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Navigating the Safety Culture Construct: A Review of the Evidence

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About the Author
A Chartered Fellow of IOSH, a Chartered Psychologist, a professional member of the ASSE, and an IOSH award-winning author, Dominic Cooper, Ph.D., pioneered the use of Behavioural Safety in the UK on behalf of the British Health & Safety Executive (HSE) while studying his Ph.D. at UMIST in 1989. A prior professor of safety, and a past professor of industrial/organisational psychology at Indiana University, Bloomington, he has authored many books, articles and scientific research papers. Primarily these have been on safety culture, behaviour-based safety and safety leadership, but also include motivation and personnel selection.

EXECUTIVE SUMMARY

Objective
This review has considered the extant literature surrounding safety culture published since 1986. The focus of the review was to ascertain the utility of the safety culture construct in preventing process safety incidents and serious injuries and fatalities (SIFs). The purpose of this report is to summarise the main findings to provide an evidence-based guide in the development of robust Safety Cultures in industry.

Theoretical Findings
Findings show a plethora of definitions are causing confusion within both academe and industry. There is an urgent need for consensus on this issue, and a need for academics to stop re-inventing the wheel.

Three influential models of safety culture were examined: Guldenmund/Schein (2000), Cooper (2000), and Reason (1998). The Guldenmund/Schein three-layered model focusing on visible artefacts, espoused values, and basic assumptions is *not* supported by the evidence. Cooper's reciprocal model of safety culture encompassing psychological, behavioural and situational elements is supported by large scale studies, while Reason's model using inter-locking sub-cultures that lead to an informed culture (equivalent to a safety culture) is also supported by evidence from safety management system research.

Using the International Atomic Energy Agency's (1991) original definition of safety culture as a framework to anchor the review shows:

- Consensus between academe and the results of public enquiries into disasters about the main safety culture characteristics. These should be the main targets to improve organisational safety cultures
- Psychological factors such as attitudes, values, and norms are rarely assessed correctly
- Common significant safety issues to avoid process safety disasters and SIFs are well known, and provide a tangible and robust focus for assessing the safety culture construct.

The above findings are used to provide a clear pathway for improving, assessing, and researching safety culture.

Practical Findings
The extant evidence was subjected to a 'survival of the fittest' test to ascertain any relationships to actual safety outcomes (i.e. incidents and injuries and actual safety behaviour). This shows:

- attitudinal and safety climate surveys exhibit non-existent to weak relationships to actual safety outcomes
- no published studies have assessed the relationships between Values or Norms and actual safety outcomes
- Situational and behavioural factors demonstrate strong and consistent relationships with actual safety outcomes.

It is concluded that the sole use of psychological factors (e.g. attitudinal or safety climate surveys) as a proxy for safety culture is fatally flawed.

The research evidence shows organisations should concentrate 80 percent or more of their safety culture improvement efforts on situational (e.g. safety management *systems)* and behavioural *(i.e. managerial safety related behaviours)* factors to prevent process safety and SIF incidents.

Contents

Introduction

The term 'safety culture' is a social construct that is used by industry and regulators to describe the way that safety is managed in organisations to avoid catastrophes and personal injuries. A construct is defined as an idea, theory, or intellectual creation containing various conceptual elements (i.e. abstract ideas) typically considered to be subjective and not based on empirical evidence.

In the case of safety culture it is true to say that in the 1980's there was no empirical (scientific) underpinning to the construct. Numerous process safety disasters which had caused the deaths of hundreds of thousands of people around the world, and hundreds of industrial workers being killed or maimed every week, pointed to 'an unknown underlying contributor' that, if identified, could help to explain and ultimately improve the situation. In a series of seemingly unconnected events across different industries, the safety culture construct was born to try and explain this unknown.

Over the past three decades much good work has been undertaken by academia, regulators and industry to make the intangible and unknown safety culture construct, known, through scientific enquiry and practical experience. However, despite good intentions, this has resulted in a safety culture typography that is so rich in its multi-faceted confusion and fragmentation that it has led to competing theories, perspectives, strategies, and research methods as well as nebulous results.

The safety culture construct has come to mean different things to different researchers and practitioners depending on their professional discipline (e.g. social scientists, managers, safety practitioners, workers) and the results of their research and/or experience. This has led to the development of various frameworks with which to view, measure, analyse, extract, and assign meaning to the construct.

The safety culture domain is now in a state of crisis. Some influential academics (mostly those from the interpretative tradition) want to abandon the term 'safety culture' altogether, and simply use the term 'organisational culture'. Conversely, industry is looking for clear guidance on how to improve their safety culture, based on valid models, from which practical strategies and methodologies emerge, that are scientifically proven to reduce catastrophic incidents and occupational injuries.

My goal in this review is to try to provide clarity by navigating this typography with a compass heading aimed at true north: how to make use of current knowledge to eliminate serious injuries and fatalities and stop catastrophic disasters.

The Starting Point

The first accounts of lax safety culture appeared following the December 3, 1984 explosion of a Union Carbide plant synthesising and packaging the pesticide methyl isocyanate in Bhopal in the Indian state of Madhya Pradesh (The Christian Science Monitor, 1984). The 'safety culture' phrase was invoked primarily to suggest that national cultures vary in their respect for safety, although in reality the issues were the same regardless of nation.

This was recognised by the US Chemical Industry Association (CMA) in 1985/1986 after a series of similar adverse incidents in the USA. They then adopted guiding principles developed by the Canadian Chemical Producers Association (CCPA) projecting management codes for research, transportation, distribution, health and safety, manufacturing processes, and disposing of hazardous wastes, as well as emergency response to accidents known as Responsible Care (American Chemicals Association, 1992). This was the first formal attempt to improve the culture of safety in an entire industry, and as such CMA mandated all its membership to implement Responsible Care.

The International Nuclear Safety Advisory Group (INSAG, 1986) introduced the term `safety culture' to the nuclear industry in its review of the 1986 Chernobyl nuclear disaster as a way of encapsulating and explaining the organisational errors and operator violations that laid the conditions for disaster. This was the first use of the safety culture construct to address organisational failings within the safety domain.

Three years later, a second reference by the U.S. Nuclear Regulatory Commission (1989) states that plant management '*has a duty and obligation to foster the development of a safety culture at each facility and throughout the facility that assures safe operations'*.

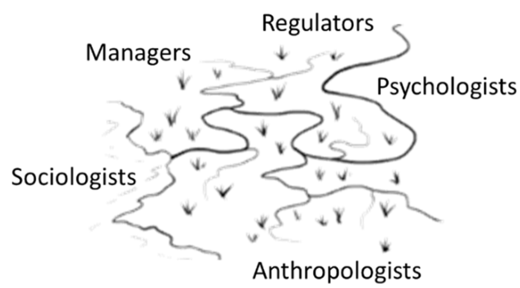
After five years in common usage, a 1991 International Atomic Energy Agency (IAEA) report defined safety culture as '*that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear power safety issues receive attention warranted by their significance*'. The IAEA stressed this statement was carefully composed to emphasise that safety culture is attitudinal as well as structural, relates both to organisations and individuals, and concerns the requirement to match all safety issues with appropriate perceptions and action.

This definition effectively moved the emphasis of safety culture from manifest symptoms (organisational errors and operator violations) to underlying contributors (that assembly of characteristics and attitudes … that … focus on ensuring safety issues receive attention warranted by their significance (levels of risk)). Nonetheless, as Perin (2005) comments in her detailed study of four nuclear power plants, 'Determining that significance [of safety issues] in particular contexts is … the crux of the quandary' (p. 14).

The Safety Culture Swamp

After 30 years work there is still no universal agreement on how to define the safety culture construct, with many rejecting or extending the IAEAs original definition. At the last count, there were 51 separate original definitions of the safety culture construct, and 30 original safety climate definitions in use (Vu & De Cier, 2014)! The safety climate construct (Zohar, 1980) is a very close cousin to the safety culture construct (with the former thought to be a manifestation of the latter at a particular moment in time) and are often used interchangeably in the literature (Gadd & Collins, 2005; Wu et al., 2010).

In this regard, safety culture refers to a durable corporate atmosphere which impacts people's management of safety in an organisation (*the way we do safety around here)* while safety climate is considered to reflect the organisation membership's shared perceptions of the way safety is being managed at a particular moment in time (*what we think of safety right now)*. The sheer number of culture or climate definitions suggests that [a] one definition does not suit all industries, [b] the field is still evolving, or that [c] anthropologists, sociologists, psychologists, etc., continue to vie with one another to get their theoretical viewpoint accepted as the mainstream. In part, the latter may be driven by academes mantra of "publish or perish"!



At the root of this lack of universal agreement is the conflict between interpretive and functionalist views of safety culture. Favoured by social scientists, interpretative approaches treat an organisation as a culture, where the cultural reality is socially constructed by those within the organisation. The emphasis of this approach is to understand the prevailing culture rather than evaluate it, and then (perhaps) come up with functional solutions to address perceived inadequacies. Managers and practitioners tend to favour the functionalist approach which views culture as a variable, i.e. that an organisation has an overarching culture and a number of sub-cultures that can be engineered to suit the prevailing circumstances.

It has been argued that interpretive and functional approaches are simply different sides of the same coin, in that managerial functionalist strategies emerge from interpretative contexts (Waring, 1992). I believe they are reciprocal, with both feeding off each other. If those working in the safety culture arena accept this perspective, most of these (often heated) debates will become redundant, and their efforts could then be directed at solving real world safety problems instead of treating it simply as a theoretical academic exercise. Recent suggestions to treat safety culture as a process rather than as an entity (i.e. a means to an end), that take a holistic look at what happens in organisations (Tharaldsen & Haukelid, 2009) is a move in the right direction.

The definitional discourse and drift from the safety culture constructs *raison d'être* has certainly generated more heat than light (Pidgeon, 1991). The rhetoric is counterproductive. In fact, it seems industry has finally lost patience with academics, and is now going its own way. Similarly, perhaps due to frustration, some influential academics are now calling for the term 'safety culture' to be dropped altogether, arguing the term 'organisational culture' should be used instead (e.g. Schein, Grote, Hopkins, etc.). This foolish course of action won't get us very far, as the wider organisational culture literature continues to experience exactly the same definitional problems and fragmentation (Giorgi et al., 2015). Moreover, if this suggestion were adopted, the priority and significance of occupational safety would be seriously downgraded: it would then be on the same footing as other operational issues such as product quality, etc., where the consequences of getting it wrong are nowhere near as tragic.

In my view, many commentators seem to have simply lost sight of the original purpose of coining the term ‘safety culture’: to promote a corporate atmosphere that prioritises the improvement of occupational safety in organisations. The intention of the safety culture construct has always been to stop low frequency, high severity events such as Bhopal, Chernobyl, Piper Alpha, Texas City, Deepwater Horizon et al., as well as high frequency, low impact events (i.e. personal injuries, etc.).

The confusion (Hale, 2000) caused by this definitional swamp has led to industry and regulators developing their own definitions of safety culture simply to make progress in developing suitable improvement strategies and programs (Vu & De Cier, 2014). As more and more definitions surface, the waters are muddied further, leading to even greater confusion. There is a very real danger of this becoming a perpetual, vicious cycle resulting in more lives lost as practitioners try to grapple with the bewildering array of options. It is time to stop re-inventing this wheel.

In practice, different definitions lead to different ideas about the best means of improving a safety culture, and thus also about the best means of developing (good) safety practices (Reiman & Rollenhagen, 2014). To some extent there are areas of consensus among those attempting to define the safety culture construct; most reflect a proactive stance to improving occupational safety (Lee & Harrison, 2000), and most reflect the way people think and/or behave in relation to safety in a given context (Cooper, 2000). Certainly, the IAEA’s original safety culture definition meets these criteria.

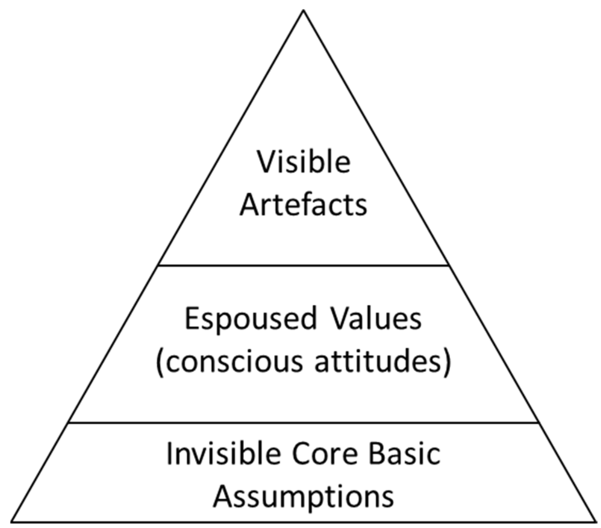
To help drain the swamp, and clarify the construct, it is important to accept that the core of the safety culture construct is about proactively managing safety, thinking positively about safety, and behaving safely: adopting practical approaches that address these may prove more useful for the way forward. For example, when assessing the quality of an entities safety culture we can ask: [a] for evidence that the organisation and its membership are being proactive; [b] in what ways they are being proactive; and, [c] what they think about the effectiveness of what they have been doing to improve safety performance. In this way the safety culture construct and strategic actions become aligned, thereby helping to keep an organisations compass bearing at true north to minimise the likelihood of more man-made catastrophic disasters and people being injured or killed.

The Safety Culture Peaks

During the period 1986 - 2000, researchers attempted to make the safety culture construct more concrete by providing theoretical models. These were [1] Guldenmund's (2000) adoption of Schein's (1992) three-layered organisational culture framework based on anthropology and organisational theory; [2] Cooper's reciprocal safety culture model based on social learning theory (Bandura, 1977); and, [3] Reason's (1998) five inter-dependent sub-cultures (informed, learning, reporting, just and flexible) based on incident analyses. Each of these attempted to provide an actionable and/or assessment framework, and each has been influential in the sense that researchers, regulators and industry have made use of them in some empirical and/or practical capacity.

Guldenmund's (2000) three-layered organisational culture framework

Guldenmund proposes that the safety culture construct has three layers: the bottom layer comprises of core basic assumptions which are unconscious and unspecified (invisible) where suppositions about safety are not articulated, but are taken for granted as the basis for argument or action. The middle layer, predicated on the core basic assumptions, reflects espoused beliefs and values which are operationalised as relatively explicit and conscious attitudes whose target is hardware (safety controls), software (effectiveness of safety arrangements), people (functional groups), and people's safety-related behaviours. Artefacts on the top layer are the manifestation of the previous two layers, which reflect all those visible safety objects (e.g. PPE, inspection reports, safety posters, etc.), from which Schein asserts it would be difficult to comprehend an entities safety culture.



Guldenmund (2000): Safety Culture Model

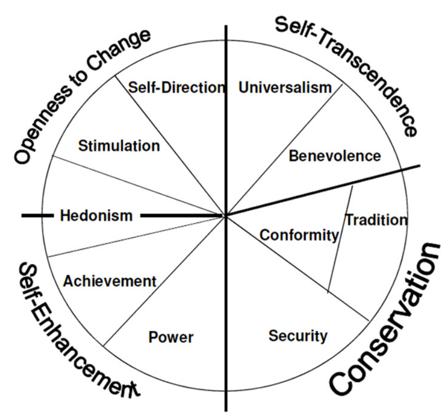
An interpretive view, Guldenmund's model sees 'Culture' as a pattern of basic assumptions, invented, discovered, or developed by a group as it learns to cope with its problems of external adaptation and internal integration. These basic assumptions differ for executives, engineers, and operators, thus the model explicitly recognises the overall organisational safety culture will comprise of different sub-cultures. The emphasis of this model, however, is on understanding an organisations safety culture and what meaning this has to the organisations membership. In practice however, assessments primarily adopt the safety survey approach (sometimes in conjunction with interviews and focus groups) to discover people's attitudes, with relatively few examining visible artefacts. From the assessment results, the core basic assumptions are *inferred* solely by the assessor(s) which has proven to be very difficult, if not impossible (Guldenmund, 2010).

The validity of any inferred core basic assumptions is predicated entirely on the levels of agreement of those who work in the organisation! This highlights how difficult it is to actually identify and understand the safety culture construct (core basic assumptions) using this framework. There are certainly much better tools than safety surveys for making use of this model, such as adaptations of Johnson & Scholes (1992) 'Cultural Web' that focuses on: [a] what the organisation does to improve safety (artefacts); [b] how effective these are at influencing daily events (impacts); [c] why it has these (justifications); why people do what they do (assumptions); and [d] what changes are required to improve safety (solutions).

If organisations are to use this model to assess the safety culture construct, there is an urgent need to derive a working taxonomy of 'core basic assumptions' to create consistency in terminology, attributes, and behaviours at each of the three layers. Original cultural commentators (e.g. Deal & Kennedy, 1982; Hofstede, 1986, 1991) used values at the bottom-layer. These were changed by Schein (1992) to core basic assumptions. Returning to values may be more practical going forward, particularly as Schwartz (2012) has identified 10 distinct basic motivational values that are seen as guiding principles in life, and that apparently are universally recognised across the world. His taxonomy of 10 basic motivational values are:

1. *Self-Direction*. Defining goal: independent thought and action-choosing, creating, exploring.
2. *Stimulation*. Defining goal: excitement, novelty, and challenge in life.
3. *Hedonism.* Defining goal: pleasure or sensuous gratification for oneself.
4. *Achievement.* Defining goal: personal success through demonstrating competence according to social standards.
5. *Power.* Defining goal: social status and prestige, control or dominance over people and resources.
6. *Tradition*: Defining goal: respect, commitment, and acceptance of the customs and ideas that one's culture or religion provides.
7. *Security.* Defining goal: safety, harmony, and stability of society, of relationships, and of self.
8. *Conformity.* Defining goal: restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms.
9. *Benevolence.* Defining goal: preserving and enhancing the welfare of those with whom one is in frequent personal contact (the 'in-group').
10. *Universalism.* Defining goal: understanding, appreciation, tolerance, and protection for the welfare of all people and for nature.

Schwartz also specifies the dynamic relations among them i.e. some values conflict with one another (e.g., benevolence and power) whereas others are compatible (e.g., conformity and security). If basic core assumptions truly are the safety culture, it should be possible to describe safety cultures and sub-cultures according to a taxonomy of values, by seeking evidence of the attributes contained in their defining goals. For example, where there is evidence of the values of tradition, conformity, security, benevolence, and universalism, an assessor *might* be able to grade that organisations safety culture (every organisation already has one) as being good (depending on the relationship to actual safety performance), compared to others, for example, that predominantly display value clusters related to power, achievement, hedonism, stimulation, and self-direction.



Schwartz (2102): Dynamic Clusters of Values

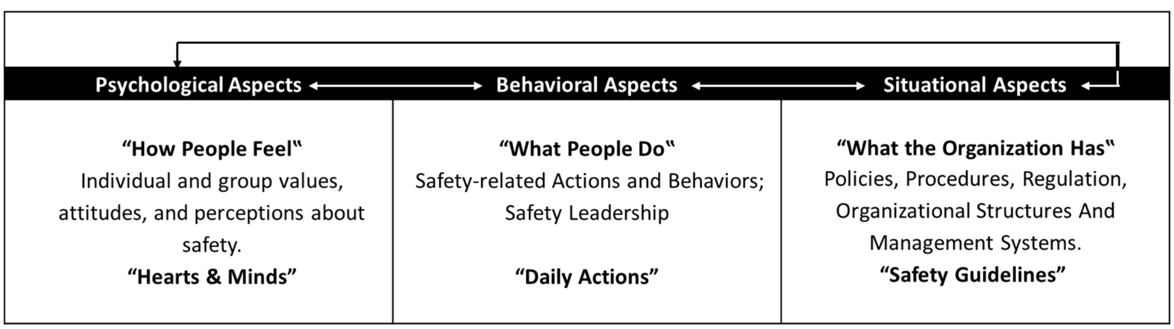
In other words, assessors potentially could identify those values predominantly *shared* by the majority of the organisation's membership in locations where there is a history of good safety performance, and compare these with the predominant values held by those where occupational safety performance has been less than stellar (e.g. Perez-Floriano & Gonzalez, 2007). While recognising that different organisations approach safety differently, academics and practitioners may be able to ascertain the ideal set of values in given circumstances that contribute to an excelling safety culture. Regardless of whether Schwartz's particular values will serve that purpose, the main point is the need to make the ‘invisible core basic assumptions’ visible, or replace them with values if this approach is to be anchored to the safety culture construct.

A particular criticism of this safety culture model is that it assumes there is a simple, unidirectional relationship between assumptions and attitudes, and between attitudes and behaviours (Cooper, 2000). This simple cause-effect model has been shown to be completely inadequate in regards to accident prevention (Lund & Aaro, 2004): Based on 596 interventions, much stronger effects are found when the situation is changed to influence behaviour, with weak effects being found when attitude modification attempts are made to influence behaviour. Likewise, the magnitude of change in attitudes and perceptions does not necessarily match the magnitude of actual changes in employee’s safety behaviour (Cooper & Phillips, 2004; Webb & Sheeran, 2006).

The major criticism of this model is that the use of invisible core basic assumptions and/or attitudes as a measure of culture change, means these now become the central core of the safety culture construct. This means a change in assumptions and/or attitudes equals a change in safety culture, rather than changes in organisational safety systems and people’s proactive behaviour to influence safety performance (effective safety leadership, hazard reduction, reduced incident rates, etc.). This is a real problem when people’s lives and an organisations assets are at stake. Let me be very clear: in the absence of clear goals and action, simply changing people’s safety attitudes and basic assumptions will not stop workplace disasters and occupational accidents!

Cooper’s (2000) reciprocal safety culture model

Treated as a sub-culture of an organisations overall culture, the reciprocal model highlights that the safety culture construct is the *product* (Schein*, 1992*) of multiple goal-directed interactions between internal psychological factors, overt behaviour(s), and situational workplace aspects. Viewed from this perspective, the prevailing organisational [safety] culture is reflected in the dynamic reciprocal relationships between: members' perceptions about, and attitudes towards, the operationalisation of organisational [safety] goals; members' day-to-day goal-directed safety behaviour; and the presence and quality of the organisation's safety systems and sub-systems to support the goal-directed behaviour.

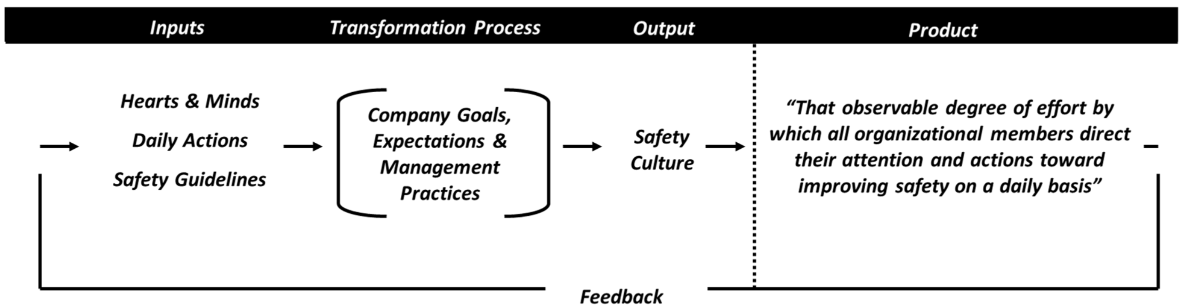


Cooper (2000): Reciprocal Safety Culture Model

A functionalist view, the potency of the Reciprocal Model for locating `culture' resides in: [1] its provision of a holistic view of the organisations efforts to improve safety; [2] its explicit recognition that the relative strength of each source may be different in any given situation: e.g. the design of the production system (situation) may exert stronger effects on someone's work-related behaviour than that person's attitudes; [3] its dynamic nature that suits the measurement of human and organisational systems which operate in dynamic and uncertain environments (Dawson, 1996); [4] its triangulated measurement methodology with which to encourage multi-level analyses (Jick, 1979) of the safety culture construct; [5] its explicit recognition that achieving safety culture excellence is goal-orientated.

The reciprocal safety culture model has been supported by large-scale studies on accident prevention (Lund & Aaro, 2004) or safety culture (Fernández-Muñiz et al., 2007; Cooper, 2008; Lefranc et al*.,* 2012) showing it provides a viable practical approach for organisations to improve their safety culture and safety performance to optimise accident prevention.

Building on his original model, Cooper's (2002) business process model of safety culture treats the psychological, behavioural, and situational aspects as the inputs to the safety culture construct, with the key transformation process being the organisations goals, expectations, and managerial practices (i.e. leadership) to create the prevailing safety culture product. Indeed, this exact approach has been formally adopted by the American Petroleum Institute (2016), and treated as a standard by the American National Standards Institute (ANSI).



Cooper (2002): Business Process Model of Safety Culture

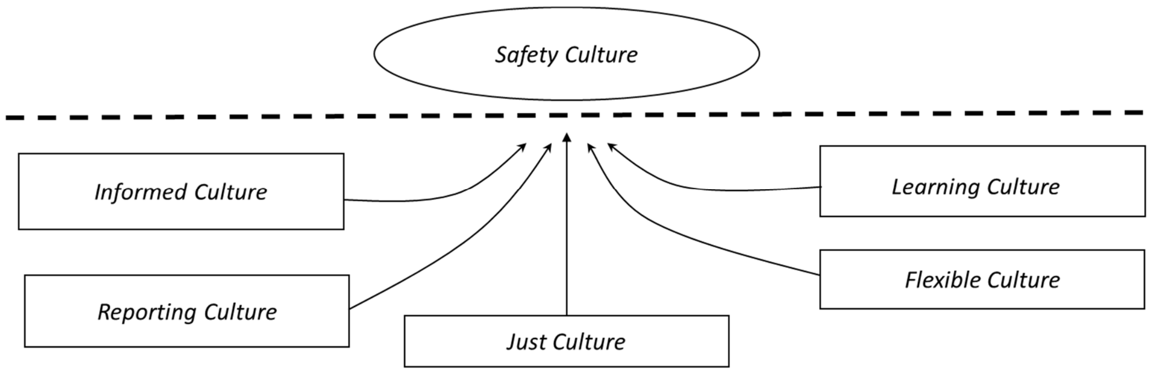
Defining the safety culture construct as a product serves a number of purposes. First, it helps to determine the functional strategies that would be required to develop the product. Second, when we understand safety culture as a product, we develop a better sense of how to measure the degree to which an organisation has a good or poor safety culture. Outcome measurements, in turn, counteract unsystematic and fragmented approaches when researching the safety culture construct (Meany, 2004).

The safety culture product was defined by Cooper (2000) as '*that observable degree of effort with which all organisational members direct their attention and actions towards improving safety on a daily basis*'. This definition is consistent with the existing consensus about the core features of the safety culture construct: being proactive – in a goal directed way, and the way people think about and behave toward safety. On many levels, it also keeps the compass bearing at true north as [a] the product is focused explicitly on the organisation's and people's routine activities to actually improve safety, and [b] is a variable that can be frequently and regularly tracked over time (i.e. assessing the effort that people put into improving safety). This product is now being used in the patient safety culture domain to good effect (e.g. Vogus & Sutcliffe, 2007).

The reciprocal safety culture model has not been without criticism about the behavioural aspect of the model. Anderson (2005) asserts that focusing on safety-related behaviours may draw substantial resources and attention away from process safety issues: unfortunately the underlying root cause of 80 percent of process safety disasters is a lack of appropriate managerial safety-related behaviours (Collins & Keely, 2003, Wood, 2013) rather than equipment failures. Hopkins (2002) notes that behavioural modification approaches do not include managers, tending to focus solely on workers front-line activities. Primarily, both concerns are intervention design issues (Cooper, 2009), not conceptual criticisms, with strong evidence showing they are unwarranted. The impact on accident prevention is substantial when both managerial and worker behaviours are simultaneously addressed (e.g. Cooper, 2006a, 2006b; 2010). To keep a compass heading of true north it is imperative that industry is concerned with the behaviour of both management and the workforce, but recognise that the behavioural targets for each will differ.

Reason's safety culture model

Primarily aimed at preventing organisational, as opposed to individual accidents, Reason (1998) proposes that a safety culture is the product of various other sub-cultures (Sub-culture is a term that can be used interchangeably to refer to a sub-group of people (i.e. department, workgroup) and an aspect of culture itself (e.g. safety culture is a sub-culture of corporate culture)). He categorically states safety culture is not a unitary construct, it is made of a number of interacting elements.



Reason (1998): Safety Culture Model

A functionalist view, Reason equates safety culture with an `informed culture', where members of the organisation understand and respect the hazards facing their operations, and are alert to the many ways in which the system's defences can be breached or bypassed. In short, an informed culture is one in which people, at all levels do not forget to be afraid; they know where the 'edge' is without having to fall over it. To be informed requires that there is a reporting culture, which in turn relies on the presence of a centralised safety information system that collates and analyses data from incidents, near-miss reports, and other sources (behavioural observations, workplace inspections, etc.), and translates that information into knowledge, so that it can be widely disseminated (e.g. Carthey et al., 2001). This requires a learning culture where there is willingness and competence to draw the right conclusions from the safety information system. Based on this, a flexible culture is required where there is the will to implement major reforms when the need is indicated. However, the reporting culture is itself dependent on a just culture (how an organisation handles blame and punishment for actual or perceived transgressions). Reason asserts that trust lies at the heart of any safety culture.

To some degree Reason's sub-cultures are objects of, and the processes that create the safety culture product: an informed culture. In terms of maintaining a compass bearing of true north, Reason's model of interlocking management systems and approaches clearly takes organisations in the general direction they want to go to stop catastrophes and personal injuries (e.g. Reason, 2005).

The Safety Culture Forest

It is vital that organisations identify the focus of their safety culture improvement and measurement efforts so they are aligned and more likely to impact safety performance. To do this it is helpful to go back to the IAEA's original definition of safety culture and use is as a framework to explore its constituent parts: '*that assembly of characteristics and attitudes in organisations and individuals which establishes that, as, an overriding priority, …. safety issues receive the attention warranted by their significance*'. Questions to explore include: [a] what are the assembly of characteristics? [b] What is an attitude? [c] what are the significant safety issues?

'That assembly of characteristics….'

In occupational safety there are an almost infinite number of characteristics that can influence safety performance, and hence the prevailing safety culture. Guldenmund (2000), for example, stresses these could be related to hardware (safety controls), software (effectiveness of safety arrangements), people (functional groups), and people's safety-related behaviours. These may be universals or industry specific.

Table 1: Common Characteristics of Safety Culture/Climate

Characteristics	Academic Summary	Results of Public Inquires
Management / Supervision	i. Management attitudes, commitment, and actions regarding safety, (Senior, Middle, and Front-line management) ii. Management concern for employee well-being	i. '*Ineffective leadership*', where leadership and the prevailing corporate culture prevented the recognition of risks and opportunities, leading to wrong safety decisions being made at the wrong time, for the wrong reasons ii. '*Blame Culture*', so that problems remained hidden as they were driven underground by those trying to avoid sanctions or reprimands
Safety Systems	i. Effectiveness of safety communication within the organisation ii. Availability of safety instructions iii. Availability of personal protective equipment iv. Status of safety people and safety committees within an organisation	i. *'Miscommunicating*', where critical safety information was not relayed to decision-makers and/or the message had been diluted ii. *'Ignoring 'lessons learned'*, where critical safety information was not extracted, shared, or enforced
Risk	i. Employees risk perception ii. Satisfaction with safety measures iii. Control over one's own safety on the job iv. Beliefs about accident causation	i. *'Inattention to Risk'* - Not recognising, down-playing or dismissing the significance of particular hazards and risks
Work Pressure	i. Perceived status of safety targets relative to production pressures ii. Effects of the required work pace iii. Effects of job induced stress, iv. Conflict among co-workers	ii. '*Profit coming before safety'*, where productivity always came before safety, as safety was viewed as a cost, not an investment
Competence	i. Importance and effectiveness of safety training,	i. '*Competency failures'*, where there were false expectations that direct hires and contractors were highly trained and competent
Procedures/Rules	i. Existence and effectiveness of safety rules and procedures	i. *'Non-compliance'* to standards, rules and procedures by managers and the workforce

Given the sheer scale of this dense forest, there is a danger that academics and practitioners won't see the wood for the trees as they try to target and influence everything to do with safety to improve the safety culture. Hale (2000) suggests the issue should be approached by asking what the construct does not include, which is a very difficult question to answer with any degree of certainty (which adds to confusion). However, a slightly different and more pragmatic approach is to identify that much smaller number of common underlying contributors to a safety culture rather than an overwhelming number of precursors, simply to reduce the number of factors to manageable levels.

To separate the wood from the trees, academics summarised the entire safety climate literature (Flin et al*.,* 2000) and identified six main characteristics thought to reflect the important contributors to a safety culture. These were: [1] management/supervision, [2] safety systems, [3] risk, [4] work pressure, [5] competence, and [6] procedures and rules. Grounded in the real world, a recent analysis of public enquiries into industrial process safety disasters identifying the common features of a broken safety culture revealed a similar list (Cooper & Finley, 2013).

The high degree of correspondence between the two sources suggests these are the main characteristics that the IAEA's original safety culture definition alludes to (see table 1), indicating they are the main underlying contributors and, therefore, industry's main targets to improve organisational safety cultures. Fixing one underlying contributor can fix a multitude of issues. So, in this part of the forest at least, there is a high level of clarity and agreement between theory and practice.

'***and attitudes in organisations and individuals which establishes that as an overriding priority …'***

An attitude is a psychological construct referring to a habitual mode of regarding anything (i.e. a consistency) and is always toward some 'object' or characteristic (e.g. safety as a whole, or particular aspects of safety such as compliance to rules and procedures). One single attitude is comprised of four separate components: a cognitive component (i.e. a consciously held belief or opinion), an affective component (i.e. an emotional tone or feeling), an evaluative component (i.e. positive or negative), and a conative component (a disposition to act).

It is now, perhaps, easier to understand why attitude change rarely leads to actual behaviour change in the safety culture domain. Imagine having to try and influence or change these four components for every single 'object' encompassed within the safety culture construct. Now add in that you have to do this for every single individual in an organisation. That's difficult in a relatively small company, but imagine if they are geographically dispersed across various cities, countries, and continents! This is why maintaining a bearing of true north is so difficult when attitudes become the central core of the safety culture construct.

The key question is 'which attitudinal component(s) are actually relevant to the safety culture domain that will make a difference?' The IAEA (1991) clearly viewed the *evaluative* and c*onative* components as key: Evaluative in the sense that a safety issue could be seen to require attention (i.e. bad), and conative in terms of a disposition to act to fix the problem(s). This perspective subsequently led to many safety improvements in nuclear facilities world-wide (see Carnino & Weimann, 1995). Adopting this limited approach to the attitude construct, could, therefore, be the wisest approach.

There are numerous surveys in the academic/practitioner arena that purport to measure safety attitudes. In reality, very few do: many focus on satisfaction with aspects of occupational safety (e.g. I am content that managers are constructive when dealing with safety problems), on safety-related behaviours (e.g. I am encouraged by my colleagues to report any safety concerns I may have), or perceptions about current safety management practices (e.g. my managers show they care about my safety). Thus, many safety culture 'attitude' surveys are actually safety climate 'perception' surveys.

It is important to note that the safety climate construct primarily refers to molar perceptions of current safety practices (Zohar, 1980), not attitudes. If attitudes are considered to be the core of the safety culture construct, logically it follows that perceptions cannot then be used as a proxy for measuring the safety culture construct (although the bulk of published studies claim that is exactly what they do). This type of muddled thinking adds to further confusion within the safety culture domain.

If attitudes truly are the manifestation of the safety culture construct, then researchers and practitioners need to seriously re-think how 'attitudinal' safety culture surveys are developed so they can be measured. Safety culture surveys need to be aimed at organisational/management, group, and individual levels; they need to be aimed at key safety culture 'objects' or 'characteristics'; they must not be conflated with perceptions, feelings of satisfaction, or behaviours; and, they should simultaneously target each of the four components of an attitude (i.e. cognitive, affective, evaluative, and conative): at the very least researchers should specify which ones they are using in their work. If this is not done, the domains compass heading to true north will be seriously affected and everyone will end up in more *cul-de-sacs* (as seems to be the case over the past three decades or so).

However, explicitly recognising that industrial/occupational safety is a social activity (Cooper & Findley, 2013), the central tenet of the safety culture construct for many practitioners, regulators, and academics, is that it refers to a '*pattern of shared beliefs, attitudes, values, and norms for groups*' that affect and influence the way individual group members think and behave. The degree to which any of these are actually shared within an organisation and across functional areas is debateable (e.g. Richter & Koch, 2004). Additional psychological variable to explore, therefore, include the concepts of values, norms and perceptions.

Values

What is a value? Schwartz (2102) summarises these as '*socially desirable concepts used to mentally represent goals and the vocabulary used to express them in social interaction, and are seen as guiding principles in life'*. Discussing the nature of values he asserts they contain six features: [1] values can be seen as beliefs (in a sense, therefore, the base of attitudes and values are the same); [2] values refer to desirable goals; [3] values transcend specific actions and situations; [4] values serve as standards or criteria; [5] values are ordered by importance; and [6] the relative importance of multiple values guides action. With six separate functions, there is considerable opportunity for confusion to creep into the way the 'value construct' is used in the safety culture domain. Unless the term is used with precision there is a danger everyone will end up in even more *cul-de-sacs*.

In practice, this means there has to be a consistency in the way the six features of a value are operationalised and used, whether by practitioners, regulators or researchers. For example, when treating safety as a value (e.g. Cooper, 2001), there is a responsibility to identify what is meant across all six features: for example, [1] *belief* - good safety is good for business; [2] *desirable goals* - our goal is to keep the product in the pipe (process safety), and achieve/maintain a zero total recordable incident rate (personal safety); [3] *Transcendent* - nothing we do is worth getting hurt for; [4] *Standard/Criteria* - we will not do anything that puts people and assets at risk; [5] *Importance* - safe production is our number one priority; and [6] *Action Guide* - if there is any doubt, safety wins out. Readers may come up with their own translations, but if a true north compass bearing is to be maintained, it is imperative that the six features of a value are specified, that all are aligned with each other, and that they are consistently acted upon.

Norms

What is a norm? Reber (1985) defines it as "*any pattern of behaviour or performance that is typical or representative of a group or a society*". For example, living in an igloo is a typical pattern of behaviour of the Inuit Nation that is not typically found in other nations, and therefore helps to define them culturally. As with all things psychological, norms break down into three sub-types: *subjective norms* (i.e. the pressure that people perceive from important others to perform, or not to perform, a behaviour); *descriptive norms* (i.e. perceptions of significant others' own attitudes and behaviours in the domain); and *behavioural norms* (the consistency of a behaviour being enacted among a group of people – i.e. the way people do things around here).

Descriptive norms seem to exert a bigger influence on behaviour than subjective norms (Manning, 2009). In the safety domain, it appears a co-workers behaviour and attitudes will influence a group member's compliance and proactive safety behaviour much more than those exerted by supervisors (Fugas et al., 2011). This points to a real need to more fully engage the workforce in safety by creating a 'safety partnership' between leadership (i.e. managers & supervisors) and employees (Cooper & Finley, 2013; Cooper, 2015) to truly affect and influence the safety culture and safety performance. Doing so will help organisations maintain a compass heading of true north, even if they don't always get everything else right.

Perceptions

The IAEA's inclusion of attitudes in its safety culture definition explicitly *'concerns the requirement to match all safety issues with appropriate perceptions and action'.* In the safety culture/climate domain, perceptions refer to a way of regarding, understanding, or interpreting how safety management is being operationalised in the workplace, at a particular moment in time (Byrom & Corbridge, 1997).

It is commonly assumed that these perceptions have a psychological utility in serving as a frame of reference for guiding appropriate and adaptive task (safety) behaviours (Schneider, 1975; Zohar, 1980), but the evidence is not clear. On the one hand, perceptions of the importance of safety training appear to predict actual safety behaviour (Cooper & Phillips, 2004). On the other hand, positive perceptions about fall protection standards and policies have been associated with greater levels of observed noncompliance to fall protection controls (Neitzel et al., 2008). Thus, the inter-relationships between perceptions about safety, their function as a frame of reference, and their influence on actual safety behaviour are not as clear as commonly assumed, with much more work being required to establish the truth of the matter within the safety culture domain.

Summation of that assembly of attitudes …

So, is it possible to see the wood for the trees in the psychological part of the forest? Well, it is very clear that the scale of the issue is much bigger and more complex than many may have realised. It also reveals that a sole focus on psychological factors as the means of revealing the prevailing safety culture is going to continue to be fraught with difficulty. For example, it has been learned that the constructs of attitudes, values and norms each comprise of various sub-concepts: four within the attitude construct; six within the values construct; and three within the norm construct. This means there is a minimum of 13 concepts to measure and assess to help reveal an organisations safety culture. If these psychological concepts are to be assembled in a coherent way to improve safety cultures, each will have to be precisely defined and aimed at the main characteristics (objects) of safety culture, and tailored to given contexts (e.g. industry). At the very least, precisely defining what is being examined would be extremely helpful for eliminating confusion and facilitating understanding of the safety culture construct going forward.

In practice, we must simplify. In my view, going back to the basics and simply focusing on what people think about the way safety is being managed at a particular moment in time (i.e. measure perceptual safety climate), and how proactively people behave to improve safety (i.e. behavioural sampling on a frequent and regular basis), and using the safety culture *product* as the outcome measure, we might just find we can maintain our compass heading to true north and actually make a difference. Both perspectives would reveal any required situational features detrimental to good safety performance (systems, processes, etc.) requiring change that can then be addressed.

'safety issues receive attention warranted by their significance…..'

Process safety is concerned with keeping the product in the pipe, so the pertinent issue here is Loss of Primary Containment (LOPC). Studies into the causal factors across process safety incidents (e.g. Collins & Keely, 2003; Christou & Konstantinidou, 2012; IAEA, 2014; Wood, 2013; Gyenes & Wood, 2014; Wood, & Gyenes, 2015) appear to show that '*80 percent of LOPC's are commonly caused by managerial behaviours*, *or lack of*'; and, that 80 percent of process safety disasters occur during normal routine everyday operations (64%) and maintenance (16%). With a depressing similarity of causes across the studies, Table 2 highlights that we do know what the significant safety issues actually are (e.g. Perin, 2005), and that this knowledge can be put to good use to maintain a compass heading of true north.

Table 2: Common Safety Culture Characteristics and Process Safety Incidents

Safety Culture Characteristics		Common Underlying Causes of Process Safety Incidents
Management / Supervision	i.	*Leadership* - Failure to adequately plan activities
	ii.	*Leadership* - Failure to adequately manage safety of operations
	iii.	*Leadership* - Failure to be adequately prepared for an incident
Safety Systems	*i.*	*Communication* – Failure to communicate
	ii.	*Ignoring 'lessons learned'*, - Failure to learn from accidents and from near-misses
	iii.	*Facility Design* - Failures in the design of plant, equipment and processes
	iv.	*Management of Change* – Failure of management of change/ risk analysis practices
	v.	*Asset Integrity* - Material conditions were not at the expected standards
Risk	i.	*Risk Appraisal* - Failure to properly identify risks
	ii.	*Risk Appraisal* - Deficiencies were not systematically identified and reported
	iii.	*Risk Appraisal* - Failure to recognise and address significant corrosion of a tank or pipework
	iv.	*Risk Assessment* – Failure to conduct risk analysis prior to maintenance
	v.	*Risk Control* – Failure to implement procedures
	vi.	*Risk Control* - Failure to avoid ignition of released hydrocarbons
	vii.	*Risk Control* - Failure to protect vulnerable areas from the impact of explosion
	viii.	*Risk Control* - Failure of primary and secondary barriers
	ix.	*Risk Control* – Failure to inspect plant/facilities
Work Pressure	i.	*Human Responses* - Too much reliance on human responses when under pressure
	ii.	*Lack of Maintenance* - Lack of resources and competing pressures
Competence	i.	*Training Provision* – Failure to fully train personnel and contractors
	ii.	*Competence Assessment* – Failure to secure and assess competence
	iii.	*On-the-job Competence* - Failure to recognise and react to early warning signals
	iv.	*On-the-job Competence* - Failure to adequately respond to the incident
	v.	*On-the-job Competence* – Failure to operate equipment properly and/or misused
	vi.	*On-the-job Competence* –Failure to complete isolations properly
	vii.	*On-the-job Competence* – Failure in emergency response
	viii.	*On-the-job Competence* – Failure in the activation of the internal emergency plan
Procedures/Rules	i.	*Absence of Procedures* - Lack of written procedures altogether
	ii.	*Quality of Procedures* - Procedures as written are unsafe
	iii.	*Procedural Compliance* - Non-adherence to operational guidelines
	iv.	*Procedural Compliance* - Good safety practices were not respected by employees for maintenance activities
	v.	*Monitoring of Procedural Compliance* - Failure to monitor Permit-to-Work standards
	vi.	*Procedural Reviews* - Insufficient audit and review of procedures particularly following accidents and near misses

With each common cause aligned to its appropriate safety culture characteristic, Table 2 shows the major targets to help stop process safety disasters (as I write, another 13 people are killed and 123 injured in an explosion in Mexico stemming from a loss of primary containment, underlining how important it is that the issues pertaining to the safety culture construct are quickly resolved).

Importantly, each of the common causes and safety culture characteristics relate to specific aspects of typical safety management systems and their sub-elements such as that contained in ExxonMobil's Operations Integrity Management System (OIMS). Thus, there are clear, tangible and readily accessible targets, as opposed to opaque individual psychological components such as fatalism, job satisfaction, etc., which are distracting and adversely affect safety culture research.

It has been noted that many large scale process safety disasters (Piper Alpha, Buncefield, Texas City, Macondo, etc.) occur on facilities with very low personal injury rates. Calling into question Heinrich's (1931) 'Accident Triangle' (Peterson, 1989; Hale, 2002; Manuele, 2008), this observation has led to a re-examination of incident triangles to identify the precursors and exposure categories (Wachter & Ferguson, 2013) and underlying contributors (Cooper, 2014) of potential serious injuries and fatalities (SIFs): these are categorised as life-threatening and life-altering events (Massachusetts Department of Public Health, 2005, 2007).

A focus on potential SIFs helps 'raise the bar' as it requires a change in philosophy from solely focusing on those events that led to an actual injury (*a reactive response*) to examining events that potentially could have led to an SIF - *a proactive response*. Making use of this work, and the work of others (e.g. Hobbs & Williamson, 2003; Haslam et al*.,* 2005; Celik & Cebi, 2009), Table 3 shows the common significant safety issues related to personal injuries and potential SIFs, nested within the safety culture characteristics.

Comparisons of Tables 2 and 3 show there is a striking similarity to those that have caused process safety issues. As such, these issues provide a tangible, robust, and valid focus for assessing the safety culture construct.

Table 3: Common Safety Culture Characteristics and Personal Safety Incidents

Safety Culture Characteristics	Common Underlying Causes of potential Serious Injuries and Fatalities
Management / Supervision	i. *Leadership* - Failure to adequately plan activities ii. *Leadership* - Failure to manage safety of operations adequately
Safety Systems	*i.* *Poor Communications* – Inadequate instructions or failure to communicate *ii.* *Poor Job Standards* – Not setting appropriate standards to guide activities iii. *Inadequate Job Methods* – Failure in design of job methods
Risk	i. *Risk Appraisal* - Poor working environment ii. *Risk Assessment* - Failure to conduct pre-job risk assessment iii. *Risk Control* – Provision and use of sub-standard equipment
Work Pressure	i. *Extreme Job Pressures* - Too much reliance on human responses when under pressure ii. *Insufficient Manpower* – Not enough people allocated to tasks iii. *Insufficient Resources* – Required resources not in right place at right time
Competence	i. *Lack of Competence* – Insufficient training of personnel and contractors
Procedures/Rules	i. *Absence of Procedures* - Lack of written procedures altogether ii. *Quality of Procedures* - Procedures as written are unsafe iii. *Procedural Compliance* - Non-adherence to operational guidelines

To assess the impact of the safety culture construct on eliminating process safety issues and personal injuries, there needs to be very clear links between any safety culture improvement initiatives and actual safety outcomes: i.e. lagging indicators (past history) and leading indicators (predictive activities) that are expected to be positively affected in the future (e.g. Brown, 2009; OGP, 2011; Cooper & Finley, 2013; Campbell Institute, 2015). With the focus on the significant safety issues nested within each of the safety culture characteristics, there should be much stronger relationships between the results of safety culture assessments and safety performance. In turn this should help eliminate the likelihood of process safety disasters, in addition to serious injuries and fatalities.

Summation of the safety culture forest

When all the above evidence is brought together, it becomes apparent that there is a very clear path through the safety culture forest.

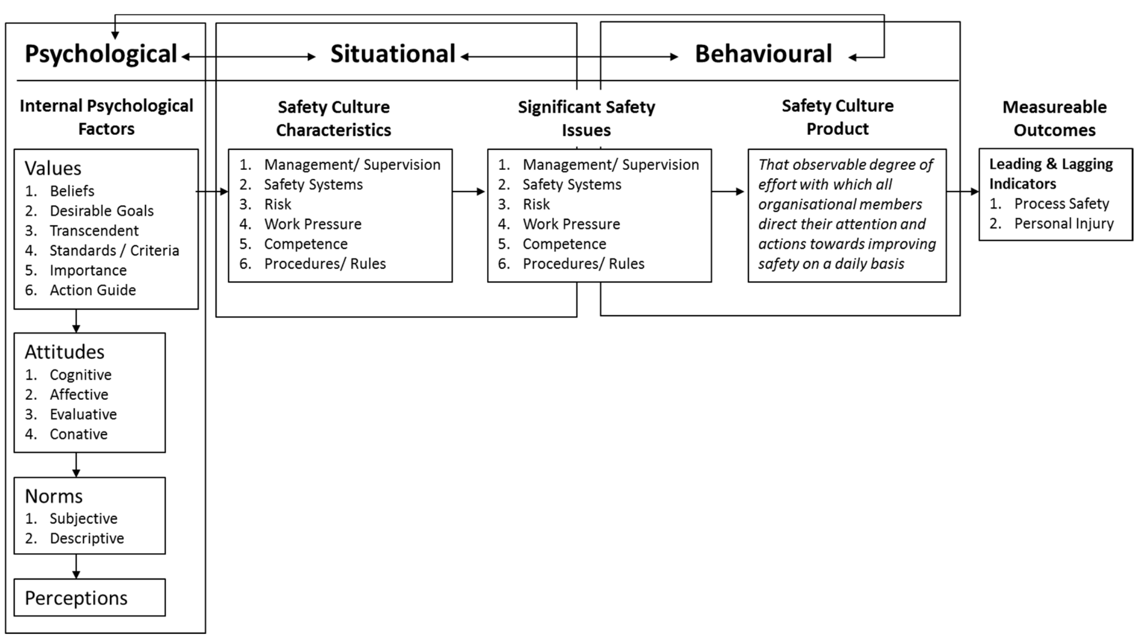
First, we see that the IAEAs '*assembly of attitudes'* could also encompass goal-driven values, cognitive-behavioural norms, and perceptions. Any work using these variables should ensure they explicitly include all of their appropriate sub-components.

Second, whichever psychological variable is being used for assessment, their object(s) should be targeted at the six common safety culture characteristics. This should be done by targeting the significant safety issues nested within each characteristic with survey and/or focus group questions, safety management system audits, and behavioural sampling (i.e. behavioural observations).

Third, any intervention should be assessed against the safety culture product (i.e. that observable degree of effort by which everyone is controlling the significant safety issues contained within each safety culture characteristic on a daily basis). In other words has the intervention led to people putting in more effort to improve safety performance?

Fourth, goal-setting research shows us that the more specific the goal, the bigger the impact (Berson et al*.,* 2014). As such, the safety culture characteristics, significant safety issues, and/or the safety culture product should each be specifically linked to specific process safety indicators and/or personal safety indicators. Ideally this would include both lagging and leading indicators.

It is simply not good enough to just correlate safety culture assessment results with global process safety or personal safety incident rates (e.g. Process Safety Event Rates; Total Recordable Incident Rates) as the ability to assess specific relationships to clearly demonstrate the utility of the safety culture construct on impacting outcomes is lost. For example, identifying which safety culture characteristic exerts the largest influence on the safety culture product. Achieving this can help inform industry about the most effective practical safety culture strategies to improve safety performance.



Revised Reciprocal Safety Culture Model clarifying the pathways of the safety culture construct

The Safety Culture Valley of Death

To keep the safety culture compass heading aimed at true north, it is essential that current safety culture knowledge is put to the ultimate test: to ascertain if the safety culture construct or its associated concepts, have a demonstrated ability to prevent catastrophes or serious injuries & fatalities.

To facilitate this test, the following standards were applied to the extant safety culture/climate research literature. If the data showed an associated safety culture concept had [1] demonstrable and reliable relationships to actual safety outcomes, they were considered survivors of the test; [2] weak and inconsistent relationships to actual safety outcomes, they were considered critically wounded; [3] no demonstrable relationships at all, they were considered to be dead; [4] no evidence at all to substantiate it, they were considered to be missing in action. The benefit of this 'survival of the fittest' approach is the clarity that establishes [1] exactly what progress is actually being made in the safety culture domain, and [2] the direction to true north.

The survival of the fittest test is presented in the same sequence as that displayed in the revised safety culture model: Psychological factors, Situational Factors, and Behavioural factors.

As the test focused solely on the relationships between a safety culture concept and actual safety outcome data, the first casualties were all those studies that used self-report data. Many safety culture/climate research studies have used self-report incident histories and safety behaviours as proxies of actual safety outcome data. All of these 'proxy' type of studies carry the twin diseases of [a] common-method variance problems where a general inflation across all correlations would be expected (Clarke, 2010), and [2] social-desirability response problems that tends to result in inflated mean scores (Paulhaus, 1989), which infect and contaminate subsequent results. Although this means the bulk of the safety culture work completed to date by numerous researchers over the past 30 years or so has been put to the sword, it does offer the singular advantage of providing clarity about the impact of the safety culture concepts on actual safety performance, without the noise.

Psychological Factors

Safety Climate Perceptions - Incidents/injuries

Despite a purported relationship of safety climate survey results to actual outcomes (Zohar, 2010), researchers have struggled over the past three decades to identify clear evidence that links safety climate to actual safety performance (Goodheart & Smith, 2014; Leitão & Greiner, 2015).

Representative of the extant literature, the following show the vast majority of published studies have not even assessed this relationship. For example, Colla et al., (2005) in the health care setting, showed only 1 of 9 published safety climate studies being linked to patient safety outcomes. They concluded that managers would be remiss if they anticipate that measures of patient safety climate reliably indicate patient safety outcomes. Similarly, a review of safety climate studies by Flin et al., (2006) reveals only 4 of 12 studies correlated their results with outcome measures. They concluded there was a lack of explicit theoretical underpinning for most questionnaires, with many not reporting standard psychometric criteria such as reliability and validity data. Christian et al., (2009) shows only 5 out of 90 studies assessed safety climate against actual recorded injuries. In aviation, a review of 23 studies by O'Connor et al., (2011) shows only 2 attempted to establish a relationship with actual incident rates. An excellent review (Kessler & Larson, 2016) of the extant literature on the relationship between Patient Safety Climate (PSC) on Hospital Acquired Infections (HAI), found no studies contained data linking PSC with HAI patient outcomes.

In sum, of 141 studies reviewed, only 12 (9%) attempted to establish a relationship between safety climate and actual safety outcome data, which is a damming indictment of the quality and validity of most scientific research into the safety climate concept to date.

Where safety climate scores have been assessed against incident data, meta-analytic reviews (e.g. Clarke, 2006) find negligible relationships with past incidents. Beus et al., (2010) found previous injury history was better at predicting safety climate, than safety climate was at predicting injuries! In a large scale study, Smith et al., (2006) with a sample of 41,608 respondents across 19 industries, initially showed that safety climate was positively related to workers' compensation injury rates, but when adjusting for the hazardous nature of the industry, the relationship disappeared entirely.

Payne et al., (2009) found safety climate was more strongly related to future incident rates (typically after a 5 month time lag or so). However, to even entertain the idea that safety climate is predictive of future incident rates (e.g. Zohar, 2003) is to misconstrue or exaggerate its effects. A safety climate assessment is simply a snapshot of the workforce's view about safety at a given time (Flin et al., 2000). What such relationships truly show is that as a result of a safety climate assessment, goals were set and actions taken to fix any problems identified: it is these goals and actions that are predictive of future performance (Locke & Latham, 1990), *not* the safety climate 5 months prior! This is shown in a study without follow-up goals: Dyreborg & Mikkelsen (2003) showed enterprises with the highest survey scores subsequently experienced more accidents than other groups. Conversely, enterprises experiencing no accidents in the follow-up period had the lowest survey scores. Clearly, the above evidence shows that safety climate is a weak and inconsistent indicator of incident rates. As such, the safety climate concept is currently considered to be critically wounded and in need of urgent surgery.

Safety Climate Perceptions - Safety behaviour

Given the major underlying assumption of many that safety climate determines safety behaviour, this relationship was put to the test with *actual observed behaviours*. A few studies (e.g. Johnson, 2007, Zohar 2000, 2002; Zohar & Luria, 2004, Zohar et al., 2104) have attempted to establish safety climate - behaviour relationships, by assessing the impact on behaviour a few months after measuring safety climate. Thus, on flawed methodological grounds, because they have not measured behaviour and safety climate at the same time, these studies are also put to the sword and excluded to eliminate noise. A few studies (e.g. Fang & Wu, 2013) were also excluded because there was no analysis of this relationship, even though data was collected at the same time.

Only three studies were found that measured safety climate and safety behaviours at the same time, again a sad indictment of the scientific research in this domain. Glendon & Litherland (2001), distributed a safety climate measure and observed actual behaviour in road construction and maintenance, but did not find any relationship. They attributed this to differences between the targets of subjective and objective measures. A longitudinal study by Cooper & Phillips (2004) simultaneously measured safety climate and actual safety behaviour during two distributions, 12 months apart. Employee's perceptions of safety climate were associated with safety behaviour at the time of each distribution. However, management actions and the importance of safety training were the only two safety climate topics consistently associated with actual behaviour during both distributions. The results also showed the magnitude of change in both safety climate and behaviour over a 12 month period do not necessarily match: Less behaviour change was associated with greater change in climate scores in three departments. Greater behavioural changes was associated with lower climate change scores in two departments, with only one department showing positive changes for both. Similarly, Neitze et al., (2008) examined aircraft maintenance engineer's exposure to fall hazards and safety climate. The results indicated that safety systems (situational factors) are very important in reducing noncompliance with fall protection requirements in aircraft maintenance facilities. Site level fall-safety compliance was found to be related to safety climate, although at the workgroup level higher safety climate scores were positively associated with lower compliance scores. Observed fall-safety compliance was also found to differ from self-reported compliance (hard evidence that self-report studies are unreliable). The available evidence shows that safety climate is a weak and inconsistent indicator of safety behaviour. Once again the safety climate concept is considered to be critically wounded.

Safety Values - Incidents/injuries
Exploring the literature for studies that measured people's values about safety to ascertain the extent to which they are related to actual safety outcomes or safety behaviour reveals only two studies. One study (Colley et al., 2103) was found that attempted to relate quantified safety values to *self-reported* safety outcomes. Another study (Reiman, 2007), with sound methodology that also reported the incident rates of three nuclear facilities over a number of years decided not to explore the link between the values and incident rates. As such, the 'values' concept is considered to be missing in action.

Attitudes - Incidents/injuries
Almost 100 percent of the attitude – incident studies used self-report measures, and are, therefore, excluded. One study (McDonald et al., 2000) collected data but did not analyse the relationship. A meta-analytic study (inclusive of self-reports) found attitudes were weak at predicting involvement in work accidents (Clarke, 2006), with a personality variable (agreeableness) showing a stronger relationship with incidents than either safety attitudes or safety climate perceptions. The attitude – incident relationship is, therefore, also considered to be critically wounded.

Attitudes - Behaviour
Exploring the attitude – behaviour relationship, Itoh et al., (2002) found no relationship between attitudes to incident reporting and actual event reporting. Lund & Aaro (2004) in a large scale study, found weak effects when attitude modification attempts were made to influence behaviour. Webb & Sheeran (2006) conducted a meta-analysis of 47 experimental causative (as opposed to correlational) studies. They showed that moderate to large changes in behavioural intentions (attitudes) across a number of domains only provided small to moderate changes in associated behaviours (and suggested most of this change was related to the effects of subsequent interventions (i.e. goals and action). Thus the attitude concept is again rated as one of the critically wounded.

Norms - Incidents/injuries
The use of the word 'norm' appears in many definitions of safety culture, and associated studies, but no published work could be found relating either subjective or descriptive norms to actual incidents or injuries, or other concrete safety outcome data. What research there is (e.g. Fugas et al., 2011) is based entirely on self-report data. Similar to values, the concept is used a lot, but there is no hard evidence to support any assertions made about 'norms' in the safety culture domain. As such, in terms of the test, 'norms' are considered to be missing in action.

Situational Factors
Safety management systems (SMS) are integrated organisational mechanisms designed to control health and safety risks, ongoing and future health and safety performance, and compliance to legislation (Cooper, 1998). The safety management system (SMS) can be considered as a systematic and comprehensive process for proactively managing safety risks that integrates operations and technical services with financial and human resource management. As such they lead to focused goals and actions that would be expected to reduce incidents (Paas et al., 2015).

Safety Management Systems - Incidents/injuries
An examination of the extant literature exploring the impact of an SMS on outcome data, shows that when a formal safety management system is installed, safety performance tends to improve. Tzannatos & Kokotos (2009), for example, compared the pre and post introduction of the International Maritime Organisation (IMO) Code regulating safety at sea from 1993-2006, and demonstrated that incidents had reduced post-introduction. A process safety example, Chevron's (2102) Operational

Excellence Management System (OEMS) outcome data from 2004-2011 shows reductions in their Total Recordable Incident Rates (TRIR), spills, emission rates, and refinery effluent exceedances. Companies certified to international standards (i.e. OSHAS 18001) tend to demonstrate that performance improvements follow: they help to improve safety conditions at the workplace, and show significant improvements in safety performance and labour productivity (Abad et al., 2013). A key element of their effectiveness for reducing incidents appears to be the auditing and review process (Shannon et al., 1997; Mearns et al., 2003). In sum, changing and optimising the situation by the introduction of a formal SMS that codifies and guides people's behaviour helps to significantly reduce the conditions for a process safety disaster and personal injuries. As such, they clearly survive the test.

Behavioural Factors

Behavioural Factors - Incidents/Injuries

There is a large body of work deliberately aimed at improving worker safety behaviour (e.g. Grindle et al., 2000; Sulzer-Azaroff & Austin, 2000) across a multitude of industries (e.g. Foods, Manufacturing, Oil & Gas, Chemical, Petrochemicals, Shipping, etc.), commonly termed behavioural safety or behaviour-based safety (BBS). Meta-analysis shows very large demonstrable impacts on both safety behaviour and injury rates (Cooper, 2009), although there are differences in the magnitude of impact between intervention designs, and settings (i.e. static versus dynamic). Nonetheless, these results hold for large-scale construction projects involving tens of thousands of third-party nationals (Cooper, 2010) and smaller scale projects in patient safety (Cooper et al., 2005). There are no reported studies specifically aimed at process safety behaviours and incident outcomes. Clearly, however, behavioural approaches aimed at improving safety behaviour and reducing injuries are highly successful (if applied correctly). Behavioural factors, therefore, also survive the test.

Summation of the survival of the fittest test

In sum, it would appear safety culture research to date has mirrored the charge of the light brigade, where 670 British Calvary mistakenly charged the main Russian guns at the battle of Balaclava in 1854 during the Crimea War: researchers have sent around a 1000 or so poorly constructed psychological safety climate surveys into the safety culture battle. The 'survival of the fittest' test shows that the concepts of safety climate and safety attitudes are critically wounded: they both have weak and inconsistent relationships with adverse incidents and safety behaviour. Research on values and norms regarding safety are simply missing in action: there is no data examining their relationship to actual safety incidents or safety behaviour. The ensemble of evidence presented above shows the minimal relationship of psychological factors to concrete safety outcomes. The claims for these psychological concepts, therefore, are still outstripping the evidence for their utility (Cox & Flin, 1998).

Importantly, this also means the sole use of psychological factors as proxies for the safety culture construct are fatally flawed. The survival of the fittest test shows they will not prevent process safety catastrophes and serious injuries & fatalities. If relied upon catastrophic incidents will continue to happen, as shown by the real example of the Deepwater Horizon in 2010: the results of a safety climate assessment indicating the platform had a strong safety culture, were presented to platform personnel one month before the disaster!

Relatively unscathed, the survivors who live to fight another day are the situational and behavioural domains: both consistently show demonstrable results in terms of reducing incidents and injuries. The common underlying contributors for both safety management systems and behavioural safety domains is structure, goals and action (Locke & Latham, 1990), respectively corresponding to situational, psychological and behavioural factors.

Safety management systems tend to be strategic and are designed to influence the behaviour of the entire organisations membership. Behavioural approaches tend to target specific behaviours, known to cause incidents/injuries in specific aspects of the organisations operational areas. In combination, they exert a significant positive impact, especially when actionable goals are set to provide focus.

Reinforcing the notion that ‘organisational (safety) culture’ can be defined as ‘the way we do things around here’, organisations should place 80 percent or more of their safety culture improvement efforts on changing the situation to optimise desired behaviours to maintain a true north compass bearing. The psychology will take care of itself.

In other words, organisations should develop the safety structures/systems which will influence people’s safety-related behaviours. In turn, to reduce any cognitive dissonance (Festinger, 1957), people will automatically adjust their way of thinking to reduce any tension/discomfort between the way they think and behave. Safety climate perception surveys can then simply be used as a diagnostic tool to uncover situational and behavioural improvement opportunities rather than using them as a ‘proxy’ for the safety culture construct itself.

The Long and Winding Safety Culture Road

Changing an organisations safety culture is not a quick and easy task. It takes a ‘*consistency of purpose, focus and execution’* from all concerned over an extended period of time (Schein says up to 20 years). Like all large scale enterprises, it is best to divide the task into smaller and manageable discrete strategies (Cooper & Finley, 2013).

The evidence for significant safety issues has shown that *management activities and behaviours* are where 80 percent of the significant process safety and personal injury safety issues mostly arise. A major shift from most organisations workforce centred safety activities, the *purpose*, therefore, has to be to target and change managerial behaviour at all levels so that their priority is truly given to safe production.

This can be achieved by *focusing* on the six common safety culture characteristics and the causes of the associated significant safety issues, nested within each, using proven methodologies and tools. Table 4 highlights evidence-based activities shown to address specific causation areas of process safety and potential SIFs. These activities can also serve as outcome measures to validate the effectiveness of any interventions and as input measures for the safety culture product: ‘that observable degree of effort…’ i.e. the frequency with which the issues are addressed can be quantified and developed into a composite measure of effort appropriate to different parts of the organisation.

As each solution is *executed*, organisations need to continually monitor goal progress in all of these areas to ensure the goals are achieved. They can then use the safety culture product ‘that observable degree of effort ….’ to assess safety culture change in each of these areas: i.e. are people putting more effort into safety than before?

Table 4: Common Safety Culture Characteristics with samples of culture change actions

Safety Culture Characteristics	Sample of culture change efforts to help avoid process safety incidents and potential SIFs
Management / Supervision	i. *Leadership* - Appoint safety champions from executive teams and a facilities senior management team (Williams et al., 2014) ii. *Leadership* – Conduct pre-job planning for all abnormal and routine activities at organisational, departmental, and workgroup levels (Cooper, 2015) iii. *Leadership* – Conduct frequent tours in the workplace. (Luria et al., 2008; O'Connor & Carlson, 2016) iv. *Leadership* - Consult with the workforce on safety matters (Clark & Ward, 2006) v. *Leadership* - Conduct regular emergency preparation exercises (Flin et al., 1996)
Safety Systems	*i. Communication* – Monitoring goal progress by physically recording progress and regularly making results known to all organisational members (Olive et al., 2006) ii. *Communication* – Senior managers conduct monthly meeting on safety with all line managers (Mearns et al., 2003) iii. *Communication* – Introduce weekly communication cycle about safety issues, incidents and dangerous situations in toolbox talks (Hale et al., 2008) *iv. Ignoring lessons learned* - Conduct thorough root cause analyses/act on the findings *v. Ignoring lessons learned* - Conduct post-task debriefings (Wolf et al., 2010) vi. *Job Methods* - Redesign job methods to optimise safety and maximise productivity (Swinstead, 2004; Al-Jasmi et al., 2014) vii. *Management of Change* - Assess all MOC requests related to same equipment/process together, not in isolation (Cooper & Findley, 2013) viii. *Asset Integrity* – Monitor Preventative Maintenance program actions (Bevilacqua et al., 2009; Marquez & Gupta, 2006)
Risk	i. *Risk Appraisal* – People identifying and reporting activities/equipment that could go wrong (Hale et al., 2008; O'Connor & Carlson, 2016) ii. *Risk Appraisal* - HSE Auditing and Inspections (Mearns et al., 2003; Wood, & Gyenes, 2015) iii. *Risk Assessment* – Systematically conduct pre-task Risk Assessments iv. *Risk Control* - Identify all ignition sources during pre-job tasks and isolate (Puskar, 2015) v. *Risk Control* - Conduct infrastructure design effectiveness reviews (Nolan, 2014) vi. *Risk Control* –Regularly inspect plant/facilities (Jovanovic, 2003)
Work Pressure	i. *Human Responses* - Identify and fix human error traps (Reason, 1995) ii. *Lack of Maintenance* - Provide all necessary maintenance resources (Eti et al., 2004) iii. *Lack of Maintenance* - Prioritise maintenance activity by risk (Noroozi, 2013)
Competence	i. *Training Provision* – Provide financial and educational resources (William's et al., 2014) ii. *Training Provision* – Encourage people to regularly talk about their mistakes to learn from them and identify any early warning signals that things might go wrong (Jahn, 2016) iii. *Training Provision* – Train line managers to be safety coaches (Utvik et al., 2016) iv. *Training Provision* - Provide team communication training and Introduce multiple educational sessions, awareness campaigns, and reminder tools for expected communication standards (Lingard et al., 2004) v. *Training Provision* - Train people until they cannot get it wrong (Ericsson & Ward, 2007) vi. *Competence Assessment* – Use BBS to assess on-the-job competence (Cooper, 2009) vii. *On-the-job Competence* – Provide emergency incident training and test peoples on-the-job responses (Flin et al., 1996)
Procedures & Rules	*i. Absence of Procedures* – Identify gaps in written procedures (Laurence, 2005) ii. *Quality of Procedures* - Ensure procedures are clear and concise (Jahn, 2016; Laurence, 2005) iii. *Monitoring of Procedural Compliance* - Monitor Permit-to-Work standards (Khan et al., 2010) iv. *Procedural Reviews* – Conduct workforce reviews of procedures to ensure they are safe (Laurence, 2005)

Discussion

Industry and Safety Culture Practice

The evidence has shown that both formal safety management systems and behavioural-based safety processes have a clear demonstrated impact on reducing adverse incidents. This was not true for psychological variables such as values, attitudes, norms and perceptions.

This review highlighted six common safety culture characteristics that both academe and public enquiries into disasters have identified independently from each other, and agree as being important. As such, these could and should provide a consistent focus for safety culture interventions across industry and academe.

Each safety culture characteristic is also a core element of certified safety management systems (e.g. OSHA(S) 18001) and each is known to be consistently associated with both process safety disasters and SIFs. A decade of research by different regulators and others examining the common significant safety issues that result in process safety and personal injury incidents has identified that various managerial behaviours (or the lack of) are consistently the root cause(s) in approximately 80% of cases. Thus, managerial behaviour must become the main target of safety culture interventions, although it is very important to also engage employees in the safety effort within a safety partnership (Cooper, 2016).

Based on this evidence, a clear pathway for improving and/or researching safety culture emerged by linking values, attitudes, etc., (internal psychological aspects) to the safety culture characteristics (situational aspects) and significant safety issues (behavioural aspects), to the safety culture product (i.e. that observable degree of effort …), which in turn is linked to actual safety outcomes (leading and lagging indicators).

In terms of improving safety culture in the real-world, the review has provided a high degree of clarity, than was, perhaps, known hitherto. Clearly, different organisations will approach the significant safety issues in different ways, in light of their country, industry, policies, risk appetite, structure and resources. Nonetheless, this review has also led to the collation of evidence-based solutions focused on management systems to bring about desired managerial behaviours, nested within each of the safety culture characteristics. Readers may want to consider these in their ongoing efforts to control process safety and SIFs.

Academe and Safety Culture

Unfortunately, this review has also shown the theoretical and academic safety culture domain is currently in a state of crisis. First in terms of theoretical approaches, and second in terms of the quality of safety culture research.

Safety Culture Theory

First, endless counterproductive debates about how to define the safety culture construct continue to cause considerable confusion within both academe and industry. Perhaps due to frustration, some influential academics are now urging industry to abandon the construct altogether, while industry itself is crying out for ’real world’ answers based on good science.

Clearly the purpose of a definition is to provide a consistent framework for action, with which to guide specific improvement strategies and achieve positive outcomes (Reiman & Rollenhagen, 2014). As such, one generally agreed upon definition would be most useful. The mechanism for reaching such agreement is unclear at this time, but perhaps the world’s safety bodies (i.e. OSHA, EU-OSHA, British HSE, Safe Work Australia, etc.) could/would take a role in driving and facilitating this.

In the meantime, I would suggest researchers and practitioners simply go back to the IAEA's original definition "*that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, safety issues receive attention warranted by their significance*". This definition is practical and clear in its intent: it reflects the need to proactively manage safety (Lee & Harrison, 2000); encourages people to think positively about safety; and encourages people to behave safely (Cooper, 2000). Moreover, as demonstrated by this review, making use of its three constituent parts has provided a clear pathway to action for industry and is, therefore, useful for directing future academic research.

Second, although influential among many safety culture researchers and industry, the interpretive view of safety culture is *not* supported by the evidence. Conversely, the functionalist view of safety culture that incorporates organisational systems and structures, goals and action which help increase the effort people put into improving safety *is* clearly supported by the evidence.

The primary problems with the interpretative approach to safety culture seems to be related to poorly conceptualised criteria and its over-reliance on nebulous psychological variables, and a lack of field research linking any work to actual safety outcomes. A major criticism of this approach is that it relies upon and asserts that changes in people's values, attitudes, and assumptions equates to safety culture change. This review of the evidence has shown these variables have not been clearly related to safety outcomes. With the best will in the world, in the absence of goals and action, just changing attitudes etc., will not stop process safety disasters or serious injuries & fatalities (SIFs). As such, major remedial work is required if this approach is to be linked to actual safety outcomes. Without such demonstrable linkages, the utility of the interpretative approach for improving safety culture and safety performance will always be questionable. This will ultimately lead to even greater fragmentation and confusion in the safety culture domain, mirroring that found in the organisational culture domain (e.g. Giorgi et al., 2015).

Safety Culture Research

First, academic safety culture research has too often overlooked the main safety culture characteristics. It has been clear for a long time from both academic work and the results of public enquiries, what the main safety culture characteristics are. Importantly, these are universally applicable to all workplace settings, which means they can provide a consistency in approach across all stakeholders if used. Unfortunately, research has splintered to such an extent that the extant body of evidence has become fragmented and is now littered with unrelated and distracting variables (fatalism, job satisfaction, psychological safety, etc.). How such variables are supposed to help industry stop process safety disasters and SIFs is unclear. At the very least all safety culture researchers should incorporate the six main safety culture characteristics into their work before adding any others they may find interesting.

Second, the measurement of safety culture/climate has also suffered from the conflation of attitudes, values, norms, and perceptions to such an extent that it is now difficult to untangle the knots. This is important because the results of such poorly developed research instruments can steer other academics and industry into more *cul-de-sacs*. As they go forward, it is imperative researchers and practitioners are very precise about what variables they are measuring, and ensure these include all the associated components of those variables in their measures. Attempts should then be made to assess any linkages between them and actual safety outcomes.

Third, this review has provided evidence of the significant safety issues commonly involved in process safety and/or personal safety issues. However, many working in the safety culture/climate domain have not been clear about the significant safety issues they were attempting to address, how their work influenced these, how their assessment/intervention methods were linked to them, what the actual safety outcomes were, and how their measures related to these. Journal editors and reviewers should ensure such information is contained within manuscripts for publication before acceptance.

Fourth, the review has shown that despite more than 30 years' work, safety culture/climate surveys have clearly failed to demonstrate consistent linkages to actual safety outcomes. This affects their utility in preventing process safety catastrophes or serious injuries & fatalities. Therefore, the sole use of safety surveys as a proxy for safety culture is fatally flawed.

Part of the problem with the safety culture/climate domain is that too many researchers have not maintained their self-discipline with content validity by ignoring the measurement of the known core safety culture characteristics. Focusing on these will help to build a consistent, comprehensive and standardised body of evidence that would facilitate standardised comparisons as we go forward. Moreover, past results have been confounded by the widespread use of self-reported violations, incidents, and safety behaviour as criterion validation measures instead of actual safety outcomes. From personal experience, one of the major difficulties here is that organisations frequently refuse to provide any outcome data to establish any relationships. As such, there is a major opportunity here for industry to help establish the validity of the safety climate construct by providing such data to those conducting safety culture/climate surveys in their organisation.

Without a doubt, perceptual surveys can be useful diagnostic tools as they can help to reveal significant safety issues. Goals can then be set, and actions taken to address the issues. However, the science involved in the safety culture/climate domain leaves a lot to be desired, and must be drastically improved if the domain is to make real progress.

Fifth, in light of the findings of the survival of the fittest test, safety culture assessments would be much better served by combining the results of situational safety management system audits, behavioural sampling efforts (e.g. behavioural safety metrics), and the results of safety climate surveys to produce an overall average score for a facility/organisation. The results could then be graded against safety culture maturity models (e.g. Fleming, 2000; Parker et al., 2006; HSE, 2011) to benchmark their assessment results with others in industry. These are typically divided into 5 safety culture maturity levels that specify an organisations level of effort (e.g. Beginning, Developing, Performing, High Performing, and Excelling) as it progresses on its safety culture improvement journey. Although no validity data is currently available for them (a major area of opportunity), Safety Culture Maturity models could also be used as a *de facto* measure of the safety culture product as they primarily focus on what organisations do.

Conclusion

In conclusion, it is pertinent to reiterate '*theory without practice is sterile and practice without theory is blind*' (Engels, 1886). This review has examined theoretical aspects of the safety culture construct, and made use of them to evaluate the extant body of evidence to identify ways forward for both industry and academe.

Industry and academe have a joint role to play in validating the safety culture construct: Industry by informing academics what they actually want, and facilitating their needs by providing access and all necessary information; and academics by doing high-quality research in the real world so that industry can achieve its safety culture goals.

It is hoped the findings of this review enable all stakeholders to make better use of the safety culture construct to prevent both process safety incidents and serious injuries and fatalities as we go forward.

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