

3.1 Surprise, Startle and Resilience

Origins and Definitions

Humans have evolved over millennia and have an inbuilt instinct to survive. Fear helps us survive, giving us reflexes to the perception of a danger.



China's 'Glass Cracking Bridge' can demonstrate the fear response. As a person places their foot down, the glass bridge appears to begin to crack, and the person reacts with fear, grabbing onto anything that might save them. However, although the cracks are only images, people instinctively react to the perception of danger.

Perception is subjective; it is shaped by a combination of our past experiences and our individual nature.

This article will look at human responses to fear and how they might affect an individual in a high performance, safety critical role. Once we understand more about the reactions, we are better placed to use a Threat and Error Management process to mitigate the risks associated.

To investigate the human reactions, let us look at some definitions to draw some distinct lines between the concepts of fear, surprise and startle reflex:



Fear:ⁱ

- An unpleasant emotion caused by a threat of danger, pain, or harm.
- A feeling of anxiety concerning the outcome of something or safety of someone
- A mixed feeling of dread and reverence.

The Oxford Languages definition of fear above uses the term *unpleasant*. While some people enjoy horror movies or dare devil sports, these hobbies actually involve almost no real threats. There is an immeasurable difference in the fear created by sky diving compared to jumping out of a plane with no parachute! The enjoyment comes from the adrenaline rush created, and not from the fear of danger actually occurring.





Surprise: A feeling of mild astonishment or shock caused by something unexpected.

A surprise is simply a discrepancy between our mental model and reality. Surprise may be caused by:

- *Something occurring that was not anticipated*, such as an unexpected gift, a change in the weather, or believing you are alone in a room and then someone says 'hello.'
- *Expecting one thing, but a different thing occurs*, like a joke where the punchline alters the meaning originally understood, or an optical illusion that suddenly becomes clear.
- *Expecting something that does not occur*, for example hoping for a certain outcome that does not transpire.



These surprises can give a full range of emotions from excitement and happiness to disappointment or despair. Surprises are a normal part of life and occur regularly when compared to the startle reflex.



Startle effect: A reflex to perceived sudden or threatening stimuli which:


- Interrupts current tasks
- Distracts attention for 5 to 10 seconds
- Influences subsequent responses

The startle effect is an involuntary and unlearned reflex. We cannot control if, or when, it will occur, and it may occur as a result of a surprise. It comes on very suddenly and will incapacitate for several seconds and may be accompanied by both physical and cognitive effects.

Under threat, the brain is instinctively wired to '*do something simple now,*' a phenomenon which is potentially at odds with the requirements of the modern flight deck, where carefully considered and communicated decisions are required. Fear might elicit increased heart rate, sweating, trembling, faster breathing, or nausea. But what is the first thing that happens when we are afraid?

The 'F' Responses

The hardwired human responses to a trauma, or in this case a startle, can be classified into named groups, all beginning with the letter F. While there are many categorizations in discussion, including: fawn, flop, friend, face, flood, and fatigue... the models generally agree on three simple terms: *fight* & *flight* (as first proposed by Cannon in 1915ⁱⁱ), and *freeze* (added after WW1 studies of shell shockⁱⁱⁱ).

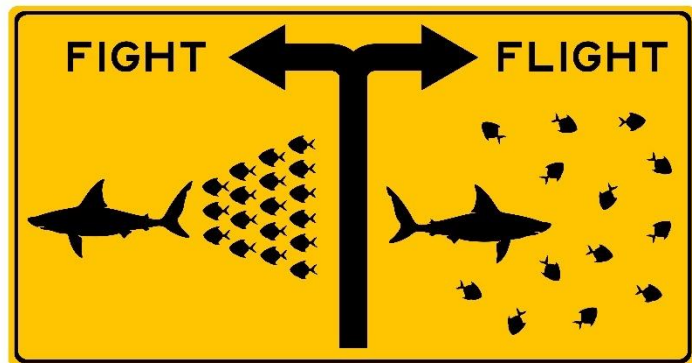


- Fight** – take action to eliminate the danger
- Flight** – escape from the danger
- Freeze** – become immobile to hide from danger

Each response will affect cognitive processing, and mental capacity will reduce, while the brain only focuses on the threat. It is important to realize that we cannot control which of these reflexes we will have in any given situation; but recognizing how people react to the reflexes, can aid us in mitigating any risks that ensue.

Fight or Flight

In preparation for fight or flight, the body releases adrenaline to increase blood flow to muscles. The adrenaline delivered to the body can cause some physical difficulties with motoric skills, such as a sudden muscular movement (jump), unexpected and unrecognized excessive strength, or loss of fine motor skills from uncontrollable shaking.



If an 'F' response occurs while the pilot is in manual control, it could cause flight path deviation or an undesirable aircraft state (UAS). A fight or flight response is particularly dangerous at critical stages of flight but could be equally concerning in other safety critical industries. The effect has been documented in aviation with tragic consequences.

Air France 447^{iv}

On 1 June 2009, an Airbus A330 entered a stall at 35,000 ft above the Atlantic. The pilots did not manage to recover before the aircraft hit the ocean. All 228 people on board were killed.

The BEA accident report states:

- “Excessive nature of the PF’s inputs can be explained by the **startle effect** & emotional **shock** at the autopilot disconnection”
- The PF’s initial, **startled reaction** was not the sole problem, but it did play a “major role in the destabilisation of the flight path”

The ‘excessive nature’ of pilots’ inputs can be attributed to the muscle jump and excessive strength from his fear reflex. This caused him to overcontrol the aircraft and fight the envelope protection system. With blood rushing to muscles and cognitive abilities reduced, the pilot was unable to see the big picture or successfully recover the aircraft.

Freeze

Another response is to freeze, becoming physically and mentally stuck. This instinct originates from the evolutionary benefits of camouflage, when freezing would mean you were not seen by the movement-detecting eyes of a predator. The primitive response is to stop doing everything, but as demonstrated by the ‘rabbit in the headlights’ analogy, the freeze reaction is not ideal in a modern day, dynamic environment. Once in the freeze reflex, the individual may be unable to interpret or resolve a situation, and therefore be powerless to move on without crew intervention.



First Signs of Recovery

As defined with startle, the initial effects within the reflex can last up to 10 seconds. After that, the hormonal surge begins to dissipate, and the individual regains some control over their responses. However, the first programmed reaction accessible in the brain is more likely to be from long standing established knowledge and skills. If someone has spent several years training in environment A, and newly transitioned to the environment B, they may find that their first reaction is a learned response from A, which may not be in line with those required for current situation in B. Applying previous knowledge to a current scenario is known as *reverting to type*, and can be seen between aircraft types and/or changing operators, as well as the reversion to simulator training.

British Airways Flight 38^v

On 17 January 2008, Speedbird 38 flew into London Heathrow. A long high-altitude flight caused ice crystals to form in the fuel oil heat exchanger (FOHE) that did not melt on the quick descent to land. The engines were advanced on the final approach but neither engine responded due to the blocked FOHE.

The pilot called: Mayday, Mayday, Speedbird, Speedbird, 95, 95...

BAW 38 crashed just short of the runway. No fatalities occurred.

The voice recorder transcript showed how the pilot reverted to type under pressure. The aircraft callsign that day was Speedbird 38, but the pilot called the mayday as Speedbird 95. This was the callsign often used in the simulator scenarios and was the one the pilot most frequently said when using it in a mayday call.

Black Swan Events

In his book *The Black Swan: The Impact of the Highly Improbable*^{vi} Nassim Nicholas Taleb introduced black swan logic as a means of examining rare events. He defined a Black Swan as an event, positive or negative, that is deemed improbable, yet causes massive consequences.



Black Swan Event: a rare event that is extremely hard to predict and beyond the realm of normal expectations that has massive consequences.

Black Swan events (BSEs) are, understandably, normally accompanied by some level of surprise and startle.

Case Study: United Airlines 232^{vii}

On July 19, 1989, the DC-10 of United 232 suffered a catastrophic failure of its tail-mounted engine due to an unnoticed manufacturing defect in the engine's fan disk. This led to the loss of almost all flight controls. The failure had never been considered before, there were no emergency procedures and the crew had received no training in how to deal with a situation like this. The accident is considered a prime example of successful crew resource management due to the way the flight crew handled the emergency and landed the airplane using asymmetric thrust on the two remaining wing engines. Despite the exceptional CRM, the aircraft crash-landed at Sioux City, Iowa, killing 112 out of the 296 passengers and crew on board.

In 1989, the case of United 232 in Sioux City was a BSE; no one had ever thought this could happen. However, after the event, the lessons identified spread quickly throughout aviation, and in 1981 when a similar accident occurred in Eastern Airlines 935^{viii}, the pilots recognised the emergency from the Sioux City crash. The crew applied techniques learned from the previous crash and landed the aircraft successfully with no fatalities. This is a prime example of evidence from operations being used to inform

future training – Evidence Based Training (EBT). Understanding that Black Swan Events occur, studying them, and analyzing actions and alternatives can assist crews if they ever find themselves in a comparable situation. This is a form of recognition primed decision making (RPDM) as discussed in the PSD chapter.

Traditional TEM practice cannot foresee a BSE, so managing and mitigating for a BSE becomes very problematic. Reflecting on the BSE definition, there are three concerns to be addressed:

1. To an inexperienced operator, the number of BSE will be far greater than for a seasoned veteran. One person’s BSE might be known to others, but it is the individual perception that makes an event a BSE.
2. BSEs rarely allow the luxury of time; their onset can happen suddenly, and they can escalate quickly from a known to an unknown.
3. By the very definition of BSE, we cannot train for them directly, as we do not know what they are.

So then, how does one mitigate Black Swan Events?

The key is to be mentally and physically prepared, and to remain alert. This requires resilience and personal discipline.

Resilience

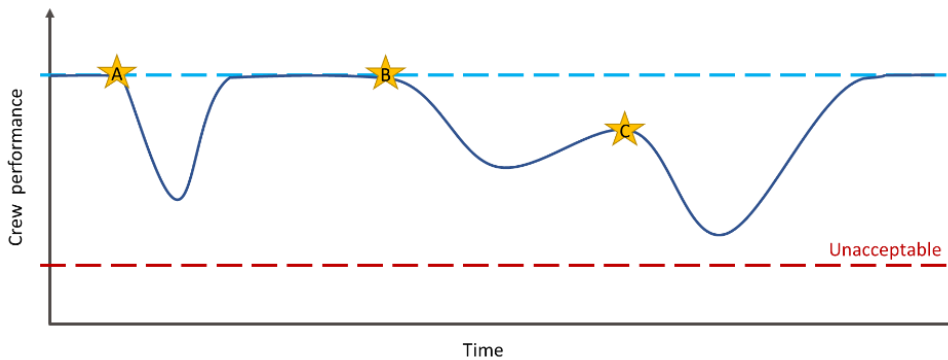
We cannot completely train out a startle reflex, but we can train for resilience, which aids recovery from surprise and startle.

Any member of a high-performance team will have undergone extensive training. Early in that training a stressful event, for example a major bleed rupture during an operation or engine failure after take-off, might have elicited a surprise and startle reaction. However, as training progresses, these emergencies become more commonplace and consequently the surprise and startle effects are reduced. To describe this capability progression, the word resilience is often used. Resilience is dependent on competence and confidence.



Resilience: The ability to recognise, absorb and adapt to disruptions. The capacity to cope cognitively, physically, and emotionally with a crisis and to recover quickly from challenges without long term negative consequences.

Imagine an adverse event occurs, which lowers crew performance (shown as star A on the graph). Given time, the crew will deal with the event and recover to their previous level of performance. But sometimes a crew might have event 'B,' from which they take longer to recover, and do not recover to the previous level before being confronted with event C. Resilience is the bounce back recovery, not just in time, but in the level of recovery.



Rather than teaching how to take specific actions, resilience training includes how to be an adaptive thinker. These skills are the human skills we see reflected in the ICAO pilot competencies and in CRM education globally.

To effectively train resilience, we can consider the elements from the TEM model. Using the same model, we can then consider what to do if the surprise and startle effect does occur.

Prepare through training

Repetition of challenging situations within training will aid in preventing surprise, as we learn (and carry out) responses to the common events. Debriefs can play a significant role in this, with “What would you do if...?” reflections and discussions establishing strategies to be employed if surprising events are encountered in the future.

However, it is important that scenarios are not predictably repeated such that teams know exactly what will happen and when. Over-scripting scenarios will reduce realism, and students will act in a programmed manner without critical thought, reducing the efficacy of training.

To improve the quality of simulations to prepare for real life situations, branching and/or flexible scenarios can be highly successful. In this training, crews will have a general plan for what they need to do, but depending on their actions, (and training needs), the scenario can adapt to allow the crew the opportunity to explore more unusual and complex situations. The more scenarios students are exposed to, the more experience they can draw on when needed.

Prepare within the performance environment

Whilst training before the flight, medical procedure, maritime voyage, or any task, will increase the crew's resilience, there are also tasks to be conducted during normal operations that will aid in mitigating the effects from surprise and startle.

To reduce the risk of a surprise occurring, individuals and teams must compare expectations and mental models against what is actually happening at regular intervals. Increased monitoring will improve the likelihood that trends will be recognised before a startling event. Automation is great at reducing some areas of workload and performs many monitoring functions. However, it is important to maintain mode awareness as complete abdication of monitoring responsibility to the computer will erode the crew's awareness. With the high reliability of modern aircraft, there is a risk of developing a conditioned expectation of normality on the flight deck.

Repair

Threat assessment is vital in managing surprise and startle effects, so if startle reflex occurs there are some key repair techniques to use:

- Recognise and communicate that a surprise/startle/fight/flight/freeze response has occurred.
- Do not make the situation worse by rash decisions. Wait until the initial startle has passed is vital.
- Communicate your actions and intentions and inform colleagues of your inputs.
- Ask questions - team members may view the situation differently.

Recover

If anyone recognises the effects of surprise or startle, the first steps are to Aviate Navigate Communicate:

- **Aviate:** Hand over or take over control - if you recognise startle, say so, and allow other crew members to assist.
- **Navigate:** Ensure the event has not disrupted navigation.
- **Communicate:** When appropriate, a good debrief with the team is essential to identify lessons learned. Report it - Your lessons may save someone else in the future!

Aviate Navigate Communicate

It is critically important, that for the duration of a pilot's career, they remain a 'student.' Operators in aviation, healthcare, maritime, and other performance environments, must stay up to date with technical information, regulatory requirements, and by practicing critical skills in terms of both those required for the task, and the human skills.

Preparedness includes the mental exercise of playing "what-if". This powerful tool is a form of Risk Assessment. Using what-if scenarios in the context of risk assessment and mitigation, starts with a probe of the hazards facing the crew at any given time.

It is already apparent that Black Swan Events are outlier events that have no predictability, and often cascade into multiple unrelated failures. Practicing risk assessment skills with the rest of the crew ignites conversation and proposes ideas for discussion.

Summary

- Fear is natural and the body has reflex responses of fight, flight, or freeze.
- Startle effect may cause incapacitation for up to 10 seconds.
- Effects of surprise and startle cannot be trained out, but resilience can aid recovery.
- Resilience in training is developed through realistic and varied simulation and/or scenario training.
- Black Swan Events are rare, unpredictable, and have major consequences
- Key mitigation strategies are resilience, personal discipline; and continuous risk assessment
- Aviate Navigate, Communicate, then ROC.

Further Reading

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