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**Cognitive issues associated with process safety  
and environmental incidents**

*Report No. 460  
July 2012*





# Publications

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## Acknowledgements

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### Revision history

Version	Date	Amendments
1	July 2012	First issued
1.01	July 2012	Amendment to Figure 3, page 8

# Executive Summary

OGP's Human factors Sub-Committee (HFSC) has studied the cognitive issues that are often associated with process safety and environmental incidents in the global oil & gas industry<sup>†</sup>.

A focus on engineering issues alone may not be sufficient to prevent future incidents. The role of people in the operation and their support of safety-critical systems requires significant attention in parallel with engineering solutions. A better understanding of the psychological basis of human performance is critical to future improvement.

The purpose of this document is to raise awareness among OGP member companies of the important contribution that cognitive issues can have to process safety and environmental incidents. The document summarises some of these issues and sets out recommendations to improve their management within the industry.

The report focuses on issues operating at the individual level as well as issues arising from the interaction between individuals. It concentrates on some of the psychological processes involved in the perception and assessment of risk and of the state of an operation, on associated reasoning, on judgement and decision making and on inter-personal behaviour. Psychological issues operating at the organisational level – such as safety culture and safety leadership – are outside the scope of this report.

The report discusses four main themes:

- Situation awareness
- Cognitive bias in decision-making
- Inter-personal behaviour
- Awareness and understanding of safety-critical human tasks

The lessons learned and the potential improvements in these areas apply as much to the level of operations management as to front-line operations.

There is experience managing these issues both within the oil & gas sector and in other high-hazard industries, a deeper understanding can make a very significant contribution to improving safety. This will in turn improve their management and may help oil & gas companies to become higher-reliability organisations, i.e. to further develop a sense of mindfulness and the state of chronic unease that can contribute to an improved ability to detect and respond effectively to weak signals of heightened risk.

This report makes three recommendations. The scope of the recommendations covers not only front-line operators, but also the client company and contractors involved in making or supporting real-time operational decision making. The recommendations are:

1. OGP members should review options for ensuring independent challenge to safety-critical decisions within their own operations.
2. OGP members should review practices used to maintain real-time awareness of safety margins. This should consider practices and tools in use within the oil & gas industry, as well as practices used in other high hazard industries.
3. OGP members should work towards adopting practices to identify and understand safety-critical human tasks. They should also work on the operational and management practices that should be in place to ensure operators are able to perform these tasks reliably. That means, for example: avoidance of distractions; ensuring alertness (lack of fatigue); design to support performance of critical tasks in terms of use of automation, user interface design and equipment layout; increasing sensitivity to weak signals and providing a culture that rewards mindfulness when performing any safety critical activity.

In addition, OGP is producing a syllabus and recommended content for training in non-technical skills appropriate for drilling and related well operations.

<sup>†</sup> OGP has not focused on any particular process safety or environmental incident in drafting this report, but instead has considered the industry's historical experience with such events.

# 1 Introduction

OGP's Human factors Sub-Committee believes that improved understanding and management of the cognitive issues that underpin the assessment of risk and safety-critical decision-making could make a significant contribution to further reducing the potential for the occurrence of incidents. The Committee established a working group with the purpose of summarising some of the key cognitive issues that can lead to failure in operational risk assessment and real-time decision making.

This document sets out the issues identified by the working group, and makes a number of recommendations. The report discusses how well understood cognitive characteristics can affect how people behave and make decisions in the face of uncertainty in complex, time-limited, critical operations.

The purpose of this document is therefore to raise awareness of these issues among the OGP member companies. There is significant potential for learning and improvement within the industry, starting with increased awareness of the psychological basis of human performance.

Note that this report does not attempt to provide either a complete or a comprehensive review of all of the cognitive and wider psychological factors that can have a significant influence on human behaviour<sup>†</sup>.

The report discusses four themes:

- Situation awareness
- Cognitive bias in decision-making
- Interpersonal behaviour
- Awareness and understanding of safety-critical human tasks

The first three are concerned with non-technical human skills, while the fourth is concerned with organisational preparedness for critical operations.

These themes all have a degree of psychological complexity to them. This report tries to strike a balance between explaining the issues in a way that will be meaningful to those who do not have professional training in the human sciences, but without trivialising or under-estimating the complexity involved. However, some of the content is inevitably technical in nature and requires some background in the applied human sciences.

All of the issues discussed lend themselves to practical management. In most cases, there is clear precedent, knowledge and experience managing them either within the oil & gas sector or, more usually, in sectors such as aviation, medicine, space, nuclear power or air traffic management. Improved management of these issues may help oil & gas companies to become higher-reliability organisations: to further develop a sense of mindfulness and the state of chronic unease<sup>‡</sup> that can contribute to an improved ability to detect and respond effectively to weak signals of heightened risk.

<sup>†</sup> For an extremely thorough and rigorous analysis of the cognitive basis of human performance and human error in complex sociotechnical systems, see Reference 1

<sup>‡</sup> A state of chronic unease can be considered to exist in an organisation when leaders at all levels have created a culture where they are made aware of weak signals and make effective and timely challenges and interventions on risk assessments and decision making

## 2 Issues

Figure one summaries many of the issues discussed in this report.

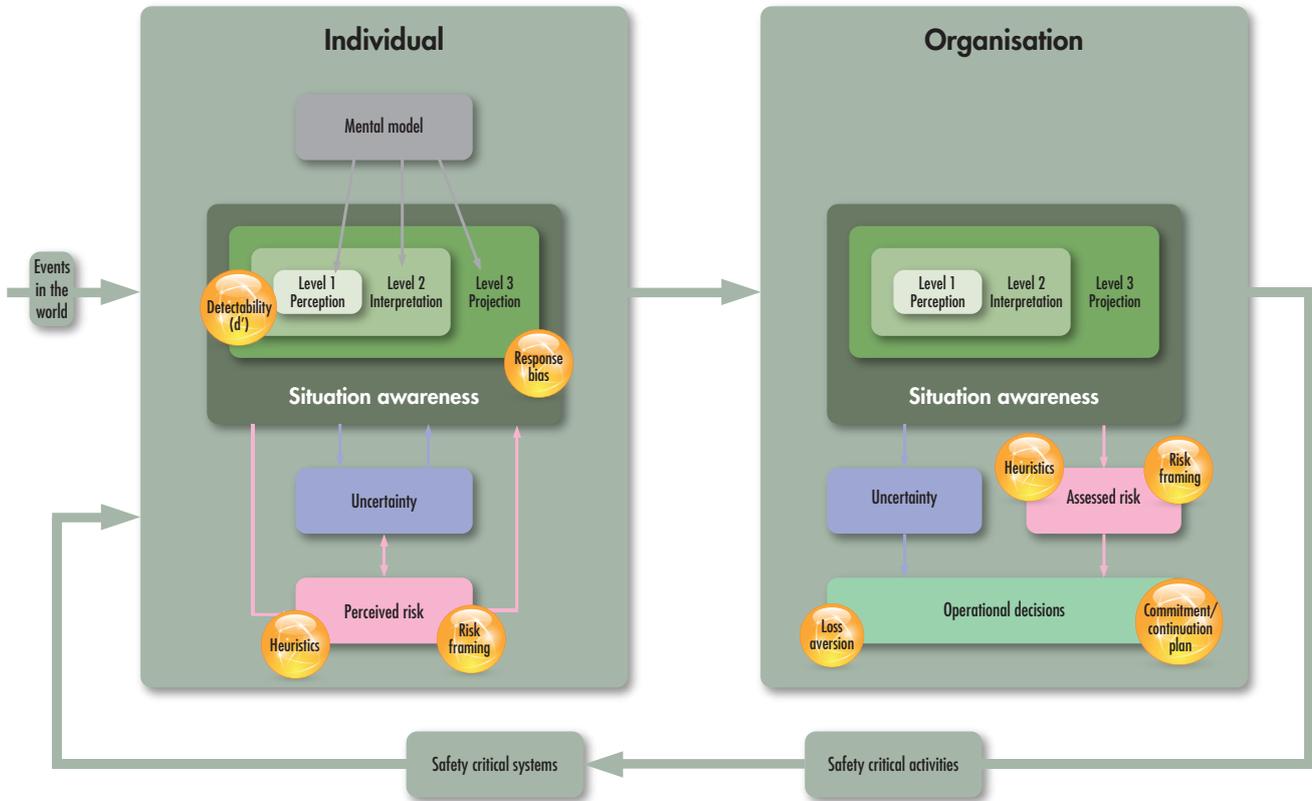


Figure 1: Illustration of the relationship between cognitive issues at the individual and organisational level (used by permission of Shell)

### 2-1 Situation Awareness

Often, in some way, incidents involve a loss of Situation Awareness (SA), i.e. a failure to seek and make effective use of the information needed to maintain proper awareness of the state of the operation and the nature of the real-time risks. This can be applied to both the awareness and prioritisation of risk, as well as to decision-making and assessment of an operation. Much of the leading work on SA has been carried out by the American psychologist Mica Endsley.

SA is a much used term in safety critical industries. However, it has the potential to be used in ways that are so general that it loses any specificity or clarity, giving little indication of what to change in order to improve. To be useful, the concept must be understood and applied at an adequate level of technical depth. SA also needs to be understood and managed at both the individual and team levels.

In psychological terms, SA is most usually defined in terms of three related levels of cognition<sup>†</sup>:

- Perception of information about what is happening in the world (Level 1);
- Interpretation of what the information means in terms of the state of the world (Level 2); and
- Projection of the likely status of the world in the immediate future (Level 3).

<sup>†</sup> Reference 2 provides a thorough review of the psychological basis of Situation Awareness, including examples of how the concept has been used in a range of applied settings.

The application of SA concepts to oil & gas operations is not new. For example, in 2006 academics from the University of Aberdeen published research that applied the concept to drilling operations in the North Sea (*Ref: 8*). This work included analysis of one major oil company's drilling incidents over 10 months in 2003 and concluded that, among other factors:

- 67% of the incidents included a failure in Level 1 SA;
- 20% were included failures at Level 2; and
- 13% were included failures at Level 3.

The study further concluded that most of these Level 1 SA errors occurred through a failure to monitor or detect information that was available to the operators.

A detailed analysis of any one incident in terms of these three levels of SA is beyond the scope of this report. But to illustrate losses in SA:

### **Level 1 SA**

This is the perception of information available to the senses indicating what is happening in the world.

Level 1 SA is based on the various sources of 'raw' information available to operators. At its most direct level it includes the information operators gain about an operation by their physical presence in a plant from what they see, what they hear, and their sense of smell. It also includes indirect information, such as the data displayed on a graphical Human Machine Interface (HMI) from instrumentation and process control systems. It can also include the results of computer simulations and other predictive techniques. Incident investigations often describe situations where operators either have to go to significant effort to obtain Level 1 SA, or apparently missed information that was available. There is a critical difference between seeing (or hearing or smelling) information and perceiving it. Just because information is available to the senses, does not mean the operator necessarily perceives it. This is behind what is commonly referred to as "looking without seeing" - a source of many road traffic accidents involving pedestrians and motor cyclists.

### **Level 2 SA**

This is about interpreting what Level 1 information means in terms of the state of the operation. It means knowing whether valves are open or closed, whether pumps are running, or whether a vessel is filling or emptying based on the Level 1 information (symbols, colours, data) presented on an HMI. At a more complex level, it is about what the operator believes is the state of a piece of equipment, of an operation, or the capability of a team, based on the information available. Critically it includes the operators diagnosis of what they believe is going on when the unexpected happens, or when the information they have available is not what they expect.

### **Level 3 SA**

This is about predicting the future state of the world based on what the operator believes is the current state.

All three levels of SA involve significant cognitive complexity and rely heavily on what psychologists often refer to as the operator’s “mental model”. A mental model captures the operators understanding of how a system operates and how it behaves. It guides what level 1 information the operator looks for and expects, provides the basis for interpreting level 1 information in terms of what the operator believes is the state of the world, and allows the operator to generate Level 3 SA, predicting what will happen in the future. In any remotely complex system the mental model held by even a highly experienced operator will almost certainly be different from the “real world” (see fig 1); but for most purposes, and in most situations, it is sufficiently accurate to allow skilled and reliable performance.

We only really learn about the importance and limitations of mental models when major accidents happen. When the cognitive dimension of incidents is properly investigated, there is often a significant discrepancy between what the operator thought was the state of the world, what was happening, or how an equipment or a process would have behaved and what the actual state of the world was, or how the system did behave.

Mental models are probably one of the single most important concepts in cognitive engineering. Their importance and the understanding of how their breakdown can lead to process safety and environmental incidents first came to major prominence following the investigation and subsequent research into the contribution that “human error” made to the Three Mile Island nuclear incident in the US in 1979<sup>†</sup>.

Note that simply providing operators with more data – a solution that is very prevalent in highly technological engineering-based industries - does not necessarily improve SA at any level. Operational decision makers need information, not data. And they need information at the right level of detail, in the right format and in the right place and time. Designing equipment, displays and working practices that recognise the importance of SA is not trivial and can require significant expertise.

The HFSC recommends:

1. That further work be undertaken to fully understand – at an appropriately technical psychological level - the implications of loss of SA as a contributor to incidents.
2. That action taken by the industry to mitigate risks of future incidents should include an assessment of the implications for SA.

### *2-1-1 Sources of error in Situation Awareness*

As with all other areas of human performance, the cognitive processes involved in acquiring and maintaining SA are complex and prone to error. While a full treatment of this is beyond the scope of this report, at least two significant factors are often prominent. These are:

- Failure to attend to or appreciate the significance of “weak signals”
- Confirmation bias.

#### *Failure to attend to weak signals*

One important source of Level 1 SA is what are often referred to as “weak signals”.

The extensive body of research into high-reliability organisations (HROs) (see for example ref 3) and, more recently, resilience engineering, makes clear that HROs are usually characterised by, among other things, a “strong response to weak signals”.

A “weak signal” is something which, in itself, may be relatively insignificant and does not justify action. Sometimes however, weak signals are early indications that something is indeed wrong.

<sup>†</sup> Chapter 5 of Reference 11 includes a very accessible discussion of some of the psychology behind this ‘error’.

In the first edition of their widely respected analysis of the characteristics of HROs, Weick & Sutcliffe (Reference 3) state that:

*“The key difference between HROs and other organisations in managing the unexpected often occurs in the earliest stages, when the unexpected may give off only weak signals of trouble. The overwhelming tendency is to respond to weak signals with a weak response. Mindfulness preserves the capability to see the significant meaning of weak signals and to give strong responses to weak signals. This counterintuitive act holds the key to managing the unexpected.” (1<sup>st</sup> ed, p 3 – 4).*

Clearly, expecting operational personnel to take action every time someone suspects they may have detected a weak signal is impractical and would make most safety-critical operations impossible. In the second edition of the same book, Weick & Sutcliffe remark:

*“Some experts argue that it is impossible to anticipate the unexpected both because there are almost an infinite number of weak signals in the environment and because the ability to pick up these weak signals is far beyond the existing technological capabilities of most organisations. Yet organisations that persistently have less than their fair share of accidents seem to be better able to sense significant events than organisations that have more accidents. Members of HROs don’t necessarily see discrepancies any more quickly, but when they do spot discrepancies, they understand their meaning more fully and can deal with them more confidently.” (Ref 3, P 45)*

Individually, weak signals may not be especially significant. However, when signals accumulate, they can provide a strong signal that an operation is proceeding at significant risk. The issue is in being sensitive to the existence and potential importance of weak signals and in being able to recognise them and act appropriately. More specifically, the issue is about how to give operational personnel the knowledge and awareness to overcome those factors that lead to failure to take advantage of genuine – though weak – signals when they do exist.

The question of why weak signals are often not attended to or not acted on can be partly understood in terms of the psychology of response bias, which is discussed in Section 2.2 of this report.

### Confirmation bias

The term “confirmation bias” refers to the psychological tendency to rationalise information to make it fit what we want to believe.

*“...all of us tend to be awfully generous in what we accept as evidence that our expectations are confirmed. Furthermore, we actively seek out evidence that confirms our expectations and avoid evidence that disconfirms them.... This biased search sets at least two problems in motion. First, you overlook accumulating evidence that events are not developing as you thought they would. Second, you tend to overestimate the validity of your expectations. Both tendencies become stronger if you are under pressure. As pressure increases, people are more likely to search for confirming information and to ignore information that is inconsistent with their expectations.” (Ref 3, p 25 – 26).*

As humans become skilled and gain experience, we develop mental “scripts” that help us understand the complexity of the world. We then decide how to act based on the extent to which conditions seem similar to situations we have experienced in the past. We use our experience to interpret what’s happened or is happening in terms of situations that we recognise, and use this to predict what will happen next.

The (fictitious) Conjured Platform has devised a working practice where, if anyone on the crew is uneasy about an event or safety-related decision – for example if the crew make a decision to diverge from a standard or agreed practice, if an important piece of equipment is faulty, or if they just feel something is not right – they ‘raise a flag’. This involves going to the drillers’ shack and placing a small red flag on a shelf. The flags act as a visible reminder to the driller and all other crew members of the ‘space’ they are operating in. If the flags accumulate, it provides a very powerful signal that they need to take stock and re-consider what they are doing, i.e. the crew has found a very simple way of turning numerous weak signals into a single strong signal.

† For an introduction to Naturalistic Decision Making, see Ref 9

In recent decades, naturalistic decision making<sup>†</sup> has been one of the major themes of applied research into how critical decisions are made in real-life in situations of time pressure and stress. The use of scripts is at the heart of our understanding of naturalistic decision making.

When we lock in on a ‘script’, we re-shape reality to fit what the script expects: when presented with ambiguous data, we make quick judgements based on what the script leads us to expect. And when a number of pieces of data conflict, our minds sometimes shape the facts to fit our ‘scripts’ or pre-conceptions. What we actually pay attention to is very much determined by what we expect to see.

Confirmation bias would lead operations teams – both in the front line and in supporting locations – to rationalise away information or data that is problematic, unclear or ambiguous, or which does not meet with what the team believe (or want to believe) is the actual state of an operation. In this way ambiguous or problematic information can be rationalised in a way that allows an operation to proceed on the assumption that everything is really as expected, and in order.

## 2-2 Cognitive bias in decision-making

The term “cognitive bias” refers to an innate tendency for cognitive activity – ranging from the perception and mental interpretation of sensory information, through to judgement, and decision making - to be influenced or swayed, i.e. biased, by emotion or lack of rationality.

Cognitive bias is fundamental to human cognition and can have both negative and positive effects. Positive effects include enabling faster judgement and decision-making than would be possible if all the information available to thinking had to be processed equally. Negative effects can include a distorted interpretation of the state of the world, poor assessment of objective risk, and poor decision-making. Cognitive bias can take many different forms and can operate in many different ways.

In recent decades, psychologists and economists have identified and studied many dozens of different types of cognitive bias. The psychologist Daniel Kahneman – who won a Nobel Prize for the application of his work to Behavioural Economics – is probably the leading researcher in the field<sup>†</sup>.

In 2008, Ori and Rom Brafman published a short book (*Ref 5*) that brought the importance of irrationality in understanding human behaviour to the attention of many business people for the first time. Although written to be entertaining to a mass audience, the core ideas discussed are based on solid psychology. The Brafmans’ book provides a reasonable, non-technical introduction to the topic of cognitive bias.

The authors set the scene for their book by saying:

*“A growing body of research reveals that our behaviour and decision-making are influenced by an array of such psychological undercurrents and that they are much more powerful and pervasive than most of us realise ...like streams, they converge to become even more powerful.” p.16.*

*“These hidden currents and forces include loss aversion (our tendency to go to great lengths to avoid possible losses)... and the diagnosis bias (our blindness to all evidence that contradicts our initial assessment of a person or situation). When we understand how these and a host of other mysterious forces operate, one thing becomes certain...we’re all susceptible to the irresistible pull of irrational behaviour”. P 17*

Incident investigations in the oil & gas sector often contain indications of decisions being made in ways that strongly suggest the influence of cognitive bias. Among the most common include:

- Response bias
- Risk framing and loss aversion
- Commitment to a course of action
- Mental heuristics

<sup>†</sup> *Ref 4 provides a very thorough and highly readable overview of research into cognitive bias since the 1970s including an explanation of the underlying psychological mechanisms and examples of how biases can affect behaviour and decision making.*

### 2-2-1 Response bias

Section 2.1 has discussed the importance of sensitivity to “weak signals” in developing and maintaining situation awareness in high reliability organisations.

The psychology of response bias can help to understand why operators may not detect or act on weak signals. It is however necessary to understand something of the theoretical background to the concept. A very brief overview of one of the most powerful and well established theories in cognitive psychology – the Theory of Signal Detection (TSD) – is necessary to explain the concept.

#### The Theory of Signal Detection

The ‘Theory of Signal Detection’ has been used for many years by psychologists and others to understand how humans make decisions and act in conditions of uncertainty. TSD is usually applied to situations where people have to decide whether to act, or make some sort of intervention, based on their assessment of the state of a system over a period of time when there is uncertainty about the actual state of the system.

The classic, conceptually simple, example of the use of TSD concerns radar operators who (before current generations of radar and display technologies were developed) had to make decisions about whether a target had been detected based on visual observation of a noisy radar display. The operators had to decide whether a patch of light on the radar screen is actually a “signal” indicating a target (e.g. a hostile aircraft or missile) in the world, or “noise”, such as electronic noise, or radar returns reflecting off water, rocks or the atmosphere.

TSD is based on two parameters which are shown graphically on Figure 2;

- how perceptually clear the signal is, (known as  $d'$  – “D prime”) and,
- the subjective bias towards or against treating ambiguous or uncertain information as being indicative of a problem (known as  $\beta$  – “Beta”).

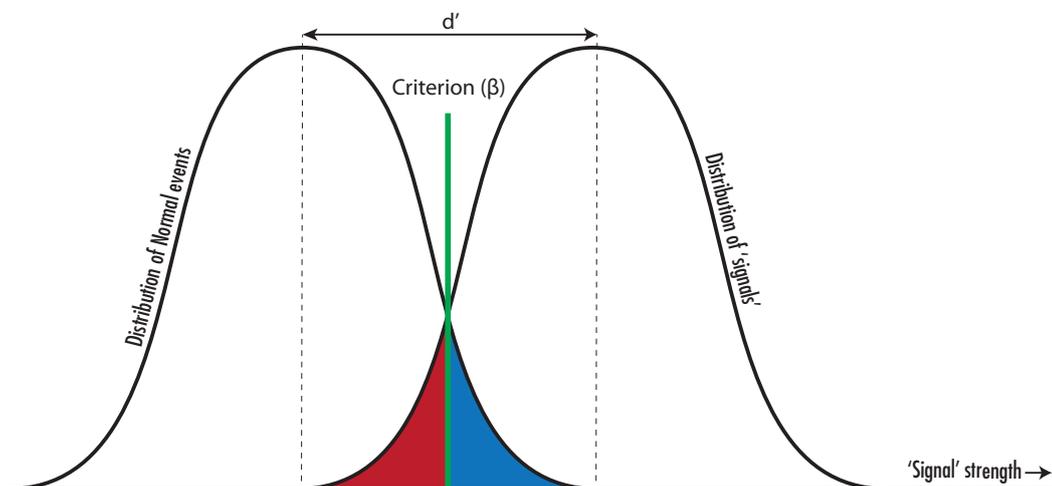


Figure 2: Illustration of  $d'$  and  $\beta$  The figure illustrates both “normal” events and signs of abnormality (“signals”) as having a distribution on some measure of strength (for example, the brightness of a radar return).  $d'$  indicates how far apart the two distributions are – how easy it is to detect the signal.  $\beta$  is the signal strength where the operator will decide that anything to the right is a signal and anything to the left is part of the normal world. Note that the area above  $\beta$  that actually belongs to the distribution of normal events are essentially false alarms (blue shading). In contrast the area to the left of  $\beta$  that actually belongs to the population of signals are missed signals (red shading).

The first of these,  $d'$ , is largely a property of the system and is relatively fixed for a given set of conditions. In the case of the radar operator,  $d'$  is affected by the size and relative luminance of the return from a target compared with background noise.

The second parameter,  $\beta$ , is subjective and is a property of the human observer. It indicates the point where the operator decides the benefits associated with taking action, even when there is doubt, outweigh the costs of not intervening even if subsequent events prove the intervention to have been unnecessary. In our radar operator example, it is the point at which he decides to declare a radar return as in fact a hostile target, knowing that this will lead to a command team scrambling to action stations, which could turn out to be needless.

For oil & gas applications,  $\beta$  will be influenced by a lot of factors, including:

- the perceived costs of incurring a delay to an operation.
- whether the individual would be held personally to account if the intervention was unnecessary (or, conversely, whether they would be held to account for not intervening).
- how peers and colleagues would view the intervention (for example, in a high risk-taking culture  $\beta$  would be positioned at a high level, such that people would only intervene when there was no doubt about the risks).
- trust that the system is robust enough to handle a disturbance even if one does occur.

Figure 3 illustrates the way these two parameters ( $d'$  and  $\beta$ ) affect the likelihood of someone intervening when in doubt.

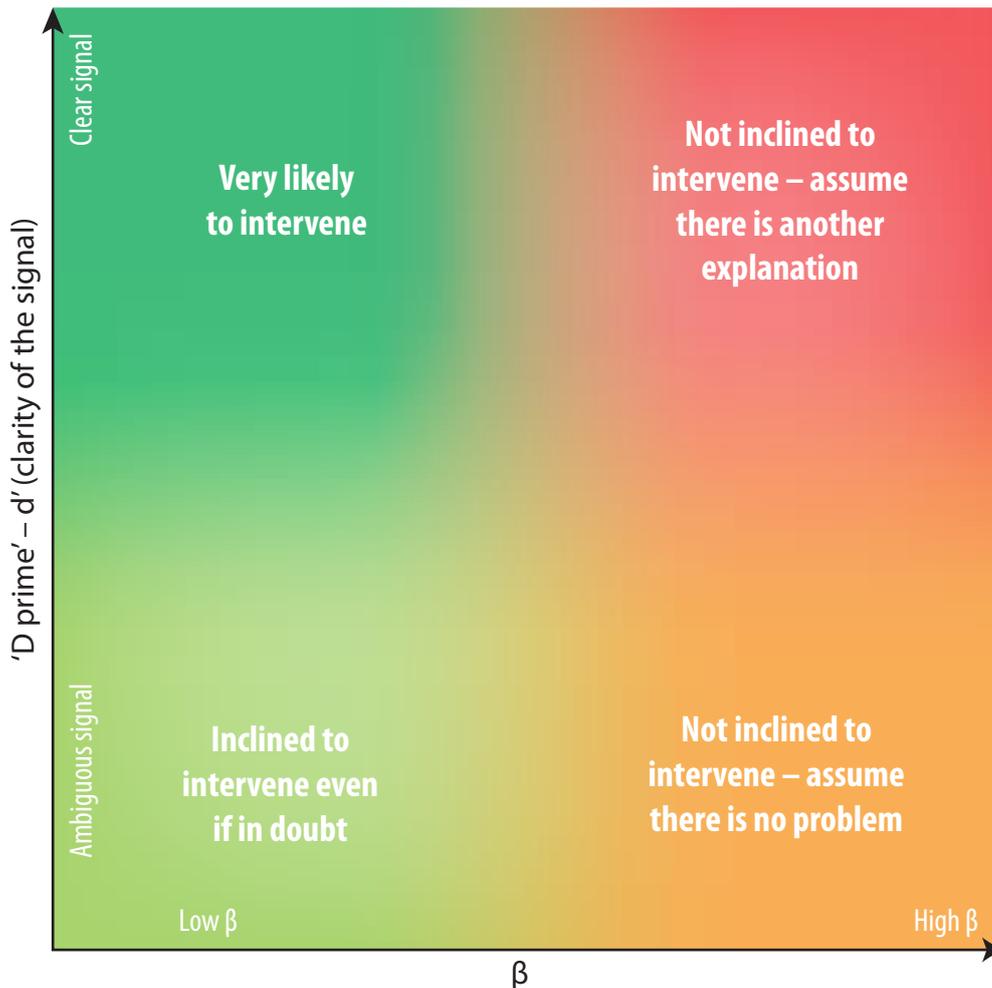


Figure 3: Illustration of effects of  $d'$  and  $\beta$  on deciding whether to intervene

From this conceptually simple example, the psychological basis of TSD can, in principle, be generalised to any situation where humans have to make decisions about the state of the world and whether they need to act in the face of uncertainty.

In the oil & gas industry operators are expected to be continually aware of whether the operation is within safe limits, or whether there is something wrong and requires intervention. They have to continually make decisions about whether what is happening is safe and, if they have concerns, they have to decide whether to intervene in whatever way is appropriate.

Response bias is also strongly influenced by what is known as “risk habituation”. People will tend to under-estimate (become habituated to) risk associated with tasks they perform regularly and that are usually completed without incident.

Risk habituation is itself very similar to the concept of “normalisation of deviance “. Normalisation of deviance came to prominence when the 2003 investigation report into the loss of the space shuttle Columbia devoted a whole chapter to comparisons between the loss of Columbia and the loss of the shuttle Challenger in 1986 (see Volume 1, Chapter 8 of ref 7; ‘ History as Cause’).

Normalisation of deviance refers to the tendency to treat events that do not conform to design specifications, safety limits, or standards - but do not result in an incident or any measurable loss of safety - as being evidence that the system is in fact operating within its safety margins.

*“In all official engineering analyses and launch recommendations prior to the accidents, evidence that the design was not performing as expected was reinterpreted as acceptable and non-deviant, which diminished perceptions of risk throughout the agency.....Anomalies that did not lead to catastrophic failure were treated as a source of valid engineering data that justified further flights”.(Ref 7, Volume 1, Page 196).*

This is equally applicable at the level of the psychology of individuals, as it is at an organisational level. Experienced crew who have “seen everything and done everything” may have experienced situations in their career in which they have operated at or beyond the limits of their knowledge or with a great deal of uncertainty and risk. In a lot of situations events proceed to a successful conclusion. Individuals who have gained many years’ experience but who have not personally experienced a major event may develop an expectation that things will be all right in the end.

Risk habituation and normalisation of deviance at an individual level are therefore also likely to influence an individual’s response bias ( $\beta$ ).

### **Combining weak signals and response bias**

The relevance of the psychology of response bias needs to be understood in the context of level 2 SA – and especially the presence of weak signals.

A “strong response to weak signals” – which is characteristic of HROs - means adopting a low value of  $\beta$  (to the left on figure 2) and being prepared to intervene even when there is a good chance that actually there is no problem and, as a consequence, accepting a high rate of “false alarms”.

Operators can be sensitised by training to;

- the importance of the subjective response bias in deciding whether to make a safety intervention; and
- the factors that influence where operators put their response bias ( $\beta$ )

Senior leaders in particular – both at the organisational and the asset level – can benefit by being aware of the psychology of how people make these judgements about whether to intervene, and how their own actions and behaviours influence how people set their  $\beta$ ’s.

### 2-2-2 *Risk framing and loss aversion*

Psychologists have known for a long time that people will make different decisions based on the way a problem is put to them. This has been studied extensively under the concept of “problem framing” (or the “framing effect”). As a simple illustration, the statement that “there is a 90% chance of an injury free operation” will evoke a different psychological response than the logically equivalent statement “there is a 10% chance of an injury”.

The term “loss aversion” refers to the bias towards favouring avoiding losses over acquiring gains. Most people would go to significantly more effort to avoid what they perceive as a loss, than they would to achieve a gain of the same value. Research has demonstrated that the desire to avoid a loss can be twice as powerful in motivating behaviour and decision making, as the desire to seek an equally valued gain.

Because of the way it is framed, the perception of risk in the minds of the workforce can be fundamentally misaligned with the reality of the safety or environmental risks that are actually faced.

The psychology behind the perception of risk and the importance of risk framing can make an important contribution to understanding how operational decision-making can go wrong, leading to failure to prioritise attention and allocate resources among the various risks faced by an operation.

Operational behaviour and decision-making, including missing or rationalising data, and not responding to weak signals, also needs to be seen in the context of problem framing, and this strong psychological motivation to avert a perceived loss.

### 2-2-3 *Commitment to a course of action*

People find it extremely difficult to change from a course of action once committed to it. This is especially true when the commitment includes some external, public, manifestation. Internalised commitments that are never verbalised or shared with anyone else are much easier to break.

Committing to a course of action does not simply mean deciding to pursue it, it means engaging at an emotional level. This emotional commitment brings psychological forces into play that can be very powerful in motivating not only how we behave, but how we see and understand what is happening in the world around us (i.e. our situation awareness).

Commitment to a course of action can be seen in all areas of life and in all types of activities. When we are overtaking another vehicle, commitment is the force that drives us to complete the manoeuvre even if the vehicle being overtaken itself speeds up limiting our time and space. Commitment has been observed many times when those investigating process safety and environmental incidents have sought to understand why the people involved made bad decisions, or behaved in seemingly irrational ways in the build up to an incident.

Recent research by NASA and others has investigated the concept of “plan-continuation errors”. This work has looked at the tendency for pilots to continue with a plan even when conditions have changed, risks have increased, and they should really re-evaluate and change plan. One study has shown that, in a simulator, the closer pilots were to their destination, the less likely they were to change their course of action. Changing a plan requires effort and can be stressful.

In oil & gas operations, once the crew identify what they believe is the principal risk, commitment (or plan-continuation) could drive thinking towards managing the principal risk despite compromising the response to other risks even if, with hindsight, those other risks prove to have been greater.

It is the emotional commitment that makes it very difficult for people to change from a course of behaviour once it has been initiated. Commitment will be enhanced when individuals with strong personalities and a strong self-image take a public position in the face of their peers – proposing an explanation, stating an opinion, or agreeing with a decision. Failing to disagree is probably a less powerful motivator, but nonetheless also difficult to revert. Public commitment brings at least the perception for a potential loss of face, weakness or perceived loss of respect among peers and sub-ordinates. Furthermore, commitment cumulates over time making it increasingly difficult to change from a chosen course of action as time passes – and particularly as the desired goal gets closer.

### 2-2-4 Mental heuristics

Heuristics are sub-conscious rules, simplifications or “tricks” that the brain uses in order to allow us to cope with the complexity of the world.

Without using heuristics and scripts the human brain would be incapable of processing, analysing, interpreting and making use of the enormous amount of information that is continuously available to the senses about the state of the world and the likely effect of different actions. Heuristics support cognition at many levels. Those that are most directly relevant to operational safety are those tricks and simplifications that help us to make judgements and decisions quickly and effectively in the face of significant complexity and uncertainty.

The critical point about heuristics is that they are sub-conscious; they do not operate through conscious will or intent.

At least two powerful heuristics may influence operational decision making;

- The availability heuristic: the tendency to predict the likelihood of an event based on how easily an example can be brought to mind.
- The representativeness heuristic: the bias people have towards giving priority to information that is readily available to them in judging the probability or likelihood of an event. The alternative, non-biased, approach is to actively look for information relating to all events of interest. The representativeness heuristic is common and extremely useful in everyday life. However, it can result in neglecting to adequately consider the likelihood of events for which information is not readily available

In combination with the other sources of cognitive bias described here, understanding the way these two heuristics influence real-time decision-making in the face of complexity and uncertainty can aid understanding of decision-making in safety critical situations.

## 2-3 Inter-personal behaviours

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Inter-personal behaviours are clearly extremely important when teams have to work together to ensure safety. This has been recognised and studied for many years, particularly in the aviation industry. Air crash investigators have concluded a number of times that inter-personal factors have interfered with sharing of information that could have avoided some high profile air accidents.

Some incident reports in the oil & gas sector include indications that inter-personal factors had contributed to individuals either not sharing and using information that was available to them, or not effectively challenging decisions that they believed were wrong.

Nowadays, the aviation industry world-wide is highly sensitised to the importance of personal relationships and inter-personal skills in ensuring safety. The US Federal Aviation Authority and the European Joint Aviation Authority (JAA) require both air-crew and ground maintenance staff to undergo specific training on a range of non-technical skills – including inter-personal skills - before they can be licensed. This training is usually referred to as some form of “crew resource management” (CRM). CRM training covers non-technical skills such as leadership, team-building and co-operation and conflict resolution that are central to optimising inter-personal effectiveness . As defined by Professor Rhona Flin and colleagues:

*“Non-technical skills are the cognitive and social skills that complement workers’ technical skills... the cognitive, personal and social resource skills that complement technical skills, and contribute to safe and efficient task performance” . (Ref 6, page 1)*

CRM also typically includes decision-making and SA as well as other topics discussed in this report that lend themselves to development as non-technical skills.

There is an overlap between CRM and the behavioural-based safety programmes that are run by many OGP members. Behavioural safety, however does not cover exactly the same scope as CRM. In particular, CRM provides more focus on inter-personal interaction, and team working skills than is usually provided by behavioural safety programmes. The HFSC recommends that OGP should put effort into developing training practices to fill this gap.

## **2-4 Awareness and understanding of safety-critical human tasks**

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The notion of “safety-critical human tasks” (sometimes known as “HSE critical activities”) is widely recognised across the oil & gas industry and in most high-hazard industries.

A “safety-critical human task” is an activity that has to be performed by one or more people and that is relied on to develop, implement or maintain a safety barrier. The fact that these tasks rely on human performance is usually either because it inherently relies on human decision-making, or because it is not technically or practically possible to remove or automate it. In any event, no level of automation can avoid some level of human involvement in an operation, for example in maintenance and inspection, whether locally or remotely.

Although some OGP members require safety-critical human tasks to be specifically identified and managed, the safety-critical nature of operator activities is not always recognised. It seems that the required performance standard, or the consequences of individuals not performing tasks to the required standard, is often poorly understood. There also seems to be an insufficient understanding of the demands that safety-critical tasks can make on human performance, what is needed to support the required level of performance, and the ways in which human performance could fail in undertaking the tasks, or the inherent human unreliability associated with the tasks.

The HFSC believes this is a key message for the global oil & gas industry about human factors in safety-critical operations. OGP members should work towards adopting practices to identify and understand safety-critical human tasks. They should also work on the operational and management practices that need to be in place to ensure operators are able to perform these tasks reliably. That means, for example: avoidance of distractions; ensuring alertness (lack of fatigue); design to support performance of critical tasks in terms of use of automation, user interface design and equipment layout; increasing sensitivity to weak signals and providing a culture that rewards mindfulness when performing any safety critical activity.

Essentially, OGP members should work towards being able to satisfy themselves that safety-critical human barriers will actually work and that the risk of human unreliability in performing them is effectively managed and reduced.

OGP members should also review practices used to maintain real-time awareness of safety margins. This should consider practices and tools in use within the oil & gas industry.

### 3 Summary of recommendations

Issue	Objective	Recommendation
<b>Potential for over-confidence in operational decision making at critical points; loss of situation awareness; failure to check; lack of sense of mindfulness or “chronic unease”.</b>	Improve awareness among front-line operations management of the importance of situation awareness, and how people make decisions in situations of complexity, stress and uncertainty. Required awareness is currently partly covered through the implementations of crew resource management, behavioural-based safety and safety leadership programmes. Further work is required to adequately capture the cognitive aspects of decision making.	OGP is producing a syllabus and recommended content for training in non-technical skills appropriate for drilling and related operations.
<b>Potential for critical decisions to be based on uncertain or ambiguous information without adequate challenge or on-going review.</b>	Find a practical means of ensuring critical decision are subject to effective challenge, especially during periods of heightened safety risk.	OGP members should review options for ensuring independent challenge to safety-critical decisions within their own operations. These reviews could consider: <ul style="list-style-type: none"> <li>Defining an independent challenge session, against a defined agenda, and with suitably trained facilitator, to be initiated at agreed points in the operational plan. The facilitator should not report to the asset operational management. The agenda should specifically document major deviations from standards, plans or technical recommendations. Facilitation of the review could be remote.</li> <li>Appointing and suitably training a member of the asset senior management as independent challenger. This individual should be known to all personnel on the asset and available to the crew at any time.</li> <li>Setting-up an anonymous reporting system (“hot-line”) for critical periods of operations allowing any staff member to report concerns confidentially with guaranteed follow-up.</li> </ul>
<b>Potential for lack of awareness or sensitivity to indications that safety margins might be eroding.</b>	Find methods of maintaining real-time awareness of where operations are located within the ‘safety space’. Identify methods of increasing sensitivity to “weak signals”.	OGP members should review practices used to maintain real-time awareness of safety margins. This should consider practices and tools in use within the oil & gas industry, as well as practices used in other high hazard industries. The scope should cover both awareness at the front-line operational level, as well as awareness at management level.
<b>Potential for insufficient awareness and understanding of the psychological complexity of safety critical task</b>	OGP members should be able to demonstrate that safety-critical human barriers will actually work and that the risk of human unreliability in performing them is ALARP.	OGP members should work towards adopting practices to identify and understand safety-critical human tasks. They should also work on the operational and management practices that should be in place to enable operators to perform these tasks reliably. That means, for example, avoidance of distractions; ensuring alertness (lack of fatigue); design to support performance of critical tasks in terms of use of automation, user interface design and equipment layout; increasing sensitivity to weak signals and providing a culture that rewards mindfulness when performing any safety critical activity.

#### Notes:

- Crew Resources Management (CRM) was originally developed for the aviation industry to train aircrew – cockpit and cabin - and ground maintenance staff in a range of non-technical skills. The aim was to sensitise those directly involved in safety-critical activities to the limitations of human performance, behaviour and inter-personal interactions that have repeatedly led to human unreliability and incidents in the aviation sector.
- Many people in the oil & gas industry have pointed to CRM training as having an important role to play in reducing the occurrence of incidents. The OGP HFSC supports this view in principle, though with an important caveat. To be relevant and effective in the oil & gas industry, the content of CRM-type training needs to be specifically customised to the context of oil & gas operations. Contextual factors that need to be reflected in CRM-type training for oil & gas include;
  - The commercial and contractual relationships that exist between operational stakeholders
  - Methods of overcoming situations where conflict might exist between those with legal and commercial accountabilities, and those who have the best technical expertise to contribute to safety critical decisions
  - The regulatory context, and especially differences in national regulatory environments
  - Cultural differences where major assets can operate in very different cultural situations.

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