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Airline pilots' perceived operational benefit of a startle and surprise management method: A qualitative study.

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Abstract: Startle and surprise can impair pilot performance and jeopardize flight safety. Self-management methods have been developed by the industry to address this acute source of stress, however, qualitative insights from pilots describing the quality of these methods are lacking. Ten semi-structured interviews with airline pilots, who had been taught a self-management method, were analyzed using thematic analysis). Pilots considered the method useful and reported positive effects (e.g., decrease in stress) when applying the method during operations. Pilots reported that the method was not often performed in full; specific steps were employed based on perceived benefit. Establishing fellow pilot status and situation awareness was considered most important, addressing own physical startle symptoms (e.g., muscle tension) were deemed less important. Pilots reported an urge to "act" rather than use the method, which is expected as the method aims to induce a pause and mitigate erroneous impulsive decisions. Barriers to applying the method included the difficult recognition of startle and surprise, and situational context. Suggested improvements for training dealt with recognition and sharing experiences from peers. The findings of the research provide directions for pilot training for startle and surprise. Future research will explore these pilot perceptions in a larger representative sample.

1 INTRODUCTION

Startle or surprise reactions have been implicated as a contributing factor in several high-profile loss-of-control aviation accidents, such as Air France 447 in 2009 (Landman, 2017a). The increased level of safety in aviation has created an "unconscious expectation of normalcy amongst pilots" (Martin et al.,2015). In the rare cases where things do go wrong, they often go wrong unexpectedly, and this can lead to a startle or surprise reaction in the pilot.

Startle is defined as a sudden involuntary reaction to an intense stimulus, such as a sudden loud noise (Rivera et al., 2014). The initial startle reflex occurs very fast, and is characterized by eye-lid closure, contraction of the face, neck and skeletal muscles, an increase in heart rate and arrest of ongoing behaviour (Rivera et al., 2014,). Attentional resources are directed towards the stimulus as a mechanism of threat appraisal (Martin et al., 2015). If the stimulus is perceived to be a real threat, the general stress response will remain, or even increase in intensity (Landman et al., 2017a, Martin et al., 2015). An example of a startling situation in aviation is a lightning strike, which is accompanied by a loud bang.

Surprise is defined as "a cognitive-emotional response to something unexpected, which results from a mismatch between one's mental expectations and perceptions of one's environment" (Rivera et al., 2014). It is of longer duration than startle. If this mismatch cannot be resolved, a feeling of stress and loss of control of the situation can arise, leading to a loss of situation awareness and ultimately cognitive

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lockup (Landman, 2017a). Attentional narrowing takes place, as attention is focused on trying to confirm the (incorrect) cognitive “frame”, instead of seeking out additional information (Landman et al., 2017a)). Surprises are common in aviation, but often inconsequential (Kochan et al., 2005). Surprise in aviation often occurs in the presence of conflicting or ambiguous cues that impede successful reframing. For example, in situations where the automation does not function as expected (automation surprise) or where complicated failures occur without a clear cause.

Startle and surprise (S&S) can occur together or on their own (Field et al., 2018). The terms are often used interchangeably in aviation (Rivera et al., 2014, Landman et al., 2017a). The resultant stress response impairs flight deck communication and decision making (Martin et al., 2016, Landman et al., 2017b) – compromising operational safety. Approaches to mitigating S&S effects include startle exposure through unpredictable and variable scenario simulator training (Landman, et al., 2018). S&S recovery techniques, alternatively, center around a breathing technique and the timely reacquisition of situation awareness (Field et al., 2018). Simulator evaluations have revealed such methods to improve pilot decision making (Field et al., 2018; Landman et al., 2020). Though, anecdotal pilot feedback suggests that methods are not used in full during relevant flight operations (Field et al., 2018).

The current study evaluates pilot perceptions of a S&S management technique that has been introduced to the operational environment since 2017. The method, from now on referred to as the “reset method”, is an adapted version of the EASA S&S management method (Field et al., 2018) and consists of five steps, which can be selectively used as desired: 1) Announce that a “reset” will take place; 2) Take physical distance (press back into the back of the seat, to prevent fixation on one cue); 3) Breathe: inhale, using abdominal breathing, and exhale slowly. Repeat if necessary; 4) Tense and relax shoulder and arm muscles, and; 5) Check the mental state of the fellow crewmember(s). After completing the “reset”, emphasis is placed on rebuilding situational awareness carefully and methodically (by calling out all observations before drawing conclusions).

To date no research has formally evaluated a S&S management method in the operational environment. This is critical as it is expected that the degree of S&S is far greater in actual, possibly life-threatening, situations (Field et al., 2018), which could make pilots forget they can use the reset method. Hence, research describing how pilots use these methods in different operational contexts will demonstrate their actual worth and explain how future method optimization adaptations could be realized. This research intends to address this current gap in knowledge, through a series of interviews with pilots from a major European airline where the “reset” method has been in use for some time. The following research objectives were established:

- Examine pilot perceptions of the operational impact of S&S.
- Understand pilot views of the benefit of a S&S management method.
- Explore possible inhibiting factors of a S&S management method.
- Discover relevant training options / adjustments to S&S management methods.

2 METHOD

2.1 Participants

Ten pilots from the same airline, trained in the same method, participated (5 captains, 4 first officers, 1 second officer; 7/10 instructors, 3/10 female). Mean flight experience was 7950 hours (SD = 3676.2), predominantly on Boeing aircraft types (6 B737, 2 B777/787, 1 A330 and 1 Embraer pilot).

2.2 Data Collection

Semi-structured interviews were carried out in Dutch and recorded via Teams. Interviews aimed to get participants to talk about their S&S experiences. After gathering demographic data and establishing whether they had experienced S&S, questions were asked about the effects of startle and surprise and the perceived effectiveness of the method. Possible inhibiting factors were discussed. For those that had not experienced S&S, questions about the method’s use in the simulator were asked. Approximately 600 minutes of audio data was collected and transcribed.

2.3 Thematic Analysis

Braun and Clarke’s reflexive thematic analysis (2016) was used, as it is suitable for providing analyses of people’s experiences in relation to an issue and for analysing factors that influence a particular phenomenon. The transcripts were coded immediately after each interview, and data grouped into themes. In this way, data saturation was determined using the method by Guest et.al. (2020) whereby interview data was collected until the point that emergent thematic insights no longer occurred. In the current study, saturation – the absence of emergent (sub)themes - occurred by the eighth interview. Coding reliability was determined using triangulation - carried out by the project supervisor. The coded quotes were divided into 5 main themes and 20 subthemes. Initial agreement was at 80.2 percent, coding inconsistencies were discussed until agreement between coders was met.

3 RESULTS

Five themes were identified. To increase the theoretical and application clarity of the analysis, themes were mapped onto both Landman's S&S model and onto the method's procedure (Figure 1). The Effects of S&S theme represents participants' physical and cognitive experiences of S&S. Method Benefits is associated with participants' views of the applicability and effects of the method, whilst Method Elements Used describes how the method was used by participants. Method Barriers represents the perceived factors which participants reported to hinder the methods application. Training encompasses comments from participants that included approaches to improving the adoption and implementation of the method. Themes are discussed in more detail in the following sub-sections. A selection of participant quotes is included that best exemplify thematic content. The 10 participants contributions can be identified with a "P" denotation (i.e., P1, P2…P10).

3.1 Effects of Startle and Surprise

Physical (e.g., increased heart rate) and psychological effects (e.g., tunnel vision) of startle were reported (Figure 1 orange boxes / paths); "you feel the adrenaline" (P4) and "…a noose being tightened around your neck" (P9). Some of the described surprise experiences were associated with significant distraction: "having [no] control over [his] thoughts and the stress that caused". Participant 5 described surprise in his colleague: "he felt a bit stuck" and "I had to pry the information out of him".

Some respondents reported not getting easily startled or surprised in the simulator, as non-normal situations are expected, sometimes "scenarios are

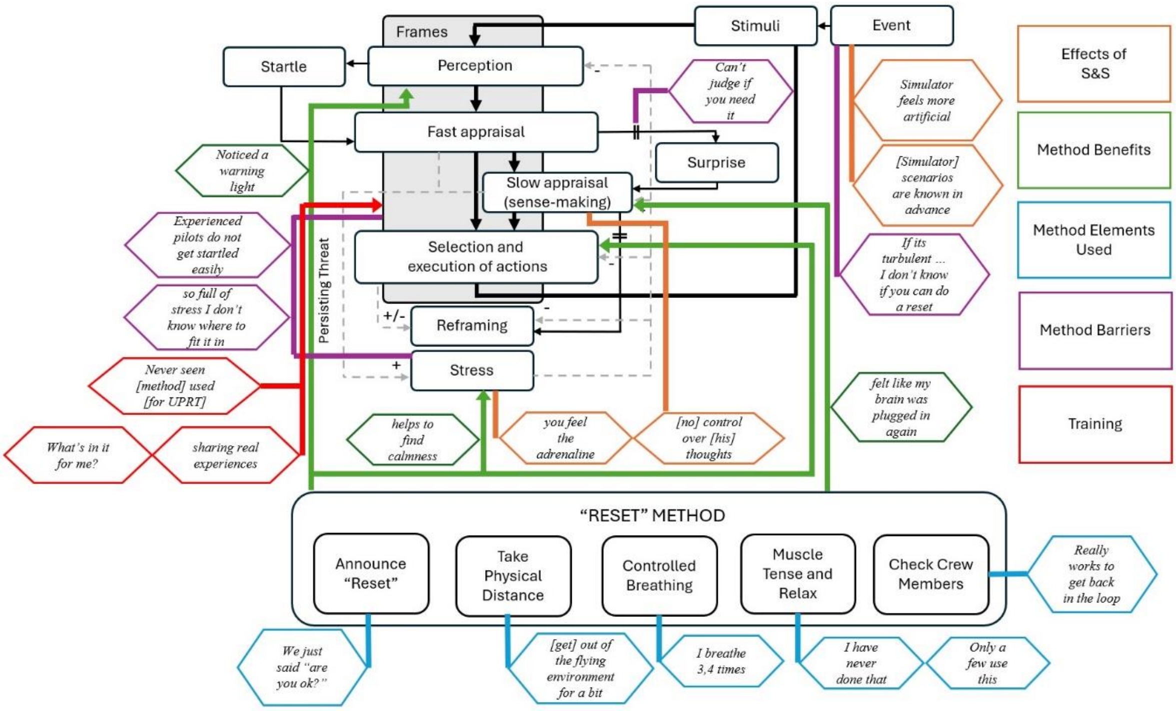

Figure 1: Mapping five themes (Effects of S&S, Method Benefits, Method Elements Used, Method Barriers and Training) onto Landman's S&S model (top) and "Reset" method (bottom). Colour coding represents thematic mapping. Selected participant quotes included clarify mapping.

known in advance" (P2), and the simulator feels more "artificial" (P2). During a proficiency check "you know what to expect" (P10) and "feeling of stress to be a lot stronger in real life" (P1) was expected.

3.2 Benefits of using the Reset Method

All interviewed participants were positive about the S&S reset method (Figure 1 green boxes / paths); Participants found it to be "effective" (P1) and that it "helps to find calmness" (P4). Perception and comprehension situation awareness benefits of the method were reported. Respectively, these included: "we noticed a warning light that we didn't notice before" (P6) and "…it felt like my brain was plugged in again." (P4) For automation surprise the participants did not see any real benefits: "I think in 90% of the automation surprise cases…[pilots] are fully aware but just expected something else..." (P8).

An unexpected benefit was the method's general stress management application. It was reported to be useful during: "a busy day with lots of disturbances on the ground" (P4) and a "dense fog situation at home base" (P6).

3.3 Elements of the Method used

This theme contained 5 subthemes representing the steps of the method: announce reset, take physical distance, breathe, relax muscles and check colleague (Figure 1 blue boxes / paths). Pilots did not always use the full method. "We didn't call it startle and surprise, just asked "are you ok?"" said participant 3. The element that was reportedly least used was the "tense/relax muscles" step - "No, I have never done that" (P6) and "only few use the muscle tense/relax step" (P4, instructor). The other steps were mainly regarded positively, especially the step "check colleague". Corroborating Field et al. (2018), this element is valuable in several cases where a colleague is startled or surprised: "I asked how are you? And then I realized this event startled him a lot…. He thought this was all [his] fault" (P6) and "If I hadn't asked this question we would have remained [a] "split cockpit" … He was still too focused on what was going on" (P7). An additional theme about partial application of the method was added when it became clear that pilots did not always use the full method. "

3.4 Barrier to Method use

Pilots stated that it can be difficult to admit one is startled, surprised, or stressed, for fear of being seen as incompetent (Figure 1 purple boxes / paths): "It is a bit of a tough-guy culture" (P6). Experience, age and level of exposure were mentioned; "experienced pilots do not get startled that easily" (P2). Assumptions about the application and value of the method, hence mapping onto Frames in Landman's model, were evident barriers. For example, instructors reported long-haul pilots, who are generally older and more experienced, perceived the value of the method to be lower than pilots flying medium haul. Participant 1 described colleagues: "People say hey, I'm 55, only 3 or 4 years to go [until pension age], I don't care [to learn new things]."

A desire to take quick action in S&S situations, rather than employ the method, was a recurring comment: "It feels that valuable time is lost" (P1), "I acted immediately and forgot to think" (P7) and "you are so full of adrenaline and stress that I don't see where to fit it in" (P8).

Environmental factors which interfered with the application of the method were commented by 2 participants. In one case there was a loud noise, making it difficult to communicate, and in the other case there was strong turbulence at low altitude: "if it's so turbulent that you can't read the instruments, I don't know if you can do a reset" (P6). This aspect mapped to the Event component of Landman's model.

The opinion that the method was associated startle more than surprise was voiced. With doubt concerning its usefulness in surprise-situations raised: "Perhaps it's overkill for surprise" (P5) and "perhaps it is a misconception from my side that it is more useful in startle" (P5). This is perhaps due to the insidious nature of surprise (that it has no clear "trigger") which makes it hard to recognize: "You can't judge if you need it because you don't realize it" (P3). Comments characterise the surprise threshold element in Landman's model, which encompasses the large degree of inter-individual and inter-scenario variation associated with surprise events.

3.5 Training Improvements

Method training comments mapped onto Frames within Landman's model (Figure 1 red boxes / paths), simulator training involves the establishment and refinement of pilot schemas and scripts to be deployed in response to given circumstances – such as S&S. Accordingly, simulator upset recovery and emergency descent training were voiced as being situations where exercising the method was difficult due to not being sufficiently addressed: "never seen it used" (P1, instructor) and "you fly the manoeuvre and continue to the next one" (P2).

Similarly, based on simulator experiences, the procedures following decompression (emergency descent) were felt to leave little room for performing a reset: "In case of a decompression, it is fine to be startled, but you really have to go down as quickly as possible, especially when at FL410" (P2). It is a complicated procedure for a situation which usually occurs suddenly, unexpectedly and with a startling and/or surprising stimulus (such as a cabin warning horn and/or a bang), where several memory items must be performed and where communication is hampered by oxygen mask use and the potential of hypoxia.

Training improvements derived from the interviews concern better S&S recognition in oneself and, importantly, in the other pilot. Notably, a sentiment prevailed that the method was more applicable to startle than surprise. Also, "sharing real experiences" (P7) and having fellow pilots recount the benefits of using the method in actual emergency situations were suggested as approaches to addressing possible machoistic culture barriers. This involves "addressing what's in it for me" and "providing an incentive for behavioural change" according to participant 10.

4 DISCUSSION

The current research presents qualitative results that consecutively demonstrate the benefit of emerging S&S theory and its application within the training environment. From a theoretical viewpoint, this research is the first to provide evidence of support for Landman's S&S model based on pilot experiences in operational practice. Previous support has been based on simulation-based research (Field et al., 2018; Landman et al. (2020). Equally important, from an application perspective, the research confirmed that the S&S reset method is a much-appreciated tool for pilots, which was perceived to reduce stress and improve situational awareness. Furthermore, pilots had not experienced negative effects from using the method. The parts of the method considered to be most useful were checking on the colleague and the breathing technique, whilst the least used was the tense/relax muscles technique. However, some respondents remarked that they would prefer a shorter method.

Some pilots indicated that they found the method less useful for surprise. This should be interpreted with caution, as the terms are often used interchangeably. A survey-based follow-up research (Vlaskamp et al., under review) did not show significant difference between the two.

The main barrier to employing the method during actual flight operations was the urge to engage in immediate problem-solving. Unfortunately, problems that are not expediently resolved will likely result in a spiralling accumulation of stress, which in turn impairs perceptual processes, facilitating cognitive tunnelling, and increases the likelihood of incorrect intuitive decisions (Field et al., 2018). Similarly, attention to a threatening stimulus takes priority over performing the reset method. This leads to the hypothesis of the existence of the "startle paradox": the higher the stress level the more the reset method is needed, but conversely, the more difficult the method becomes to initiate as the overriding stress response demotes its priority in favour of tackling the threat "head-on". The reported difficulty in recognizing the effects of S&S might also be a consequence of this effect. This reinforces the importance of the step of checking the fellow crew member's mental state. Explaining the startle paradox in training should make pilots more aware and better able to recognize and resist the tendency to act too quickly.

In the interviews pilots reported that they find application of the method difficult in certain situations such as upsets and the emergency descent. Incident reports show these to be situations with high degrees of S&S (emergency descent (BFU, 2018). These are also situations where memory actions must be performed. In addition, UPRT simulator training consists of improving upset recognition cues and developing skills to enhance the automaticity of recovery manoeuvres. Consequently, training exercises are usually explained in advance, effectively eliminating S&S effects. Restoring the flightpath is an urgent priority and training a reflexive response conforms to the existing recommendations (Gillen, 2016). However, as recent loss of control incidents show, the benefits of implementing a post-recovery reset could be emphasized since this may better prepared pilots for possible subsequent events by diminishing the detrimental effects of accumulated stress (Landman et al., 2020).

4.1 Limitations and Future Research

Limitations included the nature of its qualitative design. For instance, hindsight bias may reduce the retrospective "surprisingness" of a situation and creates a tendency to turn negative feedback into positive (Fischoff and Beyth, 1975). This effect was clear in several instances where participants described negative effects of being surprised, whilst simultaneously claiming that the reset method had not been used "because we weren't really surprised". This could be partly explained by the fact that many reflected events will have taken place a while ago, thus changing participants' perception of S&S. Finally, as is common for interview based qualitative research, a small sample was included that subsequently interferes with the generalisability of the findings.

Future research should include a wider investigation of the use of S&S methods within a larger representative sample to improve understanding of method application and benefit. A quantitative survey could build upon this current operational validation of the Landman model using structural evaluation modelling (or similar methods) to add to or refine current S&S models in order to enhance the basis for future S&S experimental work. Research in this area is currently in progress (Vlaskamp et al., under review). Research examining the optimisation of S&S training, based on pilot-informed training design, is required. In particular, research evidencing the benefit of training for manoeuvre specific and non-specific scenarios would be valuable to support pilots' judgment regarding appropriateness of the method's application. For upset recovery training this is especially important, as IATA (2019) mentions loss of control in flight (LOC-I) as one of the main causes of aircraft accidents, and specifically mentions startle as a factor affecting recovery.

5 CONCLUSIONS

The effect of the "startle paradox" during pilot training of S&S management methods should be emphasized: the more stressful a situation is, the stronger the urge to skip these methods. Even when these methods feel counterintuitive, they are likely to be useful. Methods should be trained in a variety of difficult situations, to train appropriate timing, especially in situations that require urgent action. When introducing S&S management methods, the method should be kept simple and short. For the evaluated method this may be achieved by skipping the "physical distance" and "tense/relax muscles" steps.

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