<u>The Paradox of Intuition -</u>
<u>A Neuroscience Approach to Training Pilots for Unexpected Events</u>

Laurie Earl (*NZSASI - AO5459)* **& Jim Sheffield**
Coventry University, UK, Victoria University, NZ

On January 15, 2009, US Airways Flight 1549 hit geese shortly after take-off from LaGuardia Airport in New York City. Both engines lost power, and the crew quickly decided that the best action was an emergency landing in the Hudson River (Eisen & Savel, 2009).

In testimony before the NTSB, Captain Sullenberger maintained that there had been no time to bring the plane to any airport, and that attempting to do so would likely have killed those on-board and more on the ground. Exactly 3 mins 28 secs had elapsed from the time of the bird strike to landing on the water - the crew had made a split second decision in a highly volatile moment. The Board ultimately ruled that Sullenberger had made the correct decision (Atkins, 2010)

As technology moved from analogous cockpits to fly by wire technology the aviation industry began to see many more such 'black swan' events, a term coined by Taleb, 2007 to explain events that were unusual, that surprised the crew, or that had never happened before so couldn't be trained for (Wickens, 2009).

This paper explores how pilots make decisions in complex situations, when they can't rely on procedures and where generating multiple options doesn't always make sense. Primarily we examine how intuition influences decision making and why that tacit knowledge plays a more important part than originally thought. Tacit knowledge being that piece of the iceberg that's below the surface – we don't notice it and we can't easily describe it (p35). In other words - "How we think and decide in the world of shadows, the world of ambiguity" (Klein, 2011)

We consider how hidden impulses affect judgement and the influence of experience and knowledge on decisions made under extreme circumstances. This discourse examines how the expert has built up a repertoire of patterns that aren't based on facts or rules or procedures. Instead they are built on all the events and experiences they have lived through and heard about. This is the basis for intuition.

The paradox of intuition is that emotion ('gut feelings') must inform reason (cognition) and reason must inform emotion (giving a rational response). We explore this paradox through the lens via a research framework (the dual-process model -Figure 1) which plays an important integrating role in the current behavioural decision making literature (Evans & Stanovich, 2013; Kahneman & Egan, 2011). While the terminology and application domains of the dual-process and dual-systems models vary, there is consensus on core concepts. Evans & Stanovich (2013) state that: "Our preferred theoretical approach is one in which rapid autonomous processes (Type 1) are assumed to yield default responses unless intervened on by distinctive higher order reasoning processes (Type 2). What defines the difference is that Type 2 processing supports hypothetical thinking and loads heavily on working memory."

In a similar model, Landman, Groen, Van Paassen, Bronkhorst & Mulder (2017) describes a neuroscience approach in a conceptual model to understanding the cognitive process. A pilot perceives stimuli, interprets this, assesses the situation (appraisal) and selects and executes actions.

Criticisms of the dual processing methodology point to the vagueness of their definition and the lack of coherence and consistency in their approach but Evans & Stanovich, (2013) demonstrate that there is a clear empirical basis for dual processing distinction in the fields of reasoning and decision making.

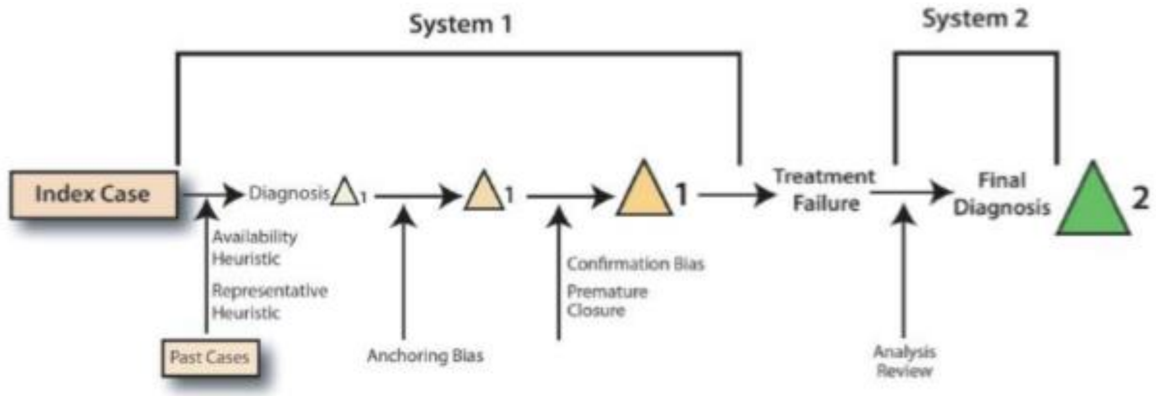

Figure 1. Bias awareness (Source: Bloxham, 2012)

What is apparent is that by using this methodology pilots can be trained in effective decision making from a neuroscience perspective. In other words they can be trained to understand what is happening in their brains and discovering, recognising and planning for adverse events. Currently we are intent on reducing errors and not enough on building expertise (Klein, 2011).

So what exactly happens in the brain when we are faced with an unexpected event we have no processes or structure to deal with? The startle/surprise effect testifies that " *Surprise is an emotional and cognitive response to unexpected events that are difficult to explain, such as subtle technical failures or automation surprises that are baffling. Surprise could impair the crew's troubleshooting capabilities" (*Martin, 2015). Lehrer (2009) explains that the emotional response that happens in the Amygdala is stronger than the rational response that occurs in the Dorsolateral Prefrontal Cortex (DLPFC). Therefore a 'knee jerk reaction' based on the emotional response can occur, particularly in those with less experience (BEA, 2012). The ability to control the conversation between what we feel and what we think sits at the crucial intersection between these two different ways of thinking in the form of the Anterior Cingulate Cortex (ACC) - the trigger between them (Lehrer, 2013)

Making decisions in dangerous circumstances requires the intuitive brain to size up the situation and form the initial impulse about what to do. The analytical brain then can be used to process the mental simulations to see if the option will work. Pilots often refer to the skill to think during a crisis as creating a "deliberate calm," which blends intuitive pattern matching with analytical thinking. (Pfeifer & Merlo, 2011).

"Deep in crisis mode it's easy to feel overwhelmed. It's common to feel you have no options and no time. You actually have more of both than you realise. It's just a matter of knowing how to create time and free up your mind." Richard de Crespigney, QF32

Analytical thinking occurs in the prefrontal cortex of the brain. It is where calculations are computed, logical sequences processed, and rational thinking takes place, This part of the brain also can tum off impulses, which is what Sullenberger did when he decided not to act on his first thought- to return to LaGuardia but decided instead to land in the Hudson River.

Along with understanding context and noticing information, cues, and data in the environment' or the lack of certain cues, an expert often also has the ability to tune out unnecessary information. Sometimes leaders can successfully employ cognitive shortcuts by utilizing heuristics, or rules of thumb. Often referred to as 'resilience', experienced flight crew understand implicitly the response to an event. Furthermore, thinking resiliently encourages us to consider how we might turn a problem into an opportunity.

Marcus Aurelius said: *"What stands in the way becomes the way".* What he meant by this was that any obstacle can be used as an opportunity for creative problem solving. So, when attacked by superior forces at unexpected locations, Aurelius did not resort to anger or panic, but instead he undertook a creative search for his available options. In turn, these options might inform future strategies, and, in keeping his cool, he was further developing his resilient habits.

In the same way, Captain de Crespigney, QF32 after seeing an overwhelming amount of error messages come up, started to think about what they had rather than what they didn't have working – "*Invert the logic – if you're overwhelmed by what's going wrong, turn the problem on its head. Go simple, be creative and work with what you have, not what you've lost"* (De Crespigney, 2018)

Currently ICAO have listed LOC-I as a top 3 safety priority due to a number of events involving inappropriate decision making (AF447, BEA, 2012), West Caribbean Airways Flight 708 in 2005 *(BEA, 2006*) and implemented new regulations which include recommendations to incorporate startle and surprise in training programmes to prepare flight crew for unexpected events. Previously airlines have practiced; Human Factors and joint CC/FC scenario based training, simulated exercises eg EFATO and debriefing, Some research and studies on training from past events as well as Human Factors technical design innovations such as Airbus inhibiting distracting, unnecessary alarms on TO till the aircraft reaches 1500. What is missing is; Realistic or challenging scenarios, Startle, Managing startle, Unexpected events training using metacognition

"By exposing ourselves to difficult situations and undergoing difficult training, we can protect ourselves from being startled when others around us are"
Richard de Crespigney – Fly

We have now learned, through the psychological practice of Cognitive Behavioural Therapy, that such "thought management" skills are genuinely teachable. By using metacognition (thinking about thinking) we can tailor the thought processes at hand and train better decision making and the control of our emotional response. One perspective is that we are really teaching people to align their assumptions and thoughts with reality. So, for example, if a storm damages our roof, we can get angry and think "why me?" or we can rationally assume that "well, this was likely to happen to someone, why not me?" The assumption that bad events can happen to us, not just to someone else, helps us avoid an irrational and unhelpful anger response (Bernard, 1991)

Barriers in the way of self control in decision making can include cognitive overload or underload - due to the active nature of the brain, it may be particularly problematic when pilots are not mentally prepared, for example, after a long period of automated flight. Loss of a fitting frame may lead to a complete "loss of grip" on the situation, as there is no frame in place to guide perception, appraisal, and action. Other barriers include emotional or physical exhaustion, stress and fatigue and ego depletion.

The dual process model domain can apply to aviation, the military, and health. Croskerry (2009) observes that dual-process theory supports simplified models that can be readily taught to learners across a wide range of disciplines. In particular, "an understanding of the model allows for more focused metacognition i.e. the decision maker can identify which system they are currently using and determine the appropriateness and the relative benefits of remaining in that mode versus switching to the other.” The dual-process model complements more detailed approaches such as neuro-ergonomics (Parasuraman & Rizzo, 2007). It is based on associative processes in intuitive judgment (Kahneman & Klein, 2009; Morewedge & Kahneman, 2010) and neurological processes (i.e., emotion vs reason) that are experienced by decision makers (Kahneman & Klein, 2010; Sheffield & Margetts, 2017) in naturalistic settings (Klein, 2008).

Training based on the dual-process model may include decision scenarios presented in the form of ‘serious’ video games (Morewedge, 2015, Morewedge et al, 2015) and checklists (Conley, Singer, Edmondson, Berry & Gawande. 2011). ‘Metacognitive moments’ embedded in complex decision processes (Wilson & Walker, 2009, led by Gawande, Sheffield et al, 2017) serve as the occasion both for possible transitions between system 1 and system 2, and for critical reflection on how cognitive biases may reduce situation awareness. Metacognition is a cognitive bias-awareness strategy that pilots can be trained to use to deliberately detach themselves from the immediate flight context, which allows them to reflect upon the thinking process, and switch perspectives as required.

One of the factors that facilitate pilot performance in surprising situations is **domain expertis**e, or accumulated knowledge and skills through practice and experience. By applying and testing hypotheses based on frames in a large number of situations, these frames become more accurate and more fixed in memory which allows one to easier relate new situations to those that have previously been encountered and to make decisions in a quick manner (Klein, 1993) (QF32).To some extent this is practised already but by repetition and recognizing such situations, pilots can apply learned coping strategies, such as taking a moment to “breathe” and reflect or returning to more transparent and understandable configurations or autopilot modes. (Boland, 2016)

Variable training. Researchers and aviation safety organisations emphasise the need for training with a variety of situations or scenarios. Training variability can be applied to reduce predictability so as to stimulate sensemaking activities and to improve reframing skills. Training variability is also thought to increase the number and elaborateness of available frames. Experiencing examples of a concept in a variety of situations may improve one’s understanding of the concept, facilitating the transfer of the knowledge and skills to new situations. In contrast, one-sided training of a small number of situations or (combinations of) failures may increase the risk of an inappropriate selection of these frames in stressful situations (Current training).

Practical training. Literature indicates that theoretical training should be enhanced with practical experience and feedback on performance (Kearns, Mavin & Hodge 2017) so that the frame-related knowledge is linked to other knowledge, environmental cues, and actions. Scenario-based training is based on the concept that knowledge cannot be fully understood independent from its context. Practical training may also be used in combination with exposure to a manageable amount of stress or startle, to make skills more robust to the effects of stress.

Essentially this paper explores how the human mind makes decisions and how to make those decisions better in a complex aviation environment where accidents are becoming less predictable. We explore why these intuitive decisions are sometimes wrong (AF 447, BEA, 2012), but often right (QF32, Hudson River landing, Al Haynes). Lehrer (2009, p4) argues that *“There is a thin line between a good decision and a bad decision.”* This paper is about that line

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