17. O que o leva, ou pensa que pode levar, a mudar comportamentos ambientais?

- Envolvimento familiar
- Programas e notícias da televisão e rádio
- Sites na Internet
- Escola/trabalho
- Acções colaborativas na comunidade
- Leitura de panfletos sobre adequados comportamentos ambientais
- Exposição a boas práticas em ambientes públicos
- Receber informações acerca das consequências para o ambiente das suas acções e comportamentos
- Outro:

18. Se, após cada acção que pratico, tivesse acesso a informação acerca das consequências (benefícios (ou malefícios) para o ambiente) dessa mesma acção, poderia mais facilmente alterar os meus comportamentos ambientais de forma a beneficiar o ambiente.

	1	2	3	4	5	
Discordo da afirmação						Concordo com a afirmação

Quando e onde preferia receber essa informação sobre as consequências para o ambiente da sua acção praticada?

- Posteriormente a praticar a acção, ao meu telefonome móvel chegaria uma mensagem SMS ou MMS
- Posteriormente poderia consultar um site da internet próprio para o efeito
- Logo que pratico a acção, no próprio local onde a pratico, num objecto transformado para esse efeito
- Outro:

Como preferia o aspecto dessa informação?

- Muito visual
- Visualmente simples
- Com alertas sonoros
- Outro:

19. Um sistema automático que me mantenha informado acerca das condições ambientais e das alterações provocadas pelas minhas acções levar-me-ia a adquirir hábitos mais pró-ambiente.

	1	2	3	4	5	
Discordo da afirmação						Concordo com a afirmação

20. Que ideias gostaria de ver desenvolvidas para o ajudar a mudar para melhor os seus comportamentos ambientais? Mencione até 3 ideias

Termina aqui o seu questionário. Muito obrigada. Caso esteja interessado em receber informações sobre os resultados deste estudo indique-nos o seu nome e e-mail. Oportunamente enviaremos essa informação.

Appendix B: Interviews

B1: Guião e instruções da entrevista (30 min)

Antes de começar, muito obrigada por ter aceitado participar nesta experiência.

Este estudo tem o seguinte objectivo: compreender de que forma imagens afectivas de paisagens ambientais (principalmente as que fazem evocar emoções positivas) fazem parte dos planos de acção e comportamento ambiental dos indivíduos.

Nos próximos 30 minutos, estará a responder a questões pré-definidas à volta da questão central: imagens de paisagens ambientais que fazem evocar emoções positivas são estimulantes como input para motivar a ter comportamentos ambientais adequados?

Não há respostas certas ou erradas, por isso responda simplesmente da forma mais honesta que conseguir.

Agora, deixe-me explicar o seu envolvimento com mais detalhe. Primeiro, faremos a entrevista guiada. Se der autorização a entrevista será gravada para mais tarde ser analisada com mais pormenor. A entrevista é composta por diferentes secções e 12 perguntas.

Utilizaremos ainda um conjunto de imagens da galeria IAPS que servirão de apoio à discussão. Pedirei para utilizar a escala SAM para classificar as imagens em Feliz vs Infeliz e Entusiasmado vs calmo. Depois de ver cada imagem, poderá dizer como se sentiu marcando a figura que melhor descreve o que sentiu. A classificação deverá reflectir a experiência pessoal imediata. Algumas imagens podem activar experiências emocionais; outras podem ser relativamente neutras.

De novo, não há respostas certas ou erradas. Diga simplesmente como se sentiu depois de ver a imagem.

Finalmente, pedirei para participar num pequeno questionário ao qual chamei “Enthusiasm and Playfulness for pro-environmental behavior” composto por 3 secções e 12 questões.

Tem alguma questão? Podemos então começar.

No final da experiência: Quero muito agradecer a participação de hoje.

B2: Expectativas sobre o uso de imagens afectivas e comportamento pró-ambiente

Expectativas

1. Que comportamento pró-ambiente tem actualmente?
2. O que pensa sobre este tópico? Foque nos valores e opiniões.
 - a. Relativamente a si e relativamente aos outros
3. O que sente sobre este tópico
 - a. Relativamente a si e relativamente aos outros
4. Que tipos de imagens afectivas (as que fazem evocar emoções) ligam ao seu comportamento pró-ambiente?
 - a. As imagens positivas são inputs mais estimulantes para comportamento adequado e motivação, do que as imagens que criam ansiedade?
 - b. Como considera que as imagens afectivas poderiam ser usadas para motivar comportamentos adequados?
 - c. E no caso de constituírem feedback *just-in-time* sobre o comportamento?

Familiarização

5. Que imagens de paisagens com valor afectivo (que fazem evocar emoções positivas) indica relacionadas com:
 - a. Água
 - b. Terra e solo
 - c. Céu
 - d. Seres vivos
6. Para a sua experiência emotiva, tendo por base um estímulo relacionado com paisagens ambientais, qual é o seu sentido mais relevante? Visão, audição, etc.
7. E relacionadas com emoções negativas? Que imagens indica? De que outros sentidos se lembra?

Associação

8. Qual é o papel que as imagens afectivas de ambiente têm nos seus pensamentos? Pode agora distinguir entre as que originam emoções positivas e as que originam emoções negativas.
9. Pode classificar estas imagens de acordo com a escala SAM?
10. Pedia-lhe agora para apontar 3 imagens de acordo com “ludicidade” (ou playfulness, em inglês).

Motivação

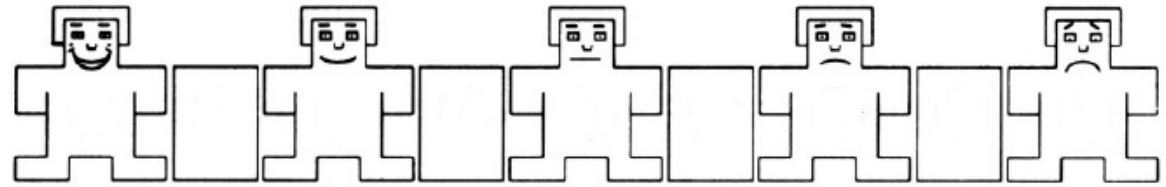
11. Focando nas intervenções orientadas à emoção, pela utilização de feedback sensorial (especificamente imagens afectivas) ao comportamento o que diria ser motivador?

Outras impressões

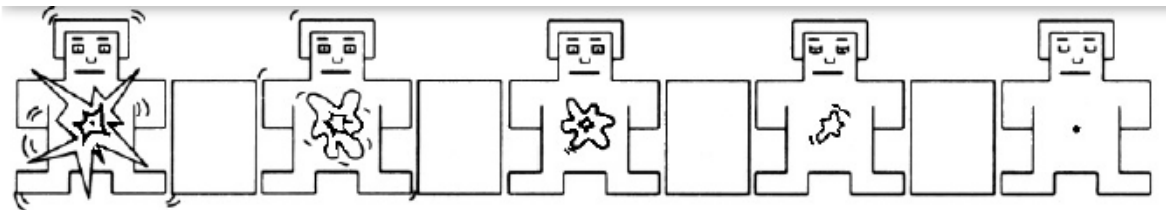
12. Outra informação, feedback à entrevista e impressões.

B3: SAM scale

Rating IAPS pictures with Self-Assessment Manikin



Happy								Unhappy
P. 1								
P. 2								
P. 3								
P. 4								
P. 5								
P. 6								
P. 7								
P. 8								
P. 9								
P. 10								
P. 11								
P. 12								



Excited								Calm Relaxed
P. 1								
P. 2								
P. 3								
P. 4								
P. 5								
P. 6								
P. 7								
P. 8								
P. 9								
P. 10								
P. 11								
P. 12								

From (Lang *et al.* 2008)

B4: Questionnaire “Enthusiasm and Playfulness for Pro-Environmental Behavior”

Section 1 – Motivation for behavior

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1. Assuming I had access to pictures as behavior feedback, I would like to use them					
2. Using such pictures and feedback would facilitate my environmental behavior					
3. I would feel comfortable having behavior feedback just-in-time					
4. The proposed behavior feedback is different from all other feedback I have already received					

Section 2 – Enthusiasm for pro-environmental behavior

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
5. I find affective images, those that make me evoke positive emotions, to be enjoyable					
6. The process of being exposed to affective images as behavior feedback is pleasant					
7. I have fun while exposed to the pictures					
8. I fell inspired by the pictures					

Section 3 – Playfulness for pro-environmental behavior

The following questions ask you about how would you feel if you would be exposed to affective images as environmental behavior just-in-time feedback

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
9. ... creative					
10. ... playful					
11. ... responsible					
12. ... aware					

Dados biográficos

Idade:

F____ M____

Formação:

Profissão:

Appendix C: AESAM evaluation

C1: Questionnaire “Emotional pro-environmental episode”

Por favor, descreva um episódio relacionado com comportamento ambiental que tenha produzido experiência emocional, mencionando o que aconteceu e as consequências que teve para si. Pode escolher um episódio positivo ou negativo.

Secção 1 - Ocorrência do episódio

1. Há quanto tempo aconteceu?
 - Horas antes
 - Dias antes
 - Semanas antes
 - Meses antes
 - Anos antes

2. Onde estava?
 - Em casa
 - Em casa de família ou amigos
 - No trabalho
 - Num espaço urbano público
 - Num meio de transporte (seu ou público)
 - Num espaço natural (praia, campo, paisagem protegida)

3. Quem estava consigo?
 - Ninguém, estava só eu
 - Amigo ou colega
 - Familiar
 - Pessoas que desconheço

Secção 2 - Avaliação geral do episódio

4. Avaliação geral

- Agradável
- Desagradável

Secção 3 - Características do episódio

5. Características

Quando pensa no episódio, diria que a emoção experimentada:

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Ocorreu de repente					
Seria previsível					
Já lhe era familiar					
Teria consequências importantes para si					

6. Consequências

Quando pensa no episódio, diria que a emoção experimentada:

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Traria resultados positivos (ajudar a concretizar objectivos ou necessidades, bem-estar)					
Poderia ter sido evitada					
É recorrentemente imaginada por si					
Foi partilhada a terceiros					

7. Reacções

Quando pensa no episódio, diria que:

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Activou uma série de emoções					
Resultou de uma experiência nova					
Seria importante facilitar comportamentos ambientais relacionados					
Seria importante mudar comportamentos ambientais relacionados					

8. Intensidade

Quando pensa no episódio, diria que:

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Pretendeu reduzir a intensidade da experiência emocional					
Pretendeu saber mais sobre o episódio que lhe activou as emoções					
Tenta mascarar para si a expressão emotiva do episódio					
O vai imaginar mais vezes no					

futuro					
--------	--	--	--	--	--

Secção 4 - Descrição verbal da experiência emocional

9. Como descreve a experiência emocional por palavras suas? Pode usar 1 palavra ou uma pequena expressão.

10. Emoções relacionadas com o episódio (marque até 3)

<input type="checkbox"/>	Tristeza	<input type="checkbox"/>	Contentamento
<input type="checkbox"/>	Alegria	<input type="checkbox"/>	Culpa
<input type="checkbox"/>	Ansiedade	<input type="checkbox"/>	Nojo
<input type="checkbox"/>	Surpresa	<input type="checkbox"/>	Prazer
<input type="checkbox"/>	Medo	<input type="checkbox"/>	Desespero
<input type="checkbox"/>	Irritação	<input type="checkbox"/>	Orgulho
<input type="checkbox"/>	Vergonha	<input type="checkbox"/>	Raiva

Dados biográficos

Idade: _____, F _____ M _____

Formação:

Profissão:

C2: Questionário “AESAM”

1. De que forma a descrição dos cenários coincidiu com a sua expectativa de intervenções ambientais orientadas às emoções?

Pior que o esperado			Igual				Melhor que o esperado
-3	-2	-1	0	1	2	3	

2. Classificação de protótipos

Que tal achou o cenário “Happy park photo”

	-3	-2	-1	0	1	2	3	
Mau								Bom
Comum								Inovador
Aborrecido								Interessante
Inútil								Útil

Que tal achou o cenário “KnowY”

	-3	-2	-1	0	1	2	3	
Mau								Bom
Comum								Inovador
Aborrecido								Interessante
Inútil								Útil

Que tal achou o cenário “Wall illuminated Light switcher tool”

	-3	-2	-1	0	1	2	3	
Mau								Bom
Comum								Inovador
Aborrecido								Interessante
Inútil								Útil

Que tal achou o cenário “Minute-by-minute”

	-3	-2	-1	0	1	2	3	
Mau								Bom
Comum								Inovador
Aborrecido								Interessante
Inútil								Útil

3. Por favor classifique as seguintes afirmações de acordo com o grau de concordância

	-3 Discordo totalmente	-2	-1	0 Neutro	1	2	3 Concordo Completa- mente
<i>Para mim o feedback visual tal como descrito é</i>							
<i>... Útil</i>							
<i>... Prático</i>							
<i>... Entusiasmante</i>							
<i>... Encorajador</i>							

	-3 Discordo totalmente	-2	-1	0 Neutro	1	2	3 Concordo Completa- mente
<i>O conceito destes sistemas está claro</i>							
<i>Receber tal feedback facilitaria o meu comportamento pró-ambiente</i>							
<i>As intervenções parecem-me não intrusivas</i>							
<i>Sinto que as intervenções são direccionadas emoções</i>							

	-3 Discordo totalmente	-2	-1	0 Neutro	1	2	3 Concordo Completa- mente
<i>Aprendi sobre bons comportamentos ambientais</i>							
<i>Eu apenas usaria estas intervenções no caso de serem gratuitas</i>							
<i>Eu aconselharia as intervenções a familiares e amigos</i>							
<i>Estes sistemas</i>							

<i>aumentariam a minha motivação para ter comportamentos ambientais adequados</i>							
---	--	--	--	--	--	--	--

4. Imagine intervenções de feedback semelhantes no futuro

Para si, como classifica a potencialidade emocional destas intervenções na facilitação de comportamentos pró-ambiente?

-3 Muito baixa	-2	-1	0 Neutra	1	2	3 Muito elevada

Qual o cenário que preferiu? Porquê?

Muito obrigada pela sua ajuda!

Appendix D: Scientific-fiction story prototype

“Sky over sea”



My name is Tatiana and I am a Russian agent for the environment. I work in the renewable energy area. I look for new ways of using the coastal zones energy. I particularly enjoy the idea of using waves and wind energy. Our research (I belong to a laboratory with state financing) has been fruitful; we make simulations in models and then prototypes in local coastal zones. However, it isn't yet operational.

What I like less in this research line is related with the aesthetical effect that these technologies cause in the landscape, reducing its amplitude and freedom sense. In fact, I think that this way of producing energy produces considerable visual damages in the landscape and that gives me a sense of sadness. Or in other words, the full happiness sense that I get from the sea decreases.

Science and technology have these impacts.

Appendix E: Reported work

The overall research is in part reported in the following work³⁴.

1. Multimedia mobile services with applications in environment (Hipolito 2007)
2. Interactive public ambient displays for environmental persuasion (Romão *et al.* 2007)
3. Designing environmental behavior sensorial feedback tools (Hipolito 2008)
4. Surrounded by high-tech environmental persuasion - Possibilities for new expressive surfaces (Hipolito and Camara 2008)
5. Assessing the receptivity of new technological tools for shaping pro-environmental behaviors: a survey study (Hipolito, Romao and Camara 2010, submitted to JTFSC)
6. Messaging for Hearts and Minds: How sensorial appeals in environmental communication work (Hipolito 2010a, working paper)
7. The sensorial effect: Dynamics of emotion in pro-environmental behavior (Hipolito 2010b, submitted to Applied Environmental Education & Communication Journal)

The most recent work was still not submitted, thus pointing to future research.

8. Sensorial feedforward interventions for anticipating undesirable environmental behaviors (Hipolito and Azevedo 2010, working paper).

Below, each work is shortly introduced.

In *Multimedia mobile services with application in environment* (Hipolito 2007) a platform of common mobile devices is described and was successfully used to test mobile public access to environmental information. This enabled the exploration of real environmental information services in mobile contexts. Furthermore, an advanced interactive prototype was developed indoors to simulate a Location-Based Service (LBS) applied to coastal zones. (Hipolito 2007) research is grounded on the Master thesis “HiGRID: an hybrid platform for mobile access to environmental information” (Hipolito 2003).

³⁴ All these publications are prior to the present dissertation that starts to consider the expression “facilitation of pro-environmental behavior”. Publications 1-4 refer changing behaviors, publications 5-7 refer shaping behaviors, thus pointing to the expressed evolution noted in the dissertation.

Following the field trips and first prototype, which implemented the basic analyses, more advanced intentions delineated new perspectives of what could be done within mobile access to environmental information. With additional inspiration from the research areas of ubiquitous computing and persuasive technology and mobile persuasion (Fogg and Eckles 2007) we came close to the technological scenarios of the informal Strategic Experiences for Environmental Knowledge (SEEK) project, that has evolved to the Developing Environmental Awareness with Persuasive Systems (DEAP) project that have framed (Romão *et al.* 2007) that follows. These projects ideas are explored together with the *Departamento de Informática of FCT/UNL*.

Interactive public ambient displays for environmental persuasion (Romão *et al.* 2007) is about exploring the potential of interactive public ambient displays, that sense and react according to user's activities and context, in fostering positive changes regarding environmental attitudes and behaviors. We introduce KnowY system, a just-in-time environmental "know-why" messaging system to inspire people to engage themselves in environmental friendly activities. Such system presents environmental persuasive messages in the form of know-why questions, before jumping to the know-how answers. The focus is on KnowY interaction dialog and in what ways users may become conscientious regarding environmental issues and guides them into convenient procedures towards the environment. *Interactive public ambient displays for environmental persuasion* (Romão *et al.* 2007) has a background in the SEEK project.

Unlike (Hipolito 2007) which is almost exclusively based on experiencing mobile devices, (Romão *et al.* 2007) is about exploring the potential of interactive public ambient displays, that sense and react according to user's activities and context, in fostering positive changes regarding environmental attitudes and behaviors.

In many ways (Hipolito 2007) and (Romão *et al.* 2007) represent the first accomplishments into areas of shaping pro-environmental behaviors with technology, and they use traditional technology in terms of research development.

Environmental sensorial feedback tools (Hipolito 2008) is about the design of new tools to motivate positive behavior changes and support increased awareness in the area of everyday life resources consumption. Environmental behavior sensorial feedback tools are designed as environmentally conscious tools and are based on a desire to embody in the look of products the high importance given to environmental matters such as reducing resources consumption. Its design focus on multi-purpose adaptability once interactive sensorial feedback (e.g. visual, sonic) is added as a response of resources consumption with minimal use of materials to increase simplicity. The designed sensorial argumentation becomes products' added intelligence and intends to

promote sustainable consumption augmenting consumers' awareness, involvement and participation.

The fourth paper, *Surrounded by high-tech environmental persuasion – Possibilities for new expressive surfaces* (Hipolito and Camara 2008) is about the central role of design as the link between products and consumers with rising public environmental concern towards the development of new environmentally conscious tools for motivating behavior changes. Designing persuasive tools and interfaces that positively motivate consumers' environmental behavior change is the goal of our research. Here, we revisit the case study of designing an environmentally friendly wall illuminated light switcher tool (Hipolito 2008) for providing sensorial feedback on energy consumption in order to help us reduce energy consumption.

In Hipolito (2008) and Hipolito and Camara (2008), we set out to explore sub-fields of pervasive and invisible computing, i.e. new kinds of information displays that provide feedback over common objects in order to shape pro-environmental behaviors towards sustainability. Particularly, we explored the field study of sustainable consumption by product design and some of the projects results that have anticipated our research or have emerged during our own developments.

The fifth paper, *Assessing the receptivity of new technological tools for shaping pro-environmental behaviors: a survey study*, (Hipolito, Romao and Camara 2010, submitted to JTFSC) is about the survey study aimed at assessing the receptivity of new technological tools for pro-environmental behaviors. Results provided data for analyzing our model. Models of pro-environmental behaviors and survey studies were studied. However, we have designed our own questionnaire within the DEAP goals.

The sixth paper, *Messaging for Hearts and Minds: How sensorial appeals in environmental communication work* (Hipolito 2010a, working paper) is about sensorial appeals in environmental communication. It advances the proposed model, describing it.

The seventh paper, *The sensorial effect: Dynamics of emotion in pro-environmental behavior* (Hipolito 2010b, submitted to AECC) is about the dynamics of emotion in pro-environmental behavior. It includes ideas on how emotion should be considered when designing innovative interventions for pro-environmental behavior; and it makes a new use of IAPS pictures related with environmental scenes and landscapes.

Hipolito (2010a) and Hipolito (2010b) represent, then, the sources for considering emotion-focused design for environment (EFD-E). The facilitation of pro-environmental behavior is related with environmental tasks enhancement at the personal level and with the facilitation of communication in the social level.

Finally, the most recent paper *Sensorial feedforward interventions for anticipating undesirable environmental behaviors* (working paper, Hipolito and Azevedo 2010) proposes that the emotion-oriented interventions for the environment may be a new research area within Computational Sustainability that links Artificial Intelligence (AI) techniques and Environment. “E-motion” is introduced as a platform of sensorial feedforward interventions that, on the move, aim at anticipating undesirable environmental behaviors, enabling the adaptation to changing conditions. These interventions are designed with the main purpose of promoting individuals’ learning on anticipating which behaviors will benefit the environment most, by developing individuals’ understanding of environmental systems relationships among subtle emotional cues. This work remain in this dissertation has part of future work.

Appendix F: Research links: places and teams

It is relevant to express that the interventions conceptualization that constitute the examples of this research resulted within a multi-disciplinary environment. The other researchers' proximity and their specific competencies became greatly useful and valuable.

At the national level, links were made mostly within FCT/UNL faculty members and students and YDreams, which headquarters are located in the FCT/UNL campus.

The first ideas of invisible computing (and reality computing) of YDreams, namely through their YInvisible projects research (2006-2008), provided valuable inspiration mainly in the course of their industry links and has contributed to this work due to the proximity of sources of information with appealing faculty lab teams³⁵. Particularly, the conception and study phases of those projects were being developed at the time this feedback research was.

Part of the research process was the 2007 "Crafts and Drafts" summer atelier, which provided an opportunity to explore electronics and other similar issues in a do-it-yourself (DIY) approach. The method used included web browsing of other worldwide ateliers and blogs, searching design magazines, exploring raw materials and objects surfaces, trying-out existing tools and experimenting easy to do electronics, with technical support of YDreams collaborators.

It was following this creative and experimental commitment that the semiconductor light-emitting diode, or LED, came up as an interesting direction for rapid prototyping. With a 100-year history (Zheludev 2007) LED are a key component of today's technology. As a tiny glowing indicator, its visual properties could well be useful to our research. Those atelier experiments motivated the connection to the Departamento de Electrónica FCT/UNL that helped to develop the concept of a more integrated electronic prototype named ECOS (Environmental Consumer Observation System) in 2008. This particular prototype was not developed. However, the ECOS acronym was used for a new intervention related to expressive surfaces.

The SEEK project and the consequent launch of the DEAP project in 2009 coordinated by Teresa Romão CITI-DI-FCT/UNL enabled to develop the survey study and much progress has been done within the master students' successful research (Lobo 2009, Lobo *et al.* 2009a, 2009b, Centieiro 2011).

³⁵ Involved academia included Applied Chemistry (FCT/UNL) and Materials Eng. (FCT/UNL).

In the international level, interest was found in the Stanford Persuasive Technology Lab (USA) oriented by Prof. BJ Fogg and in the work of Prof. Ezio Manzini (Milano) on sustainability and design. Fortunately, our work could be presented in the international conferences organized by these Professors during the research process, namely the Second Persuasive Technology Conference (2007) held at Stanford University (enabling visiting Google headquarters in Mountain View with guidance of Irene Au, Head of User Experience) and the Changing the Change Conference (2008) held in Torino.

In 2010 the work by Center for the Study of Emotion and Attention, Florida University (USA) on International Affective Picture System (IAPS; Lang *et al.* 2008) was distinguished, and a link was made (jointly with CENTRIA/DI-FCT/UNL) in order to enabling the use of IAPS in this dissertation experimental research.

Together all these research links have strongly contributed to the reported work and to the dissertation that describes the thesis work.