Behavior Grid for Improving Safety in Industrial Environments

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Introduction

The Saxion University of Applied Sciences recently started the project "Safety at Work". The objective of the project is to increase safety at the workplace by applying and combining state of the art artifacts Ambient Intelligence, Industrial & Product Design and Smart Functional Materials [1].

There is a human factor involved as well. Preliminary, safety is related to incidents happening to persons who get injured or even die. In 97% of the cases where an injury occurs [2] that what happens is within someone's control. Many incidents at work are often the result of human behavior, how people interact with each other and how people cope with risks and guidelines. Industrial environments need to be organized in such a way that people behave safely in an automatic way and that safety becomes a habit. Forcing safe behavior starts with safe products. However, in many cases this is not sufficient, and incidents still occur. Therefore communication is often a more effective medium. One cost effective, asynchronous, and persisting way of communicating to people is through ICT. The effort of changing behavior through ICT is called Persuasive Technology. In this paper we focus on ambient aspects of safety: influencing people in an invisible way to make industrial environments safer. Based on literature we work towards a model to systematically select measures to influence behavior to enhance safety. The model is a rudimentary framework still to be filled out, which is the subject of our current research projects.

Physical Factors

A safe industrial environment starts with the use of safe products. Product designers know that the safety of a product depends on physical properties, operation and function of the product, and on how the product is used and perceived by users. For example, if doors to an unsafe area are blocked, no accidents will happen there.

Physical properties of a product make a product more or less safe. Safety by Design is a concept that encourages construction or product designers to 'design out' health and safety risks during design development. Although limited research is available on safe behavior in combination with physical factors, we may learn from the area of public safety. Designing Out Crime is defined as a multi-disciplinary approach to deterring criminal behavior through environmental design [3]. It relies

upon the ability to influence offender decisions that precede criminal acts by affecting the built, social and administrative environment.

In our studies we do not focus specifically on improving physical factors. We expect that researchers from industrial design engineering field are working on improving these factors for the coming years. However, when physical factors linger to be a problem, other factors have to be taken into account.

Sensory Input

Secondly, research shows that people are often triggered to act based on environmental conditions [4, 5] while operating the product (e.g., noisy or crowded). The environment is closely related to sensory input. Humans perceive the world around them with their eyes, ears, nose, mouth, and skin. Input from senses is important for the emotional state, and daily decisions.
Neuroscience has shown that we have very little insight into our motivations and, consequently, are poor at predicting our own behavior. It seems emotions are an important predictor of our behavior. Input from our senses is important for our emotional state, and therefore influence our behavior in an ambient (invisible) way. A study by Eysink Smeets, Hof and van Hooft lists several examples of how sensory effects can be used to improve public safety [6].

Psychology

For influencing behavior we also looked at how other sectors try to achieve this. The most promising, and sector with most studies is marketing psychology. Studies [7] show that if we have to think about every decision, live becomes impossible because of the time and energy it takes to consciously consider every decision. Subconsciously, we have created shortcuts to help us to 'automatically' deal with these choices. In the book "Influence, the psychology of persuasion", Robert Cialdini discusses six principles to influence behavior for marketing purposes [8]. Cialdini states that if we have to think about every decision, live becomes impossible because it takes too much time and energy to consciously consider every decision we make. We would quickly become paralyzed. Therefore, we have created shortcuts to help us to 'automatically' deal with choices. Cialdini translated these shortcuts to six influencing principles:

1. Reciprocity - People tend to return a favor, like the pervasiveness of free samples in marketing.

2. Commitment and Consistency - If people commit to an idea or goal, orally or in writing, they are more likely to honor that commitment because of establishing thatidea or goal as being congruent with their self-image.

3. Social Proof - People will do things that they see other people doing.

4. Authority - People will tend to obey authority figures, even if they are asked to perform objectionable acts.

5. Liking - People are easily persuaded by other people that they like.

6. Scarcity - Perceived scarcity will generate demand.

In literature, we have found few examples of applying these marketing principles in industrial environments. Therefore we organized a brainstorm with students (n=15) and industry representatives (N=4). They came up with several different strategies to persuade construction workers to wear their safety helmets and safety goggles. From previous studies we know that these are often not worn because of comfort issues [9, 10] or lack of sense of necessity. Most important findings from this brainstorm encompassed: aiming for a collective goal, making both employer and employee responsible, making safety helmets en goggles more confortable, desirable and multifunctional.

However, for researchers, the principles of Cialdini are general and examples are easy to imagine. 1) Make the tough guy in the factory to behave in a safe manner and the others will conform to his behavior (social proof). 2) A worker may complete a safety checklist before he starts with his work of the day. On the checklist he commits to keeping certain safety related issues in mind. While doing his job that day, he is likely to be consistent with his commitment and keeps safety issues in mind (commitment and consistency).

People use their shortcuts every day to deal with choices. It is very interesting to gain more insight on how we can use these shortcuts to let people behave more safe.

Persuasive Technology

Except for the "ambient", invisible influencing of people, ICT can be used to explicitly coach industrial workers [11]. Persuasive Technology is defined as any interactive computing system designed to change people's attitudes or behaviors. Fogg [12] distinguishes three kinds of persuasive technology (Figure 1). The first kind is Persuasive Technology as a persuasive tool. For example a heart rate monitor: an exercise device that gives an auditory alarm when the user's heart rate falls outside a pre-set zone. The second kind is Persuasive Technology as a persuasive medium, like a mirror to shows how you will look like if you continue in your (unhealthy) habits. The third kind is Persuasive Technology as a social actor, like using chatter robots or chat-bots.

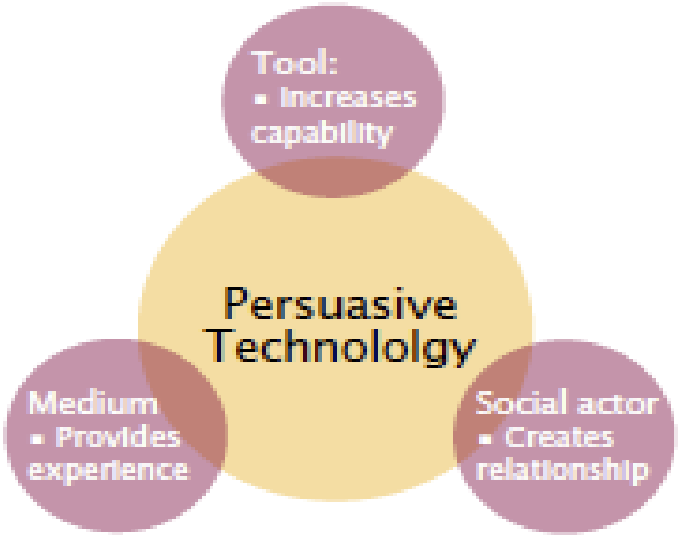

Figure 1: The functional triad

Results

From the previous section we may conclude that so-far four mechanisms have been used to influence behavior. While aiming to categorize these mechanisms, we can divide the mechanisms based on their proximity to receiver, or based on the kind of trigger they target.

Two of them focus on the environment (product design, sensory input), two of the focus on the persons themselves (psychological technics, persuasive ICT). Also, two of them aim at using emotions to influence behavior (Cialdini's measures based on marketing psychology, sensory input based on neuropsychology); two of them aiming at the more physical aspects of human-machine interaction (persuasive technology, design). This makes it possible to place the four measures in a matrix, as shown in table 1.

		Proximity	
		Personal	**Environment**
Trigger	**Reason**	Persuasive Technology	Product design
	Emotions	Psychological factors	Senses

Table 2: Axes of Persuasive Technology for Safe Behavior

Now that our understanding of behavior change is formed into a working model, the next step is to see how, and in which direction to change these behaviors. Studies conducted by the Captology group at Stanford [12] show that when you want to change behavior, it is necessary to specify the duration of the behavior change (one time, span of time, or on-going), and the type of change (flavor) you want to accomplish. The flavor explains whether new behavior is introduced, or if familiar behavior is maintained, increase, decrease, or stopped. This model [13–15] can be used to encompass our model, as for every behavior change to enhance safe behavior the two axes of our model can be placed in the duration/flavor combination.

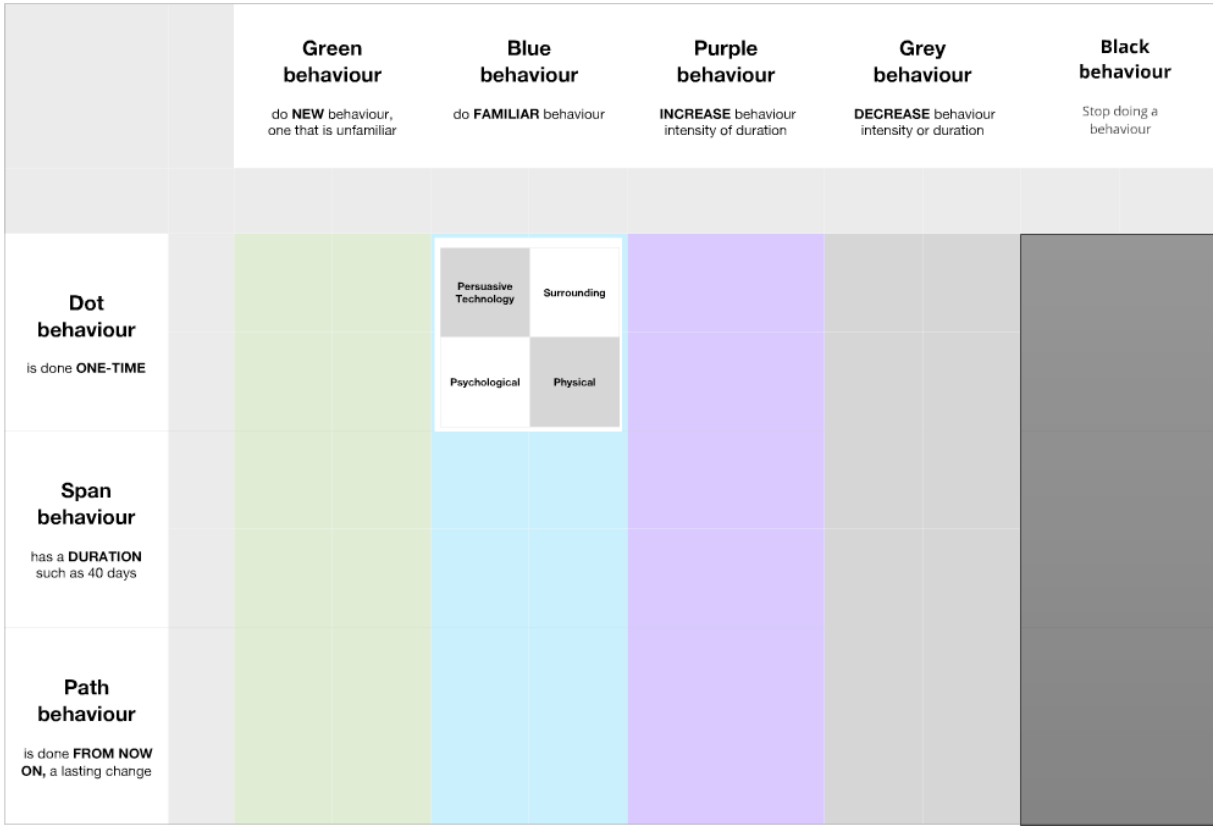

Figure 2: The concept of a safety behavior grid

For influencing safe behavior in industrial environments, we propose a further deepening of Fogg's Behavior Grid (see Fig. 2). The advances in Persuasive Technology are continuous. Product designers look for methods and best practices to get safety by design. Our behavior is influenced by what we sense with our eyes, ears, nose, etc. Also, principles from marketing may be used to influence our behavior. This all may happen in an ambient, invisible way, using Persuasive Technology as a vehicle [8].

For every type of behavior change there is not only a way to accomplish change with Persuasive Technology, but there are also psychological factors, physical factors

and our human senses. In order to achieve behavioral change to improve safety, we need to address all these factors. We aim at a framework that, given the kind of behavior (dot, span, path behavior) and give the direction in which we want to change it to enhance industrial safety (start, stop, increase, decrease, make it a habit), advises you to use one of the four basic methods: design, sensory input, psychology or persuasive technology. Our current research focuses on experiments to fill out this framework with respect to industrial safety.

Future work

The foundation of our model is laid in literature from multiple disciplines. However, no experiments have been conducted yet to validate this model. Therefore we want to encourage research into this field that forms a bridge between research, commercial parties, and education.

A deeper understanding of the way we can address human senses in industrial environments is needed. Because of the nature of this industry, the possibilities of reaching and triggering senses will be limited. From this point of view an observation study will be conducted to get an good overview of the (im)possibilities for triggering human senses.

Furthermore, we need to come up with experiments for interventions that can help to validate our model. These experiments will preferably be conducted in real life settings. The idea behind this setting is that our study is part of a public funded project, in which one of the main goals is to strengthen the participation between the academic world and businesses.

The first experiment, planned in October and November of 2012, focuses on influencing walking patterns. When walking into or out of a building, people have a tendency to take a certain exit. We argue that these walking patterns can be changed, and that they will stay active in the sub consciousness for an extended time after the intervention. These remembered patterns can be used to evacuate a building more efficiently.

At the end of 2012, and beginning 2013, psychological experiments will be set up at several large construction sites in the Netherlands. In these experiments we first try to develop a analog intervention at the site. These interventions are based on interviews with construction workers, held in November 2012. After a successful intervention, a Persuasive Technology version of the intervention will be introduces to one of the other construction sites. The goal of these interventions is to raise the amount of near-incident reports by construction workers.
The third experiment we planned (spring 2013), is an industry version of ‘If you really know me’ (also known as the Challenge Day, or in Dutch: ‘Over de Streep’). In this program workers are provoked to express their feelings about safety behavior of their colleagues in a healthy, effective and friendly environment. The goal of this experiment is to study how we can open up people to have an open conversation about safe behavior.

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