What lies beneath

Many organisations are very good at understanding the technical causes of accidents and incidents but struggle to gain a deep understanding of why the people involved behaved as they did, and therefore fail to develop recommendations to influence future behaviour. **Ronny Lardner** and **Richard Scaife** describe their award-winning project, which successfully tackled this issue.

Our project began with a request from a major energy industry client, who wished to improve the effectiveness of its existing incident investigation process. As in many other companies, this process involved structured evidence-gathering, interviewing by trained staff, development of an incident timeline, identification of critical factors, and application of a root-cause analysis model to guide recommendations.

Despite this structured process, which was very effective at identifying what happened and addressing technical failures, a gap existed in consistently identifying why people behaved as they did, and in developing recommendations that effectively influenced future behaviour. The authors were asked to review the current incident investigation process and make recommendations for improvement.

A large number of people had already been trained in and were familiar with the existing incident investigation process. We therefore deemed it most practical to introduce structured methods to help investigators, who did not possess specialist human factors expertise, to "step-out" of the existing process. This involved identifying sound behavioural models that could readily be taught to a non-specialist audience. We applied the following principles to the design of the analysis toolkit:

- Tools to be based on sound analytical methods, supported by existing research;
- Methods must help the investigators reach their conclusions on the basis of evidence gathered;
- Methods must be suitable for use by trained investigators who are not human factors specialists;
- Toolkit must be capable of being imparted via a two-day training course, delivered by internal company personnel;
- Toolkit must permit analysis of intentional and unintentional unsafe behaviour, and, optionally, identification of trends suggestive of a problem with certain aspects of safety culture;
- Toolkit must include written support, guidance, and examples for investigators.

We developed a four-step process, supported by structured worksheets, which allowed investigators to:

1 Accurately define and describe the behaviour(s) they wished to analyse;
2 Determine, on the basis of the evidence available, whether it appeared the behaviour(s) were intentional or unintentional (it is important to distinguish between behaviours that are intentional – often termed a violation – and unintentional– often termed an error.[1] While this distinction is very familiar to human factors specialists, others may focus on blame and treat all behaviour as intentional).
3 For intentional behaviour, apply ABC analysis;
4 For unintentional behaviour, apply human error analysis.

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Easy as ABC

ABC analysis[2] is a well-researched and validated technique for understanding why people intentionally behaved as they did. A refers to 'antecedents', which come before the behaviour and prompt or trigger it; B refers to the specific 'behaviour' we are interested in; and C refers to the 'consequences' of that behaviour for the person involved. The ABC model assumes the following three propositions are true:

- Behaviour is largely a function of its consequences;
- People do what they do because of what happens to them when they do it; and
- What people do (or do not do) during the working day is what is being reinforced.

Most unsafe behaviours do not involve people deliberately intending to harm themselves or others. From the perpetrator's point of view, their behaviour usually makes perfect sense. ABC analysis helps the investigator understand, from the other person's point of view, the antecedents and consequences of the unsafe behaviour, and then write them into recommendations to facilitate safer behaviour in the future.

Antecedents trigger the behaviour, or enable it to occur at least once. They can include the presence or absence of factors such as suitable tools and equipment, other peoples' example, and procedures. Consequences encourage the behaviour to occur regularly. Examples include getting injured or harmed, saving time, and getting approval from a supervisor or manager. Arguably, much traditional health and safety management activity is devoted to providing antecedents for desired behaviours (e.g. training, suitable equipment, signs, procedures, etc), while less attention is paid to how consequences reinforce safe and unsafe behaviour. ABC therefore helps the safety professional gain additional insight into what influences both types of behaviour.

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Once the antecedents have been defined, the consequences are assessed for the following, from the perspective of the person who performed the behaviour:

- If this consequence occurred, would it be positive or negative? (Note that getting injured or harmed will usually be assessed as negative);
- Does this consequence occur immediately after the behaviour (now or soon), or in the future?
- Is it relatively certain that this consequence will occur, or somewhat uncertain? (Note that getting injured or harmed will usually be assessed as something that is uncertain, i.e. it has not happened to me yet so it won't happen today).

Positive, immediate and certain consequences influence behaviour much more strongly than negative, future and uncertain consequences.

Having fully described the problematic behaviour, the next steps in the process are to define:

- a safe alternative to this behaviour;
- which antecedents will help ensure that this behaviour is triggered; and
- the type of consequences that will help reinforce the behaviour.

The results of the analysis can then be turned into practical recommendations to reduce unsafe behaviours and introduce new, safer alternatives to replace them.

Human error analysis

Various forms of human error analysis (HEA) have been widely used throughout industry, although the specific tools used for the purpose vary. The tool we developed in this case is loosely based on an approach originally developed for use in air traffic control,[3] where it was designed to integrate into an existing incident investigation process and to be used by incident investigators who were not human factors specialists, and had little or no knowledge in the field of psychology and human behaviour.

The human information-processing model proposed by Wickens[4] describes four stages of human information-processing and performance, namely: perception, memory, decision-making, and action. When performing any task, people perceive information about the outside world using all of the senses, and may use this information, along with information retrieved from memory, to arrive at decisions that are used to determine and execute action.

A human error can occur as a result of a failure in any of these four stages – for example:

- Perception error – misperceive a reading on a display;
- Memory error – forget to implement a step in a procedure;
- Decision error – fail to integrate various pieces of data and information, resulting in misdiagnosis of a process upset; and
- Action error – inadvertently operate the wrong device (e.g. a valve).

To find out why these four types of error happen, it is necessary to establish what caused the failure in that part of the human information-processing system, i.e. what were the underlying psychological factors? Determining these also provides a strong indication of what can be done to prevent such errors, or reduce their impact.

It is important to bear in mind that human performance in general is very heavily influenced by the conditions under which people perform. Such conditions are known as performance-shaping factors, and can help further clarify why an error occurred, and also provide a great deal of extra information to help specify a practical solution. Examples of performance-shaping factors that may increase the likelihood of error include very high workload, poor ergonomic design of equipment and displays, and inadequate training.

The human error analysis technique described, supported by a worksheet, allows the investigator, on the basis on the evidence gathered, to:

- Classify which type of error was involved (perception, memory, decision, action);
- Identify any performance-shaping factors; and
- Understand the underlying psychological error causes, each of which is linked to a set of example solutions, which can be further developed for specific circumstances.

To help the investigator, each error type is accompanied by industry and everyday examples, and a comprehensive checklist of performance-shaping factors.

Putting it into practice

We prepared a draft toolkit, comprising worksheets and associated guidance and examples. An experienced chemical engineer and incident analyst were trained how to use them to independently analyse and re-analyse a range of safety, environmental, and commercial incidents involving intentional and unintentional unsafe behaviours.

Initial results were encouraging, as the human factors analysis tools led to:

- Recognition of the contribution of human error, and appropriate corrective actions;
- More effective recommendations to address intentional violations;
- Praise from the regulator for the added value the tools delivered to the re-investigation of an environmental release; and
- Requests from operational managers for human factors analysis for all high-potential incidents.

Before the toolkit was finalised and implemented, a peer review was held. This involved scrutiny by internal company HS&E professionals, and a range of external human factors experts from the process industry, regulatory, academic, and aviation domains. The proposals, methods, and draft toolkit were supported, following implementation of suggested minor improvements.

Implementation in the first client organisation involved a train-the-trainer model. We ran a two-day pilot course for 20 delegates, which included four internal company staff, who subsequently trained around 100 of their most experienced incident investigators worldwide.

The next stage involved training a larger number of less experienced incident investigators. This time the two-day course contained minimal theoretical input, with the majority of time spent working in small groups to apply the methods to a range of real incidents, identify and analyse errors and violations, and formulate recommendations that were then compared to a set of model answers.

We have subsequently taken a similar approach with three other, very different organisations in rail maintenance, logistics, and offshore engineering. With these three, we had to develop some industry-specific case studies and examples for the course delegates to work on.

To date, training has been provided for some 200 incident investigators – all from various nationalities, with different levels of experience – drawn from across five different organisations, and four industry sectors. The first cadre of the Health and Safety Executive's human factors specialist inspectors has also been trained, and they plan to train others, and use the methods to aid their investigative and regulatory work.

In one multinational organisation, the approach has been successfully used in the investigation of more than 100 fatal and other serious incidents. In all, 96 per cent of the organisation's users found the toolkit useful, saying it had significantly enhanced their understanding of human behaviour, and added "science" to what had been "gut feel".

With these projects, we have proved that it is possible to train incident investigators from a technical or engineering background to successfully use human factors techniques to analyse errors and violations, thus adding insight into why incidents occurred, and how they can be prevented in the future.

Do it yourself

Practitioners who wish to determine the level of understanding – or appreciation of the role – of human error in incident causation in their organisation would do well to start with the following checklist:

- Are you satisfied with the robustness of "behavioural" recommendations arising from investigations?
- Do you find that similar incidents are repeated, and you don't seem to have got to the bottom of how to influence behaviour?
- Do your investigators have a basic awareness of human factors in health and safety?
- Do your investigation methods make a clear distinction between intentional and unintentional behaviour?
- Are you able to identify the surrounding circumstances that influenced people's performance on the day, and which could therefore influence others?

If the answer to any of these questions is 'no', you may benefit from deepening your understanding of human factors analysis methods. Start by reading some of the references provided below. ■

References

1 Health and Safety Executive (1999): *Reducing error and influencing behaviour*, HS(G)48, HSE Books
2 Health and Safety Executive (2002): *Strategies to Promote Safe Behaviour as Part of a Health and Safety Management System*, CRR 430/2002, HSE Books
3 Shorrock, ST, and Kirwan, B (2002): 'Development and application of a human error identification tool for air-traffic control', in *Applied Ergonomics*, 33, 319-336
4 Wickens, CD (1992): *Engineering Psychology and Human Performance*, 2nd Edition, Harper Collins, New York

EXAMPLE 1: ANALYSING A VIOLATION

Process control operators applied a series of safety over-rides to maintain production without first conducting a risk assessment or involving their supervisor, as specified in plant procedures. As a result, product vented from a knock-out drum, resulting in an environmental release.

The initial investigation focused on the violation by the operator, and recommended discipline, briefings, rewriting the procedure, and retraining. Further analysis by a company investigator trained in human factors methods revealed that plant management had tacitly encouraged the application of over-rides to maintain production, and had inadvertently reinforced this practice. It was also established that the over-ride key was kept in a readily-accessible location, which allowed over-rides to be used without supervisory involvement.

Additional recommendations, which flowed from the human factors analysis, ensured management's role in ensuring production versus safety conflicts was strengthened, and required removal of the key to the supervisor's custody. Without these additional recommendations, the initial ones would have had a very limited effect.

EXAMPLE 2: ANALYSING AN ERROR

An incident occurred where the lid of a rail tanker filled with hazardous liquids was not closed prior to the train's departure, resulting in a potential for spillage. Initial investigations had focused on the "carelessness" of the loading operator. A human factors analysis was subsequently requested.

It was established that this type of incident had occurred on a number of occasions, and had involved several different operators, all of whom had hitherto been considered careful and competent employees. It was established that the rail-car filling operation was a complex task, with many procedural steps. The radio communications system was not working, and the back-up communication system required the operator to interrupt the loading task to access a phone.

The human factors analysis categorised the problem as a memory error, influenced by the performance-shaping factor of interruptions from the phone. A simple solution was proposed, which involved issuing a plastic seal for each rail tanker lid, to be fitted after loading of each tanker was complete. If the loading operator was left with any plastic seals, this indicated a lid remained open. The radio communication system was also fixed. Interestingly, management's reaction to these findings and recommendations was that it had expected something more complex and expensive to implement.