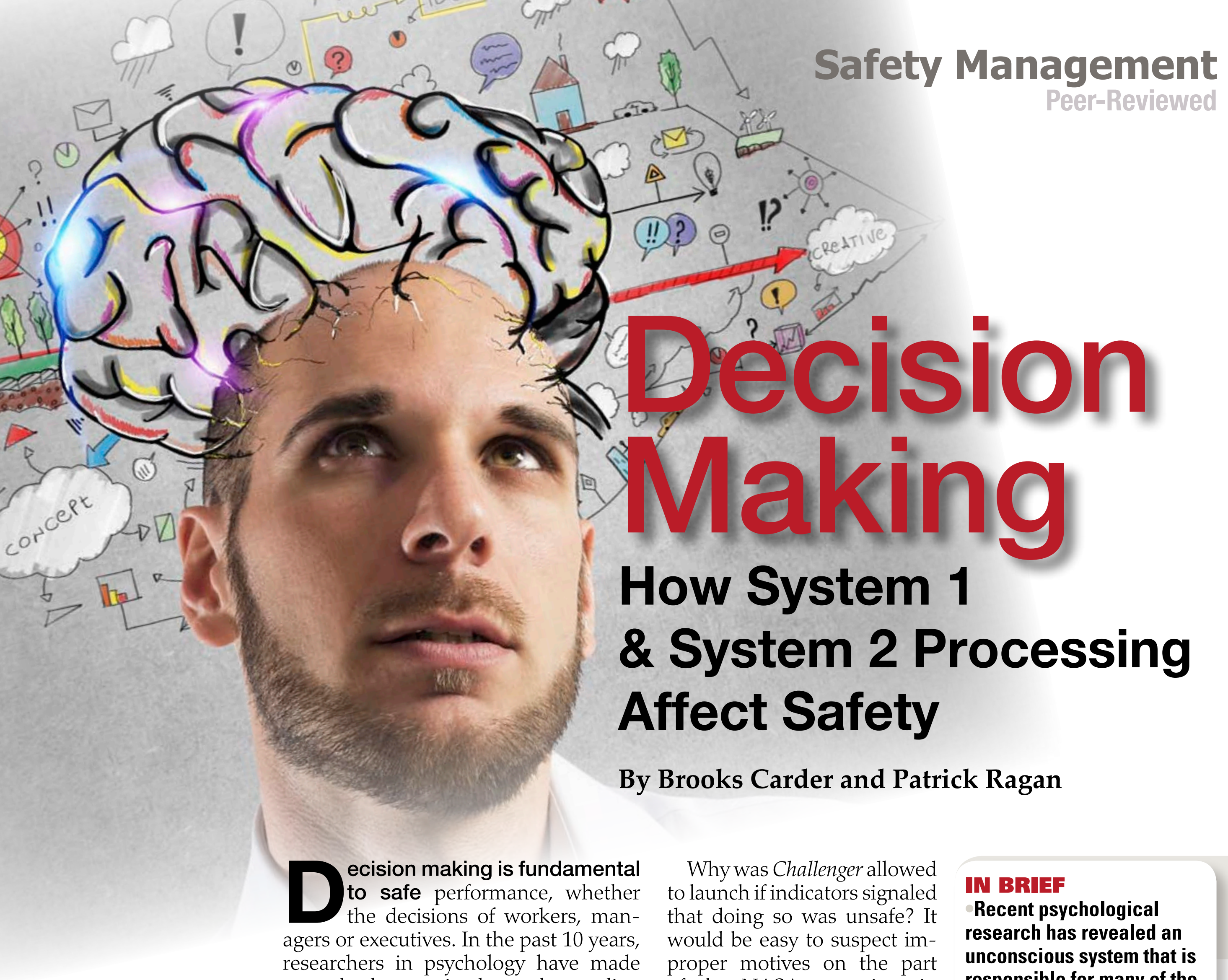

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Decision Making

How System 1 & System 2 Processing Affect Safety

By Brooks Carder and Patrick Ragan

Decision making is fundamental to safe performance, whether the decisions of workers, managers or executives. In the past 10 years, researchers in psychology have made several advances in the understanding of decision making. This article describes some of these advances and discusses their relevance to safety. It also suggests some strategies that workers can apply to avoid bad decisions, and provides background to enable OSH professionals to develop their own strategies.

When the space shuttle *Challenger* took off on its final, fateful flight, it did so despite the fact that the chief engineer refused to sign off on the launch. Furthermore, it was cold on launch day, and ample data were available indicating that problems with the seals (that failed and caused the loss of the vehicle) occurred whenever the vehicle was launched in cold weather (Feynman, 1999).

Why was *Challenger* allowed to launch if indicators signaled that doing so was unsafe? It would be easy to suspect improper motives on the part of the NASA executives in charge of the launch. After all, the flight promised to provide some much-needed positive publicity for NASA, as President Reagan was planning to call the shuttle on national television at some point during the mission.

IN BRIEF

- **Recent psychological research has revealed an unconscious system that is responsible for many of the decisions people make.**
- **This system has several biases that can lead to decisions that compromise safety.**
- **This article describes these biases, examines how they may lead to bad decisions related to safety and discusses how to protect against this.**

System 1 & System 2 Decision-Making Processes

Recent Nobel Prize winning research on the decision-making process may provide a better explanation. Kahneman (2008) describes two systems for making decisions. System 2 is the conscious process with which most

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are familiar. It is rational and responds to new information. Because it is deliberative, it is relatively slow. The operations of System 2 require attention.

Kahneman (2008) lists several activities that would be handled by the System 2 process:

•Focus attention on the clowns in a circus.

•Look for a woman with white hair.

•Maintain a faster walking speed than is natural for you.

It also handles complex tasks. For example:

•Compare two washing machines for overall value.

•Check the validity of a complex logical argument.

System 1 is an unconscious process that humans use to make many decisions, although they are not aware of its processing. Examples of activities handled by System 1 are:

•Orient to the source of a sudden sound.

•Answer 2 + 2 = ?

•Drive a car on an empty road.

•Understand simple sentences.

•Recognize that "a meek and tidy soul with a passion for detail" resembles an occupational stereotype.

System 1 can perform some complex computations. For example, when an experienced centerfielder in baseball quickly approximates where a fly ball will land, he is making a computation that would take a considerable amount of time if performed by System 2. Most people are unaware of the complexity of this decision and likely could not perform such a computation. Instead, a person simply runs to where the ball is going to land.

Along with its extensive capabilities, System 1 contains biases that often lead to bad decisions. According to Kahneman (2008), these biases include:

1) Neglect of ambiguity and suppression of doubt.

2) Confirmation bias, which is a tendency to ignore evidence that conflicts with one's initial hypothesis.

3) Exaggerated emotional coherence (halo effect). This is a tendency to believe, for example, anything a trusted figure says (which is why celebrities are used in advertising).

4) Belief that the evidence one sees is all there is.

5) Overconfidence.

6) Links a sense of cognitive ease to illusions of truth, pleasant feelings and reduced vigilance.

7) Distinguishes the surprising from the normal.

8) Infers and invents causes and intentions. Just as System 1 decision making may have been responsible for the launch of the *Challenger,* it may also be responsible for imputing improper motives to the executives who decided to launch.

9) Sometimes substitutes an easier question for a difficult one.

10) Loss aversion. If a person is offered a choice between two wagers, one of which has a higher expected return but also the small possibility of a larger loss compared to the other wager, most subjects will avoid the loss and choose the wager with the lower expected return.

11) Preference for the status quo.

Potential Effect on Safety

Several of these biases may support unsafe decisions. For example, numbers 1 (neglect of ambiguity), 2 (confirmation bias) and 5 (overconfidence) can lead to pursuing a course of action without sufficient review. Number 4 (belief that evidence one sees is all there is) could lead to a failure to look for additional information because one assumes that the evidence available is all there is.

The antidote for safe decision making is to invoke System 2. Any reflective process will invoke System 2. For example, such a process will prompt questions such as: What are some alternative ways to perform this task? Which alternative is the safest? Do you have all relevant information about how to do this? What information might be missing? What is the reason for deciding to do it this way? Is this a case of we have always done it this way so we will continue the status quo?

System 1 Biases: A Well-Known Example

Based on the characteristics and biases of System 1, it is a reasonable hypothesis that System 1 was the source of the decision to launch *Challenger.* One bias of System 1 decision making is overconfidence. NASA executives were certainly overconfident. Feynman (1999) reports that they estimated the probability of a catastrophic failure on the order of 1 in 1,000 missions. Feynman and the flight engineers estimated this probability on the order of 1 in 100. This latter estimate was proven correct, with two catastrophic failures in fewer than 200 flights.

A second bias is "what you see is all there is." People tend to think that the evidence of which they are aware is all the evidence there is. The NASA executives may not have been aware of the data on seal failures. They were certainly aware of the fact that no catastrophic failure had occurred thus far.

Another relevant bias is the preference for the status quo, which in this case would be to proceed with the launch. Many people in the same position as the NASA executives would likely have made the same decision, relying on System 1. Finally, the loss aversion bias would strongly favor continuing with the launch.

While this explanation of System 1 biases might absolve the executives of having improper motives, it does not absolve them of the responsibility of making a bad decision. One does not have to live life based on the commands of System 1. Good executives should be able to deliberate important decisions in System 2 mode.

Decision making determines much of the control of safety performance, whether the decision of a frontline worker to ignore a procedure, the decision of a manager on how to motivate employees to follow procedures, or the decision of senior management about how to train new managers. For the past 21 years, the authors have used surveys of attitude and beliefs to assess decision making and to target areas for improvement (Carder & Ragan, 2012). This process has proven to be an effective method for improving safety performance. Applying recent advances in psychology has generated new tools for understanding and influencing decision making, which ultimately improves safety performance.

Improving Safety-Related Decision Making

As an individual responsible for safety-related decision making, an OSH professional must understand how these systems work, how to protect against their liabilities and how to maximize their opportunities.

People live in System 2 every day, yet cannot directly experience the System 1 process. However, people can be aware of its intuitive conclusions and act on them. The existence of System 1 is inferred from a large number of experiments conducted by Kahneman and many others. Consider Kahneman's (2008) "Linda problem." In this situation, a subject is told, "Linda is 31 years old, single, outspoken and very bright. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations." The subject is then asked, "Which is more probable? Linda is a bank teller. Or Linda is a bank teller and active in the feminist movement."

Kahneman (2008) reports that 85% of Princeton undergraduates and 33% of social science graduate students give the latter answer. It is the wrong answer. There are many more bank tellers than there are bank tellers active in the feminist movement, so the former is more probable. The incorrect answer is coming from the intuitive process of System 1. It is common for System 2 to pass such answers along without testing.

Consider another example of a problem frequently answered using System 1 (Frederick, 2005). A pond has a patch of lily pads. The patch doubles in size each day. It takes 48 days for the patch to cover the entire pond. How long does it take the patch to cover half the pond?

Without much thinking, it makes sense that if it takes 48 days to cover the whole pond, it would take half that time (24 days) to cover half the pond. That is a System 1 answer. However, this answer ignores the fact that the lily pad is increasing geometrically. If it doubled to cover the whole pond on day 48, it must have covered half the pond on day 47. Thus, the correct answer is 47 days. System 1 thinking jumps to conclusions and can ignore important facts, such as the geometric rate of increase.

This scenario was packaged with two similar items in Frederick's (2005) research. The score varied from college to college. Forty-eight percent of MIT students got all three items correct. At one less elite college, 64% of students got all three wrong. According to Frederick (2005), even those who solved the problem reported that the 24 days answer came to mind initially.

A particularly dramatic example of System 1 at work involves subjects being shown pairs of pictures for as few as 200 milliseconds (Ballew & Todorov, 2007). They were asked to judge which of the two males pictured was more competent. Unbeknownst to the subjects, the photos were of opposing candidates in gubernatorial elections. The judgments of the more competent face account for 64% of the election winners. According to Ballew and Todorov (2007), this suggests that many voters rely solely on a System 1 analysis of a candidate's face to make voting judgments. How likely is it to find a single voter who would admit that s/he voted for a candidate based on the look of his/her face? Table 1 lists several System 1 biases and some potential consequences for safe performance.

Table 1

Safety Consequences of System 1 Bias

System 1 bias	Impact on safe performance
Neglect of ambiguity and suppression of doubt	Employee does not speak up even if s/he feels something is not quite right.
Confirmation bias	Employee remembers how s/he has never been hurt while performing this task in the past, leading to the conclusion that the activity is safe.
Halo effect	Employee does not question the project manager or company line.
What you see is all there is	If employee is not aware of anyone being injured while performing a particular task using a particular method, then s/he assumes activity must be safe, without considering potential hazards.
Overconfidence	Employee expects that his/her skill will enable him/her to take risks without incident.
Infers and invents causes	Can lead to poor incident investigations by jumping to conclusions prematurely.
Substitute easier question for harder one	The question might be, "How do we do this safely?" The answer might be "No one has ever been hurt doing it this way." That is an answer to a different question.
Preference for status quo	This stands in the way of looking for better, safer ways to do things.
Loss aversion	Leads to continuation of actions under increasing risk.

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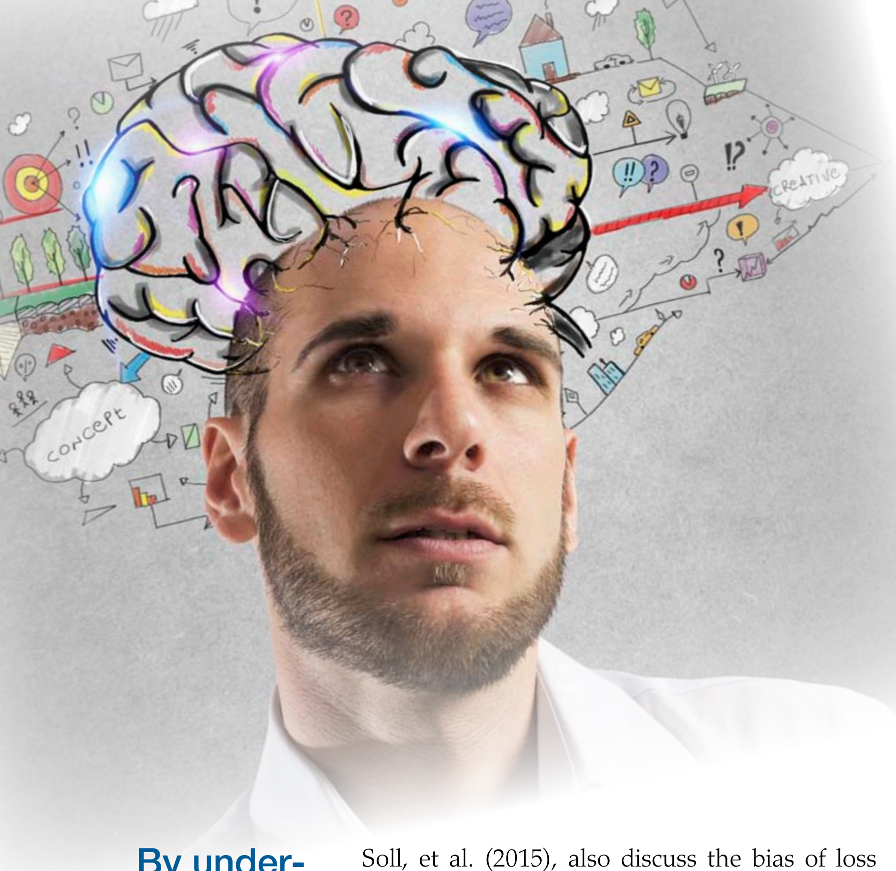
System 1 Safety Consequences

It is a fair assumption that any employee conducting a relatively routine task is operating primarily under System 1, no matter how hazardous the task might be were a mistake made. Many System 1 biases support the assumption that everything is okay even if some evidence suggests otherwise. In fact, the individuals involved would be expected to experience a sense of cognitive ease, pleasant feelings and reduced vigilance.

A general way to address such issues is to invoke System 2 thinking to review the conclusions being offered by System 1. This might involve asking questions such as, "What are some other ways to do these tasks and are they safer or more hazardous?" The answers are not as important as the application of System 2 thinking to these issues, as it forces circumvention of System 1 biases.

Soll, Milkman and Payne (2015) posit a novel suggestion for circumventing System 1 biases, particularly overconfidence; they call it *premortem.* When planning a project, those involved assume that an incident occurred. The first step, deciding what the incident was, is an initial step in avoiding the bias. All involved must evaluate the risks. The next step is to determine why the incident happened; this provides a deeper view of the risks that is not muddied by overconfidence.



By understanding and recognizing the two systems of decision making at work, OSH professionals can more effectively assess risks, investigate incidents and develop strategic plans.

Soll, et al. (2015), also discuss the bias of loss aversion, which can cause the continuation of a risky course of action to avoid losing the time and effort already expended. Many major incidents have occurred because a task was continued in the face of evidence that the process was off track. Soll, et al. (2015), use the example of mountain climbing. Many climbers have died by attempting to summit Mount Everest when the weather has turned bad or when they were too late in the day. Their solution is a "trip wire": a firm deadline to reach a certain point. While there is no simple analogy for this in a manufacturing operation, there should be extensive discussion of how a process might go off track and what to do about it.

System 1 biases are at least as much of a problem in the executive suite as on the factory floor since bad decisions by executives often have a much wider effect. The decisions surrounding the *Challenger* launch are a perfect example.

Bailey and Petersen (1989) argue that safety perception surveys are a better way to assess the performance of a safety system than are incident counts. Carder and Ragan (2012) reach a similar conclusion based on 20 years' experience and considerable research on the measurement of safety system effectiveness: Surveys are superior to incident counts.

Petersen (2000) was puzzled as to why it was so difficult to get executives to understand this. System 1 biases may be one explanation. First, using incident counts maintains the status quo. Second, the "what you see is all there is" bias suggests that many executives will not pursue information on this topic and assume that the evidence they have is all there is. This illusion of truth leads to pleasant feelings and a sense of cognitive ease.

One way to address this would be to ask these executives to make an argument for why surveys are superior to incident counts. This exercise would require them to entertain new evidence. Such a process would follow accepted attitude change techniques as well (Festinger & Carlsmith, 1959).

Kahneman's (2008) ideas apply to incident investigation as well. For example, these ideas help explain how people acted and why they did so during an incident. Were they expected to act with System 2 deliberation when the time required to perform the task was limited to a System 1 scale?

Understanding the biases of System 1 thinking also provides insight into why eyewitness reports of the same incident can differ greatly. System 1 biases, such as neglecting ambiguity and inferring and inventing, can cause witnesses to fill voids in the story; this process helps them turn an event that made no sense into one that makes sense. Witnesses are unaware that their minds are engaged in this process, however. Therefore, any incident investigator must recognize that these biases may be in play during interviews.

Conclusion

Other findings by Kahneman (2008) are worth deeper exploration. OSH professionals can use recent advances in psychology to increase the likelihood that safety decision making is appropriate, which will ultimately lead to fewer incidents. By understanding and recognizing the two systems of decision making at work, OSH professionals can more effectively assess risks, investigate incidents and develop strategic plans. **PS**

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