"Taxiing down the runway with half a bolt hanging out the bottom": affective influences on decision making in general aviation maintenance engineers

Kate Kingshott & Anjum Naweed

Central Queensland University, Appleton Institute for Behavioural Science, Australia

ABSTRACT

Maintenance engineers of aircraft in General Aviation work in a highly time pressured, complex and dynamic environment where errors in decision making could have far reaching consequences. However, few studies have investigated the role and influence of affect on the decision-making process in this setting. Using interviews and a scenario invention method, this study investigated the affective influences in decision making and corresponding responses in General Aviation maintenance engineering work in the Australian context. Preliminary findings based on inductive analysis identified a number of themes including affective response to task interruption specific to work colleagues and customers or management personnel, impact of negative rumination and the role of pride as a safety factor. Findings are discussed in terms of the impact of different affective states with implications for future research directions on crew resource training and non-technical skills development.

KEYWORDS

Decision making, aviation maintenance engineering, affect regulation

Introduction

Aircraft maintenance plays a critical role in the safety of the aviation industry, with maintenance-related incidents contributing up to 30% of all reported aviation accidents (Civil Aviation Authority [CASA], 2013). In Australia, the General Aviation (GA) sector accounts for 90% of all aircraft and 40% of total flying hours (Australian Transport Safety Bureau [ATSB], 2015). This sector, which excludes commercial and recreational aviation, is five times more likely to be involved in an accident, and indeed, rates of accidents have almost doubled since 2005 (ATSB, 2015).

The current body of literature surrounding aviation maintenance-related errors has found a number of causal factors (i.e. preconditions) for unsafe acts associated with engineers. Identified by Hobbs (2008; 2003), these include skill levels and training, time pressures, coordination of engineering teams, fatigue, procedures, supervision of other staff, environmental factors and previous violations. These factors have been discussed in the previous literature in conjunction with Reason's (1990) conceptualisation of unsafe acts which views them in context of unintentional (i.e. slips, lapses and perceptual errors) or intentional (i.e. rule-based or knowledge-based mistakes or routine or exceptional violations) categories. For example, Hobbs and Williamson (2002) have indicated that errors in decision making mainly arise from mistakes in the knowledge- and rule-based categories, with 50% of all errors in aviation maintenance occurring at the rule-based level.

These types of decisions are guided by an 'if it is *x* then *y* is applied' logic, for example, if an aircraft is brought into the maintenance hangar with an ignition problem, the first task is to check the spark plugs. Aviation maintenance engineers work under time pressure, extreme weather conditions and within confined spaces (Dumitru & Boscoianu, 2015; Latorella & Prabhu, 2000; Raouf, Dhillon & Liu, 2006). The level of feedback received about the efficacy of different decisions during decision making is also very limited which is why any interruptions or disturbances attract a high opportunity for error.

Naturalistic Decision Making (NDM) has been used to explain decision-making in real-world situations under time pressured work and within environments where unclear, complex and dynamic factors impact information processing and human performance (Hoffman, 2015). Corresponding models such as the Recognition Primed Decision Model describe how experts use situational cues to identify patterns from previous experience and construct internal representations to make sense of the world around them (Jones, Ross, Lynam, Perez & Leitch, 2011), particularly when assessing a situation (Klein, 2008). The ability to effectively assess a situation is a critical requirement in aviation maintenance tasks, where any incorrect interpretations or failure to include all substantive situational cues could impact decisions.

Affect has been described as something that impacts the decision-making process (Mosier & Fischer, 2010) though limited research has investigated how it impacts people in the context of NDM. Affect is typically defined as a form of mental processing that reflects an individual's internal subjective state. Within the context of this paper, affect includes mood, emotion and motivation, which can vary in the duration, cause and consequence (Cohen, Pham & Andrade, 2006; Knutson, Katovich & Suri, 2014). Affect can be *integral*, where the feeling is experienced in relation to a task, or *incidental*, where subjective feelings are carried over from other situations (Lerner, Valdesolo & Kassam, 2015). Current literature surrounding NDM emphasises the expertise of the decision maker, and softens the role of affect, instead favouring the expert's ability to objectively assess critical situations (Mosier & Fischer, 2010).

Extensive study of performance-shaping factors has shown that factors such as time pressure and distractions can reduce safety by provoking unsafe behaviours (Hobbs, 2008), but given the prevalence of maintenance-related errors in aviation accidents, there also a need to identify whether affective states caused by these factors impact decisions made by aviation maintenance engineers. By understanding how affect impacts decision making in aviation maintenance engineers, in particular how discrete affective states can lead an aviation maintenance engineer towards a certain decision and subsequent set of behaviours, research may be able to bridge the gap between causal factors, decisions and unsafe behaviors in this arm of the industry and identify how to effectively mitigate decision errors. It may also provide a 'safety dashboard' to indicate when decision making is likely to be erroneous and assist in the development of initiatives or strategies to prevent the decision in the first place.

Research aims

The overarching aim of the study reported in this paper was to investigate decision making in GA maintenance-engineering tasks, using the following research question: to what extent does affect impact the decision-making process in GA maintenance engineers? This paper presents a preliminary account of findings from analysis of data, describing the affective states identified in the study.

Methods

Study design

A qualitative phenomenographic methodology was used to gain insight into the decision making process, experiences, perceptions and opinions in a sample of participants (Curry, Nembhard, & Bradley, 2009; Ferroff, Mavin, Bates & Murry, 2012). A semi-structured interview process was used to elicit knowledge and support the application of the Scenario Invention Task (SIT) technique (Naweed, 2015), a generative simulation task that combines the principles of the Critical Decision Method (Klein, Calderwood, & Macgregor, 1989) and the Rich Picture Data method (Monk & Howard, 1998) to externalise the decision-making process in complex work. The SIT and similar processes have been successfully applied in a number of complex domains e.g. rail, (Naweed et al., 2012; Naweed & Balakrishnan, 2014), with participants asked to invent a challenging scenario specific to their work using illustrations, schematic drawings, representations and work plans to assist with the verbalisation and articulation of scenarios.

Participants

A total of ten GA maintenance engineers took part in the study, satisfying the recommended sample size for a phenomenological study (Creswell, 2013). Participants were recruited using a purposeful sampling approach and ages ranged from 21 to 60 (M= 41.2, SD= 11.37). Nine males and one female took part in the study, broadly representing the gender ratio in GA maintenance engineering. Experience in GA maintenance engineering ranged from 1 to 42 years (M= 17.8, SD= 10.5).

Procedure

All participants gave consent and each interview took approximately 60 minutes. The first part of the formal interview process was used to develop rapport through general discussion of the participant's background, and views of industry changes and safety. The second part applied the SIT; participants were asked to invent an everyday workplace scenario where their decision making processes were challenged. The activity was unrestricted so participants could elect to create a scenario that had already happened to them, or one that could happen to them (i.e. is hypothetically possible). A3-sized paper and felt-markers were provided to develop a pictorial representation of the scenario. The scenario was then probed to identify key decision points, how the participant made these decisions, how their feelings may have influenced their behaviour and how someone else with more or less experience would approach the task. Pragmatic validity of the scenario was ascertained through follow up checks of understanding where decision processes were both verbalised and drawn visually, allowing the researcher to capture the knowledge in action. This procedure was approved by the ethics committee of Central Queensland University - Approval number H16/05-146.

Data analysis

Data was thematically analysed using an inductive approach (i.e. no prior categorisation) to draw insight into meaningful relationships between contextual factors, affective states and the decision making process based on preceding literature (Braun & Clarke, 2006). Data were coded semantically from description to interpretation, and codes were grouped into overarching themes, with each analysed individually and patterns between themes identified. The purpose of this was to frame and add context to the scenario data in order to aid interpretation of the findings. Data analysis was refined by two researchers in all stages in order to reduce chances of personal bias.

Results

Preliminary analysis of study data revealed four themes. Each of these is presented in turn, with excerpts and corresponding participant ID tags to support findings.

Affective responses to task interruptions from work colleagues

Interruptions to tasks originated from within (e.g. work colleagues) and outside (e.g. customers and family) the maintenance organisation. Interruptions were perceived as a norm of the workplace with one participant explaining:

> *"The aviation industry in general is social and people love to have a chat, so the first thing is people walking in, either off the street, or walking in off the airfield quite often they're known to the engineers. They'll just come in and have a chat that obviously distracts the engineer from what he's doing."* [AME_Ppt_04]

Figure 1 presents an example scenario of a re-rigging landing gear task created by a participant. Requiring a coordinated effort of team work between multiple airframe engineers and an avionics technician, this scenario was depicted to highlight the complexity and dynamism in the aviation maintenance engineer's workplace, but also the perceived threat that interruptions could bring to work processes.

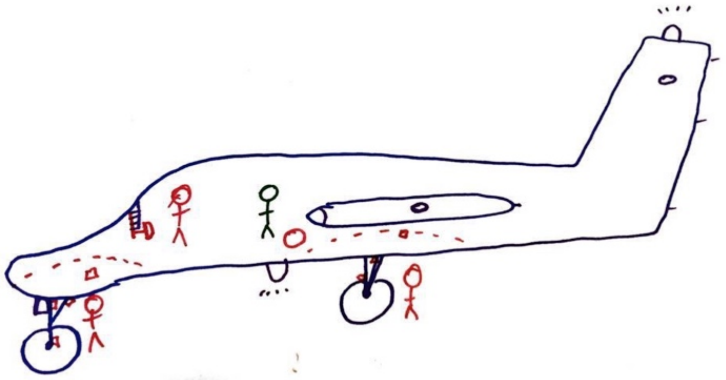

Figure 1: Scenario Depicting Multiple Engineers. [AME_Ppt_5]. The red figures depicted airframe engineers and the black figure depicts the avionics technician.

Interruptions were considered to induce affective states of feeling pressured, which gave rise to affective state responses of distraction, with participants citing that they often worked under strict time constraints to complete an aircraft. In these situations, the affective response was integral but could also be incidental, with participants indicating that subsequent affective states could potentially impact negatively on future decisions. For example, working with other engineers was described as an important safety factor, but in some scenarios, considered to lead to feelings of frustration:

> *"[Interruptions from other engineers] is mentally draining. It's frustrating. You become agitated, you become somewhat aggressive. Someone will come over and just ask, "Can I borrow whatever?" And you jump down their throat. You're really not in full control of your faculties. You're all over the place. You're thinking ten jobs ahead. I've got to get this done. I've got to get this done. I've got to get this done. I've got to get that done. I've got to pick the kids up."* [AME_Ppt_3]

In the context of this excerpt, the scenario involved completing a task within a specific time frame, and perceived pressure originated from a pilot who was waiting to leave. Feelings of frustration stemming from interruptions was prevalent in the scenarios. Another participant described feelings of frustration when being interrupted by an apprentice:

> *"Often there's a temptation just to give them a quick answer, to be able to go back to what you're doing without actually going and thoroughly investigating what their query is."* [AME_Ppt_2]

In the associated scenario, the participant described a terse response to an interruption, which, as an integral affective response, allowed them to remove the obstacle was in the way of achieving their own goals. One participant described a tendency to comply with instructions from a licensed engineer, even if they did not understand or necessarily agree with them:

> *"If someone's yelling at them to do something and it's your boss, you go 'OK'. I know some people are going to just go, 'Yep, OK. That's what he wants done'..."* [AME_Ppt_6]

While power differentials were not directly explored in the study, submitting to authority was a regular point of discussion which created a variety of affective states and corresponding responses. One participant described how apprentices that will contest others' decisions may lead to unsafe situations.

> *"You'll get some kid that won't say no. They want to say yes. The boss will say, 'Have you done that?' 'Yeah, mate, yeah, I've done that', you know, on the phone. They haven't done it. The engineer will then get frustrated, assume that it's been done, maybe it gets overlooked, then all of a sudden you see the thing taxiing down the runway with half a bolt hanging out the bottom."* [AME_Ppt_10]

Affective responses to task interruptions from customers and management

In many scenarios, interruptions from management and aircraft owners were also perceived to induce time pressure, and influenced subsequent decision making. Here, interruptions were linked to feelings of anger rather than frustration. When describing interruptions by management, participants described feeling enraged under the belief that management did not understand the requirements of a task. One participant described it like this:

> *"It got to the point where the only thing that [Management] would listen to was if we just exploded like Chernobyl. It got their attention, you know? In this scenario, when there's no time and we've got a mountain of work to do, and they show up, that's what we'd go to straightaway, just to get their attention, and that we'd rather not talk to them right now. You know? I think that because of the stress that's built up, and the time constraints, and it's their fault for letting it get to this point, you know?"* [AME_Ppt_3]

In this example, the affective response was both integral and incidental, where interruptions and distractions that induced feelings of anger influenced immediate tasks but also carried over to others. These did not only stem from management; participants described aircraft owners and operators as sources of pressure. One participant explained how in the GA maintenance sector, pressure from a customer induced feelings of anger:

> *"[Phone calls from customers] occasionally makes you angry, […] I would admit to probably twice in my career, getting angry and throwing stuff across the hangar or walking out or I think I've had two standup arguments with people in the past."* [AME_Ppt_9]

Another participant described how this sort of scenario could hypothetically lead to the unsafe behaviour in signing off an aircraft without completing a proper inspection, citing not just the customer but manifest pressures from other sources which may exacerbate the situation:

> *"You get these pressures where someone is screaming for an aircraft to be ready, but then all of a sudden, you've got to get home to take the little one to art class or horse riding. There's this process, that you may do it willingly or you may do it unwillingly, that you'll go, 'No, I'll have a look at that next time', and you'll just pen it off and off you go. Then, all of a sudden, by the time you get back to it...it might be three years later...you look at and you go, This thing's flogged out of its brain. It could have killed someone."* [AME_Ppt_10]

Impact of negative rumination on decision making

As a contextual factor, worry and disappointment was considered to induce affective states. For example, changes in regulation requirements were a growing worry and considered to impact GA maintenance. Similarly, an increase in costs was considered a source of stress, with the pressure of keeping down maintenance costs an important factor in the decision making process:

> *"You start to feel a little bit bad about yourself I think, for it costing the customer […] I should of gotten on to that earlier, I should of realised that sooner, or I made that mistake and now it's costing the customer time…"* [AME_Ppt_7]

While disappointment and worry were considered not to influence immediate task decision making, this type of rumination was fundamentally integral, and felt to have long-term outcomes for future tasks. While worry influenced the decision to return to work to ensure the safety of the aircraft, it also impacted on other areas (e.g. fatigue risk). In the following excerpt, the participant articulated a stream of thought involved in making a decision on one scenario:

> *"I was pretty worried that I hadn't done [the maintenance task]. I was tired […] but it was just concern that I hadn't done it properly. […] Can I get away with leaving it? […] what's the worst-case scenario? If I didn't do it, the engine would fail […] There's no physical way that, yeah, I could leave it in that situation, so I just basically went down, wasted a lot of my personal time and found out it was all good, but then I was happy in my own self I'd done the job. […] I got out of work at midnight and then came back to work at 6:00 the next day."* [AME_Ppt_9]

Pride as an unlikely safety factor

Not all affect experienced in the context of aviation maintenance was negative. In this theme, recurrent feelings of pride, an inwardly directed emotion, established positive feelings associated with the day to day work of participants. While experiencing considerable workload, participants were generally passionate about their professions:

> *"It's an obsession. You're working with [kit] that may be 40, 50, 60, 80 years old. It's not new technology. It hasn't changed in 100 years, but there's something about it. We do what we do because we are who we are. It's just a uniqueness that you only find in aviation people."* [AME_Ppt_10]

The pride in this context was a humbled, somewhat contended and self-reflective sense of attachment about one's choice, and belongingness to a group. Participants indicated that they often felt a sense of pride after completing a task, in particular with 'defect identification' and 'long term rebuilds' as it kept people safe:

> *"I still pride myself in what I do in making sure that people are safe."* [AME_Ppt_9]

In this way, pride was actually talked about as a safety factor, motivating engineers to engage in conscious and safety directed behaviours. A concrete example given in one scenario was that a feeling of pride provoked adherence to procedures and safety standards, preventing engineers from acquiescing to uninformed requests of aircraft owners.

Discussion

This study sought to describe the affective states that influence the decision making of aviation maintenance engineers. Preliminary results of the study suggest that GA maintenance engineer's decisions are impacted by their affective states and while they are invariably experts at their job, a degree of affective-induced subjectivity can impact assessments of critical situations.

Time pressure and impact of interruptions to task were prevalent in the scenarios provided in the study, lending support to Hobbs' (2008) research. These were associated with frustration, which arose when restricted from achieving an immediate goal, and anger. Anger has been associated with a high level of control and the feeling of being able to deal with a situation (Lerner & Tiedens, 2006). Individuals who express anger are regarded as powerful and competent (Lerner & Tiedens, 2006), which, given the prevalence around discussion of power differentials, may explain why anger rather than frustration was expressed towards customers and management i.e. fulfilling a need to exert competence and power over individuals in a position of control.

Affective responses to time pressure were interesting in terms of its influence on unsafe acts. When induced by customers, it had a tendency to lead to procedural violations, but when induced by colleagues (i.e. from task interruption), affective responses were aggressive or terse, but tended to be superficial. This indicated that it was not so much the manifestation of time pressure, but who/what gave rise to the feeling that was more important when understating the decisions to violate procedures.

Whilst preliminary, the findings identified categories around affective regulation associated with power dynamics between colleagues (e.g. apprentices, novice engineers) and customers (e.g. pilots). Peer pressure can be a powerful influence in and on behaviour, particularly in organisational setting where there is a culture of compliance and/or commitment (Merritt, 2000). The cultural dimension is embroiled within attitudinal factors and in this study, many of the scenarios featured incidents when more senior engineers snapped or responded very tersely to task interruptions. While not emphasised in this preliminary analysis, the affective responses of the less experienced appeared to create a propensity for silence. This was described as an issue of power dynamics in this study, but similar patterns of behavior have also been extensively researched as a cultural-communication gap in the aviation industry in the context of the pilot, copilot and flight crew in Commercial Aviation, leading to informed design of crew resource management programs. Similar approaches for aviation maintenance engineering, particularly in the GA context are scarce and could be explored.

While the data collected in this study showed substantial engineering expertise in achieving goals and maintaining the safety of systems, nearly every scenario evidenced apparent disconnects in different types of non-technical skills. Further investigation of this is warranted. While the results of the preliminary analysis in this study have inferred that affect does influence the decisions made during safety-critical aviation tasks, further and more directed study is required to fully explore the possible impact of this on decision making.

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