Emotions-Based Training: Enhancing Aviation Performance Through Self-Awareness and Mental Preparation, Coping with Stress and Emotions

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Abstract: Commercial aviation has achieved remarkable levels of reliability, evidenced by the exceptionally safe year recorded in 2023. However, the rarity of incidents means that unexpected events can have significant consequences for crew capacities and competencies. Evidence-Based Training (EBT) and Crew Resource Management (CRM) programs have long been instrumental in fostering effective teamwork and technical proficiency among flight crews. However, an emerging area of focus within aviation training pertains to the psychological aspects of pilot performance, particularly in managing stress, resilience and enhancing self-awareness. High-level sports have developed a range of mental preparation and sports psychology tools to equip athletes to manage unforeseen situations and adapt accordingly. Pilots, akin to high-level athletes, must perform under pressure, adapt to the unexpected, and maintain cognitive and analytical capabilities. These tools are equally applicable to pilots facing unconventional scenarios. Drawing inspiration from the field of sports psychology, this article explores how mental conditioning techniques can be integrated into Competencies frameworks to optimize pilot training methodologies.

1 INTRODUCTION

This article aims to explore the potential contribution, in terms of flight safety, of Mental Preparation tools commonly used in high-level sports and their applicability to the aviation industry. Specifically, it emphasizes the significance of "Self-Awareness" as a prerequisite to both technical and non-technical competencies outlined in the Manual of Evidence-Based Training (EBT) ICAO doc9995AN/4.

In high-level sports, athletes undergo physical and technical training to excel during competition, but many also cultivate their mental skills to handle pressure and adapt to the unknown, crucial prerequisites for delivering the expected performance.

Similarly, commercial airline pilots must maintain a high level of proficiency to respond effectively when unforeseen events jeopardize flight safety. They must be capable of analyzing, making informed decisions, and maintaining a safe flight path under adverse conditions.

Unlike high-level athletes, however, pilots do not typically receive individualized training on psychological states and stress management as part of their initial training nor during their career. Instead, such topics are covered at the crew level through Crew Ressources Management (CRM) courses and simulator training, focusing on predetermined competencies within Evidence-based Training (EBT) programs.

Yet, from a human perspective, cognitive abilities are only fully accessible when individuals are in a favorable psychological and physiological state, meaning they may be unavailable in high-stress situations. (Arnsten, 2009)

Modern-generation aircraft and complex systems demand, in abnormal situations, not only procedural adherence and piloting skills but also nuanced analysis for understanding and adaptation.

To date, neither training programs nor regulations adequately address this individual-level challenge.

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2 EVIDENCE-BASED TRAINING

2.1 Background of Evidence-Based Training (EBT)

The development of Evidence-Based Training (EBT) stemmed from the need to address aircraft hull loss and fatal accident rates by revising recurrent and type-rating training for airline pilots. Traditional training, based on early jet hull loss data, relied on repeating events without addressing evolving risks. With improved aircraft design and reliability, accidents sometimes occurred in well-functioning aircraft due to factors like inadequate situation awareness, as seen in controlled flight into terrain incidents. This shift necessitated a move away from a "tick box" training approach towards a more evidence-based and adaptive training methodology.

EBT prioritizes the development and evaluation of key competencies, resulting in improved training outcomes. Mastering a set of competencies enables pilots to handle unforeseen flight situations not covered by industry training.

Over the past two decades, data availability from flight operations and training activities has greatly improved. Sources like flight data analysis and air safety reports offer detailed insights into risks encountered in flight operations. This data has underscored the necessity for Evidence-based Training (EBT) initiatives. Additionally, it has helped define the training concepts by highlighting variations in training needs across different maneuvers and aircraft generations.

2.2 Competencies

EBT identifies core competencies that combine technical and non-technical knowledge, skills, and attitudes, aligning training content with the requirements of modern aviation (fig 1):

- Technical competencies:
  - Application of procedures;
  - Aircraft Flight Path Management, automation;
  - Aircraft Flight Path Management, manual control.
- Non-Technical competencies:
  - Communication;
  - Leadership and Teamwork;
  - Problem Solving and Decision Making;
  - Situation Awareness;
  - Workload Management.

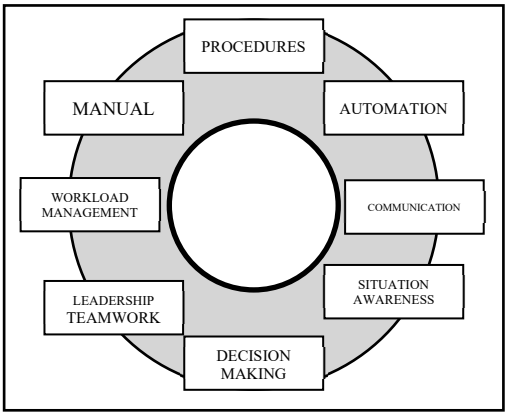

Figure 1: Technical and non-technical competencies.

3 EMOTIONS, STRESS, COGNITION

3.1 Emotions

While numerous theories and models have been proposed to explain emotions, there is no consensus on a single definition.

We can consider the neurobiological, cognitive, psychological, behavioral, and even social dimensions of emotions. (Van Kleef, 2022)

Emotions play a crucial role in decision-making (Damasio, 2006), attention, motivation, memory (Lachaux, 2011), social interactions, and of course, enable a rapid response to events involving survival by influencing behavior.

3.2 Stress

Stress (American Psychological Association APA 2018; Valencia-Florez, 2023) is a significant area of study in our Western society currently. It has been the subject of constant research, and our understanding of it has evolved over time. Stress will be addressed below by limiting the discussion to the topic that concerns us: cognitive performance in dynamic situations.

3.2.1 Acute Stress

Necessary for survival, acute stress is an adaptive reaction. Faced with a stressor, considered subjectively as such by the individual, a cascade of reactions occurs, ranging from neurobiological, physiological, psychological to behavioral aspects. Acute stress is limited in time and requires recovery time. The conse-

quences can be difficulties in attention, analysis, communication, decision-making, degradation of coordination, and sometimes inappropriate responses to the context (Staal, 2004).

3.2.2 Chronic Stress

Chronic stress is a disruption of the stress circuit with multiple consequences (Marin, 2011). It develops over time either by the constant presence of the stressor or by an emotional marking that prevents the organism from returning to balance. The effects of chronic stress are deleterious and have consequences on attention, memory, sleep, the immune system, which tends to maintain or even further feed it.

3.2.3 Emotion, Stress and Cognition

Executive control is a set of cognitive processes that enables the control and regulation of thoughts, emotions, and behaviors. It allows for situational analysis, perspective shifting, and decision-making, making it indispensable in managing complex systems. It complements automatic cognitive processes, which are responses to familiar stimuli that do not require conscious attention, yet are energetically economical.
These concepts are often described as "System 1; System 2" or "Automatic mode/Adaptive mode" (Lachaux, 2011; Kahneman, 2011)

3.2.4 Stress and Performance

During abnormal or unknown events, where the outcome is uncertain, acute stress adds to chronic stress (Knauft, 2021), altering the functioning of the executive mode, which enables adaptation. Cognitive regression under stress is well-documented in psychological and neuroscientific literature (Staal, 2004).

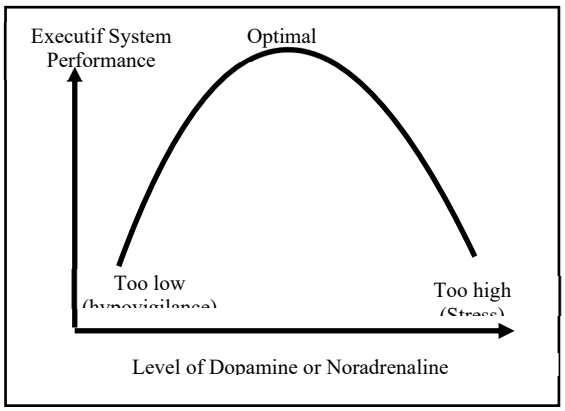

Figure 2: PreFrontal Cortex performance and dopamine/noradrenaline level.

In moments perceived as "stressful," the chemical balance between noradrenaline and dopamine in the prefrontal cortex (PFC), which houses a large part of the executive system, no longer allows for nominal synaptic functioning, influencing attention and working memory (Oberauer, 2019), and consequently affecting all functions that require analysis, perspective-taking, and reasoning.

This alteration can range from difficulty in regulating attention to total cognitive paralysis, as in the case of startle responses (Arnsten, 2009).

This leads to a tendency to operate more automatically, with deeper brain areas (limbic system) where old knowledge is stored continuing to function under stress. The drawback is that responses may be decoupled from the context, and individuals may rely on heuristics and be subject to biases in information processing and reasoning.

Tools to restore balance exist and will be described in the following sections.

3.2.5 Emotion and Stress

Emotion and stress mutually influence each other, with each being able to fuel and amplify the other (Epel, 2018). Strong emotion can generate significant stress, which in turn can amplify emotion. It is not possible to suppress emotions, but it is possible to work on managing these emotions.

Furthermore, studies on mirror neurons also explain the contagion of emotions and therefore stress (Gallese, 2001; Dimitroff, 2017). It may therefore also be interesting to work on emotion regulation in training in connection with visible negative consequences to avoid contaminating a team or crew.

4 HUMANS AND COMPLEX SYSTEMS

4.1 System Evolutions in Commercial Aviation

The latest generation of airliners is simpler to use but much more complex in design than older aircraft. Automations are ubiquitous, and their use is strongly recommended or mandated. Many systems and computers allow the aircraft to be kept within a flight envelope that respects limitations without requiring significant resources from the crew, even in degraded conditions. Among other things, there are electric controls, automatic engine and speed management, multiple protections, simplified approach procedures,

and some fully automatic maneuvers such as emergency descent or TCAS trajectories to resolve trajectory conflicts between two aircraft. The systematic application of procedures contributes to safety and allows crews to remain in a familiar environment.

Aircraft have reached remarkable levels of reliability: "the commercial aviation sector recorded an exceptionally safe year in 2023" (IATA Annual Safety Report 2023). The downside of these aircraft developments is the delicate integration of humans, who find themselves in a situation of monitoring an ultra-reliable system but may experience significant surprise effects when automation does not act correctly, and this unexpectedly.

4.2 Simple Failure Handling

During failures, pilots are trained to use procedures, often repeated in simulation, to deal with a large number of abnormal situations. These situations do not generate particular stress, and the reliability of the latest generation of aircraft means that failures are relatively rare.

The aircraft will present the faulty system and display the corresponding checklist (C/L) on a dedicated screen, with the items being few and sequenced in a simple manner to normalize the situation quickly (annunciated C/L).

System redundancy means that these simple failures will not lead to fundamental changes in flight conduct or excessive workload.

4.3 Complex Failure Handling

More complex failures such as a fire or smoke in the aircraft, inconsistent speed measurements, can generate a higher level of engagement than simple failures. These failures will also be handled using announced electronic checklists, which may include choices depending on the situation analysis. Some of these checklists will not be announced and will be at the discretion of the crew after analysis (non-annunciated C/L).

It may also be the case that a complex failure induces multiple checklists and requires flight adaptation due to degraded aircraft performance or the urgency to land at the nearest accessible airport, and a renunciation of the initial plan.

4.4 The Need of Advanced Analytical Capabilities

During multiple failures or failures outside the scope of procedures, the aircraft may have characteristics completely different from the initial aircraft. The pilot finds himself in an unknown situation and under high workload, thereby limiting his resources. The case of Quantas 032 in November 2010 is the most well-known example, with a multitude of failures that did not allow understanding the actual state of the aircraft without lengthy analysis, which took more than 45 minutes on that day.

The need for adaptation is crucial, and the cognitive resources of pilots must be available despite surprise or significant stress.

5 COPING WITH EFFECT OF STRESS IN HIGH-LEVEL SPORT

There is relevance in focusing on mental preparation in athletes since the issues faced by athletes/pilots are similar. In both cases, performing at a specific moment and under pressure is required.

5.1 Mental Conditioning (Sport Psychology)

"Mental preparation is the set of steps, methods, and techniques allowing for the development and optimization of the athlete's psychological resources in order to improve performance and/or well-being." (Sève, & Poizat).

5.2 Tools Used

Optimizing performance means that the level achieved in training should at least be reached in competition.
To do this, many tools aim to manage stress, whether chronic or acute, and work on adaptability during unexpected events.

5.2.1 Mental Imagery

The process by which a person generates, manipulates, and uses mental representations to understand the world around them, solve problems, plan actions, or recall past experiences (Et, 2021).

This mental capacity plays an essential role in various domains, such as learning, memory, creativity, and sports performance. It also allows for preparing for an action and mentally rehearsing it.

Aviation: Visualizing an approach before executing it; practicing procedures, correcting sequences...

5.2.2 Breathing

Voluntary abdominal breathing helps direct attention away from the pressure field and regulate the autonomic nervous system (Laborde, S, 2022). It is an essential tool in mental preparation because it provides space between the perception of stress and the response to be made (Haynes et al., 2024).

Aviation: Being able to focus on breathing during unexpected events. Knowing how to regulate oneself to regain cognitive abilities.

5.2.3 Temporization

Manipulation of slow and simple motor movements may be an effective means to attenuate autonomic arousal (Stearns, 2017) and also allows for analysis and adaptive mode, a step back similar to breathing.

Aviation: Physically stepping back from the situation. "Sit on your hands." Knowing how to slow down one's colleague by regulating their speech pace, for example, to bring them to a compatible activation level with the situation.

5.2.4 Relaxation (Mind-Body Connection)

Relaxation allows for tension release and induces "mental" relaxation as well (Meissner, 2006). The reverse is also true: energizing the body in case of hypovigilance allows for regaining cognitive abilities (Jazaieri and al. 2012; Morone and al. 2007).

Aviation: Identifying tensions. Knowing how to release them to gain both physical and mental fluidity.

5.2.5 Acceptance and Commitment

Inspired by Acceptance and Commitment Therapy (ACT), accepting the situation allows for committing to a solution (Hayes, Wilson, Strosahl, 1980; Monestes, Villatte 2017). This movement towards a solution reduces stress and enables quicker adaptation to the situation.

Aviation: Accepting the situation at hand to quickly initiate a solution, adapting accordingly.

5.2.6 Perspective Shifting

Working on psychological flexibility (Monestes, Villatte, 2017). Considering a situation from a different angle than the one naturally presented allows for new interpretations and considering other solutions. This tool contributes to enhancing individual resilience.

Aviation: Being able to change the point of view, consider multiple options. Listening to other suggestions.

5.2.7 Self Talk

Internal discourse can be motivational or instructional (Latinjak and al, 2023), helpful, or detrimental. Identifying words that serve performance is a way to remain effective and perseverant. It is noteworthy for trainers or instructors that a significant portion of the words used by the athlete (the pilot) often comes from the words used by the coach (Boudreault, Trottier, Provencher 2016).

Aviation: Understanding the quality of one's internal discourse, knowing if it is helpful or detrimental. Acting accordingly.

5.3.8 Athlete Ecology, Goal Setting, Motivation

These approaches help work on chronic stress. We have seen the importance of considering chronic stress in the general regulation of emotions and stress, allowing for a functionally optimal brain. (Sagy, 2002).

Aviation: Understanding that accumulated stress reduces the margin before cognitive tipping. Knowing how to recognize one's state. Sharing as needed.

6 SELF AWARENESS IN THE MIDDLE OF THE COMPETENCY MODEL?

6.1 Example of Accidents Where Stress Has Led to Overreactions or Cognitive Incapacitation

In all these events (see table 1), incapacitation due to stress, whether cognitive or physical, was noted. All competencies and CRM skills were affected, leading to the accident.

6.2 The Need to Place Self-Awareness at the Core of the Skills Model

As mentioned earlier, emotions and stress can have detrimental effects on analytical abilities, communication, decision-making, and motor skills. All skills can be impaired under stress (McClernon and al, 2011; Cahill, and al, 2021; Sadovnikova and al, 2023).

Table 1: Example of accidents where stress led to to over-reactions or cognitive incapacitations.

Company	Year	Keys words
American Airlines 965	1995	… desire to hurry the arrival; crew appeared to be confused, unaware of their location…
AeroPeru 604	1996	…mental confusion… confusion in assessment…
Korean Air 801	1997	failure to execute the non-precision approach; failure to effectively monitor; fatigue; inhibition
AtlasJet 4203	2007	Loss of situational awareness; spatial disorientation;
Spanair 5022	2008	inability to identify and solve the situation ; confusion.
SantaBarbara Airline 518	2008	crew (…) became disoriented…
Air France 447	2009	…deterioration of the crew cooperation leading to total loss of cognitive control of the situation.
Colgan Air 3407	2009	…monitoring failures, pilot professionalism, fatigue.
Air India Express 812	2010	…persistence in continuing with the landing; sleep inertia; impaired judgment.
Air Asia 8501	2014	…Inappropriate reactions; Miscommunication
TransAsia Airways 235	2015	… impaired judgment. Confusion.

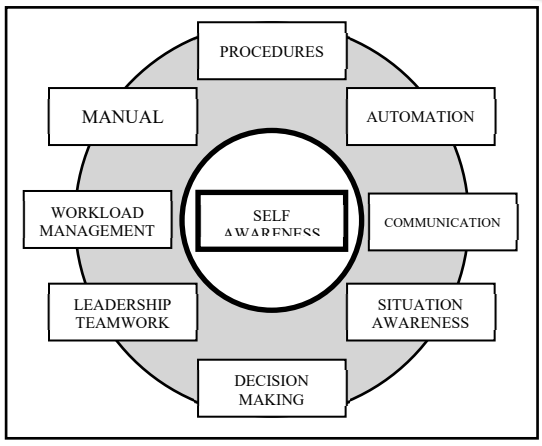

Figure 3: Self awareness at the core of the skill model.

We have seen that a significant number of accidents are due to inappropriate reactions to a situation that could have been controllable. These accidents are more numerous than those following an engine failure. Although the relationship between emotion, cognition, and decision-making is well established (Levine, 2022), the engine failure is over-trained, while "Self-Knowledge" is not. Yet, it seems indispensable (fig 3).

6.3 Reasons Why Self-Awareness Is Still not Trained

There are several reasons why this approach is not taught in aviation training:

- A cultural bias that believes that following procedures alone is sufficient for safety.
- The problem is not fully understood, which is surprising since it is experienced in other high-risk activities, especially in military aviation.
- Difficulty for an organization to control or quantify teachings, as Self-Knowledge is difficult to evaluate in the short term and can only be assessed in the face of exposure to the unexpected. The use of Human Factors-oriented Experience Feedback (EFB) is not yet developed in this direction.
- Instructional problem from the start of training. A young pilot will only hear about these topics when joining a major airline.
- The time devoted to integrating the effects of stress or emotions is almost nonexistent in initial training, no tools are provided, as the focus is on technical learning and aircraft handling. In this sense, this "Self-Knowledge," even if known, is not perceived as important.
- Flight School instructors are often pilots who are removed from these considerations due to their own training and are neither trained nor convinced of the relevance of this aspect of training. Many provide a technical response to an emotional problem.
- Regulation does not address individual performance, which should be integrated as a prerequisite for accessing skills. This topic may then be considered secondary by operators.

6.4 Instructors Training

As with the transition from traditional instruction to Evidence-Based Training (EBT), Self-Knowledge training is necessary (Soundara Pandian and al, 2023).

By understanding basic human functioning and the importance of being able to access one's full cognitive and physical capabilities in the event of unexpected situations, instructors can provide tailored and

personalized tools that will be a prerequisite and complement to CRM skills.

Self-Knowledge should be integrated into simulator sessions, practiced, and debriefed afterward. It should be an integral part of training.

Without turning instructors into Mental Preparation Specialists, it is easy to provide them with sufficient knowledge to move beyond the descriptive and deliver tools adapted to pilots' issues during training.

7 ENHANCING PILOT TRAINING

Crew Resource Management (CRM) courses are delivered annually to crews. They are covered by a program established by the regulatory authority and must address CRM topics on a triennial basis. To date, there is no formal demand for Self-Knowledge training. It is also not integrated into simulator sessions.

It would be essential to teach the techniques mentioned earlier from the beginning of aviation activity so that the tools are naturally used when needed.

A young pilot must recognize their stress (Lupien et al., 2022), be able to express their emotions from their first hours of flight, and understand their stress. It's a matter of safety. They should be offered means to address it. However, there is often still a barrier to sharing doubts, fears, or problems that have solutions. Pilots empirically build solutions that likely already exist as they gain experience and skills.

Recognizing emotions and stress should be systematic in high-risk systems, given the importance of maintaining cognitive abilities under stress.

Paradoxically, some airlines have entities that address the well-being and stress of flight crews:

- The CIRP (Critical Incident Response Plan) intervenes after an incident during a flight, potentially impacting chronic stress or even causing post-traumatic syndrome.
- GAIN (Gestion et Accompagnement Individuel des Navigants) assists pilots lacking confidence or facing specific problems in their professional lives. These two entities are not involved in training.

8 CONCLUSION

In conclusion, the findings of this study underscore the critical role of self-awareness in the context of airline pilot training. Through an examination of stress and emotion management tools drawn from the domain of high-level sports, this research elucidates the potential for enhancing pilots' resilience and, consequently, the safety of commercial flights. The discussion has highlighted the inherent parallels between the demands faced by high-level athletes and airline pilots, emphasizing the need for a holistic approach to pilot training that encompasses both technical proficiency and psychological preparedness.

By incorporating principles of self-awareness, mental imagery, breathing techniques, temporal manipulation, relaxation, acceptance, perspective shifting, and self-talk into pilot training curricula, aviation training institutions can better equip pilots to navigate the complexities of the aviation environment.Moreover, the identification of barriers to the integration of such strategies, as outlined in this study, underscores the necessity for systemic changes within aviation training programs and regulatory frameworks.

Looking ahead, it is imperative for aviation stakeholders to prioritize the development and implementation of evidence-based training programs that address the psychological dimensions of pilot performance. By doing so, the aviation industry can foster a culture of continuous improvement, resilience, and safety, ensuring that pilots are equipped with the necessary tools to confront the challenges of modern aviation. A step to Emotion-Based Training?

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