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INTEGRATING PERSUASIVE TECHNOLOGY IN PROTOTYPES OF INTERIOR WALLS TO STIMULATE BEHAVIOURAL CHANGE

M. Mohammadi[1,2], C. Hammink [2]*, M. Dominicus[1], K. Hermans[1,2]

[1]Faculty of the Built Environment, Eindhoven University of Technology, De Wielen 1, 5612 AZ Eindhoven, The Netherlands.
[2]Research Group Architecture in Health, HAN University of Applied Sciences, Ruitenberglaan 26, 6826 CC Arnhem, The Netherlands
*Corresponding author; e-mail: coosje.hammink@han.nl

Abstract

Sustainability has gained influence and importance in the building industry since the 1960s. Originally, sustainable materials and energy reduction have been in the spotlight, but recently other aspects have become more influential as well, such as trying to influence people's behaviour. This paper explores the possibility of influencing behaviour through the use of the Built Environment. Due to the fact that people spend 87% of their time indoors, the adaptation of buildings presents an opportunity to contribute to decreasing energy and resource consumption through behaviour change. One way of accomplishing this is persuasive technology, since its definition contains any interactive system designed to change people's attitudes or behaviours. However, at present, most of the applications of this technology can be found in the fields of industrial design and computer sciences. Hardly any literature specifically deals with the incorporation of technology aimed to persuade humans through the use of buildings or building elements. Nonetheless, the technology identified in literature can be applied to the built environment. To integrate this persuading technology in the built environment, we have chosen to develop a prototype of an interior wall meant to stimulate behaviour change. In this research paper we will explain this prototype in further detail. In the discussion, this article will evaluate feedback and suggest areas for future investigation. Furthermore, implications of these prototypes of interior walls to stimulate behaviour change in the design process will be elaborated upon. Lastly, due to the limited knowledge on this subject, this article serves as a foundation for future development of other persuasive (prefab) building elements.

Keywords: persuasive technology; prototypes; product development; built environment; behaviour change

1 INTRODUCTION

Ever since the influential Brundtland [1] report, the attention for sustainability has risen tremendously. At first, research focused mainly on ecological and economic sustainability. However, lately the behavioural aspect of sustainability has received more attention as well [2]. To balance the ecological, economic and social side of sustainability, a new paradigm within sustainability has arisen, in which smart technology is used to stimulate people to display pro-environmental behaviour. This persuasive technology differs from 'regular' technology in that it not only supports people's daily activities, but also seeks to influence human behaviour and/or attitudes [3][4].

The majority of applications is found in the fields of Health and Medicine, Engineering, Industrial Design and Computer science [5]. Surprisingly, principles and concepts used in persuasive technology have not yet found their way into the construction and design of buildings, even though we spend most of our time indoors (87%) [6]. Within literature and research on the built environment and sustainability, the focus is still primarily on the technical improvements for sustainability [7]. In order to promote sustainability in the living environment, not only technical solutions should be sought after, but behaviour change should also be pursued and building occupants should be included. To achieve this a balance between personal characteristics and environmental characteristics should be found [8]. Current research states that behaviour is the outcome of the person-environment relationship [8] [9]. Technology can be used to bridge the gap between the occupants and their environment and can be used to facilitate (behavioural) changes in social, ecological and economical areas. This paper serves to give an insight into the overlap between people, the environment and technology (see Fig. 1).

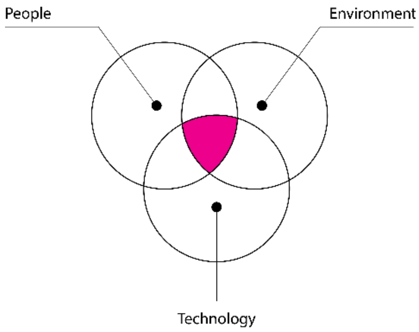

Fig. 1: PET Model.

First, this paper will discuss the (built) environment, (behaviour change in) people and (smart) technology. Secondly, literature and references projects on where these fields (partially) overlap are discussed. In the third step, one experimental prototype that fit into the overlapping area is presented. Lastly, implications for the design process in the built environment are discussed.

1.1 (Built) Environment

Einstein once remarked, "the environment is everything that is not me" [9]. The environment is a complex, multi-dimensional and multi layered system [10] [11]. Social ecological models are used to unravel the multidimensional structure of human environments and will be used as a framework within this research [12]. Human behaviour within a specific environment has been studied from a social, psychological and cultural context [12]. The outcome of the relations between these three different environments can be seen as behaviour (see image 2). The WHO defines environment as all the physical, chemical and biological factors external to a person, and all the related behaviours [11]. In this paper we will examine the use of the environment as an instrument for behaviour change. Moffatt & Kohler [12] divide the environment into a natural environment and a cultural environment (Fig 2). The overlapping area between these two environments can be described as the man-made environment or, as we use it in this paper, the built environment. The built environment consists of 5 layers, of which the layer 'building-level' can be subdivided into six layers [13].

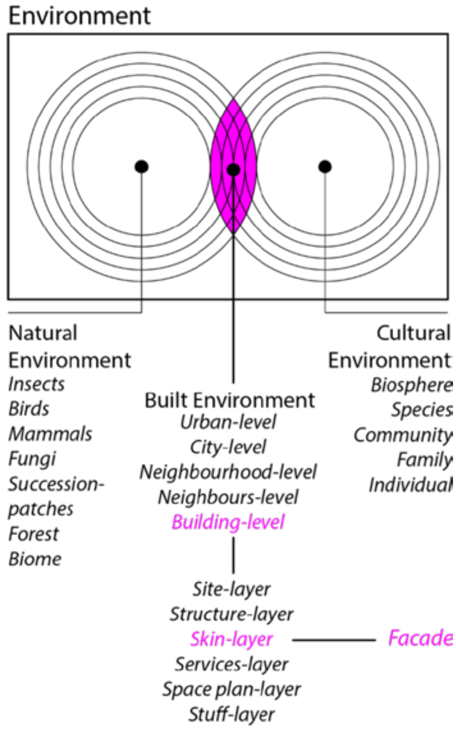

Fig. 2: Research Focus [13] [14].

1.2 Behaviour change (People)

Behavioural change is a field of research that has received ample attention in a number of fields, whether it is in criminology, psychology or, more recently, design research, people seek to influence their own, or other people's behaviour. People may seek to change their own behaviour, such as eating healthier or saving money, but there is also a need for behavioural change from a societal point of view. Many of the challenges today's society faces, can be mitigated by behaviour change [15] [16] [17] [18].

1.3 Ambient Technology

Incorporation of a certain degree of intelligence in the built environment has been introduced in the previous century. Domestic technology was the first trend in which digital tools were applied in order to achieve comfort and security for the user [19]. This technology has seen an expansion into the domain of ambient technology, in which the degree of comfort and security can be (automatically) adjusted to the current demands and wishes of the user. For example, ambient technology is capable of analysing the residence, and based on this information can adjust the climate accordingly. Ambient or smart technology is different from persuasive technology in that the goal of the latter is to change behaviour, whereas in ambient technology, this is not necessarily the

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case. However, ambient technology does offer an insight in how technology can be implemented in the built environment.

2 USING (BUILDING) DESIGN TO CHANGE BEHAVIOUR

Little to no research is available on integration of products that can modify behaviour into buildings. However, literature on persuasive and ambient technology can be used to gain insights into the technological possibilities and underlying frameworks to stimulate pro-environmental behaviour change using the built environment, or more specifically building interior walls. In paragraph 2.1 and 2.2 we examine the literature on respectively persuasive ambient technology and operant conditioning in order to derive conditions for our own persuasive building (element) design. In 2.3 we will examine the application of these conditions in interior walls.

2.1 Ambient Technology

Ambient technology creates an electronic environment that is sensitive and can react to the presence of people [20]. This aspect of ambient technology can be employed to stimulate behavioural change. Ambient technology is embedded in the environment and would ideally be adaptive to a person's specific wants and needs [21]. These environments provide the possibility to stimulate occupant to display more sustainable behaviour. The literature on ambient technology uses an amalgamation of different behavioural theories and knowledge on source credibility, multiple sources, attitude and behaviour formation, information processing, mental shortcuts and sustaining behaviour [21]. For each of these clusters, persuasion principles have been identified, which can be used in designing ambient technology for behavioural change [20].

2.2 Operant Conditioning

One of the persuasion principles used in literature on ambient technology is the use of feedback (to sustain behaviour) [20]. For the development of this building product, we have used a classical form of feedback: operant conditioning. When using operant conditioning, feedback can be given in four ways: (i) positive reinforcement (ii) negative reinforcement (iii) presentation punishment and (iv) removal punishment [22]. For this product we chose to explore the possibilities for negative feedback, or '(presentation) punishment'. Research shows that there are many examples of the effectiveness of enforcing rather than encouraging behaviour. However, most persuasive technology at this time is based on the latter, whereas with this product we explore the possibilities for 'punishment' as feedback. In this case we use presentation punishment as we are approaching energy (over-)consumption as a behaviour we want to decrease or suppress. Research found that when trying to diminish certain behaviour, people are more likely to do so if they believe they are going to be punished rather than being offered rewards [23].

After selecting the type of feedback, the reinforcement schedule can be examined. This product uses a continuous scheme; allowing for rapid learning, but not as effective in creating long-term habits [22]. In order for the appropriate response to take place, 'cueing' is used, in terms of using lighting and colours to indicate the type of response needed (e.g. reduce energy use) [22].

2.3 Application of Ambient Technology in Interior walls

Several elements of the behaviour changing process are discussed in literature on ambient technology [21] and different types of feedback and feedback schemes have been derived from literature on operant conditioning [22]. The next chapter will go into the details of the product design and will explain how the conditions identified in literature on operant conditioning and ambient technology can be used in the design process for persuasive building interior walls.

3 TRANSLATING THEORY INTO PRODUCTS

Innovation can be described as the creation of a new or improved product, service, or process [24]. The OECD defines innovation from a broader perspective; "Innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production and marketing tasks, striving for the commercial success of the invention". This iterative process is capable of influencing human behaviour [25] [26]. Therefore, we can describe (building) product development as a driver for behaviour change. In line with the OECD, we can define product development ('New Product Development') as a process of developing a design for a new product, including all the relevant plans for production, distribution, and sales [27]. The foundation of successful product development is using participatory and empirical research. In this model the user is a part of the total design process, by engaging these users in the design process, the behaviour change indicators can be determined [27]. In literature we can distinguish several product development models [28]. Most of the models subdivide the design process into multiple phases, which lead to a more controlled end product and controlled behaviour change [28] [29]. It concerns developing a normative model consisting of 7 stages, in which every stage includes a number of activities; (i) idea, (ii) preliminary assessment, (iii) concept, (iv) development, (v) testing, (vi) trial and (vii)

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launching. These seven stages of Cooper are corresponding with the six stages of Ulrich and Eppinger [30], and Roozenburg [27]. These authors distinguish the following stages; (i) concept development, ii) system level design, (iii) detail design, (iv) testing and refinement and (v) production (ramp up). In this research we combined the models of Cooper, Ulrich and Roozenburg, to get a new model, in which the cycles of empirical scientific inquiry are used to influence the level of persuasion (see Fig.3).

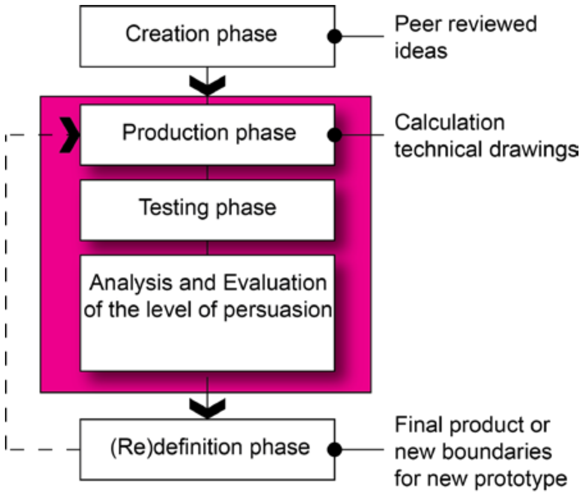

Fig. 3: Product Development Model.

4 PRODUCT DEVELOPMENT OF PERSUASIVE WALL SYSTEM

In this paragraph we will go into our design in which we will experiment with the level of persuasion by developing a persuasive building wall system. Several ideas are generated by a team of experts in the field of architecture and design and are peer reviewed by another team of experts. The developed product, the 'white box', is a combination of three interactive interior walls. The white box aims to persuade occupants to exhibit more green behaviour. It aims to make occupants aware of energy use, by using operant conditioning (feedback). If the energy use in the white box is too high, the white box interacts with the occupant by using presentation punishment [22]. This interaction is manifested by changing the amount of cubic meters of the space in the white box, by decreasing the height of the ceiling and by using round objects, which are pulled and pushed through the walls with a certain frequency. This is made possible by using flexible double membranes made of high elastic fabric and by allowing space between two membranes with a wooden scissor structure (figure 4 and 5).

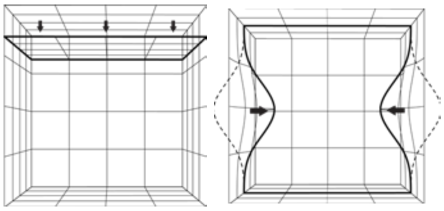

Fig. 4: Actions of the White Box.

The expansion of the scissor structure is possible through a solid wooden construction. This wooden construction is a framework, which is necessary for the internal and external stability (see fig 5, 6).

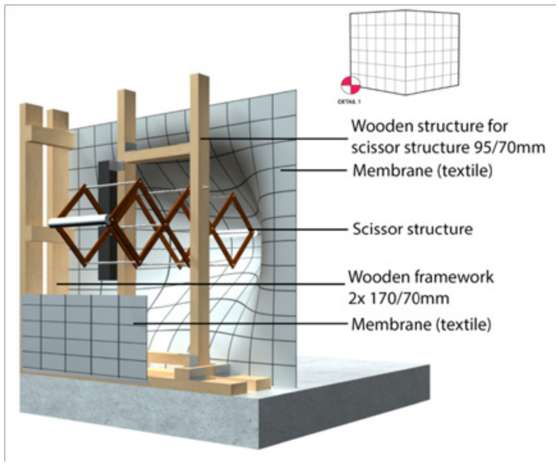

Fig 5: Technical detail White box.

The objects, which are pulsating and pushing on the membrane, react to the level of energy use. If the energy use is too high, the round objects will begin to pulsate. The pulsating objects are built based on scissor structures, which are able to expand and to fold back. A round polystyrene shape is fixed at the end of the scissor structure, which is causing a smooth, curved membrane when the scissor structure is expanded.

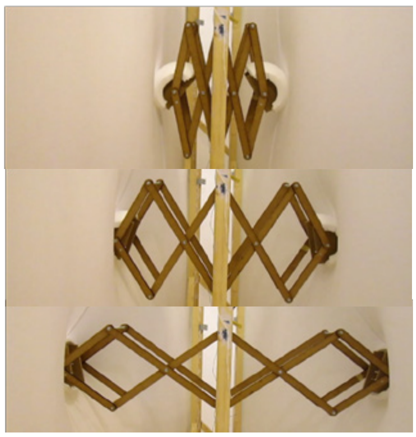

Fig. 6: Expansion of the scissor structure.

The movement of the scissor structure is possible through the use of an Arduino controlled motor, which allows the white box to increase or decrease the speed of expansion (fig. 6 and 7).

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Fig. 7: Pulsating objects in the walls of the white box.

To examine the potential of this product, a variant of the white box has been implemented in an existing building. This variant, the so-called ‘breathing wall’, has been placed into a room of a hotel (Motel Spatie, Arnhem). A fully covered space with a flexible membrane such as PVC or Lycra, is not suitable everywhere. Therefore, the walls of the white box were further developed into single wall elements. The single wall element has the same characteristics as the wall of the white box, except it has more feedback options such as led lights. These led lights can be red or green depending on the energy use; furthermore, the wall will pulsate using the scissor structure (see fig. 8). The user has to take action in order to return the wall to a ‘silent mode’. The hope is that these actions will stimulate the user to be more aware of the use of energy.

The feedback system of the breathing wall and the white box can be interpreted as a form of presentation punishment, where the occurrence of the feedback is supposed to diminish or suppress the behaviour [22].

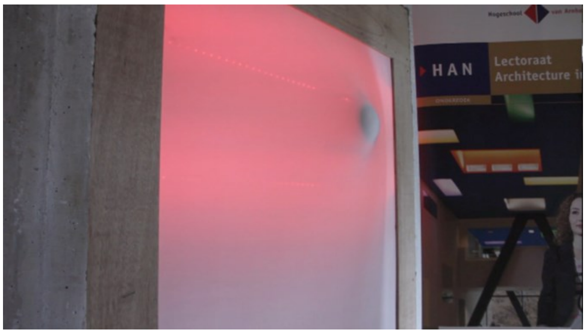

Fig. 8: Breathing wall.

The breathing wall operates using continuous feedback, which means that every response is reinforced. In order to achieve the iterations and input of users, the white box was displayed at the Dutch Design Week 2014. Visitors could use the white box and gave information on how to improve this prototype. The reaction of these visitors was divers, some felt uncomfortable, others felt surprised or found it interesting. Visitors that gave positive responses to the persuasive wall indicated that they felt it was the right interface for this type of information and was unambiguous in its message. Visitors that felt less comfortable with the product doubted the effectiveness of the product for changing long-term behaviour (habit forming). Both groups raised the matter of ethics in the further development of the product.

5 CONCLUSION & DISCUSSION

At the moment hardly any literature on the use of persuasive technology in buildings or building elements exists. The current literature on behaviour change products is focused primarily on stand-alone products, which are not part of a larger, embedded system (like a building). This research attempts to start with the creation of a framework for integrating persuasive technology in the built environment. This has led to the development of two products: the white box and the breathing wall. In the development of these building interior walls technological and social challenges were encountered. The first challenge lies in the use of persuasive technology in prefab building elements. New building methods should create an integrative system, as all building elements are intertwined. Furthermore, the technical elements, such as the wiring, the controlling system and more, have to be implemented in an earlier building phase than is presently done. Current methods for using technology in the home environment, are built in afterwards and do not allow for this full integration to take place.

Besides the changes in the production, at this point in time, we don’t know if the pulsating elements are indeed triggering the users to change their behaviour. Moreover, the implementation of the white box and the breathing wall can be seen as affecting the autonomy of the occupant. The research on the level persuasion can give indicators as to the effectiveness, but will also be employed in order to identify the user boundaries. Lastly, we realize that the white box and the breathing wall will in this state not be suitable for direct introduction into the market, but combining the reactions of users and the gathered data from the hotel will allow for an evaluation of the level of persuasiveness of the principles employed in these products. This will enable us to conclude if integration of these persuasive products in the built environment is a development that can contribute to behaviour change.

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