Thinking and feeling inside the cockpit: Dimensional representation of psychological effect and cognitive error in the 100 most fatal civil aviation accidents

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INTRODUCTION

Descartian dualism had a detrimental effect in the study of the nature of **emotion** and **cognition** in philosophy and science for the last three centuries, something that led to their treatment as largely separate entities. This distinction is apparent also in the study of the human factor in aviation were cognitive and psychological features attributed to the flight crew were historically studied and assessed as somehow distinct entities.

"if we are to understand how complex behaviours are carried out in the brain, an understanding of emotion and cognition interactions is indispensable (Pessoa nature).
Human factor in aviation is a Complex human behaviour were individual pilot characteristics are merged with human to human and human to machine interaction".

"Human Error" or "Human Factor"? | "What" or "Why"?

Manipulation of human Error in aviation : In the majority of human factor models speaking of human error is somehow synonym to speaking of human factor, with little- if at all -differentiation between the two. As a result, human factor investigations have traditionally focused on **"what"** caused the accident, rather than **"why"** it occurred with many causal factors in reports being merely brief descriptions of the accident or error.

…but how often is human error mediated from emotional factors in civil aviation accidents?

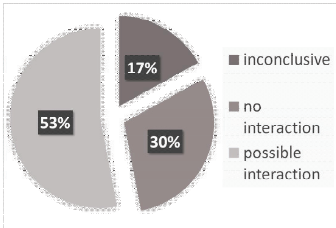

Figure 1. Possible interaction between psychological and cognitive variables in the 100 most fatal civil aviation accidents

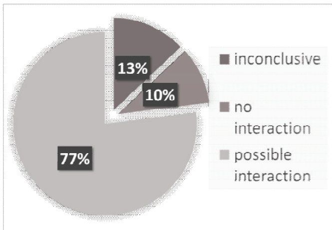

Figure 2. Possible interaction between emotional and cognitive variables in the Human Factor cases of the 100 most fatal civil aviation accidents

In a recent study, the presence of **at least one cognitive and one psychological variable**, attributed to the cockpit crew and implicated in the accident, was found in **53%** of the cases of the 100 most fatal civil aviation accidents, while in the human factor cases the possible interaction was found to be as much as **77%** (Stavrakis Kontostavlos et al 2018) .
We have to start thinking of the human risk factor in aviation as a constant and dynamic interaction between emotional and cognitive variables and **not just as a neurocognitive variable-error**. This is the reason why human error is not in the majority of the cases a cause but on the contrary a **symptom** that can be assessed and studied.

Aerospace Neuropsychology

"Aerospace Neuropsychology is the integration of neuropsychological methodology, theory and practice in aerospace settings, in order to study and assess individuals in every aspect of the human machine interaction with an aim to fly (Stavrakis Kontostavlos et al 2016)." **Core differences** of aerospace neuropsychology with the existing causal and descriptive models of human risk factor in aviation is the **manipulation of cognitive error** and the **data driven approach** based on aviation accident analysis.

METHOD

The 100 most fatal civil aviation accidents were subjected to data driven content analysis searching for recurrent cognitive and emotional/psychological variables implicated in the accidents. Results from content analysis were subjected to multidimensional scaling (MDS), with individual matrices for co-occurrence of cognitive and psychological variables simultaneously. Non-metric MDS (through ALSCAL) was applied in order to explore a two-dimensional graphical representation reflecting the map of human factors implicated in the accidents in question. Further clarification of the underlying construct of the possible interaction matrix was attempted using a multidimensional scaling trigonometric solution (MDS-T), (Mylonas et al. 2009,2016). Distances represent composite measures of the spatial relationships of neurocognitive errors and psychological/ emotional states.

Operational Definitions:

Psychological Effect: Any individual characteristic, internal state or environment effect of a pilot or flying crew that can have a possible distinct effect on cognitive performance. Personality traits, mental health variables, subconscious Homeostatic control systems, crew dynamics, personal life factors, operational and cultural effects are included in this human factor source.

Cognitive Error: A subject's innate or situational vulnerability to error. A cognitive error is the result of a neurocognitive mechanism gone wrong and is linked to the human brain by account of cognitive functionality. Attentional resources, memory, language, perception and decision making are included in this factor source.

RESULTS

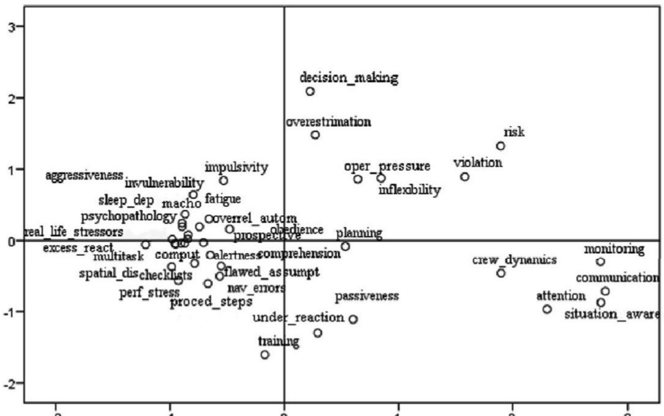

Fig. 3. Multidimensional scaling (ALSCAL) of cognitive and psychological variables coexistence and possible interaction in the 100 most fatal civil aviation accidents. Distances represent composite measures of the spatial relationships of neurocognitive errors and psychological/ emotional states. Five conceptual clusters pertaining to (1) individual pilot characteristics, (2) sociotechnical cockpit performance, (3) organizational/operational features and supervising outliers (4) training-level of involvement and (5) decision making-overestimation are identified.

Cumulative Causation Clustering

"Causative relevance to an accident is related to the synergic effect of the variables pertaining to a cluster. Changes in one cluster can lead to consecutive changes in another whilst total effect is greater than the sum of the individual parts".

- **Individual Pilot Characteristics**: 61.5% of all data. Perceived individual characteristics and skillse formed a distinctive group, with further discrimination between cognitive and psychological variables bounded respectively below and above the X axis. A visual representation of coexisting cognitive and psychological variables inside this dense area is indicative of the possible effect of the psychological variables in the cognitive performance of the pilot.
- **Sociotechnical cockpit performance**: Representation of variables that could be conceptualized as recurring ad hoc inside the cockpit. Variables: *situational awareness, monitoring, communication, attention* and *crew dynamics* are perceived as cognitive and psychological features that represent the interactive environmental challenges between systems and human resources of the airman during flight. These variables include but are not limited to Crew Resource Management involving interaction human-to-human (e.g. crew dynamics) and human-to-aircraft/human-machine interaction (e.g. monitoring).
- **Organizational/operational features**: Operational pressure (e.g. goal oriented behaviour in order to meet the company's flight schedule time tables under potentially dangerous situations) tend to form distinct proximities with individual characteristics that are separated from the dense area where most personality traits lie. These variables are*:* *risk- involved behaviour, inflexibility* and *violation of procedures*. It appears that the co-occurrence of the above in conjunction with operational pressure holds a significant weight as a prone to accident conceptual cluster.
- **Supervising Outliers: *decision making & training***: These cognitive variables seem to have a supervising role in the aerospace setting and have a detrimental effect should they breakdown. **(i) Level of involvement**: Adequacy of trainingo seems to define the level of involvement in a potentially dangerous situation, forming a distinct cluster with the psychological variables passiveness and under reaction. Inadequate pilot training is often followed by passiveness and under reaction resulting in lower level of involvement in a critical situation. **(ii) Overestimated decision making**: Decision making on the other hand has a proximity with overestimation of capabilities, a finding which is relevant to literature regarding over-assessment of abilities in pilots]. Probabilistic reasoning related to overestimation of capabilities by the pilot and its effect on decision making set the ground for the emergence of cognitive biases in aviation accidents.

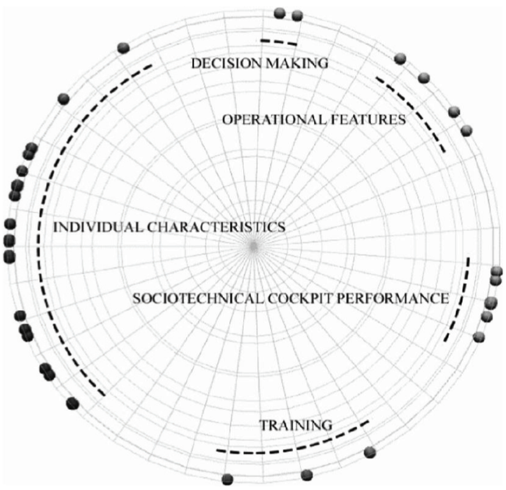

Fig. 4. Clustering of cognitive and psychological variables coexistence and possible interaction in the 100 most fatal civil aviation accidents through trigonometric transformations on the circle (MDS-T). Distances represent composite measures of the spatial relationships of neurocognitive errors and psychological/emotional states.Dimensionality and conceptual clusters described earlier were confirmed.

Aviation accident paradigms

West Caribbean Airways Flight YH708 crashed near Machiques, Venezuela resulting in 160 fatalities (all), after the absence of any appropriate action by the crew to correct the stall of the aircraft.
Scan the QR Code to learn more:

Korean Air Flight 801 crashed near Guam resulting in 228 fatalities (228/256) after the captain's failure to execute the non-precision approach and the cockpit crews's inadequacy to challenge his decisions.
Scan the QR Code to learn more:

DISCUSSION

Single source human factors were identified in a few cases related to psychological variables, mainly regarding **psychopathology** and **murder suicide**. The qualitative difference of these cases is their relevance to a **determinate act** by the pilot directly related to the accident cause and not to an error.
On the other hand, almost in each case where a neurocognitive error was identified in an accident, **at least one psychological variable was respectively identified** pertaining to the same accident. In the majority of cases, coexistence of psychological and cognitive variables yielded a complicated multidimensional visual structure, suggesting a possible **psychological and cognitive interaction**.
Whereas some behaviours may be characterized reasonably well by distinct emotional or cognitive attributes, such that emotion and cognition are partly separable, often integration of emotion and cognition **blurs the distinction between the two**. The same holds for **complex behaviors in the cockpit**, where individual pilot characteristics are merged with complex human to human and human to machine interactions that occur spatiotemporally during flight. Moreover even the pilot himself cannot assert a level of **metacognitive supervision** in what exactly he feels or thinks while flying. In the end, if we are to understand how complex behaviours are carried out in pilot's brain, an understanding of the **interactions** of the two is indispensable.
As multidimensionality was readily apparent in scaling this interaction, several **meaningful constructs** directly related to **real-flight data** were recognized. These human factor constructs are more than just face value since they are related to events and circumstances that could be **re-enacted** over and over when in the air. The human factor constructs and dimensions identified in the present study could be of **ecological validity** and hold a **predictive value**. In this light they could be linked to study methods and **assessment procedures** of the human factor in civil aviation based on **what actually went wrong** in an accident.
Besides, a paradox exists today: **human factor in aviation has been thoroughly described but not yet adequately defined**. As a result, human factor investigations and assessment methods have traditionally focused on **"what"** caused the accident, rather than **"why"** it occurred with many causal factors in reports being merely brief descriptions of the accident or **error**. It is argued that a significant number of fatal aviation accidents **could have been avoided** if the underlying factors that have contributed to the pilot error were controlled. Contrary to human's **innate vulnerability to error**, **psychological effect** can be assessed and in a number of cases predicted.
The **methodology** used in this study based on a **real-flight-data driven approach using aviation accident analysis** could be a method of choice for the study of the human factor in aviation. **Aviation accident analysis** has been offering valuable knowledge and expertise towards the **optimization of safety procedures** and mechanical reliability of the airplane. One should wonder though if the same insight has been gained from the accidents into the black box that is the human equation in aerospace settings (Stavrakis Kontostavlos et al 2016).
Results from this study are discussed towards the direction of a current need to review the existing **examination procedures** and create new **reliable tools** in an ongoing effort to calculate meticulously the necessary variables for **safe flight** under an ad-hoc and data based methodology.