Design for behavioural safety

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Designing for Behavioural Safety

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Abstract

Safety is defined as “The state of being protected from or guarded against hurt or injury; freedom from danger” (Oxford Dictionary, 2016) whilst behavioural safety describes a behaviour that is directly related to increasing safety such as wearing a crash or safety helmet or driving in a responsible manner. There has been a large uptake of behavioural safety approaches over the past decade in a wide range of applications including industrial, occupational, healthcare and even social environments. Such approaches are based on the findings that a significant proportion of accidents are primarily caused by the behaviour of human operators rather than being an artefact of poor or faulty product design. The concept of designing for behavioural safety has two ways of addressing this issue: On the one hand it comprises design of facilities, processes and products in a way that minimises hazards and risks to the people who will use them. On the other hand, it can involve guiding people to change their behaviour in certain ways to establish or maintain personal safety indirectly through design. In this chapter, some of the important theoretical models of designing for safety are described along with case studies of how the theory has been applied in different environments.

Keyword; Safety, Behavioural Safety, Behavioural Change, Safety by Design.

Introduction

Safety in general is defined as “The state of being protected from or guarded against hurt or injury; freedom from danger” (Oxford English Dictionary, 2016) whilst behavioural safety describes a behaviour that is directly related to increasing safety such as wearing a crash or safety helmet or driving in a responsible manner. Safety has become an increasingly essential feature of modern society, particularly as so many accidents which cause injuries are caused by the human operator; for example, the US National Highway Traffic Safety Administration (NHTSA, 2015) reported that 92% of traffic accidents are caused by human error. Given that this applies much more widely, it is recognised that there is an explicit need for safety design in many everyday situations. Irrespective of where and what we design, safety should be an integral part of the design process. We therefore need to understand what constitutes safe design and then adapt everyday procedures – and more importantly the behaviours of those engaging in the processes in response to those procedures – to make safety more instinctive. Design must consider safety over the whole product lifecycle, from inception, to development, implementation, commissioning, operation and maintenance, and if relevant, eventual decommissioning and disposal. The principle of Designing for Safety should also apply across a broad spectrum of different scenarios including occupational safety (particularly in work and industrial environments), healthcare (e.g. hospital environments), transport, and perhaps most importantly the domestic environment.

In the industrial context, Grindle et al. (2000) noted that there have been two main routes to changing behaviour to a safer level in the workplace: engineering and behavioural interventions. The engineering perspective has also been termed Safety Engineering and involves the fitment of rails, guards and personal protective equipment to reduce the hazards prevalent in the industrial environment. Grindle et. al. noted that the main disadvantages of
this method include the time, resources and capital required to identify and then mitigate every possible hazardous condition within the environments. This would be particularly problematic for the Small to Medium Enterprises (SMEs) who are unlikely to have the necessary capital to conduct such reviews and interventions. This approach also has the drawback of not expressly developing a safety culture but instead possibly nurturing an over-reliance on safety systems. In turn, this could lead to accidents as a result of unsafe areas which are presumed to be safe, because they have not been identified and mitigated, e.g. through barriers or guards. Finally, any safety design or barrier put in place could potentially be circumvented or mitigated - intentionally or otherwise - thus vastly reducing the effectiveness of such interventions.

In the following, the chapter first looks at principles of designing for safety more generally before it focuses specifically on designing for behavioural safety. The discussion is supported by references to underpinning theories and by a number of examples and case studies. Specifically, the numerous concepts and theories that are under discussion here are summarised in Table 1, below, together with the authors and examples of how the theories have been applied in real-world situations.

Table 1: Summary of Different Theories, Concepts and Applications of Behaviour Change

<table>
<thead>
<tr>
<th>Concept/Theory</th>
<th>Author</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Engineering</td>
<td>Grindle and Dickinson, 2000</td>
<td>Rails, guards, protective equipment within the manufacturing environment</td>
</tr>
<tr>
<td>Theory of planned behaviour</td>
<td>Ajzen, 1985</td>
<td>Encouraging parents to pack healthy foods into children’s lunch-boxes</td>
</tr>
<tr>
<td>Health Belief</td>
<td>Hochbaum, 1958</td>
<td>Prediction of health-related behaviours, particularly in regard to the uptake of health services.</td>
</tr>
<tr>
<td>Stages of Change</td>
<td>Prochaska and DiClemente, 1982</td>
<td>Prevention of Musculoskeletal Disorders in the occupational environment</td>
</tr>
<tr>
<td>Motivational Interventions</td>
<td>Sigurdsson and Artnak, 2012</td>
<td>Incentivised interventions for work-station use</td>
</tr>
<tr>
<td>Choice Architecture</td>
<td>Thaler and Sunstein, 2008</td>
<td>Washing machine/spin-dryer that cannot be opened until function is complete</td>
</tr>
<tr>
<td>Safe by Design</td>
<td>Ryland, 2012</td>
<td>Closure of the rail network for safe maintenance operations; safety of construction sites</td>
</tr>
<tr>
<td>Design with Intent</td>
<td>Lockton et. al., 2010</td>
<td>Traffic calming measures to slow vehicle speeds</td>
</tr>
<tr>
<td>Mindful Design</td>
<td>Niedderer, 2013</td>
<td>Shared space road design</td>
</tr>
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</table>

**Design for safety and design for behavioural safety**

The concept of ‘Design for Behavioural Safety’ can be considered as an approach that encourages safer products, environments, and behaviours. It brings together the collective skills of designers and safety professionals who may have differing perspectives - for safety professionals, the prevention of injuries and fatalities may be their main function whilst designers typically are tasked with effectively creating processes, products and facilities. The concept can be seen to have at least two different approaches.

Firstly, it can refer to responsible professionals within a given situation or an organisation to eradicate safety risks through design during any design development process. This means there is an attempt to design out risks at source so that there is actually no need to change people’s behaviour and practices. We refer to this approach here as ‘design for safety’. This
approach recognises that along with a number of other important parameters including purpose, usability, quality and cost, safety should be determined during the design stage. Historically this hasn’t always been the case. An example of how the principle of design for safety can clearly be demonstrated by studying the evolution of vehicle design. In figure 1 below, which shows a stylish Lotus 7 it can be seen that the vehicle contains many unforgiving surfaces. These include sharp edges on the dash and a thin-rimmed steering wheel with a somewhat prominent feature on the centre of the wheel, each of which could be highly likely to cause injury to the driver in the event of an accident.

Figure 1: Interior Driver Environment of Lotus 7

When this is compared to modern-day cars such as the example below, it is evident that injuries are much less likely in the modern design - the steering wheel is designed to be much less hostile in the event of an accident and an airbag is also present within the steering-wheel hub which will offer enhanced protection in an accident scenario.

Figure 2: Interior Driver Environment of Modern Vehicle Design

Such safety features are examples of exactly what design for safety aims to achieve; it involves an understanding of the potential hazards that a product introduces and determines a way to minimise potential consequences in the event of an accident or misuse. Therefore, in the example above, design engineers and manufactures in the vehicle manufacturing industry are preventing injuries by considering the hazard of the car crashing early in the design process. In many ways, this is similar to the concept of the Choice Architecture approach (Thaler and Sunstein, 2008) in that the safety of the operator is considered in the technological functioning of the product; for example, certain everyday items (washing machine, spin-dryer, microwave etc.) cannot be opened when they are operating in order to prevent injury. Thus the chance of harm is reduced by modifying the architecture or environment of the feature. In other words, this is one end of the behavioural change spectrum that shifts the context.

‘Choice Architecture’ is therefore a process used to describe the way in which decisions may be influenced by how the choices are presented. This term essentially refers to the practice of influencing choice by changing the manner in which options are presented to people. For example, this can be done by setting defaults, framing, or adding decoy options. Choice architecture often involves a ‘nudge’ (as opposed to some other intervention) that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives (Quigley, 2013). Choice Architecture simply refers to the context in which we choose and make decisions, but this is important because the context itself can influence the way we think and the decisions we make. Thus, where our behaviour changes due to some aspect of the choice architecture which surrounds us, we can be said to have been ‘nudged’.

In addition to the design process itself, ‘design for safety’ should also be considered an important, if not essential feature of any institutional practice, particularly where there is a previous history of unsafe habits. This might include occupational situations as well as numerous everyday social settings; for example in the domestic environment to ensure child safety or in healthcare situations where patient safety is paramount. In these contexts, the concept of designing for safety can be considered to include the design of facilities, processes and products in a way that minimises hazards and risks to the people who will use them.
As an example of patient safety, in 2003 the UK Department of Health acknowledged that
the use of design in many safety-critical industries had produced significant improvements in
safety, quality and efficiency and recommended that a similar approach was now needed
within the healthcare industry. As every year, more than 900 million items are dispensed in
hospitals, community pharmacies and some doctors’ surgeries in England and Wales it was
recognised that potential harm could occur from medicines if patients were not able to easily
identify their medicine, or could not work out how to use it safely and effectively and could
not readily identify any special precautions required. As the majority of medicines are
dispensed for older people or people with long-term medical conditions including mental,
sensory and physical disabilities, a re-think of the design on dispensing methodology was
undertaken to ensure that important information on the dispensing label was presented as
legibly as possible. This led to recommendations for a re-design of the dispensing label so
that it could not obscure important information on the commercial medicine pack, including
the braille labelling intended for patients with poor vision (National Patient Safety Agency,
2007).

The second approach to design for behavioural safety seeks to change people’s behaviour
from involving actions that are largely unsafe, to actions which are less likely to be
associated with risk of harm. This also involves guiding people in a certain way (i.e.
changing their behaviour) to either establish or maintain personal safety indirectly through
design. For example, in the early 1990’s Conoco introduced the STOP (Safety Training
Observation Programme) programme on a number of their gas production platforms in the
Southern North Sea (Fleming and Lardner, 2001). STOP was designed to encourage safety
observations and conversations at the worksite, and allowed the identification and correction
of unsafe trends in behaviour or working conditions. Training and supervisor-led coaching
was used to introduce employees to the five-step STOP “safety observation cycle”, which
involved:

1. **Decide** to make observations;
2. **Stop** or pause during other work, to make time for observations;
3. **Observe** people at work, and working conditions to identify unsafe behaviour or
   conditions;
4. **Act** on observations, for example speaking to a colleague observed working safely or
   unsafely, and providing encouragement or taking corrective action, as required;
5. **Report** observations and corrective actions on using a pocket-sized STOP card, which
   was then handed to a supervisor for review, collation and any further action required.

The remainder of this chapter will focus specifically on the second meaning described
above, i.e. on how design can either directly or indirectly lead to behavioural modifications
which ultimately affect safety. In other words, it will look at how we should consider
designing for behavioural safety as being an important aspect of everyday social and
occupational functioning across a range of situations.

**Design for behavioural safety**

In practice it is not always easy explicitly to design for safety, particularly where risk is
uncertain or actions of individuals are unpredictable. Therefore it is useful to try to affect or
change behaviour so that essentially people act in a manner that is intrinsically and
predictably safe for a given situation or scenario.

*Principles and background theories of designing for behavioural safety*

There are some general principles to designing for safer behaviour: Firstly, behaviour should
be guided so that it operates within the limitations of a particular system so that individuals
do not or cannot exceed those limitations. Secondly, changing behaviour should not be seen as a quick-fix to improving overall safety performance. Behaviour modification strategies should ideally be introduced gradually and should be targeted at specific requirements. Thirdly, interventions that are introduced to secure a more general behaviour change result or are targeted at individuals without taking into account technological, social and environmental influences are unlikely to work. For example, advising motorists to slow down in certain areas for ‘safety reasons’ is usually insufficient without helping individuals to understand the social (and often catastrophic) consequences of what might happen if they did not.

In order to understand these concepts better, it is worth considering how the principles of designing for behavioural safety fit within theoretical frameworks of behaviour change. Behaviour change has become relatively prevalent in general theories of behaviour, and models are largely based on the socio-psychological literature. Such theories encompass a wide range of psychological, social, societal and contextual factors including emotions, habits and routines. The theories of change support interventions by describing how behaviours develop and change over time. Behavioural models are designed to help us understand behaviour and identify the underlying factors that influence it. Therefore an understanding of both aspects is needed in order to develop effective intervention strategies. Some early theoretical models of behaviour change have much relevance to modern approaches to designing for behaviour change and they are now discussed with regard to their applicability and relevance to behavioural safety.

Firstly, the theory of planned behaviour (TPB) is perhaps one of the most widely cited and applied behaviour theories and is one of a closely inter-related family of theories which adopt a cognitive approach to explaining behaviour which focusses on individuals’ attitudes and beliefs. The TPB (Ajzen 1985, 1991; Ajzen and Madden 1986) evolved from the theory of reasoned action (Fishbein and Ajzen 1975) which proposed that intention to act was the best predictor of behaviour. In the safety domain, the Theory of Planned Behaviour probably has limited applicability overall but is does provide the foundation for subsequent models of behavioural change. For example, the Health Belief Model (HBM - Hochbaum, 1958; Rosenstock 1966; Janz and Becker, 1974; Sharma and Romas, 2012) is a cognitive model which supposes that behaviour is determined by a number of beliefs about threats to an individual’s well-being and the effectiveness and outcomes of particular actions or behaviours. Some constructions of the model feature the concept of self-efficacy (Bandura 1997) alongside these beliefs about actions. Perceived threat is at the core of the HBM as it is linked to a person’s ‘readiness’ to take action and perceived benefits associated with a behaviour, (i.e. likely effectiveness in reducing the threat.) This can be weighed against the perceived costs of, and negative consequences that may result from the behaviour (perceived barriers) such as the side effects of treatment, to establish the overall extent to which a behaviour is beneficial. As with the Theory of Planned Behaviour model, the applicability of the HBM to safety in the industrial environment is somewhat limited although it could well be applied in other situations where safety is imperative, such as the domestic environment.

The Stage of Change (SoC) model (also referred to as the Trans-theoretical Model) (Prochaska and DiClemente 1982; Prochaska et al 1992) is a widely applied cognitive model which sub-divides individuals between five categories that represent different milestones, or ‘levels of motivational readiness’ (Heimlich and Ardoin 2008), along a continuum of behaviour change. These stages are (i) pre-contemplation, (ii) contemplation, (iii) preparation, (iv) action, and (v) maintenance. First developed in relation to smoking (and now commonly applied to other addictive behaviours) the rationale behind using a staged model is that individuals at the same stage should face similar problems and barriers, and thus can be helped by the same type of intervention (Nisbet and Gick 2008). Whilst practitioners acknowledge many hundreds of different interventions, the SoC model identifies a key number of ‘processes’ which are most widely used and investigated.
The three models (TPB, HBM, SoC) described above certainly help to explain how behavioural change occurs although their relevance to designing for behavioural safety could be considered as somewhat tenuous. Nevertheless, they do provide a basis for understanding how human behaviour can be altered and therefore illustrate how it is necessary to consider both behavioural theories and design approaches when developing successful interventions that will encourage safer behaviour. What is required is a need to understand more comprehensively the link between behaviour and design.

The need for a systemic approach to designing for behavioural safety

In relation to the models described above, Anderson (2003) observes an increase in the use of behaviour modification approaches to designing for safety. Such modifications generally involve the observation and assessment of certain behaviours of 'front-line personnel' in an industrial context. The rationale behind design for behavioural safety approaches within industry is that accidents are caused by unsafe behaviours and that by modifying the behaviour, changes in safety will eventuate. Such approaches, whilst loosely based on the behaviourist theories described above could be summarised by the statement 'behaviour that is strongly reinforced will be maintained'. There are reports of some successes with such behaviour modification in a range of industrial and commercial environments as well as in everyday scenarios. These approaches have a number of advantages in addition to reducing incidents, including increased communication about safety, management visibility and employee engagement. Whilst such approaches are not necessarily based on what are now recognised Behaviour Change theories, they do illustrate how strategic behavioural change can effectively improve safety. Using the offshore industry (Fleming and Lardner, 2001) again as an example, Time Out For Safety (TOFS) was another technique developed on BP Amoco’s Andrew Platform, which is located in the North Sea. TOFS was designed to encourage all Platform employees to stop any operation if they were unsure about anything or had concerns about safety. It also aimed to encourage employees to take more ownership for their own and others’ safety. TOFS was adopted by the entire Andrew platform six months after platform commissioning and a distinctive feature was its simplicity. The technique provided team members with a mechanism to stop any operation if they were uncertain about anything or had safety concerns. Employees ‘called a TOFS’ by making a “T” sign with their hands and this signal was particularly necessary in noisy environments where it could be difficult to hear colleagues. The technique provided a medium to promote this positive behaviour and made it clear that employees were able and in fact expected to stop a job if they felt this was necessary. Supervisors and managers encouraged frontline staff to call a TOFS by reacting positively and leading by example - on occasions, senior management demonstrated their commitment to TOFS by shutting down the platform for a TOFS.

Continuing with the application of designing for behavioural safety theory, it is thought that not only are many accidents caused by human error as stated above, but that up to 90 percent of all accidents are triggered by unsafe behaviours which tend to interact with other negative features that are evident within a particular system. More often than not, the unsafe behaviour maybe the final action that is needed to cause a failure within the system even though there may have been many other components of the system that had been far from perfect for days, weeks or even years (Heinrich, 1959; Reason, 1990). For example, company operational procedures, equipment maintenance and training of staff, to name three aspects, may in some cases all have been deficient for many years prompting an untrained member of staff to eventually perform an unsafe action leading to an accident. Whilst the unsafe action may have ultimately and directly caused the accident, it is easy to see how the other operational deficiencies within the system would have played their part in this action. So there are concerns that traditional design for behavioural safety approaches applied in industrial contexts could focus simply on the operators, as observed by Anderson
(2004). Whilst as many as 90% of accidents may be caused by ‘human error’, company management often see the ‘human’ in the term human error as referring to the ‘operators’ whereas the actual problem may in fact lie within the company mind-set. Focussing on individual operators (1) ignores the latent conditions (the operational aspects described above) that may underpin accidents all along; and (2) implies that accidents can be prevented simply by operators taking more care. As Anderson maintains, for a design for behavioural safety programme to be successful, it must of course identify at-risk behaviours and then observe them with the aim of encouraging safe behaviours and removing unsafe ones. However, as operational and management decisions can often be excluded from design for behavioural safety approaches it is essential that there is a visible management of safety and that there is a high level of trust between management and employees. Otherwise, any management decision to initiate a behavioural approach to encourage safer behaviour may itself be flawed.

Applications of design for behavioural safety: preventing work-related musculoskeletal disorders

There are as yet few studies, which directly look into how design leads to behavioural safety changes in the occupational health and safety domain. Furthermore, there are factors which can influence adoption of a particular design and, in turn, influence how effective that design is in promoting safety once it has been produced or implemented. Some application of theoretical models of design for behavioural safety, such as those described above, are however evident within the research literature.

For example, Whysall, Haslam et al. (2004) examined a number of strategies designed to reduce the incidence of work-related musculoskeletal disorders (MSD) in a number of organisations. They found that most organisations focused heavily on the physical aspects of work such as force, posture, cycle time, workstation layout, and so on. They also found that, although organisations were generally receptive to such advice aimed at reducing the risks which lead to MSD, the effectiveness of the advice in reducing actual numbers of employees suffering from MSD depended on the organisations accepting and implementing the measures recommended, involving changes of both individual and collective behaviour. They used the example of ‘(safer) ‘Stage of (Behaviour) Change’ theory (Prochaska and DiClemente 1982; Prochaska et al 1992 as listed above) to explain this by commenting that if behaviour change is to take place in this regard, recipients needed to hold positive attitudes and beliefs relating to the desirable behaviour if efforts to effectively achieve change were to be successful. Another factor identified in the study concerned the lack of post-project follow-up to assess the effectiveness of the MSD reduction strategies. This led to uncertainty as to the extent to which certain interventions were effective.

In an attempt to address the lack of post-project follow-up in their first study (Whysall, Haslam et al. 2004), two years later Whysall, Haslam et al. (2006) again utilised the Stage of Change model (Prochaska and DiClemente, 1982 described above) for MSD prevention. However, this time, they evaluated the effectiveness of various interventions at a number of stages following the original intervention. There was an initial evaluation at 6-months’ post-intervention and then follow-up research including repeated evaluations at 15 months and at 20 months’ post-intervention. The organisational and worker surveys used comprised three sections including:

- Demographic characteristics and background information (e.g. size of company, role of respondent, tenure)
- Stage of change assessment
- Attitudes toward reducing MSDs

The worker survey included additional sections:

- Musculoskeletal discomfort experienced in the previous 7 days
• Discomfort rating

The findings of the study were that targeted organisational interventions that were introduced according to the workers’ ‘stage of change’ indeed resulted in significant reductions in MSD, as opposed to workers who followed standard interventions where no reductions in MSD were found. Within the Stage of Change model, the phases include pre-contemplation (resistance to recognising or modifying problem behaviour); contemplation (recognition of the problem, thinking about changing, but not ready to act); preparation (intending to change in the next 30 days, and/or having made specific plans to do so); action (having engaged in behaviour change, no longer than 6 months ago) and maintenance (initiated changes over 6 months ago, working to consolidate gains made and avoid relapse). Prior to the implementation of the interventions, the majority of workers in the tailored intervention condition were in the pre-contemplation and preparation stages (36% and 41%). At 20 months post-intervention the majority were in maintenance (33%). The study supported the view that scope exists for improving interventions, at least for MSD, by targeting advice according to the ‘Stage of Change’ model.

Some of the current literature relating to the theoretical work on avoidance of MSD either through application of the Theory of Planned Behaviour or the Health Belief Model suggests that an improved design alone (for example, a new IT workstation) is not enough to cause behaviour change or affect safety. To counteract this, some effective methods for initiating or helping to develop this change of behaviour have been proposed. One such example is from a recent study by Robertson, Ciriello et al. (2013) amongst workers in two separate groups: (1) those who were trained in safe behaviours for sitting and standing when using workstations and (2) those who were not. Those who were trained were observed to follow the safety guidelines more often than those who were minimally trained. Furthermore the trained group also reported significantly lower amounts of discomfort and MSD across the 15 days of testing. According to these findings, appropriate design along with training on how to effectively use the design can lead to a behavioural change towards safer working practices.

The study could suggest that training can be at the heart of a behavioural change programme and that design is relatively unimportant. However, other recent research is not in agreement with this finding, instead suggesting that training alone is not sufficient to effectively alter behaviour to be more in line with recognised safe practices. There are suggestions that other methods are further required to bring about the desired change. One such method suggested by Sigurdsson, Artnak et al. (2012) was the use of Motivational Interventions. Their study involved training workers in how to optimally set up and use their keyboard for safe operation. The participants were separated into two groups; those who received vouchers as incentives if they were observed to be using their keyboard with a negative tilt-as instructed; and those who received no incentive at all. It was found those who were incentivised applied the best-practice rules when using their keyboard whereas those who were not incentivised made no alterations to its position following the training course. Furthermore, after the discontinuation of incentives, two out of three of the participants continued to use the keyboard in its optimal position. This suggests that incentives may have a lasting effect on safe behaviour even after the incentives have ceased, although this may be rather because it allows people to get into the habit of the correct usage rather than because of any motivation related to the voucher at this stage. This study finds not only that design alone is not enough to change behaviour (most keyboards have the ability of negative tilt but few people use it) but training in a design’s proper usage may still not be sufficient to alter individual behaviour. In turn, this would suggest that it is most effective if a design intervention and a behavioural intervention are applied together, while in isolation they are not sufficient to invoke a sustainable change in behaviour.

In a similar vein Yu, Moon et al. (2013) conducted a study to establish whether designing a system which gave feedback on maintaining a safe-seated postural performance could
influence the extent to which participants altered their behaviour when seated. A chair was designed which automatically monitored performance with regard to best practice guidelines and either gave: 1) no feedback; 2) immediate feedback - whereby a pop-up appeared on their computer informing them of their poor posture; or 3) delayed feedback where feedback on their posture was given by a pop-up at the end of each test session. It was found that both feedback conditions led to improvements in seated posture compared to the no feedback condition. The immediate feedback condition was also found to be more effective in encouraging participants to maintain a safe posture compared to the delayed feedback condition. A similar study by Sigurdsson and Austin (2008) supported these findings and also found lasting effects on maintaining a safe posture even when the level of feedback on performance was reduced. These provide further evidence of the need to support a design intervention with either training or explanation of what is expected when a design intervention is introduced.

All of these studies are important as they suggest that not only is feedback essential for changing behaviour but also that a design which incorporates this feedback can be a particularly effective mechanism to initiating the desired behaviour change and may even lead to prolonged results even when the feedback has been reduced or removed. Furthermore, if the intervention is supported by formal training as well as feedback, then the intervention may yield the most desirable and sustainable results of all approaches.

Applications of design for behavioural safety: risk prevention in the construction industry

Perhaps some of the clearest examples of how design can influence behavioural safety can be found within the construction industry and there are several published studies which examine this in practice. The UK construction industry has attempted to improve the safety of its workers and reduce the number of accidents and deaths within it for many years (Hartley and Cheyne, 2010). Interventions and initiatives have tackled various aspects of risk, ranging through design, elimination, protective equipment, and behaviour. However, the construction industry is still dangerous accounting for typically around 30% of fatal injuries to employees and 10% of reported major/specifed injuries. In Hartley and Cheyne’s study, a number of visual cues which helped to encourage safe behaviour were identified repeatedly, including housekeeping, pedestrian walkways, safety signs, personal protective equipment (PPE) usage and the behaviour of people already on site. Influences on behaviour were discussed through focus-groups involving those working on-site. ‘First impressions’ were thought to impact on risk-taking behaviour amongst the workers on the construction sites by the workers adopting the best safety practices through these initial observations.

Such findings relating to construction sites have potential implications for the general management of safety within the construction industry. They establish the importance of creating an impression of a high level of safety culture at all times. Based on the increased risk of injury and death within the industry, the Health and Safety Executive (HSE, 2012) described the concept of ‘safe by design’ which involves the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of the building or structure being designed. This includes construction, use, maintenance and demolition. It encompasses all design including facilities, hardware, systems, equipment, products, tooling, materials, energy, controls, layout and configuration. The ‘safe by design’ approach begins in the conceptual and planning phases with an emphasis on making choices about design, materials used and methods of manufacture or construction to enhance the safety of the finished product. Ultimately, the Safe by Design concept is a clear example of designing for behavioural safety.
Following the HSE’s lead, numerous organisations now recognise and actively use the principles of ‘safe by design’ within the working environment. The Construction industry in particular is one obvious key stakeholder in this regard but a further clear example of implementation of the general principles of “Safe by Design” can also be found within the UK’s Network Rail (The Rail Engineer, 2012). Within railway operations, closure of the railway network for carrying out work is costly and therefore work carried out in such circumstances normally has strict time constraints. Detailed planning is therefore required to ensure that ‘hand-back’ of the railway infrastructure can be safely achieved. Under such conditions ‘safe by design’ is critical when assessing all aspects of the work to be undertaken. Safety systems for personnel and materials handling must be considered and incorporated into all work designs and those planning the work must consider whether or not a safe system of work can be established that allows the railway to continue running. If a safe and practicable system cannot be identified, then work may need to be undertaken by shutting down the railway network which is costly and creates poor public relations between the industry and the customer.

Applications of design for behavioural safety: enhancing road safety

Another example of design for behavioural safety was described by Lockton et al (2010) in their model of ‘Design with Intent’ (DwI). Within this concept, Lockton et al propose that certain ‘designs are intended to influence or result in certain user behaviour’ including crossing the road at designated locations (figure 3). The starting point of the DwI method is the existence of a product, service or environment - a system - where users' behaviour is important to its operation, or where it would be strategically desirable to alter the way it is used. The goal of the design process is to modify or redesign the system to achieve this: in other words, to influence the users’ behaviour towards a particular ‘target behaviour’. Lockton et al also reviewed examples from a variety of disciplines and whilst many of them relate to changes to encourage sustainable design, there are some obvious safety-related examples. For example, in road safety, several ‘traffic calming’ measures (figure 4) built into the road environment can be thought of as ‘Design with Intent’ since the principle of the design concept is to slow the traffic down (thereby changing driver behaviour towards safety) particularly in a built-up environment. Other road safety measures include pedestrian crossing facilities where the road-users are prevented from crossing the road at undesirable locations through the use of guard-rails and barriers.

The concept of ‘Mindfulness’ is another example where the ultimate goal is behavioural safety achieved through design interventions, especially in social contexts (Niedderer, 2013). It proposes that the benefit of ‘mindful’ design is its ability to shift the focus from an external to internal “locus of control”. The latter enables conscious decision making and commitment in the individual as an essential basis for attitude change and for lasting behaviour change. To once more use road-user behaviour as an example, the principle of ‘shared space’ in road design could be conceptualised in terms of ‘mindful’ design within behavioural safety since it supposes that the road users will take responsibility for both their own safety and also that of other road users when using a particular road junction. In ‘shared space’ environments (figure 5), the control of the road manoeuvre is entirely determined by the actions of the road-users rather than being controlled by conventional traffic engineering measures such as signage, road-markings and signals. This creates a radical behaviour change forcing the users to proceed with much great caution within a shared-space intersection compared to a conventional intersection as the users are ‘mindfully’ aware that all other road-users are in a similar ‘uncontrolled’ situation.
Summary

Overall this review has found that the research area of how design can lead to behaviour change in a safety environment is at this point not a mature research area. There is still a lot that can be explored and that needs to be tested to further aid insight. The current review started by giving an overview of several theories of design for behaviour change which helped to initially establish the foundations on which the research area is built upon. Current literature shows how design can lead to change in behaviour in the safety domain (Grindle et al. 2000 and Wirth, Sigurdsson 2008). The findings of the most appropriate studies were then reviewed illustrated by the studies by Robertson, Ciriello et al. (2013), Hartley and Cheyne (2010), Rail Engineer (2012), Lockton (2010) and Niedderer (2013). Overall it appears that in order to implement effective behavioural changes in the safety domain it takes more than the simple installation of barriers or the implementation of new designs. Instead a more holistic approach involving analysing what stage an organisation or an individual is at, in terms of its readiness for change, effective training in optimal safety practices followed by immediate feedback on performance and positive reinforcement of these practices. This will in turn lead to the most effective adoption of new and ultimately safer methods of thinking and behaving within an organisation.

The review of theories, approaches and examples has shown that design for behavioural safety is an evolving landscape of work that utilises many theories and debates. More ‘traditional’ theories tend to be distinct and sit within either the individual or contextual spaces. Adding design to these traditional approaches and new domains of use perhaps start to lead to theories and approaches utilising the middle ground, which is a more system-based approach where individual and contextual factors are not mutually exclusive.

The review indicates that in the event that a behaviour change in a given situation is desirable or necessary, it is probably not sufficient to try and invoke this through design alone. Rather, the literature suggests that a design intervention design supported by feedback is the most effective approach to initiating the desired behaviour change and may even lead to prolonged results even when the feedback has been reduced or removed. Furthermore, in the event that the intervention can be supported by formal training as well as feedback, sustainable and desirable modifications to behaviour can eventuate. In isolation, neither feedback/training nor design are sufficient to invoke a long-lasting change in behaviour.

1. References


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**Andrew Morris**

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Graham holds qualifications in Ergonomics/ Human Factors at both an Undergraduate and PhD level from Loughborough University. Since qualifying he has progressed to apply his knowledge to a number of diverse research areas and projects. Examples include working on a range of projects in the Transport Safety research area using Human Factors to help prevent road accidents, injuries and fatalities. He is currently working in the area of National Security research, investigating Human Factors issues in the event of a Chemical, Biological, Radiological or Nuclear (CBRNe) incident.
Figure 1: Interior Driver Environment of Lotus 7

Figure 2: Interior Driver Environment of Modern Vehicle Design

Figure 3 - Pedestrian Crossing Facility

Figure 4 - Traffic calming