Brain-Centred Hazards: Risks & Remedies

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Abstract

A great deal of progress in personal and process safety has been made through the effective identification and control of hazards in our workplaces. Front-line workers and leaders alike are taught to observe their work environments for physical, technological and behavioural elements that can cause or contribute to personal injuries, releases and accidents. But what if potential hazards and associated safety risks are also hidden in the human brain, not just the shop floor? And what if these brain-centred hazards are exacerbated by the fact that critical organizational elements—including work environments, technological interfaces, operating procedures, work schedules and even risk management and organizational cultures—are not aligned with how the human brain actually works? Neuroscientists have confirmed in recent years that different systems in the human brain compete to control human behaviour. Nobel prize-winning research by Kahneman and Tversky (amongst others) introduced us to the "dual-process" system of the Fast Brain and Slow Brain. The Fast Brain produces automatic, reactive, habitual and emotion-based actions. The Slow Brain, the "executive" centre, operates with conscious cognition, producing analytical, reasoned and thoughtful actions. Unfortunately, the Slow Brain is not in charge much of the time. Why is this a problem? The troubleshooting capabilities of the Slow Brain are often a critical line of defence against all types of hazards in the work environment. This means that jobs involving routine and repetitive tasks are at risk of being performed "without thinking" with the Fast Brain in charge, leading to increased error potential. The good news is, everything from organisational culture and leadership messaging, to work schedules, procedures, human machine interfaces and incident investigations can be revamped to align with brain science, to reduce exposure. Taking a data-driven, brain-centred approach, uncovers weaknesses in operational and safety systems and enables leaders to deliver sustainable human performance reliability.

Key Words

Human Factors

Brain-centred hazards

Human Reliability

Neuroscience

Introduction

Knowing that risk is created by exposure to hazards, all members of the workforce have been enlisted to become "hazard recognizers." Front-line workers and leaders alike are taught to observe their work environments for physical, technological, and behavioural elements that can cause or contribute to personal injuries and/or organisational accidents. The purpose of hazard identification is to determine the right hierarchy of controls, beginning with elimination of the hazard or substitution of materials and processes. A great deal of progress in personal and process safety has been made through the effective identification and control of these external hazards in our workplaces. But what if the potential hazards and associated safety and business risks also are housed in the human brain? And what if these Brain-Centred Hazards, as I have coined the phrase, are exacerbated by the fact that critical organizational elements—including work environments, technological interfaces, operating procedures, work schedules and even risk management and organizational cultures—are not aligned with how the human brain actually works?

This paper outlines some of the Brain-Centred Hazards identified by applying recent neuroscience research to our modern workplaces. Specifically, three key lessons from neuroscience are explored in detail so leaders can be alerted to the types of risks lurking in every one of their worksites. Then, this paper introduces a mitigation approach that enables leaders to reduce exposures to these newly-identified hazards. What is most crucial for leaders to understand is that, left unattended, Brain-Centred Hazards can create high-consequence exposures as serious as toxic chemicals or loss of controls. In fact, some of our most serious organizational accidents have involved Brain-Centred Hazards typically identified as "human errors."

The Fast Brain is First

Neuroscientists have confirmed in recent years that different systems in the human brain compete to control the single output channel of human behaviour. Of most importance is the "dual-process" system of the Fast Brain and Slow Brain. The former is housed primarily in the Limbic System or Paleomammalian complex, and produces automatic, pre-conscious, reactive, habitual, and emotion-based actions. The latter is housed primarily in the brain's pre- frontal cortex, its "executive" centre. The Slow Brain operates with conscious cognition, producing analytical, reasoned, reflective, and thoughtful actions. This conscious part of the brain is the human defence system against impulsive emotion-laden reactions that can put a person at risk and cause him or her (and others) harm. And, the problem identification, analysis, and troubleshooting capabilities of the Slow Brain often are a critical line of defence against all types of external hazards and exposures in the work environment or work processes. Unfortunately, neuroscientists now tell us that the Slow Brain is not in charge much of the time. That is, our actions are directed primarily by the Fast Brain, and therefore, are often pre- conscious, habitual, and/or reactive in nature.

The Fast Brain is the initial controller because it is both speedier and more energy-efficient. The human brain uses more energy than any other body organ—upwards of 20% or more of the body's available energy—even though it constitutes only 2% of human body weight. For this reason, the human brain has evolved to rely on its fast processor as often as possible, even "live wiring" its neuronal pathways to facilitate automatic, reflexive behaviour without us consciously choosing to do so.[1] Take driving a car as an example. Most adults over 25 years of age have practiced driving long enough that they can do it "without thinking," meaning without consciously going through all of the steps of procedure involved in driving a car. Similarly, in the workplace, jobs involving routine and repetitive tasks are at risk of being performed "without thinking"; that is, they are performed with the Fast Brain in charge, not the analytical, reflective Slow Brain. And, as with driving, most of the time such routine tasks will be done safely and productively. Yet, performing a job task from the Fast Brain creates high error potential, including failure to consciously complete every step of procedure every time, and failure to double check our actions. Conscious cognition, housed in the Slow Brain, has to be activated in order for the self-reflective part of the brain to perform self-checks on our work.

The Fast Brain Sees in Sketch Mode

One of the ways in which the Limbric Brain is fast is in how it processes visual information, which is 90% of the information received by the human brain. In just 4/10 of a second, the human subcortical vision system evaluates the external environment and begins to direct habitual behavioural responses. Specifically, the subcortical system located in the thalamus—part of the Fast Brain—processes colour, shape, and movement information and creates a "sketch" of a visual object, similar to a caricaturist drawing a person's face. If the anterior cingulate cortex (ACC) that connects the Fast Brain and Slow Brain does not perceive any discrepancies between the "sketch" and its experience- driven expectations of the external environment, action is taken without ever engaging the thinking or cognitive parts of the human brain.

Looking in Fast Brain mode is sufficient if your survival depends on scanning the physical environment for one or two predators, like large cats on the African savannah. In the complex work environments of today, however, such generalized looking typically fails to uncover key situational clues like weak signals for upsets in the making. Notably, without seeing and understanding weak signals, preventive action cannot be taken. That's why the Situational Blindness that results from the Fast Brain modes of scanning and sketch-seeing, including failure to detect critical changes in the work environment and/or changes in technological conditions surrounding job tasks, is one of the most serious Brain-Centred Hazards. Conscious cognition, housed in the Slow Brain, has to be activated for humans to fully see and accurately analyse and interpret all aspects of the external environment. Unfortunately, it takes half a second just to activate our cognitive capabilities, and by that time, habitual or impulsive action directed by the Fast Brain already has commenced. Activation of the Slow Brain has to precede critical task performance in order to ensure active situational awareness and reliable task execution.

Fatigue Impairs Brain Performance

Recent evidence from functional MRIs (fMRIs) has definitively proven that neurophysiological or cognitive fatigue causes performance impairment. This type of fatigue results solely from insufficient delta-wave or deep sleep in either the last 24 hours (acute fatigue) or the past 7 days (cumulative fatigue). And such deprivation of deep sleep in even a single 24-hour period has been proven to cause measurable impairment of cognitive performance capabilities. Specifically, fMRI studies visually demonstrate that sleep deprivation significantly degrades the following types of Slow Brain functions:

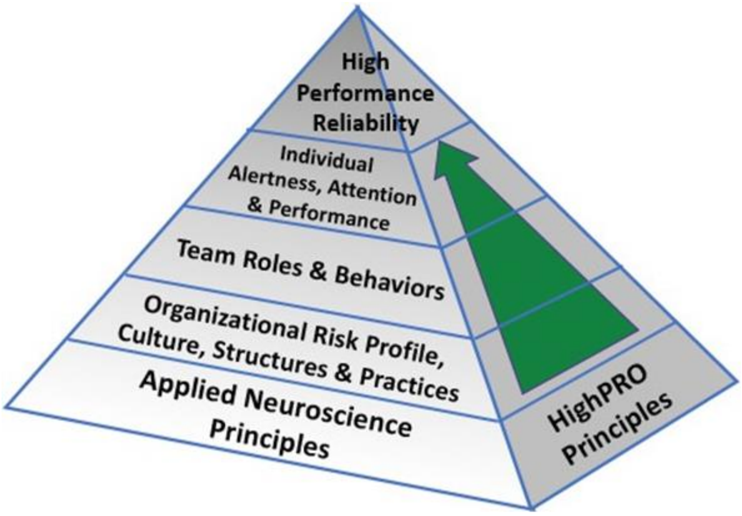
- Attention to detail
- Impulse and risk inhibition
- Accurate memory recall
- Problem analysis
- Conceptual thinking
- Planning ahead
- Decision making

In addition, reaction times are slowed, irritability is heightened, and judgment is impaired when a person is in a state of sleep deprivation and associated cognitive fatigue.

From a safety and reliability perspective, numerous risks are created when one or more employees are operating with moderate to severe cognitive fatigue, whether acute or cumulative in nature. For one, employees cannot effectively "think ahead" or conceptualize solutions for problems that start to emerge. The thinking, reasoning and troubleshooting capabilities of the Slow Brain—the capabilities that serve as a person's best defences against harm at work—are not functioning effectively (or at all) when sleep-deprived. In addition, humans lose their self- awareness capabilities when cognitively fatigued, resulting in the inability to assess how impaired they actually are.

Without the Slow Brain in operation, conscious self- reflection and self-monitoring just don't happen. Loss of self-awareness is especially dangerous when combined with the elevated risk-taking that occurs among sleep- deprived people. Given that surveys consistently show fatigue is experienced by a high percentage of the workforce worldwide every day, it is not surprising that cognitive fatigue is often viewed as the number one Brain-Centred Hazard in modern workplaces. In fact, the National Transportation Safety Board in the U.S. has designated "Addressing Human Fatigue" as the first item on its Most Wanted List for ensuring safe roads and safe transport. And, the U.S. Nuclear Regulatory Commission has cited workplace fatigue as a hazard to be managed[2] so that "personnel are fit to safely and competently perform their duties."

Figure 1 – Brain Centric Reliability System™



What Can Be Done?

Neuroscience has provided new knowledge and understanding about potential hazards originating in how the human brain works. But what should leaders do with this new science? Reflecting on the hierarchy of controls for addressing workplace hazards, it is clear that companies cannot eliminate Brain-Centred Hazards altogether, as that would require the elimination of all humans from the business. Even substitutions typically are not a viable approach, especially in process industries or labour-intensive industries where automation cannot fully replace humans. Rather, what must be done in all companies where humans perform safety-critical job tasks is the implementation of new systemic layers of defence that are designed to drive Brain- Centric Reliability™ (BCR™) System practices and behaviours into our workplaces. More specifically, leaders have to re- think and re-design their worksites, instituting organizational and team structures, systems, practices, and procedures that are brain-aligned (see Figure 1). The effective activation and essential engagement of employees' capabilities for conscious cognition must be supported at the organizational, team, and individual levels of the enterprise. For this reason, everything from the organizational culture and leadership messaging to workforce training, work schedules, operating procedures, human machine interfaces, and even incident investigations need to be revamped to align with new brain science.

To illustrate this concept of brain-aligned organizational elements, consider two important facets of every workplace: the organizational culture and standard operating procedures (SOPs).

Culture

With respect to culture, it is now recognized that leaders' messaging and modelling (what they say and do) set organizational culture and corresponding member behaviours. When leaders transmit messages of urgency to their workforce, they probably don't realize that such time pressures actually diminish Slow Brain engagement. The ACC in the neocortex picks up urgency messaging as a stressor, and engages the Fast Brain to deliver a finished task as quickly as possible. But a finished task is not the same as error-free performance. Facilitating high

performance reliability requires different cultural messaging from leaders. Specifically, the human brain needs to be primed with messages of Right-First-Time Reliability, such as: You always have the time to do the job right, and, Take your time so you do the task right the first time. This type of reliability-centred messaging signals the human brain to "think through" job tasks, focusing on execution of correct actions rather than the speed of actions.

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Chart 1 – Error Prone Sample of Standard Operating Procedure

Authored By:	Loss of Burners in 87F-103	Doc No.: **105.4483** Rev No: 3
Doc Custodian: CX-4 Process Specialist		**Operating Guideline**
Approved By: Area Team		
Date Approved: 10-14-2013	Next Annual Certification Date: 10-14-2014	Effective Date: 10-14-2013

Step 1.0	**Description**
NOTE: If at anytime during the process of relighting the Furnace problems are experienced that cause a significant delay, notify PDU of a possible gasoil wash.	
1.1	Verify that the Furnace has shutdown and pilots are out.
1.2	Reduce the Unit Charge to Minimum immediately. a. Increase the external recycle to reduce the fresh feed. b. Block in the gas oil and distillate products.
1.3	Proceed with the Furnace relighting process.

Standard Operating Procedures

In terms of SOPs, many leaders are deeply frustrated by incident investigations that conclude with the finding: "Failure to follow procedures." Yet, how many leaders ask whether SOPs are brain-aligned, meaning are they written for ease of usage by the human brain or do they require second-guessing and interpretation by the users?

If interpretation is required, the probability of incorrect actions increases significantly. Chart 1 contains a verbatim excerpt from a Loss of Burner SOP in a U.S. oil refinery. This SOP covers a highly safety-critical task, yet it is extremely unclear in several respects. For example, what is meant by a "significant delay" in the important NOTE section of this SOP? Is it 10 minutes or 60 minutes? In Step 1.1, how does an employee "verify" that the "Furnace has shut down and pilots are out"? In Step 1.2, what is the "Minimum" to which the Unit charge is to be reduced "immediately"? In Step 3, how is the Furnace relit safely? This real example of an SOP relies on the memory of employees for reliable procedural execution when, in fact, human memory is itself a Brain- Centred Hazard, often referred to as "brain fog" or "memory is mushy". If error-free actions are required, as they are in all safety-critical tasks, then a Brain-Aligned SOP™ consultation is required. Every step of procedure must clearly define the "how to" action required. Sufficient white space and other brain-friendly approaches must be deployed. These and other Brain- Aligned SOP™ Design Principles can make the difference between error-prone task execution and high human performance reliability.

Steps for Success

In light of recent neuroscience findings, companies cannot continue with operations-as-usual that leave Brain-Centred Hazards unidentified or unaddressed. Instead, new brain- aligned operational and safety defences must be instituted to reduce exposures to these key hazards in our workplaces. Generating high reliability in task performance necessitates the use of Applied Neuroscience combined with High Performance Reliability Organization (HighPRO) Principles, as promoted by the Brain-Centric Reliability™ System. But, where to begin? Achieving sustainable results in the most efficient manner can be aided by a company-configured Reliability Roadmap. This Roadmap can be crafted with data from a BCR™ Operations Analysis, which documents Brain- Centred Hazards and uncovers associated weaknesses in a company's operational and safety systems for risk and the right reliability management. The data-driven selection of brain-aligned solutions for the organizational, team and individual levels of the enterprise enables company leaders to deliver deep and lasting human performance reliability.

1 Eagleman, David. Incognito: The secret lives of the brain. New York, Pantheon Books, 2011.

2 U.S. Nuclear Regulatory Commission, Regulatory Guide 5.73: Fatigue Management for Nuclear Power Plant Personnel, 2009.