Saxion Research Centre for Design & Technology



Influencing behaviour for safe working environments

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Safety at Work (in Dutch Veiligheid op de werkvloer) is an initiative of the Saxion Research Centre for Design & Technology. The project focuses on how to achieve safety in working environments by using ambient technology. These include personal safety, a safe environment and safe behaviour. The project started on 1 January 2011 and will run for four years. The consortium members are Saxion, University of Twente, Novay, Thales Netherlands, Norma MPM, PANalytical, TenCate Protective Fabrics, Alten PTS and Noldus Information Technology. Also, there is a changing group of participating companies that occasionally participate in the program team. The project is funded by the Stichting Kennisontwikkeling HBO (SKO) under registration RAAK PRO-2-013.

Executive summary

Safety at work

The objective of the project Safety at Work is to increase safety at the workplace by applying and combining state of the art artefacts from personal protective equipment and ambient intelligence technology. In this state of the art document we focus on the developments with respect to how (persuasive) technology can help to influence behaviour in a natural, automatic way in order to make industrial environments safer. We focus on personal safety, safe environments and safe behaviour.

Direct ways to influence safety

The most obvious way to influence behaviour is to use direct, physical measures. In particular, this is known from product design. The safe use of a product is related to the characteristics of the product (e.g., sharp edges), the condition of people operating the product (e.g., stressed or tired), the man-machine interface (e.g., intuitive or complex) and the environmental conditions while operating the product (e.g., noisy or crowded). Design guidelines exist to help designers to make safe products. A risk matrix can be made with two axis: product hazards versus personal characteristics. For each combination one might imagine what can go wrong, and what potential solutions are.

Except for 'design for safety' in the sense of no sharp edges or a redundant architecture, there is a development called 'safety by design' as well. Safety by design is a concept that encourages construction or product designers to 'design out' health and safety risks during design development. On this topic, we may learn from the area of public safety. Crime Prevention Through Environmental Design (or Designing Out Crime) is a multi-disciplinary approach to deterring criminal behaviour through environmental design. Designing Out Crime uses measures like taking steps to increase (the perception) that people can be seen, limiting the opportunity for crime by taking steps to clearly differentiate between public space and private space, and promoting social control through improved proprietary concern.

Senses

Neuroscience has shown that we have very little insight into our motivations and, consequently, are poor at predicting our own behaviour. It seems emotions are an important predictor of our behaviour. Input from our senses are important for our emotional state, and therefore influence our behaviour in an 'ambient' (invisible) way.

The first sense we focus on is sight. Sight encompasses the perception of light intensity (illuminance) and colours (spectral distribution). Several researchers have studied the effects of light and colour in working environments. Results show, e.g., that elderly people can be helped with higher light levels, that cool colours like blue and green have a relaxing effect, while long-wavelength colours such as orange and red are stimulating and give more arousal, and that concentration and motivation of pupils at school can be influenced with light and colour settings.

Identically, sound (hearing) has physiological effects (unexpected sounds cause extra cortisol -the fight or flight hormone- and the opposite for soothing sounds), psychological effects (sounds effect our emotions), cognitive effects (sounds effect our concentration) and behavioural effects (the natural behaviour of people is to avoid unpleasant sounds, and embrace pleasurable sounds). Smell affects 75% of daily emotions and plays an important role in memory, itis also important as a warning for danger (gas, burning smell). Research has shown that smell can influence work performance. Haptic feedback is a relative new area of research, and most studies focus on haptic feedback on handheld and automotive devices. Finally, employers have a duty to take every reasonable precaution to protect workers from heat stress disorders.

Influence mechanisms: Cialdini

To influence behaviour, we may learn from marketing psychology. Robert 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. Therefore, we have created shortcuts to help us to 'automatically' deal with choices. He translated this shortcuts to six influencing principles:

- Reciprocity - People tend to return a favour, like the pervasiveness of free samples in marketing.
- Commitment and Consistency - If people commit to an idea or goal, orally or in writing, they are more likely to honour that commitment because of establishing that idea or goal as being congruent with their self-image.
- Social Proof - People will do things that they see other people doing.
- Authority - People will tend to obey authority figures, even if they are asked to perform objectionable acts.
- Liking - People are easily persuaded by other people that they like.
- Scarcity - Perceived scarcity will generate demand.

Persuasive technology

Persuasive technology is defined as any interactive computing system designed to change people's attitudes or behaviours. B.J. Fogg of the Stanford University distinguishes three kinds of persuasive technology. 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 first 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 (some type of conversational agent, a computer program designed to simulate an intelligent 'person' that has a conversation with one or more human users via auditory or textual methods). Fogg introduces the Behaviour Grid to classify several kinds of behaviour, as well as provides methods for designing persuasive technology.

Outlook

How can the insights from this document be used to influence behaviour in order to enhance safety at work? We conclude the following areas of interest:

- An increasing amount of technology is available to support invisible and ubiquitous monitoring of people. We have to further explore what kind of persuasive techniques contribute to which desired behavioural change.
- Changing behaviour patterns means changing the one behaviour pattern by another, which brings us to psychology. We have to find out what kinds of incidents occur during work, and the behaviour that is at the basis of these incidents. We have to find out what is keeping people from behaving the way they should.
- We need a model; maybe an expansion and adaption of the SHEL model, to encompass persuasive technology design aspects. Hereby we will focus on industrial environments. We need to choose, adapt and/or develop a model and method like a Demand Indicator that makes safety factors explicit and practical.

Eventually, we aim to design a model to match behavioural aspects to certain senses. With this model researchers and project partners can determine which human sense or other influence mechanism to target when aiming for a specific behavioural change.

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1. Introduction

The Research Centre for Design & Technology of the Saxion University of Applied Sciences has started the project Veiligheid op de werkvloer ('Safety at Work'). The objective of the project is to increase safety at the workplace by applying and combining state of the art artefacts from information and communication technology, industrial design and high-tech functional materials. In this state of the art document, we discuss how 'ambient intelligence', and in particular persuasive technology, can be used to influence behaviour and in this way enhance safety in industrial work environments. In additional documents we discuss the state of the art on personal protective equipment (Brinks and Luiken, 2011) and situational awareness technology (Van Leeuwen and Griffioen, 2011) for protection at the workplace.

Ambient intelligence (AmI) is a vision on the future that refers to creating environments that are sensitive and responsive to the presence of people (Aarts et al, 2001). In such environments, devices support people in carrying out their everyday life activities in an easy, natural way using (sensor) information and intelligence that is hidden in the network connecting these devices. As the sensing devices grow smaller, more connected and more integrated into the environment, the technology disappears into the surroundings and weaves themselves into the fabrics of everyday life until they are indistinguishable from it (Weiser, 1991). We focus on safe environments that lead to safe behaviour. Can (ambient) technology help to influence behaviour in a natural, automatic way to make (industrial) environments safer?

This document is organised as follows. First, in chapter 2, we shortly address what safety in work environments exactly means. In particular, we focus on personal safety, safe environments, and safe behaviour. We refer to the risk analysis and requirements document for a more detailed description of the safety topics in work environments we focus on (van Houten and Teeuw, 2011). In this chapter, we also introduce the SHEL model to be able to systematically order the (behavioural) factors that can be influenced.

In the next three chapters, we focus on general mechanisms to influence behaviour. In chapter 3 we focus on direct, physical ways to influence behaviour. For example, the design of a product or the way an environment has been structured may either provoke risky behaviour or enforce safe behaviour. In chapter 4 we focus on the more ambient ways to influence behaviour, in particular we focus on

the way our senses can be used. For example, a lemon scent encourages cleaning. Are there also ways to encourage safe behaviour? In chapter 5 we focus on what we can learn from marketing psychology to influence behaviour. We use the principles from Cialdini (2008) for this purpose.

Next, in chapter 6 we focus on persuasive technology, i.e., technology that is designed to change attitudes or behaviours of the users through persuasion and social influence. Persuasive technology is used, e.g., in human-computer interaction. Also, personal, mobile devices are important for persuasion (Fogg, 2007). In chapter 7, finally, we present our outlook and conclusions.

Can ambient or persuasive technology help to influence behaviour in a natural, automatic way to make industrial environments safe? To answer this question, we first have to know which factors in industrial work environments can be influenced anyhow. We therefore explain the SHEL model in this chapter, which is a commonly used model to categorise human safety factors. Next, we further focus on safe behaviour, personal safety, and safe environments. We conclude this chapter with our focus on safety factors.

SHEL model

In order to design and develop an ambient environment for safety at work, it is necessary to have insight in the factors that affect safety at work in a positive or negative way. The SHEL model (see Figure 1) is a commonly applied model for studying human factors (Hawkins, 1987).

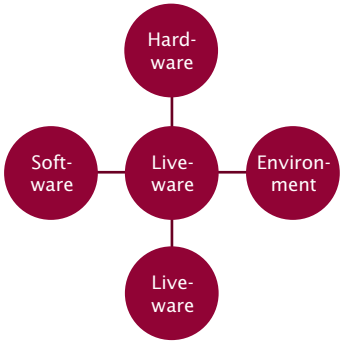


Figure 1: *SHEL model.*

The SHEL model consists of:

- Hardware (H): equipment, machinery, appliances, displays.
- Software (S): procedures, regulations, practices.
- Liveware (L): the human within the system, the central component of the model.
- Environment (E): the situation in which the L-H-S system must function, the social and economic climate as well as the natural environment.

Liveware is the central component of the model, but also the component that is least predictable and that is most susceptible to individual differences such as experience, education, ethnic differences, age and internal changes (fatigue, motivation, hunger).The SHEL model allows us to analyse each of the four interfaces of the Liveware component that affect human performance in a positive or negative way:

- Liveware - Hardware: man-machine-interface, product design, physical characteristics, ergonomics.
- Liveware - Software: checklists, conventions, manuals.
- Liveware - Environment: (physical) radiation, climate, noise, shock &vibration, (social-psychological) mental stress, work pressure, multi-tasking.
- Liveware - Liveware: teamwork, communication, leadership.

Special attention should be given to dynamic changes on each of the four interfaces. These changes are a potential risk because they disrupt the daily routine. Examples are the introduction of other equipment, other colleagues and other procedures, but also maintenance, power surges and machine breakdowns.

The factor liveware: Safe behaviour

Clearly, for safety a human factor is involved. In this context, we may distinguish accidents and incidents from each other. An accident implies something that happens outside somebody's control. An accident often refers to something unexpected, happening by chance, like a car accident that is happening, or like meeting an old friend 'by accident'. Incidents at work are often the result of human behaviour, how people interact with each other and how people cope with risks and guidelines (as defined by, e.g., the Health and Safety Act (Dutch: Arbowet).

In case of a mishap, especially one causing injury or death, often the term accident is used. However notice that in 97% of the cases where an injury occurs, that what happens is within someone's control and therefore an incident (Hawkins, 1987). Research shows that a strong safety culture depends on each employee making safety a habit (Anderson and Lorber, 2006). Safe behaviour therefore often means replacing one habit by another. Through courses, training and risk assessment a better understanding and acceptance level may be created for safety at work.

This document is about changing habits, either by enforcing them in a direct way (chapter 3), or by influencing them in a more invisible way (chapter 4 and 5), or by using technology (chapter 6).

Personal safety

Safety is about accidents and incidents happening to persons who get injured or even die. Persons can be protected against injuries by using functional materials and personal protective equipment (Lareau et al, 2010). These materials may be smart as well. Microsystems and microelectronics may be integrated into clothes to provide sensors, actuators, and the mobile and wearable devices for processing, communication and tracking. One of the main challenges for clothing, e.g., is to find the balance between protection, comfort, and cleaning in relationship with sensors woven into functional materials. Protective equipment is outside the scope of this document, except for the topics directly related to influencing behaviour. A project discussion of protective clothing is presented by Brinks en Luiken (2011).

Safe environments

Not all incidents lead to injuries or death. Often it is a matter of narrow escapes. Environments can be designed to prevent incidents, or to detect them in advance. This brings us to smart environments and the research area of situational awareness. Situational awareness refers to the continuous observation of the environment, of events that happen, of changes that take place, the interpretation and combination of the stream of observations in order to get a clear understanding about the environment, and the predictions that can be made about the future situation (Endsley and Garland, 2000).

Situational awareness is also outside the scope of this document, except for the topics directly related to influencing behaviour. A project discussion of situational awareness is presented by Van Leeuwen and Griffioen (2011). However notice that safe environments are about

ambient intelligence: environments that are aware of the presence of people and react on it, by adapting themselves or by anticipating on what is going to happen. Safe environments are also about behaviour: environments that make people aware of the situation, and therefore make them change their behaviour. These issues will show up in several sections of this document (in particular in chapter 3 and 4).

Figure 2: *Product lifecycle.*

Focus of this document

As explained in the risk analysis and requirements document of the project (Van Houten and Teeuw, 2011), we focus on industrial environments. Safety in these environments can be related to several phases of the product lifecycle, as shown in Figure 2. With respect to the application of persuasive technology to enhance safety, we are particularly interested in influencing behaviour in an ambient, 'invisible' way. We mainly focus on two phases of the product lifecycle (as indicated in Figure 2). First we focus on safety during the production and construction process. During this phase, the culture and the organisation of a company are important. Second, we focus on the safe usage of the resulting products by the end-user (which may be in an industrial environment again). Besides culture and organisation, during this phase the individual behaviour is important.

3. Direct ways to influence safety

The most obvious way to influence behaviour is to use direct, physical measures. For example, if you prohibit access and block the doors to an 'unsafe' area, clearly no accidents to visitors will happen there. If you have to close a machine before you can start it, it becomes e.g. physically impossible to get your hands into the running machine. On the other hand, work may become impossible due to too restrictive measures. There has to be a balance between 'technical measures' and 'practical workability'. In this chapter we focus on measures to directly influence behaviour. We focus on product design (hardware aspects), on communication and incentives towards employees (software aspects), and on organizational measures (liveware aspects).

Product design (liveware – hardware interface)

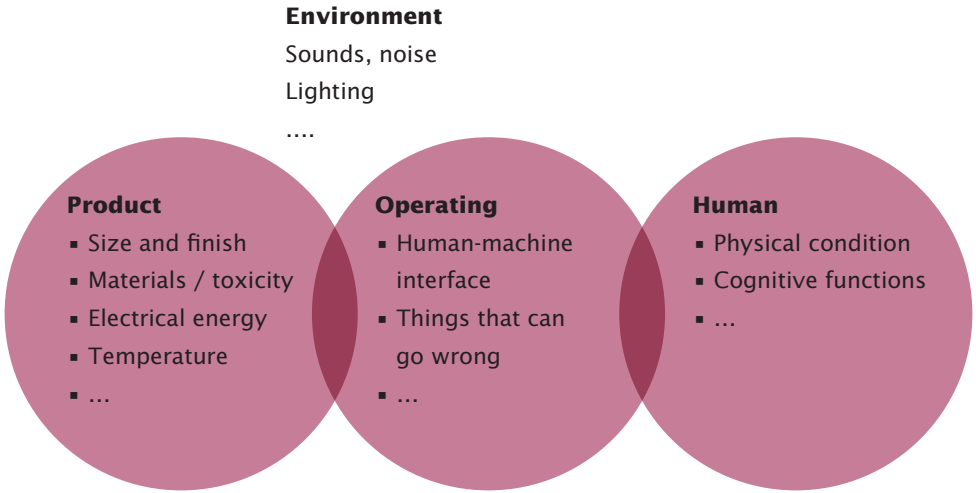


Figure 3: *Product safety.*

The safety of a product depends on its physical properties, the operation and function of the product, and on how the product is used and perceived by users. In Figure 3we see the SHEL model from a product design point of view. A safe use of a product is related to the characteristics of the product (e.g., sharp edges), the condition of people operating the product (e.g., stressed or tired), the man-machine interface (e.g., intuitive or complex) and the environmental conditions while operating the product (e.g., noisy or crowded). In industrial environments, a failure in each one of these aspects is a potential safety risk.

Therefore, with respect to product design, we first mention the (generic) physical properties of a product that makes a product more or less safe, in terms of factors like sharp edges or protruding segments. The Consumer Safety Institute (in Dutch: Stichting Consument en Veiligheid) has developed a risk assessment method that has been based on the vision of "Design for All". The method, called the Demand Indicator (in Dutch: Eisenwijzer[1]) provides designers a method and practical information to design products as safe as possible. The method is based on risk matrices and consists of five steps:

1. Find out the hazardous characteristics the product possesses. They use a list of nine product hazard categories:
   - Size and finish (like sharp edges)
   - Potential energy (like the stability of a product, being able to turn over)
   - Kinetic energy (like moving parts)
   - Electrical energy (like danger of electric shock)
   - Extreme temperature (like burns and fire)
   - Radiation (in particular ultraviolet radiation)
   - Fire – explosion (like flammable products)
   - Materials – toxicity (like chemicals, volatile toxic materials, cleaning products)
   - Product handling (like requiring forced attitude, overload, or excessive effort)
2. For each product hazard, look for combinations of personal characteristics that give an increased risk of an accident. They use nine personal characteristics as well:
   - Eyesight
   - Hearing
   - Cognitive functions
   - Psychological functions
   - Movement (restrictions)
   - Balance (restrictions)
   - Sensory function
   - Endurance
   - Anthropometry (body size and weight)
3. Read about the personal characteristics that are relevant. For several groups (elderly, children), design suggestions can be found.
4. Consider for each increased risk of what might go wrong. An example database exists for these purposes.
5. Consider solutions to reduce hazards. If no design solutions exist, warnings on the product or use information may be applied.

Note that besides the physical product properties, we also have the 'operational' properties of the product (in particular a machine) in use. For example, design for safety also means to anticipate on product failure. In safety-critical systems techniques like data redundancy or fault tolerance are used to make the product more reliable and herewith safer for use (see, e.g., Storey (1999)). Since this side of design for safety is less related to human behaviour, we do not focus on it in this document, however.

Except for 'design for safety' in the sense of no sharp edges or a redundant architecture, there is a development called 'safety by design' as well. Safety by design is a concept that encourages construction or product designers to 'design out' health and safety risks during design development. That is, products or environments may explicitly be designed to avoid risk and therefore enhance safety. A well-known example is the anti-theft chair that has been designed in England to avoid thefts of bags in places to go out. Identically, good and bad practices for e.g. construction safety exist[2].

1) See http://www.eisenwijzer.nl

2) See e.g. http://saferdesign.org/ or http://www.designforconstructionsafety.org/ or http://naturalprotection.eu/

Design of the environment (liveware – environment interface)

As with products, environments can be designed to enforce safe behaviour as well. An example of physical measures to enhance safety is the prevention of access to unsafe areas. In chapter 4 we will further elaborate the use of light, colours, music, and other sensory perception to make environments safer. Besides prevention (pre-accident), the design of the environment may take some post-accidental aspects into account as well: is it easy to reach the place of an accident by emergency workers, has the workplace been designed in such a way that others can see what happens for the purpose of a quick response and/or to witness afterwards what has happened, etc.

On this topic, we may learn from the area of public safety. Crime Prevention Through Environmental Design (CPTED - pronounced as sep-ted and also known by various other labels like Designing Out Crime) is defined as a multi-disciplinary approach to deterring criminal behaviour through environmental design (Design Council, 2011). CPTED strategies rely upon the ability to influence offender decisions that precede criminal acts by affecting the built, social and administrative environment. Three common strategies for designing out crime are natural surveillance, natural access control and natural territorial reinforcement[3].

Natural surveillance means taking steps to increase (the perception) that people can be seen. Natural surveillance occurs by designing the placement of physical features, activities and people in such a way as to maximize visibility and foster positive social interaction. Examples are measures like placing windows to overlook sidewalks and parking lots, ensure potential problem areas (pathways, stairs, etc.) to be well lit, but avoid too-bright security lighting that would hinder the view for potential observers, etc. Natural surveillance measures can be complemented by, e.g., video surveillance for areas where window surveillance is unavailable. Clearly these measures may be applicable for safety at work as well.

Natural access control limits the opportunity for crime by taking steps to clearly differentiate between public space and private space (in our case: between safe and risky areas?). By selectively placing entrances and exits, fencing, lighting and landscape to limit access or control flow, natural access control occurs. Examples are to use a single, clearly identifiable, point of entry, to use structures to divert persons to reception areas, to use waist-level fencing to control access and encourage surveillance, shoulder-level fencing to promote social interaction, and high, closed fencing to prevent access.

Natural territorial reinforcement promotes social control through in particular improved proprietary concern. Clearly demarcating a private space, for example, creates a sense of ownership (owner takes responsibility) as well as creates an environment where intruders are more easily identified. A natural territorial reinforcement can be realised by, e.g., restrict private activities to defined private areas, displaying security signs at access points, placing seats and refreshments in common areas. It increases the proper use of areas, makes the user feel safer and being controlled.

Besides the subject-related guidelines, which may be translated to the context of safety at work, designing out crime uses some methodological tools and techniques as well which may be applied for safety at work. Designers working on crime prevention and reduction need to think beyond the user: to understand how to prevent crime for occurring, they have to fully understand how crimes happen. Therefore, except for user-centred design they also apply the viewpoint of an abuser-centred design. Another mechanism is the concept of a Crime Lifecycle Model to identify where (pre-crime, post-crime) anti-crime elements can be incorporated. The analogy with 'accident-centred design' or accident Lifecycle Model is clear.

3) See also http://en.wikipedia.org/wiki/Crime_prevention_through_environmental_design

Rules and discipline (liveware – software interface)

In the SHEL model (see chapter 2), the 'software' refers to all procedures, regulations, and practices. From our project risk inventory (van Houten and Teeuw, 2011), we already know that organisation and discipline are important aspects to enhance safety at work. Clearly, the rules within an organisation may have a direct effect on safety. A nice example of discipline can be found within the oil company Shell (not to be confused with the SHEL model). Shell wants to achieve 'Goal Zero' (i.e. no accidents) by preventing safety rules to be violated. Therefore, rules and safety standards have to be simplified, have to be the same everywhere, and have to be consequently applied by managers (Konter, 2009). Therefore, holding the banister is a symbol of simply to keep the safety, also in office environments. If workers are consistent in this, though it seems not really necessary, it becomes a habit that when needed in more dangerous circumstances (like on an offshore oil platform) they will routinely apply.

Teamwork and incentives (liveware – liveware interface)

Clearly, with respect to an organisational culture of discipline as mentioned in the previous section, communication and personal feedback are important. Direct feedback by colleagues may have the most impact. Personal feedback to enhance safety at work can be positive or negative. That is, safe behaviour can be rewarded with positive feedback to emphasize that this behaviour is desired. On the other hand, risky behaviour can be followed by negative feedback to stop it and/or to prevent that it happens again. Negative versus positive feedback is also the balance between punishing risky behaviour versus stimulating safe behaviour by positive incentives.

From the area of mobility, there are many examples of (research into) changing behaviour through the use of incentive-based information and persuasion. We further elaborate on persuasion in chapter 5.

This chapter concludes with some final remarks on incentives in the sense of 'monetized' inducements or financial rewards for adopting particular behaviour. In travel practices, these kinds of measures often take forms such as discounted tickets for using public transport at certain times. Also, there are facilities such as campsites that offer reduced rates for those who arrive by public transport or bus. Clear evidence of the impact of financial rewards on travel behaviour are shown by peak avoidance programmes in the Netherlands (Ben-Elia and Ettema, 2011). Financial rewards have shown to be effective in reducing car travel at peak times and to reduce congestion for particular parts of the road network. It is an interesting research question whether incentives can be used to stimulate safe behaviour.

4. Senses (liveware - enviroment interface)

We perceive the world around us with our senses. The traditional five senses are: sight (eyes), hearing (ears), smell (nose), taste (mouth), and touch (skin). Human beings have a multitude of senses. In addition to the traditionally recognized five senses, other senses include temperature, kinaesthetic sense (position monitor), pain, balance and acceleration. Senses are physiological capacities of humans that provide inputs for perception. Therefore, we can use (a combination of) these senses to influence the perception and behaviour of workers as a means to reach a safer working environment. Primarily we focus on the distant senses: hearing, sight, smell, and temperature. In addition we also focus on one near sense: touch. We do not cover other senses like taste, as they are mainly perceivable inside the human body. Therefore they are less suitable for influencing behaviour in (work) environments. In the following sections, we explore recent research on senses from other domains.

Introduction

The senses are studied by a variety of fields, most notably neuroscience, cognitive science, and philosophy of perception. Victor Lamme, professor of cognitive neuroscience at the University of Amsterdam, states that our behaviour is largely determined by factors into which we have little insight like our tendency not to disagree with group consensus or our fear of other ethnicities. Based on several case studies (among which a murder case in which the assailant was acquitted after pleading “sleepwalking”) we conclude consciousness is simply a spectator which interprets our behaviour in the best way it can. In this sense free will does not exist, according to Lamme.

Whether one agrees or not with Lamme, it is clear from neuroscience that we have very little insight into our motivations and, consequently, are poor at predicting our own behaviour. Not our reason or knowledge or intellect might be the best predictor of our behaviour, but also our emotions. Input from our senses are important for our emotional state, and therefore influence our behaviour in an ‘ambient’ (invisible) way. Therefore we focus on how behaviour can be influenced by our senses in this chapter.

A study of InHolland lists several examples of how sensory effects can be used to improve public safety (Eysink Smeets, van ’t Hof & van der Hooft, 2011). From the literature, there are only a few examples of using senses to influence behaviour for the purpose of safety in working environments. Therefore, we show exam-

ples from other domains, which might be mapped on, e.g., industrial safety.

Sight

The first sense we focus on is sight. Sight encompasses the perception of light intensity (illuminance) and colours (spectral distribution).With respect to light intensity, Philips has done several case studies about lighting, for example in relationship to aging (Knoop, 2009). The deterioration of the visual system with age has implications for the visual performance and alertness, and herewith for the performance of many tasks. Therefore, elderly people can be helped with higher light levels. Scientific research of Phipps-Nelson, Redman, Dijk & Rajaratman (2003) even concludes that daytime bright light exposure can reduce the impact of sleep loss as compared to dim light.

Besides the visual aspects, light also has a biological (nonvisual) effect as well as plays an important role in evoking emotions. For example, Philips developed a

Figure 4: *Four lighting scenes in the Philips SchoolVision concept (Knoop & Vis van Heemst, 2010).*

SchoolVision concept that supports the rhythm of activity in a classroom with changing patterns of warm light and daylight white. Four lighting scenes are available (see Figure 5). In the Normal scene standard light levels are suitable for regular classroom activities. When pupils need to be more active, the cool fresh light in the Energy scene helps to invigorate them. For more challenging tasks, the teacher can switch to the fresh bright light in the Focus scene to aid concentration. And finally, the warm light in Calm scene brings a relaxing ambience to individual work or quiet time (Knoop & Vis van Heemst, 2010). The University of Twente used the concept to explore ways in which lighting can contribute to learning processes in primary schools. The project consisted of two parts: a field experiment and an experimental laboratory study. The results indicated that pupils who were exposed to the School Vision light system scored, on average, eighteen percent higher in concentration tests and were more motivated in the longer term[4].

Several other researchers have studied the effects of light and colour in working environments as well. Already some time ago, Wexner (1954) found that the colours blue and green were most associated with a secure and calm feeling by most people in modern, western countries. Orange was most associated with distress, stimulation, and hostility. Jacobs and Suess (1975) did experimental research to measure the influence of colour on anxiety. Participants showed less anxiety in blue and green spaces compared to red and yellow ones. Others came to identical conclusions. Cool colours like blue and green have a relaxing effect, while long-wavelength (warm) colours such as orange and red are stimulating, and give more arousal. For example, from an investigation into the influence of colour and light on the experience at railway stations, Peters (2008) concludes business travels like cool colours and day-trippers like warm colours. In general, colour leads to a more positive perception of the experience of the station and wait (Van Hagen, Sauren & Galetzka, 2010). Bronckers (2009) found that coloured light does have a significant influence on atmospheric perception. Participants in this study assessed a warm white light setting to be more suitable for a living room and office than a cool white light setting, which they found less cosy, more tense, and less preferred. Yellow was assessed as the least tense light.

With respect to working environments, Kwalled & Lewis (1990) assessed the ef-

4) See http://www.utwente.nl/organization/stories/effect-licht-in-leeromgeving-schoolkinderen

fects of different types of light on (office) worker productivity and mood. They expected that participants in a red illuminated office would report more tension and make more errors. However, the participants in the red illuminated office made the fewest errors, and participants in the white illuminated office the most. Dijkstra, Pieters & Pruyn (2008) tested the effects of wall colouring in a healthcare setting. Their results suggest that using a green coloured environment reduce feelings of stress, and an orange coloured environment increased feelings of arousal. However, their results also suggest that creating a healing environment by using wall colours is quite complex, and only modest effects may be expected.

Hearing

Our hearing system has two important functions with respect to the perception of our environment (Carles, Barrio & de Lucio, 1999). First, sounds from for example birds, water, voices, cars, and wind,help people to govern functions like spatial ability and orientation. Secondly, the hearing system functions as an alarm and warning system for dangerous situations. Carles, Barrio & de Lucio (1999) particularly studied the influence of the interaction between visual and acoustic stimuli on perception of the environment. Their results

show a preference for natural sounds, compared to man-made sounds. Natural sounds results in more relaxation.
According to Treasure (2011) the effects of sound can be divided into four categories:

- Physiological effects (unexpected sounds cause extra cortisol -the fight or flight hormone- and the opposite for soothing sounds);
- Psychological effects (sounds effect our emotions);
- Cognitive effects (sounds effect our concentration);
- Behavioural effects (the natural behaviour of people is to avoid unpleasant sounds, and embrace pleasurable sounds).

Especially these last two categories are of interest for our research. For example, open space office workers have a significant decrease in productivity because of concentration problems (cognitive effect) when they are exposed to phone calls, conversations, photocopiers and other noise pollution. Treasure states that the productivity of people working in open spaces where a variety of other sounds are heard is dramatically reduced compared with labour of people who work in a quiet area (productivity reduce by 66%!). Also, Treasure states that the misuse of sound in shopping malls can lead to a decrease of 28% in sales.

With respect to working environments, O'Shea & Wolf (2011) investigated whether an endoscopist listening to Mozart while performing a colonoscopy impacted adenoma detection rates. The results show that an endoscopist blinded to the study outcome had a higher adenoma detection rate while listening to Mozart (66,7%) as compared to without Mozart (30,4%). Their research has been triggered by the fact that a set of research results indicate that listening to Mozart's music may induce a short-term enhancement on the performance of certain kinds of mental tasks (spatial-temporal reasoning), which is called the "Mozart effect".

An example of influencing behaviour by sound is the so-called Mosquito, an electronic device used to drive away loitering young people. The name Mosquito indicates it's small and annoying. In the USA and Canada it is called a Sonic Screen. The device emits a high-frequency pulsing sound that, is extremely unpleasant to those between the ages of 13 and early twenties, but can be heard by almost no one older than 30 as the ability to hear high frequencies deteriorates in humans with age ('ultrasonic tone'). The sound is designed to so irritate young people that after several minutes, they cannot stand it and go away. Some tuning in the age spectrum is possible, e.g., tuning to a lower frequency for ages 19-25, where loitering by older age groups is a problem. The idea was 'invented' in the manufacturing industry by Howard Stapleton. When he was 12 and visiting a factory in London with his father, he could not bear to go inside a room where workers were using high-frequency welding equipment (Lyall, 2005).

Smell

The third important human sense is smell. In general, for communication over long distances humans use sight and hearing, whereas smell is a case of shorter distances (as opposed to animals that, e.g., use scents to mark their territory). Like sound, smell works on the emotional part of the brains. Scents have the power to strongly influence people because the sensory input goes directly

to the emotional seat and memory centre of the brain. The human sense of smell affects 75% of daily emotions and plays an important role in memory[5]. For companies looking to attract customers and develop a long-lasting relationship with them, emotion and memory are critical connections. Therefore, scents are very important in marketing campaigns and branding efforts. The most common approaches are either to relate a scent to a product, or to use environmental odours ('ambient scents')[6]. Also, Spangenberg, Crowley & Henderson (1996) discovered that pleasant environmental smells result in a good mood, with the result that their respondents evaluated a store more positively as well as showed a higher level of approachable behaviour.

Smell is influencing our behaviour (Hellema, 1994). Smell has several functions. First, like hearing, smell is important as a warning for danger: gas, burning smell, poisonous food. Unpleasant odours are often dangerous odours like, e.g., spoiled food, what we will not eat. Animals smell their enemies first, before they see them. Second, smell is used for pleasure (cultural role[7]. Humans use their senses not only for primary survival, but also to enjoy life. Because odour sensation is directly connected to the emotional centres in the brains (limbic system), the fun is quite immediately. Scent stimulates the intuitive, direct benefit, this is another kind of pleasure than watching or listening. Third, smell is used for the taste (!). Smell and taste are closely linked. Think of children who pinch their noses as their parents want them to eat something dirty. Smell is responsible for 95% of the taste of food. Fourth, scents are attracting or disposing us. Therefore smells are e.g. used for sexual communication.

Research has shown that smell can influence work performance. Sakamoto et al. (2005) investigated whether the exposure to aromas during a work break affected work performance. Different groups were assigned to a jasmine aroma, a lavender aroma, or no aroma during work break. Comparing the three groups Sakamoto discovered that workers in the lavender aroma condition indicated higher concentration levels than for the other groups. Therefore indicating that with the use of certain aromas people can actually be influenced in working harder, faster or more efficient. These developments may be characterised as aromatherapy, a form of alternative medicine that uses volatile plant materials (so-called essential oils) and other aromatic compounds for the purpose of altering a person's mind, mood, cognitive function or health.

Another study by Holland, Hendriks & Aarts (2005) confirmed that unobtrusive exposure to certain scents influenced the behaviour of participants. In their studies they exposed participants to citrus-scented all-purpose cleaner. This scent made listing cleaning-related activities more easy, identification of cleaning-related words faster, and caused participants to keep their direct environment cleaner. Participants were unaware of this influence, as was confirmed with a questionnaire. The results of these studies show that scent influences what people do and think.

Touch

A sense even more near than smell is touch. Haptic feedback is a relative new area of research, and most studies focus on haptic feedback on smartphones, touchpads, LCD-displays, and automotive control systems. In recent years, haptic feedback was used to give fighter pilots more direct feedback while steering a fighter aircraft, and training airplane pilots in flight simulators. Also, haptic feedback is used to simulate medical procedures (Jacobus & Griffin, 1998). With the use of haptic feedback doctors can learn how to execute certain surgeries, without the danger of harming real patients.

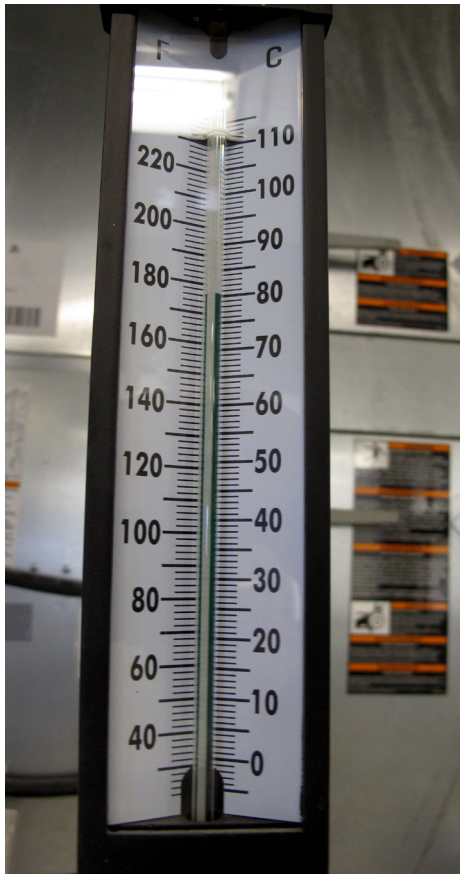
Recently, Philips Research started studying the Emotions Jacket[8]. This jacket fits tightly on the human body and uses a series of actuators, much like the vibrator motors found in modern smartphones. These vibrator motors are located in the

5) See e.g. http://www.brandessence.com.tr/en/koku_bilimi.html
6) See e.g. http://www.scentmarketing.org/
7) See a.o.http://www.bbc.co.uk/sn/humanbody/truthaboutfood/sexy/smellarousal.shtml

8) http://www.research.philips.com/technologies/emotionsjacket/index.html

arms and torso of the jacket, and are activated in response to what a user is watching on a TV-screen. With this jacket it is possible to recreate feelings being experienced by actors on the screen. The idea behind this is that people who experience the physical manifestations of an emotion (fabricated by the jacket) also experience the emotion itself. Scientifically, the link between fabricating touch to experience emotions is not very well explored.

Boll, Asif & Heuten (2011) studied the use of tactile interfaces for car navigation systems. The idea is that a driver could perform a new and additional task (such as car navigation) better if the navigation instructions are presented via a sensory channel that isn't already being used (for the driving itself). They use a tactile belt consisting of eight vibrator pointing in different directions. The results show that this tactile spatial display helps drivers successfully navigate in an urban environment. However, the results did not show any differences in the cognitive workload of drivers using the tactile display compared to those using a conventional car navigation system.



Temperature

Feeling of hot or cold depends on the air temperature, the relative humidity of air, the presence of hot or cold objects in the surrounding area, the presence of air movement (breeze, ventilation), and one's physical exertion and clothing. Most people feel comfortable when the air temperature is between 20˚C and 27˚C and when relative humidity ranges from 35 to 60%. When air temperature or humidity is higher, people feel uncomfortable. Such situations do not cause harm as long as the body can adjust and cope with the additional heat. Very hot environments can overwhelm the body's coping mechanisms leading to a variety of serious and possibly fatal conditions.

The most commonly used measure in the workplace is the wet bulb globe temperature (WBGT) index[9]. The American Conference of Governmental Industrial Hygienists (www.acgih.org) publishes threshold limit values (TLVs) that have been adopted by many governments for use in the workplace. The process for determining the WBGT is also described in ISO 7243 (Hot Environments - Estimation of the Heat Stress on Working Man, Based on the WBGT Index).

Employers have a duty to take every reasonable precaution to ensure the workplace is safe for the worker. This duty includes taking effective measures to protect workers from heat stress disorders if it is not reasonably practicable to control indoor conditions adequately, or where work is done outdoors. Certain steps can be taken to reduce discomfort. These include[10]:

- Using fans or air conditioning;
- Wearing light, loose fitting clothing;
- Taking more frequent rest breaks;
- Drinking cold beverages (ones that do not have caffeine or alcohol);
- Allowing flexibility to permit less physically demanding activities during peak temperature periods;
- Using screens or umbrellas to create shade.

9) See e.g. http://en.wikipedia.org/wiki/Wet_Bulb_Globe_Temperature
10) See e.g. the Canadian Centre for Occupational Health and Safety, www.ccohs.ca.

5. Influence machanisms: Cialdini

In his book “Influence, the psychology of persuasion”, Robert Cialdini discusses six principles to influence behaviour for marketing purposes (Cialdini, 2008). 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. These mechanisms are the six principles to get through life (see Figure 6). They have many advantages, however they can also be used to exploit us. In this chapter we discuss the six principles to see how they can help us to enhance safety in work environments.

Figure 5: *Six influencing principles of Cialdini (2008).*

Reciprocation

According to sociologists and anthropologists, the rule of reciprocation is one of the basic norms of human culture. The rule requires that one person tries to repay what another person has provided. It expresses that we feel indebted to those who do something for us, or give us a gift. In marketing this mechanism is frequently used while handing out free samples. For example:

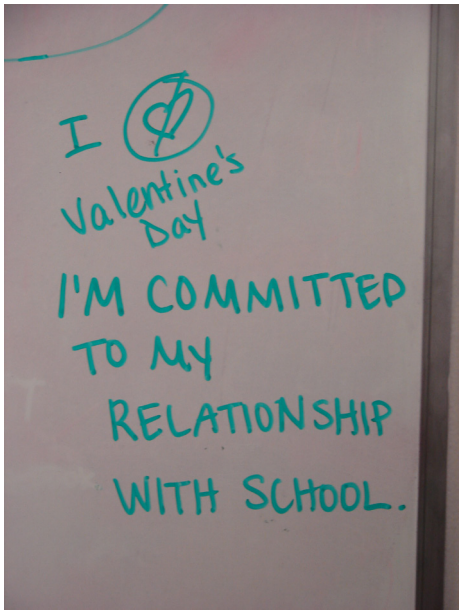
- Supermarkets often let customers taste their finest steak. After tasting this free piece of steak, customers are more likely to buy it from a salesman.
- A researcher randomly sent Christmas cards to people unknown to him and mentioned his address on the Christmas card. He received an astonishing amount of Christmas cards back.
- In many restaurants you get candy at the bill. Waiters who do indeed get more tips. Strohmetz et al. (2002) found that servers who gave diners a piece of candy when presenting the bill increased

their tips by 3.3 percent. If they provided two pieces of candy to each guest, the tip went up by 14 percent. Giving one piece of candy, then as the server is leaving the table turning back and offering another piece increases the tip by 21 percent.

The reciprocation rule works not only for physical gifts, but also for information, favours, or a positive experience. These gifts don't even have to be expensive. Using free samples like a shampoo or perfume sample is very effective. A compliment is free to give....

Commitment and consistency

People have the desire to be and look consistent within their words, beliefs, deeds, and attitudes to themselves, and the people around them. Once we commit to a point of view, we have a hard time changing it. This tendency comes from three sources. First, personal consistency is highly valued by those around us. Second, it provides a beneficial approach to daily life. Third, it makes our lives easier by providing a shortcut (for making automatic choices). We only need to remember our actions in an earlier situation, instead of processing all new information and forming our opinion based on all this new information.



This mechanism can be used when we want to make people commit to our cause. Cialdini states that it is far more effective to ask people "Will you please call me if you have to cancel?" than "Please call if you have to cancel." In the former case, people have to respond with a clear "Yes, I will." Publicly committing to something makes people more likely to do it.
Toy Manufacturers misused this rule by advertising with popular toys just before Christmas. Then these toys were not available in the stores. Parents who had promised their child that they got the toys, had to give something else at Christmas, but bought the toy in January because they promised it and by then it was back in the stores.

The tendency to be consistent gets stronger as people get older. For older people it is harder to make a change. The solution is to praise them for past decisions, and use the old habits in applying the new ones.

Social Proof

The principle of social proof is in essence very simple: when people are uncertain about what to believe, what to decide,

and how to act in a certain situation, they tend to look at what other people do or believe. This principle is most effective under two conditions: uncertainty and similarity. When people are unsure, they are more likely to look at other people, and copy their behaviour. This effect is particularly enhanced when the behaviour is shown by people that are more similar to themselves.

- A widely spread example of this principle is the reuse of towels in hotels. Cialdini and colleagues tested different signs to encourage guests to reuse their towels. When the guests were given a sign that the majority of guest in that hotel reused their towels, almost half of the participants did the same. When confronted with a sign that appealed to environmental or economic advantages, the response was significantly lower.
- Another example are the cries on many books like "over 100,000 copies sold."
- If you see a full tips jar, people tend to give more than if the tips jar is empty.
- If a person stops on a busy street and looks up, more people tend to look up.

Marketeers and creators of TV commercials often use this principle by adding testimonials from satisfied customers. They show the target audience that people who are similar to them have enjoyed a product or service.

Liking

People prefer to say 'yes' to individuals they know and like. Liking is basically influenced by three features. The first feature is physical attractiveness. Physical beauty provides an advantage in social

interaction, which means attractive people are more persuasive in getting what they request and in changing attitudes of other people. The second feature is similarity. People are more likely to agree with other people who are similar to themselves, even though the similarities are very trivial, like the same birthday. The third feature is praise. People are receptive for compliments. Compliments enhance the liking of the praise-giver. When we meet people repeatedly in positive circumstances, this also enhances their liking.

- The sale of stamps for children (kinderpostzegels) is successful. If a child is committed to a charity, do you say no?

This principle can be used to an advantage by intensifying the knowledge of customers. By openly addressing their preferences, they will become more open to agree with us.

Authority

Through all times and ages, people respected authority. While judging the authority of someone, people especially pay attention to(academic) titles, impressive clothing, and expensive cars. Even if the authority is illegitimate, it still strengthens the likelihood that the so-called 'authority' will influence people.

Between 1961 and 1962 Stanley Milgram carried out a series of experiments in which human subjects supposedly were given progressively more painful electro-shocks in a careful calibrated series to determine to what extent people will obey orders of an authority, even when they knew that obeying the orders would be painful and immoral to innocent victims. Stanley Milgram's experiments to determine how people will obey authority regardless of consequences are among the most important psychological studies of this century and show the surprising ease with which ordinary persons can be commanded to act destructively against an innocent individual by a legitimate authority. The experiments came under heavy criticism at the time but have ultimately been vindicated by the scientific community. In his book 'Obedience to authority' Milgram explains his methods (1974).

This rule explains why people start looking for authority when they are uncertain about a specific subject.

Scarcity

The last influence technique Cialdini discusses is scarcity. The basic of this principle is that people assign more value to opportunities when they are less available. The more uncommon a thing, the more people want it. This principle holds up for two reasons. First, cognitively we think that things that are difficult to obtain are more valuable. Second, as things become less available, we lose freedoms. When loosing freedoms, people respond by wanting to have them more than before.

Many companies create scarcity by marketing expressions like "only two rooms left in this price category", "only available today" or "gone is gone".

The principle of scarcity also applies to information. When we receive information that seems to contain exclusive information, we perceive it as more valuable. The principle especially holds up under two conditions. First, when an item is newly scarce, we think it has a higher value. Second, when we need to compete with others to obtain the scarce item, we also perceive it as more scarce than when we are the only one in line.

Applying Cialdini for safety at work

In the literature, we have found no direct examples of applying the marketing principles of Cialdini in industrial work environments. However, the principles are general and examples are easy to imagine. We want to conclude this chapter with some examples of how the six principles form marketing psychology could be applicable at work:

- 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 & consistency)
- Make the tough guy in the factory to behave in a safe manner and the others will conform to his behaviour (social proof).
- Certain workers of a transport company may be uncertain on how to load

a new truck. They will look towards colleagues to decide how to load this new truck (social proof).

- A car mechanic receives from his boss a brand new iPod mini. Several weeks later his boss asks him to replace the broken engine of a customer's car with a unreliable second hand engine, instead of a reliable new one. With doubts in his mind he replaces the engine (reciprocation).
- A construction worker is unhappy about the safety procedures on the building site and approaches his boss. The boss listens to his story and replies: "Thank you for your awareness. When I was working on the site years ago, I too found it important to be aware of possible dangers. However, you should not worry about it in this case. Thanks again for your awareness, and now go back to work!" (liking).
- The CEO of a large oil company pays a visit to an oilrig in the North Sea. He arrives with his expensive private helicopter, and greets the workers in his tailor-made suit. The CEO requests from the workers to raise the daily production, even though it stretches the capabilities of the oil rig to the max (authority).
- In a machine factory a single management position falls free for the first time in years. The position will be given to the senior worker who behaves most safely during the next week. All senior workers work overtime to reach this goal (scarcity).

6. Persuasive Technology

Persuasive technology is a research area that became well known during the late 90's and early 00's due to the work of B.J. Fogg of the Stanford University. Formed after discussions during CHI 97 and later conferences[11], persuasive technology is often defined as "any interactive computing system designed to change people's attitudes or behaviours". (Fogg, 2003). Other definitions of persuasive technology are hard to find, because most authors and researchers use the definition given by Fogg.

The functional Triad

Fogg (2003) distinguishes three kinds of persuasive technology (see also Figure 7). In one of his earlier publications Fogg (1998) has given straightforward examples of what persuasive technology can be, and how it can be classified.

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. This device motivates a person to put in extra effort during fitness exercises. In this example the device is used as a persuasive tool, because it gives people new power, and it increases capability (Fogg, 1998).

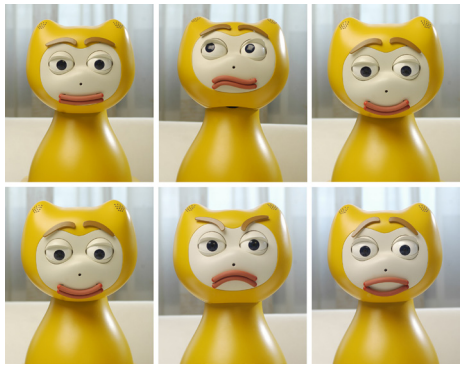
The second kind of persuasive technology (as a persuasive medium) was studied by Andrés del Valle & Opalach (2005; 2006). They studied a device that uses behavioural data in order to provide users a continuous feedback on their behaviour in a natural way. According to Andrés del Valle and Opalach, at some moment in time people want to improve their quality of life. They do this by changing some habits. However, personal goals are difficult to achieve and healthy habits are not as simple to maintain, as people would like to. The Persuasive Mirror is an example of how technology can help to improve behaviour. Computerized persuasion, in the form of visual feedback, gives the support needed. The use of a mirror to achieve behavioural change

11) The ACM CHI Conference on Human Factors in Computing Systems is the international conference on human-computer interaction.

seems logical, as most people are more receptive for visual stimuli than auditory or tactile stimuli. Andrés del Valle and Opalach's Persuasive Mirror modifies the user's reflection by using (gathered sensor) data from daily activities. Selecting and analysing this data based on the behaviour changes they chose as personal goals, the mirror will give feedback in the form of a mirror-reflection to persuade users to keep insisting in their commitments (e.g. looking older and fatter in the mirror-reflection).

According to Fogg (1998), this way of using devices is an example of persuasive technology as a persuasive medium. Persuasive mediums in essence provide experiences. Providing first-hand learning, insight, and understanding of cause/effect relationships can do this.

The third and last example is persuasive technology that functions as a social actor. This is the case when the focus of the persuasive technology is to create a relationship with its user. Rewarding people, providing social support, or modelling behaviours and attitudes can do this.



An example of persuasive technology in the form of a social actor is the so-called iCat. A study by Midden & Ham (2008) explored the persuasive effects of social feedback with the use of an iCat. The iCat (invented by Philips Research) is a robot that mimics facial expressions and talks to humans. The study consisted of an experiment with three conditions. In two out of three conditions the iCat was present and provided (positive and negative) social feedback while participants completed a simulated washing task. In the third (control) condition, the iCat was not present, and only factual feedback was used.Results show that social feedback provided by an embodied agent (iCat) can create behaviour change among users. This effect is greater than the effects of factual feedback.

Social actors can help to establish social norms between users and computers; they can also invoke social rules or

provide social support. In the healthcare industry, providing social support is considered to be an (financial) attractive solution to provide more care to elderly people.

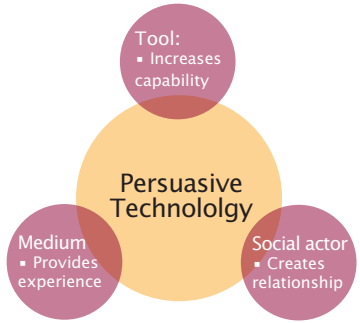
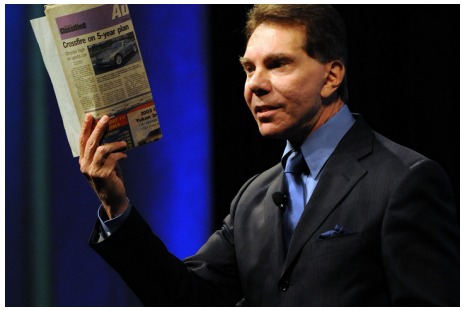


Figure 6: *The functional Triad (Fogg, 2003).*

As shown by these examples, persuasive technology can be categorized by its functional roles. Fogg (1998) proposes this 'Functional Triad' as a classification of the three "basic ways that people view or respond to computing technologies". Besides functioning as tools, media, or social actors, persuasive technologies can also function as more than one category at the same time.

Often, when a conversational agent persuades a user using social influence strategies, the user cannot directly use similar strategies on the agent (Fogg, 2003). This is a feature that distinguishes persuasive technology from other forms of persuasion: the users being persuaded often cannot respond to the technology. This is a lack of reciprocal equality. With modern technologies and algorithms this lack of reciprocal equality becomes less prominent. For example: the TV and radio are basically one-way media. However, in recent years, users of these media become more empowered to respond and interact with the broadcasting through the use of twitter, SMS, and the like.



Fogg's Behaviour Grid

Besides classifying the different kinds of persuasive technology, it is also important to know how behaviour can be changed. A model that can help accomplishing this is the Behaviour Grid developed by Fogg (Fogg & Hreha, 2010). Fogg describes 15 ways behaviour can change. The purpose of the grid is to help people think more clearly about behaviour change.

The Behaviour Grid has two axis. The horizontal axis describes the five flavours of behaviour. The vertical axis categorises the duration of the behaviour. In the next two paragraphs we discuss these two axis.

Axis of duration

According to Fogg & Hreha (2010), behaviour can span over different periods of time: one time (dot behaviour), span of time (span behaviour), or on-going (path behaviour). Dot behaviour is done only once, like making a detour while driving home. Other examples are choosing not eat meat one day, drinking a cup of decaffeinated coffee this morning, or wearing a pair of normal shoes instead of safety shoes to work today. Designing for dot behaviour means that are no specific long-term implications devised for the product. Therefore, there is often a lower behaviour activation threshold.

Span behaviour is behaviour that is done over a period of time. Designing for this type of behaviour requires thinking about regular triggers, because people must stick to this behaviour for a longer period of time. Examples of span behaviour are: wearing extra safety gear for a whole week, not taking sugar in your coffee for a month, or using another entrance for entering the office for a longer period of time.

Lastly, path behaviour describes behaviour that is done from now on. They are permanent in nature, and triggers must be used, until it becomes part of someone's routine. Habits that can be created using path behaviour are: biking to work every day, not drinking coffee anymore, thinking more consciously about energy consumption at home. This type of behaviour is hard to induce, and constant triggers must be used to make the behaviour a habit.

Axis of flavour

Fogg & Hreha (2010) distinguish five different flavours of behaviour. These flavours were all given the name of a colour. The five flavours are: green, blue, purple, grey, and black.

Green behaviour is behaviour new to people. Because it is new to people it may require to make the intended behaviour very simple, connect it to known and existing behaviour, and to reduce anxiety about the new behaviour. Examples of green behaviour are: driving a car for the first time in your life, become a vegetarian, or start wearing safety goggles during dangerous tasks.

Blue behaviour is familiar for people. Designs for blue behaviour can draw on past experiences. They often do not need to be explained. Green behaviour can become blue behaviour when a person becomes familiar with a certain task or habit. Examples of blue behaviour are: walking to the supermarket, boiling water, and wearing a safety helmet when working on a building site.

The purpose of purple behaviour is to increase familiar (blue) behaviour. This can be done by increasing the duration or intensity, or by increasing the complexity level. For example: checking the safety equipment more frequently, or walking to the supermarket multiple times a day can both be categorised as purple behaviour.

With grey behaviour we start to describe behaviours that decrease over time. Grey behaviour means the decreasing of a certain type of behaviour in intensity, duration, or frequency. For examples: drinking fewer cups of coffee, paying less attention to safety, or using less toxic materials during work. Some type of behaviour decrease can also be seen as purple behaviour. Because using less toxic materials can also be seen as gaining more awareness for the dangers of using toxic materials.

Finally, black behaviour is the ceasing of behaviour. For example not drinking coffee anymore, not wearing safety helmets and stop using certain toxic materials during work.

It is important to note that, depending on the target audience, different flavours can be assigned to the same behaviour. For example, when the ultimate goal is that every worker wears a safety helmet all the time; for some workers this will be green behaviour, for others blue or purple behaviour.

Relevance of the grid

Fogg's Behaviour Grid may help to focus only on relevant research for the project.

Safety at Work

Ideally, all the research and solutions of Safety at Work will focus on long-term (permanent) awareness on safety.

	Geen behaviour (new)	Blue behaviour (familiar)	Purple behaviour (increase)	Grey behaviours (decrease)	Black behaviour (stop)
Dot behaviour (one time)	Install an air conditioner for the workplace	Tell a colleague about safe behaviour	Build more safe workplaces	Make less noise today	Not use the risky route tonight
Span behaviour (duration)	Try wearing spectacles for a week	Use recommended clothing for two weeks	Take more rest this week	Disturb less colleagues this week	Don't use toxic substances this month
Path behaviour (from now)	Start using hygienic gloves	Close the door when going home	Always wear safety helmet	Listen less MP3 from now on	Never eat at the work floor again

Figure 7: Fogg's behaviour grid with safety examples (http://behaviorgrid.org/).

Designing Persuasive Technology

Until a few years ago, there were few examples of persuasive technology in daily life. In recent years persuasive technology has become more eminent in our houses, workplaces, and public space. We are increasingly more surrounded by devices and media that change what we think and how we act. Countless examples are available for researchers, and give them the opportunity to learn rapidly about persuasion and persuasive technology. When the occurrence arise that designers or researcher want to create an entirely new persuasive technology, this can be a challenge.

Many designers do not have experience creating products with a persuasive goal, and there is no proven design process. In order to prevent some of problems many design teams encountered in recent years, Fogg proposes an eight-step design process for creating persuasive technology, as shown in Figure 8 (Fogg, 2009).

Attempts to create Persuasive Technologies often fail. One problem is that many projects fail because they are too ambitious. Teams that are new to designing Persuasive Technologies should scale back their ambitions and save the difficult behaviours for later projects, after they learned to succeed in designing technologies targeted at more tractable behaviour changes. The eight steps are used to outline a path to follow in designing Persuasive Technologies that will increase the probability of success.

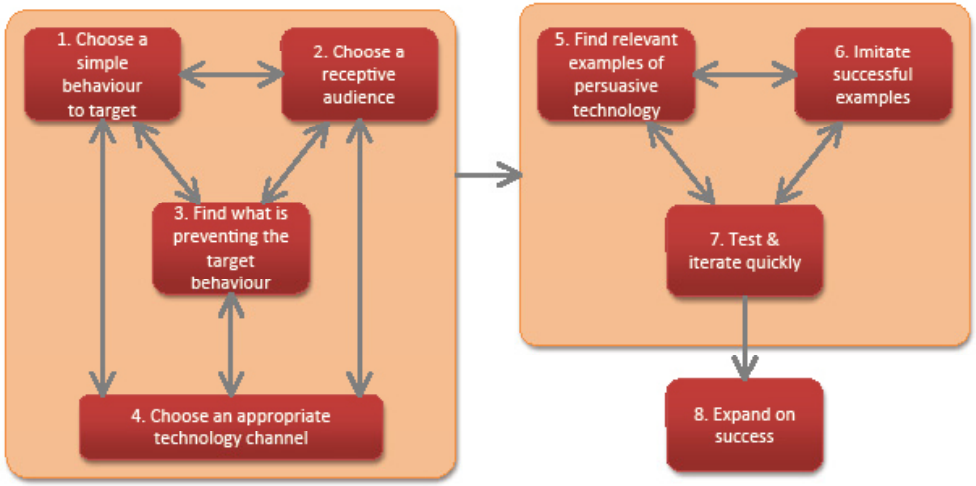


Figure 8: *Eight steps in early-stage persuasive design (Fogg, 2009).*

Step 1: Choose a simple behaviour to target

Fogg recommends choosing the smallest, simplest behaviour that matters. It doesn't need to be the final objective, but it can contribute to it. The goal needs to be very specific (for example: stretching 20 seconds a day, is part of the final objective to reduce overall stress).

A large, vague goal can be broken down in two ways:

- As an approximation of a larger objective;
- As a first step in achieving the larger goal.

Step 2: Choose a receptive audience

Designers should choose the audience that is most likely to be receptive to the targeted behaviour change, and should be familiar with the technology channel. The goal of step 1-7 is to create a product that persuades someone (not everyone) to adopt the target behaviour. Once a design team has developed an intervention that is working, it can be expanded to users that are less receptive. Often early adopters or other adventurous people can be chosen as a target audience.

Step 3: Find what prevents the target behaviour

What prevents the audience from performing the target behaviour? There is always a combination of three categories:

- Lack of motivation.
- Lack of ability.
- Lack of a well-timed trigger to perform the behaviour (easiest to create).

In most cases the persuasive technology must boost motivation, facilitate the behaviour, or both. Be aware that in case the target audience lacks both motivation and ability, the team needs to back up and rethink the previous steps.

Step 4: Choose a familiar technology channel

It is often difficult to determine which channel is best to choose. Basically, this depends on the results of the first three steps. In most cases this means that the design team cannot select an intervention channel until the first three pieces of the process have been completed. Teams should always try to use a channel that is familiar to the audience. In case that a channel must be used that is unfamiliar to the audience, this will take considerably more time.

Step 5: Find relevant examples of Persuasive Technologies

The team can start a search for relevant examples of persuasive technology for their project. Making educated guesses is a good approach, because companies often do not share their conversion data with outsiders. Also imitating methods of experts can be used.

Step 6: Imitate successful examples

The team should not be afraid of using something that is similar to other successful Persuasive Technologies. This requires insight from the team, because they need to come up with a way to adapt that success formula of the already existing product for their product.

Step 7: Test and iterate quickly

Multiple small tests will teach the team more than one big final test. Each test should take not more then a few hours. Because designing for persuasion is much harder than designing for usability, many attempts to change behaviours fail.

Step 8: Expand on success

If the persuasive technology works for the current audience, is can be expanded to other audiences. Or the target behaviour can be made more difficult.

Ambient Persuasive Technology

In chapter 1 we introduced the concept of ambient intelligence: the computer becomes invisible. Many researchers on persuasive technology have showed interest in studying this topic as well. Mistry, Maes & Chang (2009), for example, introduced a wearable device in a pendant around the neck consisting of a tiny computer with projector and camera. Users can interact with the device using gestures as well as the device can project information for the user on e.g. a hand or a table. In this way the user gets a 'touch screen' projected on any surfaces or physical objects. The idea is to make computer interfaces more natural (invisible).

Also, in modern consumer electronics an increasing amount of technology is available to support invisible and ubiquitous monitoring of people. With cheap gyroscopes, accelerometers, compasses, pressure sensors, light sensors, and GPS in smartphones most gestures and movements can be observed.

A trend in recent research is that not only technologies with graphical user interfaces (GUI's), auditory interfaces, or haptic feedback are used with which the user can interact. More and more we see that persuasive technology is supported by 'ambient' user interference. An explorative study by Ham, Midden& Beute (2009) looked into using persuasive technology that can persuade users without receiving the user's conscious attention. Participants were given a multiple-choice task. After the task they received positive or negative feedback through the presentation of a smiling or sad face for 150ms (supraliminal) or 25ms (subliminal). Both conditions led to the desired effect. Interesting about this study is that it addresses persuasive technology by using ambient intelligence. Ham, Midden & Beute (2009) as well as Davis (2008) label this as ambient persuasive technology. Davis states that e.g. the WaterBot (Arroyo, Bonanni & Selker, 2005) is a good example on how ambient displays can be used for non-annoying, incremental persuasion.

Example: WaterBot project (Arroyo, Bonanni & Selker, 2005)

WaterBot can be used in normal household faucets to motivate people to turn off the tap when they don't use water. It motivates people to conserve water by providing real-time visual and auditory reminders. Colour illuminated water is used while the tap runs. The water changes colour every few seconds, and therefore reminds people that the tap is still running. Positive ear cons (auditory icons) are played every time the tap is closed.

The Waterbot is a system to inform people and motivate their behaviour at the sink. It is a platform for experimenting with safety, hygiene and water conservation in a sink. The purpose is to increase safety and functionality and ultimately motivate behaviour change.

In general persuasive technology can be effective is the two ways, either by changing environments (environmental persuasion) or by using mobile systems, which is more prominent (i.e. less ambient). Using the environment to persuade people to change their behaviours can be reached by using displays, lightning, or sound. Using the environment (public spaces) allows for incremental persuasion. According to Davis (2008), this is behaviour change as a result of a repeating exposure to the persuasive technology.

Ham & Midden (2010) argue that using ambient persuasive technology can be more influential than normal persuasive technology because people often lack

motivation or cognitive capacity to consciously process (complex) information. They studied this idea by giving participants a series of tasks during which the participants had the opportunity to conserve energy. During these tasks participants received feedback of their energy consumption. Each participant received one specific type of feedback: factual feedback or lighting feedback. In the (common) factual feedback condition participants received the feedback as a number representing the energy consumption in Watts. Additionally two numbers were shown indicating low and high consumption. In the lighting feedback, green light indicated low energy consumption, while red light indicated high energy consumption.

Ham & Midden expected that lighting feedback would have stronger persuasive effects, and should be easier to process for participants. Results indeed indicate that participants in the lighting feedback condition use less energy than participants in the factual feedback condition. Also, participants in the factual feedback condition process the feedback slower. Ham & Midden conclude that lighting can be used as ambient persuasive technology. In addition, they "propose that ambient Persuasive Technologies are generic technologies that are intentionally designed to change a person's attitude or behaviour or both, that can be integrated unobtrusively into the environment and exert an influence on people without the need for their focal attention."

So ambient persuasive technology may be a solid attribution to our research. It explicitly adds an always-present environment for user interaction to persuasive technologies. With the use of sensors, actuators, and the like; gathered data can be processed to persuade or influence people to behave more safely.

7. Outlook

The advances in persuasive technology are continuous. Product designers look for methods and best practices to 'design for safety' (products to be safe to use). The safety by design developments include both products and environments, with the 'design out crime' community as a nice example. Our behaviour is influenced by what we sense with our eyes, ears, etc., and designers may use (or misuse) these facts to enhance products or to increase productivity. Identically, principles from marketing may be used to influence our behaviour. This all may happen in an ambient, invisible way, using (persuasive) technology as a vehicle.

The question is whether the insights from this document can be used to influence behaviour in order to enhance safety at work, in particular to make safety at work a natural habit. From this document, the following areas of interest may be concluded:

- We observe that an increasing amount of technology is available to support invisible and ubiquitous monitoring of people. With cheap gyroscopes, accelerometers, compasses, pressure sensors, light sensors, and GPS in smartphones most gestures and movements can be observed. Our key interest is in how technologies such as these can influence behaviour, and thus can be used to enhance safety at work. We have to further explore what kind of persuasive techniques contribute to which desired behavioural change.
- Some people may be driven by 'green' motives and replace their habits by other habits. However, the majority of people make choices based on the ease of use, efficiency and financial consequences. Changing behaviour patterns then basically means changing the one behaviour pattern by another, i.e., replacing the one habit by another habit. This brings us to the field of influencing behaviour, marketing and psychology. We have to find out what kinds of incidents occur during work, and the behaviour that is at the basis of these incidents. We have to find out what is keeping people from behaving the way they should.
- The SHEL model gives us insight in human factors that have to be taken into account to enhance safety at work. The SHEL model does not describe if e.g. certain senses contribute in a greater or lesser extent to the susceptibility of humans. Therefore, we need a model; maybe an expansion and adaption of the SHEL model, to encompass persuasive technology

design aspects. Hereby we will focus on industrial environments. We need to choose, adapt and/or develop a model and method like the Demand Indicator (chapter 3) that makes safety factors explicit and practical.

Eventually, we aim to design a model to match behavioural aspects to certain senses. With this model researchers and project partners can determine which human sense or other influence mechanism to target when aiming for a specific behavioural change.

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