THE RELATIONSHIP BETWEEN EMOTIONAL AWARENESS AND HUMAN ERROR IN AVIATION

by

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DECLARATION

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I declare that “The relationship between emotional awareness and human error in aviation” is my own work and that all the resources that I have used or quoted were indicated and acknowledged by means of complete references.

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SIGNATURE DATE

Andrea Stipp

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SUMMARY

The general purpose of this study was to determine whether a relationship exists between emotional awareness and human error in aviation. A quantitative analysis approach was used to explore this by means of a cross-sectional survey design. The independent variable emotional awareness and the dependent variable human error were contextualised and operationalised. During the empirical phase, biographical information was collected and the Hartmann Emotional Boundary Questionnaire was administered to a purposive sample consisting of 173 aircrew members within the South African Air Force.

Factor analysis revealed an eight-factor structure: *involved; exactness; blend; openness; structured; unstructured; flexibility;* and *imagination.* No differentiation was found between the mustering groups in relation to emotional awareness and human error. However, correlations differentiated between aircrew with *zero human error* and aircrew with *"more than ten years' aviation experience".* The test for differences between human error and the emotional awareness sub-construct *"imagination"* indicated a medium significance. From this relationship, the researcher deducted that *"imaginative aircrew are prone to err".*

Key terms

Aircrew, emotional awareness, situational awareness, human error

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LIST OF ABBREVIATIONS

ATC	air traffic controller
CRM	Crew Resource Management
EA	emotional awareness
EI	emotional intelligence
HE	human error
ICAO	International Civil Aviation Organisation
SA	situational awareness
SAA	South African Airways
SAAF	South African Air Force
SACAA	South African Civil Aviation Authority
TEM	Threat and Error Management
HFACS	Human Factors Analysis and Classification System

CHAPTER 1: OVERVIEW OF THE RESEARCH

This dissertation explored the relationship between emotional awareness (EA) and human error (HE) in aviation. Chapter 1 provides the background and motivation for this study. Guided by these, the researcher formulised the problem statement and research questions, and discussed the paradigm perspectives ‘research design’ and ‘methodology’.

1.1 BACKGROUND AND MOTIVATION FOR THE RESEARCH

Safe aviation requires aircrew with the highest level of skills to work safely with machines. Despite advances in technology to assist aircrew members, human factors remain at the centre of aviation accidents (Bach & Biede, 2016; Walton & Politano, 2016). Recent accident data attributes more than 95% of aviation accidents to human error. Civil aviation authorities prescribe Crew Resource Management (CRM) as the first line of defence to avoid threats and errors. Although Threat and Error Management (TEM) involves a high level of vigilance, experts contest available theories and argue that they are limited in scope and application.

Numerous aviation experiences reported in safety literature reveal effective but re-active safety risk management. Often, aviation organisations reflect on their safety culture only after an air disaster, whilst aircrew hide behind Cicero’s famous quote “to err is human”. Although human factor studies agree that emotion influences how aircrew observe and perceive reality, human error theories are descriptive, rather than prescriptive.

The International Civil Aviation Organisation (International Civil Aviation Organisation [ICAO], 2002) finds that human error is the main contributor to more than 90% of all aviation accidents and incidents. Furthermore, aircraft accident analyses and applied human factor studies are becoming increasingly concerned with human-machine integration and the human limitations that influence safe performance and aviation safety. Human limitations unfortunately result in human error (Kern, 2009).

1.2 HUMAN FACTORS

To address human-machine integration and human limitations, aviation regulators, ICAO and South African Civil Aviation Authority (South African Civil Aviation Authority [SACAA], 2016) prescribe mandatory and applied human factor training, integrated with Crew Resource Management (CRM) to teach aircrew safety concepts and skills such as situational awareness, stress management, emotional intelligence and communication skills.

It is no secret that aircrew consider CRM training as a “tick in the box” currency to be “fit to fly”. Since TEM entails enhanced SA, the researcher is of the opinion that CRM is not ticking the safe box. To maintain situational awareness and reduce human error, emotional awareness is essential. The researcher believes, findings from her study will propel a new human factors perspective, broadening the scope of CRM training. As EQ training is not prescriptive, the researcher suggests emotional awareness training to provide aircrew self-knowledge and strategies to manage and regulate their emotion thereby enhancing situational awareness.

1.3 SITUATIONAL AWARENESS

Situational awareness is an essential prerequisite for safe aviation operation (Sarter & Woods, 1991) and aircrews develop it as an intrinsic part of learning how to fly (Melander & Sahlstrom, 2009). For aircrews to perform safely, accurate cognitive and environmental data must continuously be integrated. Aviation analysis, and specifically accident analysis, refers to the concept of situational awareness to explain “how” and “why” an accident occurred. This study originated from the researcher’s interest in human error, which led to her exploration of the phenomenon called situational awareness.

Endsley (2000) defines situational awareness as a key concept in aviation safety. Understanding human error, it is important to reason from the theory of Endsley’s (2000) taxonomy model, which assigns 76.3% of human error to a failure in perceiving a situation correctly, 20.3% to a failure in comprehending the situation correctly, and 3.4% to a failure in projecting the situation correctly. Furthermore, according to Wickens (2002), perception errors result from communication errors, mental model errors, memory errors and cognitive biases. Advances in technology require continuous human-machine integration, which raises additional safety concerns (Barker, 2011; Kanki, Helmreich & Anca, 2010; McGuinness, 2004; Strauch, 2004; Wiegmann & Shappell, 2003).

Situational awareness has many definitions. Sarter and Woods (1991) criticise situational awareness as ill-defined and with little consensus and empirical evidence to support a colloquial understanding. Although many researchers have attempted to specify components of situational awareness, they are too general (Doane, 2003; Melander & Sahlstrom, 2009). Whereas situational awareness definitions focus on external information of which aircrew need to be aware, little progress has been made to support information acquisition and attention filtering. This poses a problem to aircrew in understanding this phenomenon.

Although situational awareness and the importance thereof is recognised and explained during Crew Resource Management (CRM) training (Hughes, 2013; Odendaal, 2012), Kern (2009) recognise the value of emotional awareness training to enhance situational awareness to reduce human error.

1.4 SITUATIONAL AWARENESS RELATED TO EMOTIONAL AWARENESS

Brown and Moren (2003) explored safe behaviour in aviation related to the phenomena *emotional awareness* and *situational awareness*. The researcher agrees and argued that emotionally aware aircrew understand themselves and others, therefore they have the ability to differentiate between their emotional representations and reality. Emotionally aware aircrew regulate their emotion and thoughts, and they spend their energy on strategies to stay ahead and avoid human error.

Kern (2009) refers to human error as the "blue threat" inside and explains that emotional awareness is a personal mastery skill that can reduce human error. The only available approach in aviation is a theoretical situational awareness explanation that names human factors like stress, experience, expectancies, workload and attention (Endsley, 2000; Strauch, 2004), but makes no reference to the role of emotions (Kern, 2009; Pollatos & Schandry, 2008). The study in hand focused on human error related to emotional awareness. Some people are not aware of their emotions. To act upon emotions, one needs to be aware of them (Newby & Narain, 2016). Emotionally aware people are not only acutely conscious of their thoughts and feelings, but also attuned to the messages their body sends them and to aspects of their emotional states. This heightened sensitivity is beneficial in several ways (Davidson & Begley, 2012). People are driven by tension locked into their bodies, which has been induced by thoughts and emotions.

We spend so much time in our heads that we almost forget we have a body at all. This can end up undermining our physical and mental well-being (Williams & Penman, 2011). Realising the importance of emotional awareness as distinguishable components, namely the extent to which one attends to and values one's emotions, and the extent to which one can identify and describe one's own emotions (Kerns & Berenbaum, 2003; Davidson & Begley, 2012; Goleman, 2004; Jawer & Micozzi, 2011; Lehrer, 2009; ~~Reuven, 2007~~; Williams & Penman, 2011). To cultivate emotional awareness, we need to become fully integrated with our bodies (Williams & Penman, 2011) so as to be able to perceive interceptive signals (Pollatos & Schandry, 2008). Jawer and Micozzi (2011) suggested that emotionally unaware parents effectively teach the same ignorance of feelings to their children. Like in this study, they propose that alexithymia is tied to concrete thinking that is dissociated from emotion and needs to come home to the core of being.

Emotional awareness is affected by various influences such as stress, social factors, lack of knowledge, fatigue and sensory overload (Kanki et al., 2010). Strauch (2004) believes that high workload, competing task demands and ambiguous cues all contribute to human error, even with experienced and well-trained aircrew. Emotional awareness involves attentiveness to the internal aspects of one's self, such as memories and feelings (Govern

& Marsch, 2001). The current study focused on reducing human error that leads to accidents, by focusing on the emotional awareness of aircrew.

Recent years have witnessed a proliferation in human error frameworks. Aviation uses system models and taxonomies to classify information processing failures, and emphasises the system in case of an accident in a “just” culture, and not the individual *per se* (Wiegman & Shappel, 2003; Kanki et al., 2010).

Brown and Moren (2003) argue that by applying the psychology of emotions in CRM, aircrew can understand why they behave the way they did. CRM training can devise more varied training methods for improving both the aircrew’s intra-action and interaction. In this study, the role of emotional awareness will be investigated as a factor that contributes to human error in aviation.

In 1986 the ICAO Assembly recognised Resolution A26-9 on human factors in an attempt to increase awareness about the influence of human factors on safe performance. This ignited extensive CRM training and regulation in the aviation industry around the world. Furthermore, CRM was introduced to provide aircrew members with a better insight into and a better understanding of the role that human factors play in aviation incidences (ICAO, 2013). CRM was also developed as a response to new insights into the causes of aircraft accidents, following the introduction of flight recorders. Information gathered from these devices suggested that many accidents do not result from a technical malfunctioning of the aircraft or its systems, nor from the lack of aircraft-handling skills or technical knowledge, but they are caused by the inability of aircrew to respond appropriately to the situation. Inadequate communications between crew members were found to often lead to a breakdown of situational awareness levels (Kern, 2009).

Worldwide, aviation does not recognise emotional awareness as a human factor as it is hypothesised in this study. The term ‘situational awareness’ as defined in CRM courses leaves pilots with an abstract comprehension as if it is something dispositional and axiomatic, rather than something that provides a deeper understanding of emotional awareness and how it could enhance safe performance (Govern & Marsch, 2001).

Furthermore, the aviation industry is considered a man's world where the "real-men-don't-cry" kind of aphorism prevails (Vermeulen & Mitchell, 2007). The notion of "the right stuff," which originated in the United States military air force, is epitomised by aviators and astronauts who possess extreme levels of confidence, assertiveness and competitiveness driven to achieve personal goals (King, McGlohn & Retzlaff, 1997). This hard-core attitude and behaviour was popularised in movies such as "The Right Stuff" and "Top Gun". Furthermore, military training aims to produce "warrior heroes" and in aviation, a mistake-free performance (Brown & Moren, 2003). No real evidence of this generalisation, belief and culture with regard to aircrews exists, but remarks during safety courses have highlighted the fact that this hard-core attitude does not cater for emotion.

Human factors training was included in CRM training mainly by experienced male pilots (Mitchell, Kristovics & Vermeulen, 2006), but according to Brown and Moren (2003), there is a general lack of vocabulary for emotions in the flying community. In fact, many discussions with pilots confirmed the problem that aircrew do not realise the value of emotional awareness to reduce human error. Is the "hard-core" attitude to blame for ignoring the role that emotions play in an operational environment? Interviews with many display pilots revealed only a few individuals who could verbalise emotion accurately while flying an airshow display sequence (Ehmke, 2012). This omission of the human factors trait 'emotional awareness' in CRM training was the impetus for the current research into human error management, which opposes the hard-core "Top Gun" image and focuses on 'emotional awareness' instead of the general aviation term, 'situational awareness' (Kern, 2009; Moon & Berenbaum, 2009).

Lehrer (2009) suggests that we need to find ways to be as perfect as possible by assessing our flaws and our talents, whereas Dijksterhuis, Chartrand & Aarts (2007) argues that anyone who is constantly making poor decisions can benefit from a more emotional thought process. Important for this study in which we are trying to conceptualise human error, Goleman (2004) argues that destructive emotions prevent the mind from ascertaining reality as it is. Adding to this, visual appearances affect expectations, memories and associations. Relevant to this study, Kern (2009) observes that a loss of emotional awareness is often a precursor to a loss of situational awareness.

Situational awareness is influenced by many environmental factors, some too complex to be measured. Literature guided this study to explore the stable trait emotional awareness instead. The researcher hypothesised that levels of emotional awareness, influences human error. The research was planned against the background of aviation and attempted to measure the trait emotional awareness in relation to recorded human error data in the South African Air Force (SAAF).

1.5 PROBLEM STATEMENT

Aircrew requires a high degree of concentration and emotional stability to be able to perform safely. Even more so, adverse weather conditions demand from them a clear mind so as to be prepared for any emergency (Butcher, 2002; Kern, 2009; Odendaal, 2012). Often, failure of information transfer, which is vital for decision making, leads to human error (Brown & Moren, 2003). Adding to this, military operations that often have to deal with complicated missions, bad weather and time constraints, have a smaller margin for human error than do commercial operations (clearly not a homogeneous organisation) (Kanki et al., 2010).

Central to this study, researchers argue that if missions seem uncontrollable, aircrew uses emotional defences such as denial, projection or reaction formation to perform (Murray, 2011). In support of this argument, aircrew who survived air accidents often reported hazardous attitudes resulting in a loss of situational awareness (Griffin, Young & Stanton, 2015). Thus, human error often results from being aircrew being unaware of emotional states in respect of intra- and interpersonal communications, degraded trust, ego and stress (Davidson & Begley, 2012; Kanki et al., 2010). Literature provides evidence that emotional awareness is a stable Human Factors trait to be explored within the human-machine interface (Killian, 2012).

Organisational and system approaches focus mainly on human error studies of large groups. Supporting Reason's Swiss Cheese model, the aviation Human Factors Analysis Classification System (HFACS) explains quantifiable accident causation within a system and series of human errors (Kanki et al., 2010; Reason, 1990; Wiegmann & Shappell, 2003). Kern (2009) argues that although the systems approach is important, we tend to neglect the individual origin of human error and its contribution to accidents. Kern (2009) observes that a loss of emotional awareness is mostly a precursor to a loss of situational awareness. He states that this problem is an opportunity for a different approach to human error management, providing aircrew with emotional awareness and skill to perceive their environment and react in real time (Kern, 2009).

Goleman (2004) argues that our traditional way of understanding intelligence does not allow for the role of emotions in thoughts and decision making. He believes that people who experience negative emotions do not absorb information efficiently, but tend to focus their attention on preoccupations that interfere with an attempt to focus elsewhere. Adding to his argument, a German study explored the relationship between emotional awareness and emotion regulation strategies (Newby & Narain, 2016). The concept of emotional awareness is defined as the ability to perceive adaptively, and to understand and manage emotions in the self and others (Salovey & Mayer, 1990; Schutte et al., 2001). Considering the importance of levels of emotional awareness for emotion regulation strategies and safe performance, this study was directed to explore emotional awareness related to human error.

1.6 MEASURING INSTRUMENT

A study performed by Brown and Moren (2003) guided the researcher to explore the emotional intelligence sub-construct; emotional awareness. The Boundary Questionnaire was considered suitable for this study since the survey measures levels of emotional awareness referred to as ‘degree of separateness’ or connection between mental functions and processes to enhance safe behavior valuable for effective threat and error management in aviation.

The Boundary Questionnaire measures specific emotional awareness traits relevant to safe behavior in aviation, associated with open mindedness, creativity, and imagination versus reality. Emotional aware aircrew differentiate clearly between reality and imagination and self and others and tend to prefer well defined structures (Hartmann, 1991). Since 1980, more than one hundred published papers referenced Hartmann’s Boundary Questionnaire. The scores on the Boundary Questionnaire are distributed across the spectrum and range from people with ‘thin’ to ‘thick’ boundaries of the mind. These boundaries indicate people’s degrees of separateness in terms of emotional awareness that result in various pathological predispositions like stress, anxiety depression, poor concentration and false perceptions (Jawer & Micozzi, 2011). Pulley (2009) in turn describes emotional awareness as an ongoing attention to one’s internal state.

Emotional awareness is a key component of emotional intelligence (Bar-On,1997; Goleman, 1998; Killian, 2012). Brown and Moren (2003) state that emotion is powerful and influence awareness, thinking and actions, whether thinking was stimulated by emotion or not. A number of studies over the past decade have indicated a significant relationship between emotional intelligence and safe performance (Bar-On, 1997; Bar-On, Handley & Fund, 2006). The average predictive validity coefficient for these studies is .55 (Bar-on, et al., 2006). Brackett and Salovey (2006) support these results and revealed correlation coefficients ranging between .22 and .46. The consensus of findings indicates that the most powerful emotional intelligence contributors are conceptualised in the model proposed by Reuven Bar-On.

Bar-On's model consists of five meta-factors, namely:

a. Intrapersonal (self-awareness); the ability to understand emotions as well as to express our feelings.

b. Interpersonal (social awareness and interaction); the ability to understand others and relate to their feelings.

c. Stress management (emotional management and control); the ability to manage and control our emotions.

d. Adaptability (change management); the ability to solve problems of an intra- or interpersonal nature.

e. General mood (self-motivation); the ability to generate a positive mood and motivate oneself.

An extensive study of Bar-On's model and the meta factors and sub-scales of emotional intelligence directed this study more specifically towards emotional awareness and its relationship with human error (Killian, 2012). The question arose whether being unaware of one's own emotions will break down situational awareness as well as situational understanding. The study in hand proposes that emotional awareness is required for perceiving the correct information in each situation and it is therefore comprehended and projected in effective decision making. Kern (2009) studied many accidents and concluded that the reason why highly skilled and trained professionals did not realise what was going on regarding their situation, team or equipment at the time of the accident, was because they lost all awareness of what was going on with themselves. From this statement, one can deduce that the aircrew members had low emotional awareness, they were supressing stress or they experienced sensory feelings of overload. Kern (2009) observes that a loss of emotional awareness is mostly a precursor to a loss of situational awareness. Davidson and Begley (2012) explain how people with similar backgrounds respond in different ways to the same situation, for example, why some are resilient in the face of stress, while others fall apart. The question was whether emotional aware aircrew actually realise when they fall apart. Are they aware of their unique stress-coping ability to realise the difference between eustress to distress. Are they aware that they do not speak up when in doubt or stressed, but instead project an image of an inflated ego, due to shame or feelings of insecurity (Brown & Moren, 2003; Murray, 2011). Goleman (2004) argues that if people could be emotionally aware, they should recognise feelings and perceive both their inner state and environment realistically and in context.

Some people simply find it difficult to "name" their feelings accurately. As Jawer and Micozzi (2011) explain, some feelings are repressed or denied and do not register in our awareness. They argue that a person with limited emotional awareness (thick) appears aloof, imperturbable or even dull and is dissociated from his/her feelings. Davidson and Begley (2012) report research results that indicated lower insula activity in the brain of participants on the alexithymia (difficulty identifying and describing one's emotion) scale. The research indicates a correlation between levels of emotional awareness and insula activity, which is the brain's monitoring station for the visceral organs like the heart, lungs and stomach. As Jawer and Micozzi (2011) explain, emotionally aware people are acutely conscious of their thoughts and feelings and attuned to the messages their body sends them. They know for example that the reason why they shout at someone is because they are stressed about something else.

Resilience indicates how long it takes an individual to recover emotionally in the face of adversity (Davidson & Begley, 2012). Some people recover quickly, while others are overcome or paralysed by intense emotions like stress, which illustrates the importance of emotional awareness and knowing your own emotional state and limitations in aviation (Kern, 2009). Whenever a pilot or air traffic controller (ATC) (referred to collectively as aircrew) experiences an emergency, it is critical to remain calm and attend to the problem, and not to get overwhelmed by or flooded with anxiety. An Air Force light aircraft accident in 2011 at the Kai River airfield in the Eastern Cape illustrated the result of low emotional awareness. The pilot was stressed during an emergency and could not attend to the problem adequately, which caused human error.

Aircrew need to pay attention to a large amount of data inside and outside their cockpit (Plant & Stanton, 2012). Melander and Sahlstrom (2009) argue that the situational content is constantly negotiated and the pilot is required to understand the information pertaining to the environment in relation to task demands. Murray (2011) believes that if the pilot is aware of his/her emotional limitations, proper emotional awareness training might provide the necessary skills and resilience to remain calm in adversity, attend to an emergency correctly and save not only lives, but also the aircraft.

Situational awareness is an essential prerequisite for safe operations (Wickens, 2002). Sarter and Woods (1991) stress that the term “SA” is not appropriately understood in aviation terms and they refer to situational awareness as an ill-defined phenomenon. McGuinness (2011) defines situational awareness as the situation-specific inferences represented in a person’s mind when deciding. He explains that situational awareness is a dynamic, multifaceted phenomenon that involves a perception and understanding of oneself and the situation in the relevant context. He extrapolates emotional awareness as a metacognition of situational awareness. Melander and Sahlstrom (2009) regard situational awareness as a mental phenomenon. Unfortunately, since no comparable index exists that distinguishes between states of awareness in aviation in a reliable manner, this presents a dilemma for researchers who study the effects of situational awareness (Govern & Marsh, 2001). Doane (2003) explains situational awareness as a range of complex cognitive abilities. He argues that there is no consensus about a definition for situational awareness and states the term has been criticised for being circular and inadequate to explain and measure related to human error.

When the aircrew’s cognitive limits are stressed, various emotional predispositions may combine to induce human error (Kanki et al., 2010; Wiegmann & Shappell, 2003; Murray, 2011; Kern, 2009). Since situational awareness is too complex to measure (Govern & Marsh, 2001), literature guided this study to explore the relationship between emotional awareness and human error. The researcher is of the opinion that there is a need for a comprehensive understanding of emotional awareness as a Human Factor trait to manage human error in aviation. The relationship between emotional awareness and human error needs to be explored to demonstrate that low emotional awareness may result in human error. The researcher was concerned with understanding emotional awareness related to human error and hopes that this study might bring a new perspective to aviation safety and contribute to safe performance.

1.7 RESEARCH QUESTIONS

The researcher based her research on scientific human factor literature, previous research limitations, recommendations, and aviation safety data. Accordingly, she formulated specific and general research aims to conceptualise emotional awareness and human error for application within the applied science of aviation human factors and human error management.

The researcher realised a gap in the body of knowledge regarding aviation psychology and applied human factors and discovered that the aviation phenomenon “situational awareness” was difficult to fathom and measure. She was interested in reconceptualising this critical aviation safety construct, “situational awareness”, that had been conceptualised by Reason (2000). With regard to aviation safety concerns, the researcher hypothesised that although situational awareness cannot be measured, it is closely linked to emotional awareness and human error. Therefore, she raised the question whether a significant relationship exists between emotional awareness and human error. By exploring emotional awareness and human error, she hopes to add value to error management in aviation and bring about a new understanding to safe performance.

Exploring recorded aviation human error data directed the hypotheses that were formulated in this study to explore the relationship between emotional awareness and human error.

1.7.1 Research questions for the literature review

The researcher formulated the following research questions based on the literature review:

- Research question 1: How does this study fit into the current framework of aviation psychology and the applied human factors paradigm?
- Research question 2: Conceptualise human error in aviation.
- Research question 3: Explore emotional awareness in aviation.
- Research question 4: Will understanding emotional awareness encourage safe behaviour traits to effectively manage human error?

1.7.2 Research questions for the empirical study

The researcher formulated the following research questions for the empirical study:

- Research question 5: Are there any differences between human error incidences related to gender, aviation experience and mustering?
- Research question 6: Is there a relationship between emotional awareness, human error, gender, aviation experience and mustering?
- Research question 7: To enhance aircrew performance, can the emotional awareness construct be divided into sub-constructs? Can these sub-constructs be related to human error?

1.8 AIMS OF THE RESEARCH

This study aimed specifically at exploring significant differences of levels of emotional awareness related to aviation human error. The general aim was to address human factors application in practice, to explore the value of emotion awareness for effective human error management.

1.8.1 General aim

The general aim of this study was to explore the relationship between emotional awareness and human error in aviation among aircrew members in the South African Air Force. To explore emotional awareness related to human error, the researcher formalised specific research aims. These aims involved conceptualising and operationalising emotional awareness related to human error, as synthesised against the background of aviation human error management.

1.8.2 Specific aims

In support of her research question and general research aim, the researcher conceptualised this study based on available literature and recorded human error data. By reasoning from the general human factor paradigm to the variables, she formulated specific aims to explore the relationship between emotional awareness and human error. The specific aims of this study are discussed next.

1.8.2.1 Specific aims of the literature review

Research aim 1: Conceptualise the human factor paradigm in aviation.

Research aim 2: Conceptualise human error in aviation.

Research aim 3: Conceptualise emotional awareness related to aviation.

Research aim 4: Conceptualise the theoretical relationship between emotional awareness and human error.

1.8.2.2 Specific aims of the empirical study

Research aim 5: Operationalise human error measurement in aviation.

Research aim 6: Operationalise emotional awareness measurement with the Boundary Questionnaire.

Research aim 7: Operationalise the relationship between emotional awareness and human error in aviation.

1.9 THE PARADIGM PERSPECTIVE

Paradigms are all-encompassing systems of interrelated practice and thinking that define the nature of their enquiry along three dimensions, namely ontology, epistemology and methodology for researchers. If the researcher believes that what is to be studied consists of a stable external reality, then we can adopt an objective and detached epistemology stance towards that reality to apply a methodology that relies on the control and manipulation of reality.

The aim of such research was to provide an accurate description of the laws and mechanisms that operate in social life, which implies a positivist approach (Durrheim, 2006). It is important to note that Comte coined the term ‘sociology’ in 1822 to constitute the foundation for the development of the social sciences, and he argued that knowledge is based on observation through the senses, rather than on belief. Durrheim (2006) explains positivism as realism, which suits those who are pursuing objective facts.

Since the internationally applied human factor ‘discipline’ is concerned with human performance (Harris, 2012), Munene (2016) realised the gap in aviation accident analyses as well as the prevalence of human error and deficiency in aircrew, thus he suggested that emotion awareness strategies should be employed. Theoretical studies and empirical evidence support these views and are concerned with emotional awareness traits as an integral part of safe performance. Human factors practitioners and aviation psychologists added to these arguments by relating emotional awareness as the most prevalent human factor trait for human error management (Tehrani & Molesworth, 2016).

1.10 RESEARCH DESIGN

A research design is the “strategy for the study and the plan by which the strategy is to be carried out” (Coldwell & Herbst, 2004). When developing a research design, the researcher must decide about four dimensions: the purpose of the research; the theoretical paradigm informing the research; the context within the research is conducted; and the research techniques employed to collect and analyse data. Mouton (2008) compares the research design with building a house, which involves the systematic, methodical and accurate execution of the design. One can say that the planning and compilation of the procedures and methods for building a house entail a similar process as that involved in the design of a research project.

This research was designed in accordance with the aims articulated in the problem statement (Msweli, 2011). The design therefore reflects the plan of how the researcher intends to answer the research questions. According to Msweli (2011), a deductive research design approach guides the research based on questions that require an explanation of incidences that can be quantified (i.e. “how” and “what” questions). A deductive research design is also applicable when asking “where”, “how many” and “how much” questions. In this research, the deductive method was the most applicable method for obtaining answers for the quantitative study.

Since the research design provides the necessary evidence to enable the study to answer the question as unambiguously as possible, the design that was chosen for this study involved a logical method. The research design was used to plan the research and constructed to maximise the validity of its findings (Mouton & Marais, 1990). Hofstee (2006) recommends that detailed information be obtained regarding the research design and its applicability, before commencing with the study.

1.11 NON-EXPERIMENTAL SURVEY RESEARCH

Survey research was explored as a systematic method for collecting data from a representative sample of individuals by using instruments composed of closed and/or open-ended questions, observations, and interviews. A survey is one of the most widely used non-experimental research designs across disciplines to collect large amounts of survey data from a representative sample of individuals. The survey group is a sample taken from the targeted population and data is gathered by a variety of modes (face-to-face; telephone; mail; electronic (web-based and e-mail). Survey research is considered one of the most important research designs and survey instruments, and survey methods are frequently used to collect data for the quantitative, qualitative, and mixed research designs (Kalaian & Kasim, 2012).

1.12 RESEARCH VARIABLES

Hopkins (2008) explains that in quantitative research the aim is to determine the relationship between two phenomena (the independent variable and the dependent variable) in a population. Every variable should be exhaustive, and it should classify every observation in terms of one of the attributes composing the variable. Attributes composing a variable must be mutually exclusive – hence we should be able to classify every observation in terms of one attribute only (Babbie, 2008).

1.12.1 Independent variable

Emotional awareness has been highlighted in various human factor studies as a safety performance indicator (Fruhen, Mearns, Flin & Kirwan, 2014). Because it recognises the limitations of human factor research, this study aims to explore the human factor construct, emotional awareness (EA), as the independent variable. Hartmann explains emotional awareness as being related to different levels (Jawer & Micozzi, 2011). It was operationalised by the Boundary Questionnaire that was developed by Dr Ernest Hartmann to indicate how different people experience their feelings to various degrees. To operationalise the independent variable, aircrew members were requested to complete the Boundary Questionnaire on a pre-selected day, in order to explore their individual emotional awareness levels.

1.12.2 Dependent variable

The dependent variable for this study, human error, was categorised per recorded human error severity as follows: (0) zero-reported human error; (1) hazards; (2) incidents; and (3) accidents (Yantiss, 2011). Worldwide, incident and accident reporting is compulsory and regulated, as stipulated in legislation (SACAA, 2016). An effective reporting culture should provide reliable data as a true indication of human error incidences in the flying environment. Different human error classifications will be defined and discussed in Chapter 2 as part of the literature review.

1.12.3 Moderator variables

Moderator variables indicate under which conditions or for which participants the relationship between two variables differ. The moderator variables that could influence the relationship between emotional awareness and human error in this study are aviation experience and aircraft type (referred to as mustering) (Gibbon, 2014b).

1.13 TYPE OF RESEARCH

Quantitative research designs are either descriptive (subjects are usually measured once) or experimental (subjects are measured before and after treatment). This study is a non-experimental study that will establish the causality between two variables. For an accurate estimate of the relationship between variables, a descriptive study usually needs a sample of hundreds or even thousands of subjects, and statistics is a valuable tool in organising a useful argument from quantitative evidence (Jose, 2017). Statistics involves a set of mathematical techniques that allow the researcher to make claims about the nature of the world, using forms of principled statistical arguments (Durrheim, 2006). This method enables the research and description of social structures and processes that are not directly observable. Positivist research is based on the belief that the scope of the programme evaluation is limited to those aspects of social programmes that can be observed and tested objectively, using a variety of methodologies and procedures (Posavac & Carey, 1989). A non-experimental (quantitative) design was used to measure the relationship between the variables in the current study.

1.14 UNIT OF ANALYSIS

According to Babbie (2008) there is no limit to what can be studied and units of analysis are those things we examine, namely individuals or collectives. The unit of analysis refers to the “what” of the study, in other words “what” object, phenomenon, entity, process or event that the researcher is interested to investigate. The current researcher views the topic and unit of analysis as very relevant to the background of applied aviation psychology and human factors. In this study, pilots and ATCs in the SAAF will be the unit of analysis, and they will be referred to collectively as aircrew.

1.15 VALIDITY

Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration (Babbie, 2005). Validity in quantitative research is concerned with establishing how good measuring instruments measure what they are supposed to measure and validity is established during the data collection and analysis phase (Msweli, 2011). Msweli names five major types of validity, namely construct validity, predicative validity, content validity, internal validity and external validity. Conceptualisation, operationalisation and validity checking are related tasks in the positivist tradition (Durrheim, 2006). When using an existing instrument, it is essential that information is available about the construct validity and reliability of that instrument. Internal validity sustains its findings and conclusions. A way of conceptualising internal validity is in terms of a classic form of logical argument called a syllogism. The findings produced by the design can be sustained, which indicates a relationship between emotional awareness and human error in aviation within the SAAF. A study has external validity when its findings or conclusions can be generalised beyond the confines of the design and the study setting (Durrheim, 2006).

1.16 RELIABILITY

Bergh and Theron (2003) defined reliability as the consistency of measurements and the dependability of a measurement instrument, that is, the extent to which the instrument yields the same results in repeated trials (Babbie, 2005). Msweli (2011) states that reliability measures can be assessed through test and re-test, or by comparing scores of a test administered to a single group to measure the same construct or trait. However, reliability does not ensure accuracy any more than it does precision (Babbie, 2005). The researcher was cautious about the effect of bias to make the research findings look good, and therefore she attended to objectivity and remained neutral during data observations and interpretations.

1.17 METHODS TO ENSURE ETHICAL RESEARCH PRINCIPLES

Hofstee (2011) suggests naming the potential ethical problems and obtaining formal approval to conduct the study. This study was conducted in accordance with three ethical principles: first, respect for the autonomy of all individuals participating in the research; second, non-maleficence by not harming any person who is part of the research in any way; and third, beneficence, by contributing to the applied human factor science (Durrheim & Wassenaar, 2002; Msweli, 2011). Ethical clearance was obtained from UNISA prior to the research. Since this study took place within the parameters of the SAAF, approval had to be obtained from the Chief of the Air Force and the Chief Director Force Preparation. Approval from Dr Ernest Hartmann to use his Boundary Questionnaire was also confirmed (Jawer & Micozzi, 2012). Furthermore, UNISA procedures to secure sensitive and confidential SAAF information were adhered to, as well as special methods to archive confidential information.

Hofstee's (2011) principle was followed to protect aircrew from any potential harm, therefore all reasonable and ethical attempts were made to counteract it. The researcher identified and considered all possible ethical threats in the study. A consent form was completed voluntarily by all the informed participants (aircrew) prior to the test (Durrheim

& Wassenaar, 2002). The aircrew had a full briefing regarding the nature of the research, after which they decided whether they wanted to participate or not. The confidentiality and security of all research data were protected strictly. The findings of the analysis were reported in accordance with ethical guidelines (Msweli, 2011). Communication and feedback of the test results occurred on a one-to-one basis. This feedback included suggestions for specific emotional awareness therapy according to the participant's unique emotional boundary type (Jawer & Micozzi, 2011). Pope (1992) argues that providing effective and constructive feedback to participants is a challenging skill to master, which the researcher believes was achieved.

1.18 RESEARCH METHOD

The research question was formulated according to the independent and dependent variables specified in the hypotheses and research questions. The researcher discussed the various available measures for emotional awareness and found the Boundary Questionnaire most suitable to measure the specified independent variable (Zborowski, Hartmann, Newsom & Banar, 2003). This research was conducted in three phases, with each of these phases consisting of several steps.

1.18.1 Phase 1: Literature review

A literature review concerning two constructs – human error and emotional awareness in the military aviation paradigm – was carried out and integrated theoretically. The researcher identified deficiencies in previous studies to emphasise the importance of emotional awareness to manage human error, which is neglected in aviation and CRM programmes.

1.18.1.1 Step 1: The independent variable: Emotional Awareness

Emotional awareness was conceptualised in an incident that occurred in 1991 during Operation Desert Storm, where a naval officer recognised a threatening radar blip as a silkworm missile. This happened although there was no logical explanation of how he could detect the difference between an American combat aircraft and the approaching enemy missile on the radar. He had seconds to decide before attacking the fast-approaching threat and ordered his men to fire. His accurate decision had psychologists fascinated. They questioned this incident – how he knew the truth innately, and consequently made the right decision because it felt right, saving many lives with this critical decision. The researcher claimed that he was aware of his emotions and the innate truth upon which he acted, although no visible evidence could explain why he had felt that way.

Similarly, in 1949, a parachute brigade of fire-fighters was dispatched to put out a blaze in the Rocky Mountains. A veteran with nine years' smoke-jumping experience was in charge when a fire was overwhelming, blowing straight towards them. The veteran ordered his men to retreat, but they ignored him and tried to escape the fire. The veteran intuitively devised a creative escape plan that had never been used before. He lit a match and ignited the ground in front of him and seconds later stepped into the ashes of his own fire, thus being the only survivor. His technique has since become a standard firefighting method. Lehrer (2009) argues that the men were in the grip of stress, which narrowed their thoughts. In contrast, the experience of the veteran and his emotional awareness kept him calm enough to access his inner resources and save his own life.

Decision making is an important element in aviation, and it is considered as subconscious logical analysis. Goleman (1998) explains it as the brain's calculations to derive at a weighted conclusion. Brown (2003) actually studied emotional awareness and concluded that we instantly know what the right thing is to do, without going through a logical reasoning process.

According to a number of Harvard studies, during the first thirty seconds of an encounter people sense intuitively what basic impression they will have of the other person – even after fifteen minutes or a year. Similarly, people who watched thirty-second snatches of teachers giving a lecture, could assess each teacher's proficiency with 80% accuracy. According to Goleman (1998), intuition represents the capacity to sense messages from our internal store of emotional memory and our own reservoir of wisdom and judgment. Thus, emotional awareness suggests that one should acquire all relevant information when a decision is needed; however, one should not analyse the information, but allow your subconscious mind to digest it. In addition, various studies contend that innate knowledge mostly provides the correct choice (Dijksterhuis, Chartrand & Aarts, 2007).

Stein and Book (2011) state that in the emotional intelligence model, emotional awareness refers to the ability to monitor one's own emotions, and it represents the fundamental skill to be intelligent about our emotional life. Jawer and Micozzi (2011) support this with their wise words, "when we ignore what matters most to us, it will become the matter within us". Literature indicates that emotional awareness creates a clear mind that makes us aware of and able to manage emotion, resulting in sharpened senses. These discussions argue the importance of a balance between thinking and feeling.

Emotions are innate to human beings, and help us to survive and succeed in life (Izard, 1992). They are evident in young children, and their innocence is always a pleasure to watch, as they express their emotions. They are completely open and honest without any defence mechanisms to mask their intent to help or to disguise their emotions. They are easy to read, and their feelings and needs are clearly displayed. Unfortunately, over time and with experience, emotions become tools driven by cognitive processes and agendas. A sense of movement is reflected in the word "emotion", which is derived from the Latin word *emovere* ("to move from") – it can therefore be argued that emotion acts as an impetus for a need.

For this study, emotional awareness is coined as human factor and defined as the ability to be aware of different emotions. According to Goleman (1998), we have to differentiate between emotions, to know what we are feeling and why (Bar-On, 1997). Importantly, emotion not only influences how reality is perceived, but it also affects our decision making and behaviour (Brown & Moren, 2003). Aircraft accident analyses relate human error to emotion, which is why the researcher formulated the research question of whether emotional awareness can be related to human error.

Guiding this research, emotional intelligence and emotional awareness show many similarities, and originate within the concept of social intelligence identified by Thorndike in 1920. Dr Claude Steiner used the term “emotional literacy,” and adding to this, Salovey and Mayer (1990) were among the first to propose the term “emotional intelligence” to define the ability to deal with emotions. Emotional intelligence refers to the competence required to identify and express emotions, and to assimilate emotions in thought. Accordingly, prior to identifying and expressing emotion, the researcher argues the importance of emotional awareness as the ability to be aware of emotions first. According to the researcher, emotional awareness is the primary condition leading to aircrews’ safe performance.

Supporting this argument, Daniel Goleman (1998) focused on the interface between psychobiology and behaviour, and claimed that emotional awareness matters twice as much as cognitive abilities or technical expertise. Additionally, Goleman, (1998) considers emotional awareness to have a competitive edge, and in his opinion, emotional upsets interfere with one’s mental state, limiting your performance. Related to aviation and situational awareness, accurate perception is integrated with innate messages from the environment. Negative emotion tends to focus attention on our own preoccupations, and interferes with attempts to focus elsewhere. With regard to aircrew, Goleman (1998) commented that out-of-control emotions make smart people stupid.

Tehrani and Molesworth (2016) emphasises the importance of emotional awareness to prevent human error, as emotionally intelligent individuals cope better with life’s challenges and stresses. She argued that individuals with a high emotional awareness would be less likely to err, and more likely to act in a responsible and safe manner. Furthermore, Landman, Groen, van Paassen, Bronkhorst and Mulder (2017) and Matthews, Strater and Endsley (2004) believe that a scientific understanding of emotional awareness will contribute towards the science of applied human factors in aviation and towards safety strategies to enhance safe behaviour and aircrew performance.

1.18.1.2 Step 2: The dependent variable: Human error

To “err” is human, they say, and making mistakes is part of the human condition. In the world of aviation, however, human error has serious consequences. In terms of ICAO and IATA statistics, 95% of all accidents are related to human factor. Kern (2009) claims that all accidents and incidents are attributed to human error. It has been suggested that human factors such as stress, sensory overload, information overload and mistrust adds to a breakdown in human performance. Worldwide, human error is categorised using a modified version of the Skill-Rule-Knowledge (SRK) framework of Rasmussen, namely skill-based, rule-based, knowledge-based, and procedure violations. The Swiss cheese model of accident causation illustrates that, although many layers of defence lie between hazards and accidents, there are flaws in each layer that, if aligned, can allow the accident to occur (ICAO, 2013).

Reason (1990) uses the Swiss cheese model of accident causation to illustrate that if the holes in multiple layers of cheese (flaws in the defences of the human system) are aligned with each other, accidents (human errors) may occur. The metaphor emphasises the significance of casual human factors leading to an accident and explains how latent errors can affect complex systems. Based on the Swiss cheese model and human error classification, the Human Factors Analysis and Classification System (HFACS) is a framework developed and tested within the US military force as a tool for investigating and analysing the human causes of aviation accidents. The HFACS addresses human error at all levels of the aviation system, including the condition of aircrew and organisational factors (Wiegmann & Shappell, 2003). An aviation accident or incident is thus not seen in isolation, but investigated as a series of events and various contributing factors in an organisation.

The SHELL model developed by Edwards in 1972 was modified into a 'building block’ structure by Hawkins in 1984 and Hawkins and Orlady (Hawkins & Orlady, 1993), indicating the four components and human interfaces with software, hardware, environment, and live-ware of the aviation system. The SHELL model suggests that the human is rarely, if ever, the sole cause of an accident (Wiegmann & Shappell, 2003). The systems perspective considers a variety of task-related factors that interact with the human operator, thereby affecting performance (Wiegmann & Shappell, 2003).

Threat and error management (TEM) is an applied human factor safety concept regarding aircrew performance to enhance aviation safety. It classifies human error into five categories, namely intentional non-compliance errors; procedural errors; communication errors; proficiency errors; and operational decision errors.

Aviation science argues that human error is inevitable. For safe performance, CRM and human factor training aim to reduce error as far as possible. Aviation safety requires defences to mitigate risk, therefore pro-active error detection is required to reduce errors. To date, aviation psychology and applied human factors have been unable to define a safe aviator profile. A taxonomy of behavioural traits is required to guide aircrew selection and CRM training to reduce human error.

1.18.2 Phase 2: The empirical study

1.18.2.1 Step 1: The non-experimental study

The current study was a non-experimental quantitative study to explore the causality between two variables: emotional awareness and human error. Babbie (2008) explains the effects of an independent variable on a dependent variable by taking the form of an experimental stimulus, which is either present or absent. The survey methodology measures variables by asking people questions and examining the relationships among them (Coldwell & Herbst, 2004). The Boundary Questionnaire was self-administered by aircrew over a two-year period during annual CRM training.

1.18.2.2 Step 2: Research sample

Babbie (2008) suggests that the overall matching process for a study can be achieved through the creation of a quota matrix constructed of all the most relevant characteristics. Alternatively, we might recruit more subjects than our experimental design requires. In this study, aviation, hazard, incident and accident reports determined and directed the human error sample. Randomly assigned participants avoided the main sample of interest to be tested in isolation.

1.18.2.3 Step 3: Data collection

Firstly, the Boundary Questionnaire developed by Dr Ernest Hartmann was selected as measuring instrument to measure the independent variable, emotional awareness. Jawer and Micozzi (2011) explain the applicability of the Boundary Questionnaire by arguing that ‘thick boundary’ people are less aware of feelings and most often maintain a calm demeanour, while denying or distancing themselves from strong feelings. Feelings are described as flowing like water in continuous motion. In the case of people with thin emotional awareness boundaries, the flow is quicker and more direct, resulting in better inner reality and legitimacy.

This study administered 70 items of the Boundary Questionnaire on a unipolar five point Likert scale. Each item was allocated ratio variable scores from 0 to 4, where 0 indicated “not at all” and 4 “yes, definitely”. The data was coded and tabulated for SPSS analyses. The researcher contacted Dr Hartmann and Jawer and Micozzi for approval to use the Boundary Questionnaire.

Secondly, like the SHELL and HFACS models that were discussed, aircraft investigations and analysis attribute the causes of accidents to various degrees to **m**anagement, **m**an, **m**achine, **m**edium and **m**ission, which is referred to as the 5M principle (Stolzer, Halford & Goglia; 2011; Yantiss, 2011). The 5M principles was used to classify the human error data in this study.

(1) Management (M_1)

The responsibility of management towards aviation safety is far reaching and reflected within the safety culture and just reporting concept (Dekker, 2014). As defined in the HFACS, management involves resources, aircraft missions, approval of systems design concepts, CRM training, regulations, maintenance, employment, adequacy of accident investigations and corrective measures (ICAO, 2016b).

(2) Man (M_2)

Humans are ultimately the most important element in the aviation system and human factors are the most quoted causal contributor to human error, which results in accidents. Human error stems from human shortcomings and inadequacies of emotion, senses and human behavioural patterns. The researcher considered human factors and limitations and these guided the research question. She identified current shortcomings within CRM training regarding ergonomics, fatigue, motivation, trust, responsibility, discipline and environmental stressors (ICAO, 2016b).

(3) Machine (M_3)

Despite major technological advances, machine limitations are reflected in inadequate design, use outside the design parameters, improper maintenance, material fatigue, man-machine interface and machine-environment interface. Mitigation methods such as regular inspections, maintenance, human factor training and accident investigations are used to negate the harmful influence of machine-induced accidents that remain within the human component (ICAO, 2016b).

(4) Medium (M_4)

Although aircrew members have little control over environmental influences, terrain, weather and noise, the role of the medium should be borne in mind when planning flights, selecting routes and specific flying areas (ICAO, 2016b).

(5) Mission (M_5)

This category refers to exceptional cases when a known risk is calculated against three factors, namely exposure, probability and severity. Where the inherent risks associated with the operational mission are outweighed by the importance of accomplishing the task (ICAO, 2016b).

1.18.2.4 Step 4: Formulation of research hypotheses

A hypothesis is a tentative statement about the world involving conjectures about relationships that have not yet been verified: It is a prediction. Hypothesis testing is done to determine what is true and would explain certain observations or phenomena. A hypothesis is an a priori statement of expectation that includes who is involved and to which treatment or intervention they will be exposed, the outcome measures to be used, and the comparison group (Msweli, 2011). The relationship between emotional awareness (EA) and human error (HE) is indicated as follows:

- (H0) There is no significant relationship between emotional awareness and human error.
- (H1) There is a significant relationship between emotional awareness and human error.
- (H2) There is a significant relationship between emotional awareness, human error and experience.
- (H3) There is a significant relationship between emotional awareness, human error and mustering.

1.18.2.5 Step 5: Data analysis

The results are discussed in Chapter 5. The researcher planned to explore the relationship between two variables for statistical significance and to determine how large the effect size is (Muijs, 2011). The success of quantitative research depends on the researcher's ability to use observed statistics to reject or fail the null hypothesis. Conclusions from test statistics can result in Type I or Type II errors if the wrong hypothesis is rejected (Allen, Titsworth & Hunt, 2008). A correlation coefficient that was used to express the relationship between variables in a precise manner gave an indication of the degree, size or strength of the relationship, as well as the direction of the relationship (Grieve, Van Deventer & Mojapelo-Batka, 2006). An inverse or negative relationship means that when one variable increases, the other variable decreases, as in the proposed inverse relationship between emotional awareness and human error in this study.

The small random sample size (N = 173) and nominal and ordinal data scales directed this study to explore non-parametric techniques. Data from each aircrew member was ranked as per original data and counted only once. The data did not influence each other as assumed by non-parametric tests. To limit the effect of outliers, non-parametric tests were conducted with ranks rather than the actual data in order to explore possible relationships between the following variables: aviation experience; mustering; emotional awareness, and human error (Vermeulen & Mitchell, 2007).

The researcher explored the relationship between human error (dependent variable) and emotional awareness (independent variable) groups by conducting the Kruskal-Wallis test to test for differences between groups and to compare multivariate data. The mean rank scores of the independent variable were compared with human error ranks to guide further analysis in the study. The Kruskal-Wallis test was used to test for any significant differences within the ranked mustering groups and experience. The scores of 173 aircrew members (N = 173) were ranked according to the independent mustering variables and coded as follows: helicopter pilot = 1; fixed-wing pilot = 2 combat pilot = 3; air traffic controller = 4.

1.18.2.6 Step 6: Reporting and interpretation of results

Mouton (2008) explains that interpretation involves the synthesis of one’s data with larger coherent wholes. One explains observations or data by formulating hypotheses or theories to account for observed patterns and trends in the data. The present study related emotional awareness with human error and with the aviation safety concept of situational awareness. Babbie (2008) mentions that questions need to be asked in terms of reporting and interpretation. The researcher placed the project in the context of previous research and formulated her questions accordingly. The Boundary

Questionnaire and human error results were interpreted within the applied human factor perspective.

1.18.3 Phase 3: Conclusions, limitations and recommendations

According to Mouton (2008), fieldwork refers to the part of the research process where the researcher leaves her study and enters the real world (World 1) to collect, select and analyse data. The research field of this study was aviation – within the applied aviation psychology and human factor sciences.

1.18.3.1 Step 1: Conclusions

The sample population target was SAAF aircrew, more specifically SAAF pilots and air traffic controllers (ATCs). The results of the Boundary Questionnaire and human error were concluded and discussed within the applied human factor perspective, related to human error with practical application to reduce human error with CRM training.

1.18.3.2 Step 2: Limitations of the research

The sample size for a quantitative research study may be a challenge, since the availability of human error data is limited due to various reasons – including under-reporting. The willingness of aircrew to participate in the survey could also be a problem, especially among those with a history of many incidents. Aircrew members have negative associations with psychological testing, since they are annually subjected to medical and psychological testing by the South African Institute of Aviation Medicine to obtain valid flying ratings.

1.18.3.3 Step 3: Recommendations

The research in hand explored the relationship between aircrew's emotional awareness and human error within aviation. Research results were explained against the background of the applied human factor paradigm. Emotional awareness training was explored with a view to its inclusion in the applied human factors dealt with in CRM safety training so as to reduce human error, thereby contributing to aviation safety.

1.19 CHAPTER LAYOUT

Chapter 1 presented the scientific orientation to the research. Chapter 2 and 3 encapsulate the literature review and Chapter 4 the experimental quantitative design. Chapter 5 will discuss the research results, and Chapter 6 contains the conclusion, limitations and recommendations of this study.

1.20 CHAPTER SUMMARY

The background and motivation for this study were discussed, as well as the problem statement, aims and objectives. The paradigm perspectives, research design and research methodology were also discussed and explained. Endsley and Jones (2012) mentioned the need for practical situational awareness training in aviation, and this, together with the researcher’s identification of a gap in the science of applied human factors for effective CRM, formed the premise for this study. Although CRM training addresses situational awareness theoretically as prescribed by ICAO (International Civil Aviation Organisation [ICAO], 2013), theory does not prescribe the practical application of situational awareness. This gap created the impetus to research emotional awareness as a leading variable that may be related to human error in aviation. Human Factor studies provided evidence of a positive relationship between emotional awareness and human error. This study aims to motivate the use of emotional awareness training strategies to reduce aviation human error to acceptable levels. Additionally, emotional awareness traits could be introduced for consideration in general aviation safety and it may contribute not only to Human Factors for CRM, but also as introduction to future studies.

CHAPTER 2: LITERATURE REVIEW ON HUMAN ERROR

2.1 INTRODUCTION

Several researchers have investigated the difference in situational awareness between pilots who perform well and pilots who do not, which led to research aim 3, namely to conceptualise aviation human error. The researcher obtained ethical clearance from the Chief of the South African Air Force to conduct this specific survey as well as approval to analyse captured safety data for the period 2005 to 2015. The researcher coded the safety incidence data according to four levels of safety severity.

Technology in aviation has evolved exponentially to keep up with an increasing demand for air transportation in seamless skies. Aviation safety experts became increasingly aware of the human-machine performance challenges associated with keeping up with both safety demands and technology acceleration. Accordingly, the aviation safety initiatives introduced a human-centred approach to the Human Factors (HF) and Ergonomics discipline. Despite ICAO regulation and many human factor safety initiatives such as Crew Resource Management (CRM), aircraft accidents continue to occur. In fact, aircraft accident investigation statistics confirm human error (HE) as the main cause of all accidents and incidents (Barker, 2014; Harris, 2011; Landry, 2012).

Aviation safety studies are consistent with the above findings and support the view that the human factor, situational awareness, is crucial for human performance and flight safety. It is therefore interesting to note that evidence from research proposes that emotional awareness has a critical effect on our cognitive processes, our behaviour and our decision making as part of situational awareness (McKeown, 2013).

The purpose of this study was to conceptualise the phenomenon ‘situational awareness’ related to emotional awareness and human error from an aviation human factor perspective. In this regard, this researcher defined and conceptualised the constructs of emotional awareness and human error. Emotional awareness is the extent to which aircrew identify, attend to and value their emotions (Moon & Berenbaum, 2009). The researcher argues that this ability would enhance situational awareness, thereby reducing the probability of human error.

2.2 CONCEPTUAL FOUNDATION

To answer the research question, the order of the variables for this study flows from emotional awareness influencing situational awareness and resulting in possible human error (see Figure 2.1). The variables related to the following aviation concepts were discussed in order of possible causal link:

- Situational awareness (SA)
- Threat and error management (TEM)
- Aviation psychology and the applied human factors (HF) discipline
- Human error (HE) within the aviation system
- Human error analysis models
- Emotional intelligence (EI)
- Emotional awareness (EA)

2.3 THE AVIATION HUMAN FACTOR DISCIPLINE

The concept ‘human factors’ (HF) has evolved over the last 60 years to become an independent discipline that is used synonymously with ergonomics, denoted as Human Factor Ergonomics (HFE) (Karwowski, 2012). To be specific, “human factors” is an international discipline associated with human error (Harris, 2012). Applied Human factors were initially confined to the Ergonomics Research Society in 1949, the HF and Ergonomics Society in 1957 and the International Ergonomics Association (IEA) in 1959.

Human factors are embedded in the selection, training and design processes within threat and error management (Harris, 2012). ICAO (2002) integrated the concept of ‘human factors' with safety management systems (SMS) in aviation and defines human factors as people in their living and working situations, their relationship with machines and with procedures within a specific environment. Human performance capabilities, limitations and human behaviour are considered central to human factors. Threat and error management aims to reduce human error and increase aviation safety, human performance and efficiency (ICAO, 2013).

The IEA (International Ergonomics Association [IEA], n.d.) defines ergonomics or human factors as the scientific discipline concerned with an understanding of the interactions among humans and other elements of a system (such as aviation), and applied theory, principles, data and methods to optimise human well-being and overall system performance. The ergonomics discipline promotes a holistic human-centred approach to work systems design that considers physical, cognitive, social, organisational and environmental factors.

The problem with the regulation and application of human factors lies within aviation safety training. Regarding safety, we cannot afford to pass on human factor knowledge, skills and training superficially (Wilson, 2012). The paramount objective of the human factor discipline, therefore, is to understand the interactions between people and everything that surrounds them, and based on such knowledge, to optimise human well-being and overall system performance (Karwowski, 2012). Previously, technology was the main impetus for ergonomics. The human factor discipline aims at understanding human error within the human-machine interaction (Karwowski, Salvendy & Ahram, 2010). Thus, reducing human error by focusing on human factors to increase system performance and safety are the main objectives of human factor ergonomics (Salas & Maurino, 2010).

Aviation specialists argue that human factor research should consider the total context within which aircrew must operate when performing a task (Harris, 2012; Landry, 2012). In the past, scientific literature myopically focused on either the cognitive or physical system individually. Only recent research recognises that interactions occurring between all the systems can have a profound influence on the performance and dictate overall system safety (Harris, 2012).

Internationally, HF specialists support the view of interactions between the various elements within the aviation environment that cause human error. Safety specialists agree that a systems approach will optimise safety within the complex aviation system (Marras & Hancock, 2014).

2.3.1 Human factors within the complex aviation system

The systems approach is the most dominant concept used in aviation safety to analyse aircraft accidents (Underwood & Waterson, 2013). The ICAO and the SACAA adopted the term "Safety Management Systems" (SMS). An SMS is a framework of data to manage the flow of information and actions in an organisation or system (ICAO, 2013; SACAA; 2016). The systems approach then focuses on a "complex whole" with the emphasis on interacting, interrelated and interdependent elements (Salas & Maurino, 2010; Landry, 2012). Byron (2007) defines an SMS as a systematic approach to managing human errors, including organisational structures, accountability, policies and procedures. Human error management is a consolidated and pro-active safety approach that entails a comprehensive and effective effort within a complex system (Kritzinger, 2006).

People often think of a human error as an erroneous action made by the last person to touch the aircraft before things went wrong. Although there might have been an erroneous action, it is important to consider the context of the entire complex aviation system and contributing organisational factors that may have contributed to the accident (ICAO, 2013).

Numerous human operators are involved and interact within the complex aviation system at any given moment (Landry, 2012). Kramer (2013) explains the complexity of the aviation system and the teamwork required between pilots and ATCs regarding

Instrument Flight Rules (IFR) (Kramer, 2013). ATCs need to ensure that pilots comply accurately with the instructions. Human error can occur if an instruction is not adhered to – even if it was due to an innocent oversight. Consequently, human error can have an adverse effect on the highly fluid air traffic situation and complex aviation system (Kramer, 2010).

Ernest Gann, American aviator and author, avers that *fate is a hunter.* An insignificant human error such as commencing a missed-approach procedure at the wrong point can put a pilot outside safety margins. In addition, it is particularly hazardous to start a climb past the minimum approach position (MAP) or below the minimum decision altitude (MDA) (Miller, 2013a; 2013b).

Human Factor research has concluded that human errors occur three times more often in the military sector than in civil aviation. The reason for this is that military flight operations can be far more complex than in the civilian sector, due to the operational environment, mission timing constraints and workload (O'Connor, Hahn & Nullmeyer, 2010).

2.4 CONCEPTUALISATION OF HUMAN ERROR IN AVIATION

Internationally, is air traffic increasing and threat and error management is becoming more complex as the airspace becomes more saturated. Accordingly, ATCs and pilots (aircrew) are challenged daily to maintain high safety standards within these complex aviation systems and stressful air traffic control situations (Brink, 2009; Tshabalala, 2011). It should also be pointed out that the human error phenomenon is complex and comes in many forms. Human performance is adversely affected by human error and poses a serious threat to the safety of flight operations (Harris, 2011; Kern, 2009). The aircrew are at the forefront of human error and performance limitations could result in a breakdown of situational awareness. This may in turn result in flawed decision making that causes accidents (Hollnagel, 2013).

Human error can be defined as those occasions when a planned sequence of mental or physical activities fails to achieve its intended outcome (Shuen-Tai & Wei-Min, 2011; Liang, Lin, Hwang, Wang, & Patterson, 2010). The roots of human error are diverse and pose a challenge to effective threat and error management (Harris, 2011). The Classical Rasmussen Decision Ladder categorises human error into three different types of information processing that are skill-, rule- and knowledge-based (Rasmussen, 1986). Limitations with regard to aircrew skills, knowledge and attitude, combined with human factors such as stress, work overload and individual predisposition, may cause human errors and result in aircraft accidents (Kanki et al., 2010).

Human error is a primary risk in aviation safety. Research in aviation supports the argument that human error remains the main cause of aircraft incidents and accidents (Dekker, 2014; Froslee, 2012; Harris, 2011; Kern, 2009; Kilingaru, Tweedale, Thatcher & Jain, 2013; Walker, O'Connor & Little, 2013). Human errors are inevitable and affect both performance and aviation safety adversely. In addition, it is usually the culmination of failure of certain human factors such as emotion, communication, decision making and degraded situational awareness (Walker, et al., 2013). A case in point is the analysis synopsis of the National Transportation Safety Board (NTSB) aircraft accident that confirms that numerous human errors contributed to the Asiana Airlines Flight 214 accident on 6 July 2013 in San Francisco. Although the pilots were qualified, extremely experienced and well trained, they were not immune to human errors, and descent below the visual glide path on the final approach to San Francisco, California resulted in an impact with the seawall (National Transportation Safety Board [NTSB], 2014).

A better understanding of the etiology of human error is required to mitigate its catastrophic consequences (Griffin, Young & Stanton, 2015). In aviation, system reliability is high, and accidents are seldom caused by one single human error (Avers & Johnson, 2011). Accidents occur when multiple human error contributors combine and fail to cope effectively within a complex environment such as aviation. To conceptualise human error clearly in aviation, we need to understand the organisational context, the system and influences in which they occur (Hollnagel, 2013).

2.4.1 Human error in the complex aviation system

Undoubtedly, there is no room for human error in aviation, which is a complex sociotechnical system involving numerous interacting human operators at any given moment. The flawless collaboration of these human operators is paramount to ensure a seamless and exact performance (Harris, 2011). Human error is found to be the main contributing factor in events leading up to an accident or to the severity of the outcome (Avers & Johnson, 2011; Harris, 2011; Kern, 2009; King, 2013). Landry (2012) argues that the different system components need to be engineered in such a way that they are resistant to one single human error. Early human error detection and alerting mechanisms need to be built into the complex aviation system so that human error may be identified and mitigated pro-actively.

Pilots and ATCs are front-end operators in the complex aviation system and they face challenges imposed by the need to operate and control a multivariate lagged and complex system in a heterogeneous multi-task environment (Tshabalala, 2011).

To reduce future aircraft accidents, human error analysis is necessary to trace the chain of human error events back through all the contributory events and latent errors. Aviation safety experts have divided human error into three categories: acts of omission, commission and precision. The most common errors in aviation are due to omission, for example, to omit setting the flaps correctly on the aircraft just before landing, due to human factors such as stress, work overload or complacency (Hobbs, 2008).

According to Arendt and Adamski (2011), aviation accident statistics reflect a 60 to 90% human error relation in aircraft accidents.

While the advances in technology and the increasing number of applications for unmanned aerial vehicles (UAV) may eventually reduce aircrew, the impact on safety will probably not improve until humans are completely removed from the complex aviation system. This will entail a completely automated and thoroughly debugged set of protocols for the design, engineering, manufacture and operation of UAVs wherein human factors are not allowed to influence any aspect. Until then, aircraft will continue to crash due to human error (Burnside, 2006).

Because humans are fallible, human error will be inevitable and cannot be eradicated (Dekker, 2011). To improve aviation safety, the risk that human factors pose to safe operations can only be managed to acceptable levels. To date, managing human error in aviation has remained a challenge and research is needed to change or influence aircrew behaviour using all available resources with CRM training (Brooker, 2010; Tehrani & Molesworth, 2016).

Human error is an inevitable part of flying and can never be eliminated completely (Dekker; 2011). Human factor and ergonomic models such as Threat and Error Management (TEM) and Crew Resource Management (CRM) have gone a long way with regard to training aircrew and ATCs the necessary human factor skills (Harris, 2011). Dekker (2011) believes that to understand why an accident occurred, we must look at the functioning of the individual parts to understand the linear sequence of human error events within the system.

2.5 HUMAN ERROR ANALYSIS MODELS

Worldwide, aviation safety experts agree that human factors are responsible for human errors that lead to aircraft accidents. Pilots and ATCs are the two main frontline operators who interact continuously within the aviation system at any given moment (Landry, 2012). To ensure a safe flight, it is important to identify human factors pro-actively – before human error can result in an accident.

The Human Factor field has changed in scope into a multidisciplinary field that draws on principles from the behavioural and social sciences as well as industrial systems engineering to optimise human performance and reduce human error. Aviation safety experts analysed numerous accidents and classified human error into five broad categories in terms of the accident analysis synopsis (Hackworth & Holcomb, 2008).

1. Procedural errors. Slips, lapses and mistakes.
2. Communication errors. Failures in the transfer of information, including misstatements, misunderstandings and omissions.
3. Decision errors. When the crew follows a course of action that unnecessarily increases the risk to the flight in a situation not governed by formal procedures.
4. Proficiency errors.
5. Intentional non-compliance errors.

Additionally, Hobbs (2008) differentiates between physical errors and psychological errors, and listed the following psychological errors that contribute to human errors in aviation.

1. Perception errors
2. Memory lapses
3. Slips
4. Wrong assumptions
5. Procedural violations
6. Fatigue

Kern (2009) highlights the continuous struggle of human performance experts to discover a broad-spectrum antibiotic to cure the human error disease. Findings from Tshabalala's study (Tshabalala & De Beer, 2014) support the argument that human factors lead to human errors. He studied ATCs and found that emotional intelligence, work stress, work performance and emotional coping within the stressful aviation environment contributed to human error. Brink (2009) studied 64 South African ATCs and found statistically significant relationships between stress and EI. In the current study, the researcher aims to extend previous aviation human factor research and focus specifically on the first emotional intelligence construct, namely emotional awareness (EA), within the existing human factor paradigm and human error framework.

The South African Air Force must manage acute pressures in a dynamic and demanding environment. Additionally, aircrew perform air operations within shared African airspace, challenging terrain and weather conditions, with limited navigation systems and ground facilities. Aviation studies, threat and error models and the HFACS accentuate a renewed human factor approach and prescribe training to embed skills for safe behaviour (O'Connor & Campbell, 2010; Salas & Maurino, 2010). Current human factor training is limited since it does not train aircrew with adequate knowledge, skills and attitude to proactively detect threats and errors (Harris, 2011). For effective threat and error management aircrew need to be aware of hazardous attitudes and cognitive biases such as gender biases that affect their attitudes and perceptions (Gibbon, 2014a; Harris, 2012; Kern, 2011)

2.5.1 Accident causation and human error analysis models

The requirement for the highest aviation safety standards possible within the aviation system cannot be emphasised enough. Various human error analysis models have been developed as safety tools to manage the human factor and enhance aviation safety (Landry, 2012). Aviation safety models focus primarily on the systems approach, and they recognise the importance of interacting, interrelated and interdependent elements (Salas & Maurino, 2010; Landry, 2012). Illustrating the scope of human factors leading to human error, the researcher explored the primary human error analysis models. The following accident causation models will be discussed: the SHELL model (Hawkins & Orlady, 1993), Swiss Cheese model (Reason, 1990, 2000), 5M and HFACS (Wiegmann & Shappell, 2003).

2.5.1.1 The SHELL model for human error accident causation

The ICAO prescribes the classic SHELL model (Hawkins & Orlady, 1993; International Civil Aviation Organisation [ICAO], 2013) to illustrate the relationship between the different aviation systems and human components (see Figure 2.1). The SHELL model is a classic human performance model used for threat and error management to explain how various aviation elements interact (ICAO, 2013) and it consists of the following five elements:

1. S – Software (procedures, checklist)
2. H –Hardware (physical system, like the aircraft, the ATC console)
3. E – Environment (weather, working conditions, organisational culture)
4. L – Live ware (pilots, ATC, mechanics, navigators)
5. L – Live ware (other aircrew)

This model highlights the continuous interaction between the five elements, namely the influence human factors have on aircrew integrated with software, aircraft (hardware), and co-pilots or ATC (other live ware) within the dynamic aviation environment. The researcher simplified her understanding of this model with the human being (L) at the centre acting as the glue in the middle, striving to keep the other elements within the system together in harmony. The effectiveness of this harmony depends on the strength of the human or live ware and the glue that holds them together (Ehmke, 2012).

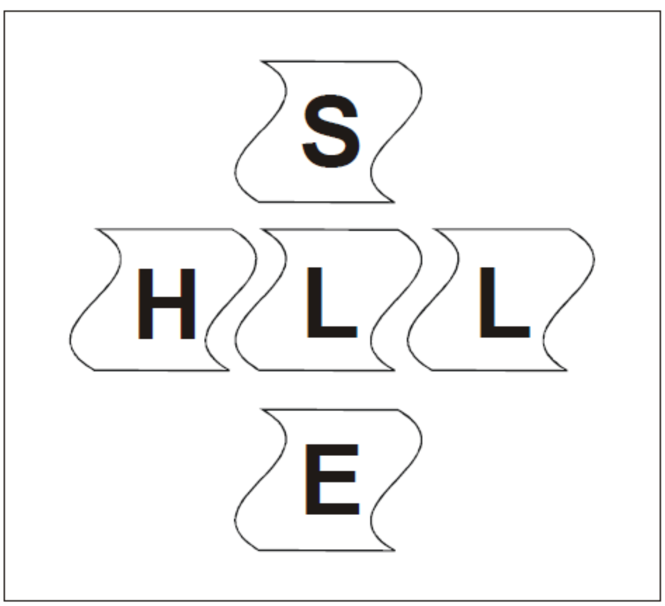


Figure 2.1 The SHELL Model
Source: ICAO (2013, p. 2-7)

2.5.1.2 Swiss Cheese model (Reason, 1990) for human error accident causation

Another classic human error management system of accident causation is the well-known linear “Swiss Cheese” Model (ICAO; 2013; Reason, 1990). According to Reason, accidents occur when there are breakdowns in the interactions among the SHELL components (see Figure 2.2). These failures, which are depicted as “holes” lining up within the different layers of the system, degrade the integrity of the entire aviation system, thereby transforming what was once a productive process into a failed system. The Swiss Cheese model is primarily descriptive and not analytical.

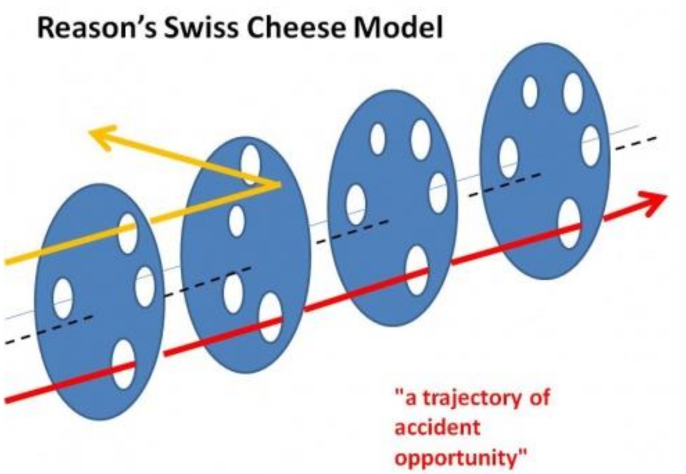


Figure 2.2 The Swiss Cheese Model

Source: SKYbrary Wiki (https://www.skybrary.aero/index.php/James_Reason_HF_Model)

2.5.1.3 The 5M Principle of Human Error (HE) accident causation

Although not invented by the SAAF, the 5M human error analysis model developed by T.P. Wright, is similar to the components within the SHELL model (as previously discussed), illustrated in a pie chart. The 5M categories are **m**anagement, **m**an, **m**achine, **m**edium and **m**ission interlocking circles. The 5M human error model supports human factor causation distribution, which consistently indicate ‘man’ as contributor to human error (Yantiss, 2011).

2.5.1.4 The Human Factors Analysis and Classification System (HFACS)

The ICAO suggests the HFACS model as a quantitative framework for threat and error management. The HFACS is the most comprehensive human factor causation model developed for aviation by Wiegmann and Shappell (2003). The HFACS framework identifies active and latent human factors in the aviation system associated with human error (Figure 2.3). This comprehensive framework is based on Reason's Swiss Cheese Model, to illustrate how causal human factors align over time, adding up to and resulting in human error. Related to the current study, this framework was defined by analysing hundreds of aviation accident reports. To understand the influence of human factors during accident investigation and determine possible human errors, each level of the HFACS model is evaluated to discover all relevant and latent human conditions (see Figure 2.3).

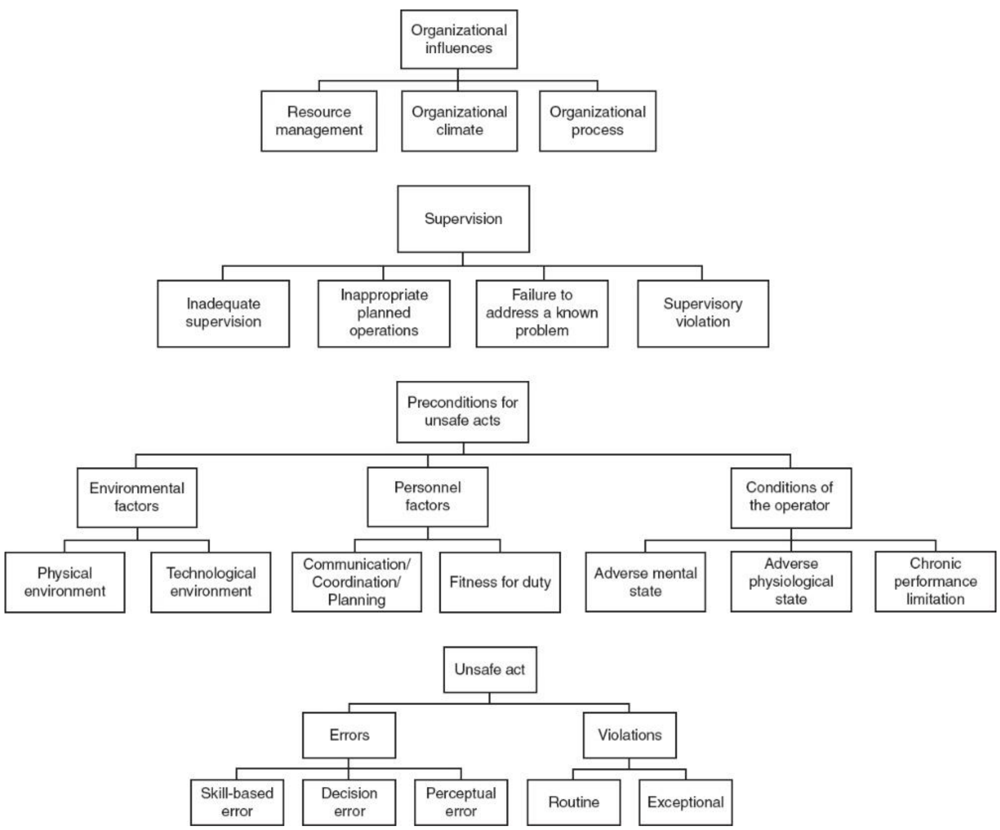


Figure 2.3 Human Factors Analysis and Classification System (HFACS)
Source: McCune, Lewis & Arendt (2011, p. 155)

A relevant study conducted by Froslee (2012) and using the HFACS model identified the following adverse mental states that lead to human error:

1. Decision errors are honest mistakes due to a lack of knowledge or bad choices.
2. Skills-based errors result from vulnerability to failures of attention, memory and/or techniques.
3. Perceptual errors occur when sensory input is degraded, and decisions are made based on faulty information.
4. Violations are wilful deviations from procedures.

2.6 AVIATION THREAT AND ERROR MANAGEMENT

Globally, aircraft accident rates remain high. Aviation research confirms human error and reduced situational awareness as primary human factor, while human error models are criticised as not sufficient in providing adequate causal explanations (Plant & Stanton, 2012).

Human performance is a primary safety measure (Landry, 2012), effected by adverse mental states that lead to human error (Tehrani & Molesworth, 2016). Wiegmann and Shappell (2003) highlight situational awareness, task fixation, distraction and mental fatigue due to lack of sleep or stressors as primary human factors. Secondary factors include overconfidence, complacency and misplaced motivation. A study by Cooke (2012) indicates that the highest number of human errors is caused by perceptual-motor bungles and decision errors.

Adding to these studies, a revised version of the Fleishman method was used in a NATO study on pilots from several countries. The most important abilities and skills identified for safe performance were situational awareness, memory, motivation and reasoning. Fleishman's method was also used in a study of German ATCs (Eissfeldt, Heil & Broach, 2002), while a number of extra scales were added such as cooperation, communication and the ability to handle stress (Martinussen & Hunter, 2010).

Data from aircraft accident investigations (AAI) confirm that human factors are mainly responsible for a breakdown in situational awareness and the primary cause of human error (Durso & Alexander, 2010). Furthermore, the aviation system requires effective communication between the flight deck, aircrew and ATCs. Failure in the information transfer process, degraded situational awareness and flawed decision making, have led to many accidents (Brown & Moren, 2003). The value of this study for effective threat and error management is supported by Brown and Moren (2003) who suggested that human factor training includes concepts such as ‘inquiry’, ‘advocacy’ and ‘assertion’.

2.7 HUMAN FACTORS RELATED TO HUMAN ERRORS IN THE COMPLEX AVIATION SYSTEM

Over the course of hundreds of nautical miles, ATCs are responsible for organising a chaotic flow of air traffic efficiently and effectively. They apply standard arrivals (STARs), precise radar vectoring, speed and altitude control to compress air traffic into organised "streams" and direct them safely to individual runways. Often, though, it appears that pilots erroneously think, "What's 10 or 20 degrees? The ATC won't notice!” However, if the controller fails to notice the seemingly insignificant deviation, the entire air traffic system could be severely disrupted, due to one seemingly insignificant human error (Kramer, 2013).

According to Pestal (2010), decision making must be objective and not clouded by emotion. Pestal explains the human error potential in seemingly insignificant transgressions and emphasises the critical importance of being aware of these small violations and wilful deviations from procedures – no matter how trivial they might seem. Emotional decisions create the first bad link in a potential accident chain (Pestal, 2010).

Hazardous emotional states have been identified as the primary human factor responsible for aircraft accidents. In effect, an emotional state is influenced by a variety of environmental stresses (Kanki et al., 2010). Excellent multi-tasking abilities, as well as extraordinary levels of attention and response speed are required to maintain situational awareness in a stressful environment (Pecena et al., 2013). It is important to note that synergy, teamwork, workload, data interpretation, stress and leadership are interrelated human factors affecting CRM. Although automation increases safe performance, overreliance on technological solutions often results in human errors (Kanki et al., 2010; Lintern, 2011).

2.8 HUMAN FACTOR TRAINING TO MANAGE HUMAN ERRORS IN AVIATION

For effective threat and error management, the ICAO prescribes mandatory human factors training for aircrew. Human factors training relates to the effectiveness of all the available resources (Figure 2.1) as well as interpersonal activities such as leadership styles, communication, decision-making, problem-solving and judgment, to achieve safe and efficient flight operations (ICAO, 2002; 2013).

2.9 THE HISTORY OF APPLIED HUMAN FACTOR TRAINING FOR CREW RESOURCE MANAGEMENT

A fatal runway collision in March 1977 between two Boeing 747s at Tenerife Airport – KLM Flight 4805 and Pan Am Flight 1736 – resulted in a tragic disaster. This accident serves as a textbook example of the complex interaction between human error, organisational influences and environmental preconditions. KLM realised the human factor training limitations after analysis of the accident and initiated basic human factor training based on the SHELL model (Figure 2.1). Although human factor training is focused on skills training and addresses the challenge of optimising the human/machine interface, aircrew members generally regard human factor training as unwarranted psychological meddling (Kanki et al., 2010).

2.10 AVIATION SAFETY TRAINING INITIATIVES TO REDUCE HUMAN ERROR

2.10.1 PAVE

Exploring the scope of applied human factor training, limitations are reflected in current safety management tools and CRM training initiatives such as the acronym for the popular PAVE checklist (**p**ilot, **a**ircraft, en**v**ironment, **e**xternal pressures), which allows pilots to identify hazards and human error risks.

2.10.2 IMSAFE

The IMSAFE acronym provides aircrew guidance in terms of **i**llness, **m**edication, **s**tress, **a**lcohol, **f**atigue and **e**motion (Wiegmann & Shappell, 2003; Wright, 2012).

Illness

According to Wright (2012), even a minor illness suffered in day-to-day living can seriously reduce situational awareness. Although the safe option is not to fly while suffering from any illness, aircrew often divert from SACAA aviation medical standards. If this rule is considered too stringent for a particular illness, aircrew should contact an Aviation Medical Examiner for advice (SACAA, 2016).

Medication

Wright (2012) comments that aircrew performance can be degraded by prescribed and over-the-counter medications, as well as by the medical conditions for which they are taken. The Germanwings accident in 2015 (Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile [BEA], 2016) alerted medical practitioners to rethink ethical disclosure of medication and the risk posed with evaluation by independent aviation medical examiners.

Stress

Schwarz, Kallus and Gaisbachgrabner (2016) argue that stress can impair aircrew performance, often in extremely subtle ways. Psychological stress degrades situational awareness and may result in human error.

Alcohol

Aviation medical research warns against the hazards of alcohol consumption and flying. Results indicate that as little as one ounce (28 grammes) of liquor, one bottle of beer, or four ounces (60 grammes) of wine can impair performance and degrade situational awareness (Wright, 2012).

Fatigue

According to Wright (2012), fatigue and lack of adequate sleep continue to pose a threat to aviation safety, as it may not be apparent to aircrew until serious errors are made (Wright, 2012).

Emotion

Tehrani and Molesworth (2016) conducted a study examining the effect of mood on performance. In support of this study, results indicated that affective states such as anger, anxiety or ego, have a negative influence on aircrew performance and may cause human error (Stein & Book, 2011; Wright, 2012).

2.10.3 The aviation safety training conundrum

Considering the effect of human factors, aviation safety training aims to understand human errors and discover counter-measures that are necessary to mitigate human errors before they become consequential (Gunther, 2010).

Recent studies in aviation safety emphasise the need for extensive studies in the human factors discipline, so as to provide aircrew/ATCs with the necessary psychological skills to perform optimally (Antoško, Pil’a, Korba, & Lipovský, 2014; Brink, 2009; Cooke, 2012; Harris, 2012; Kern, 2009; Tshabalala, 2011). Human factor training aims at empowering aircrew to understand emotion, thought and behaviour to act pro-actively and mitigate human error (Dekker, 2011).

2.10.4 Military Crew Resource Management training

Due to the demanding operational environment, mission timing and workloads, military aviators may find it more difficult than civilian aviators to identify and avoid errors. Despite some research on military human factor training over the past two decades, there is still scant literature or studies available on military human factor training programmes (Kanki et al., 2010; O'Connor & Campbell, 2010).

The SAAF introduced the concept of 'human factors' as part of 'crew resource management' for effective threat and error management. The training includes transactional analysis (TA), communication skills and emotional intelligence training. In 1990, the chief of the SAAF, General J. van Loggerenberg, officially instructed that human factor training be applied as CRM in the South African Air Force. On 17 September 1990, Major D.J. Keth and Major J.O. Branders presented the first SAAF CRM course at Loskopdam. General van Loggerenberg personally attended this historical event to demonstrate his support (Branders, 2013). More than two decades later, Chief of the South African Air Force, Lt Gen. F.Z. Msimang also realised the importance of future human factor research and development in the field of aviation safety. He therefore supported this study with enthusiasm and inspired the researcher throughout her studies to conclude it with confidence.

2.10.5 Civilian human factor training

For effective threat and error management, Air Canada safety programmes included essential human factor skills such as leadership, emotional awareness, preparation and planning, monitoring, feedback, situational awareness, communication, decision making, and workload management (Dowd, 2010). Shuffier, Salas and Xavier (2010) propose that the following human factors be taught: communication, briefing, mutual performance monitoring, team leadership, decision making, assertiveness and situational awareness. Human factors such as problem solving and decision making are reliant on Level 3 (comprehension) situational awareness (Endsley, 2000). SAA considers the following human factors – cognitive limitations, fatigue, work overload, inadequate training, poor maintenance of equipment and errors induced by ATC – as challenges that can exacerbate latent human error (Odendaal, 2012).

The famous successful emergency landing of US Airways Flight 1549 on the Hudson River on 15 January 2009 is a reflection of effective CRM and successful culmination of trained human factor skills. In effect, multiple human factor skills contributed to enhanced situational awareness that culminated in a safe emergency landing on the Hudson River, after a total engine failure was caused by bird ingestion (Hollnagel, 2013).

Some aviation researchers criticise the human factor training limitations of the systems approach (Tshabalala, 2011; Cooke, 2012), in that they do not place enough emphasis on individual human errors or, as Kern (2009, p 1) refers to it, “the threat inside” or the “blue threat”. Unchecked egos and negative emotional states often result in pushing the limits of fatigue and stress that could result in distraction (Kern, 2009). Cooke (2012) recommends an enhanced individual safety culture, and presents the notions of human behaviour and behavioural change through a comprehensive understanding of human error in order to provide a behavioural change model to develop safety-based thinking and behaviour.

Aviation safety specialists support the hypothesis that threat and error management requires human factor training, therefore they argue that training is a controllable variable (Salas & Maurino, 2010). Kern (2009) strongly supports the individual-focused approach to human factor training and argues the importance of emotional awareness for effective threat and error management. Martinussen and Hunter (2010) support the view of Kern (2009) and believe human factor training should focus on both system and individual. Aviation studies conclude that effective threat and error management requires the following human factors traits to be addressed (Helmreich & Foushee, 2010):

- Avoiding tunnel vision and being aware of factors such as stress
- Active monitoring of all information systems
- Staying ahead of the curve in preparing for contingencies

- Communicating plans
- Communicating workload distribution
- Prioritising secondary operational tasks
- Planning for sufficient time
- Recognising and reporting work overload
- Ensuring all crew members are aware of status and changes in automation
- Recognising potential distractions

Human factor specialists concur that a breakdown of aircrew situational awareness is central to human error and a prerequisite skill linked to optimum performance. A review of the literature supports the hypothesis that emotional awareness is singled out as the key Human Factor trait related to human error (Salas & Maurino, 2010; Wickens, 2002; Di Nuovo, Cannavo, Di Nuovo, Schmorrow & Fidopiastis, 2011).

2.11 CONCEPTUALISING THE TERM 'SITUATIONAL AWARENESS'

Situational awareness is a key concept in the discipline of human factors, research and threat and error management (McGuinness, 2004; Pion, 2013). It provides the basis for safe behaviour, effective decision making, use of procedures and automation, effective team interactions and informed expectations (Salas & Maurino, 2010). Situational awareness is widely recognised as a leading contributor in the field of human factor research (Bencini-Tibo, 2012). It contributes to safety by providing for the effective detection of human error, communication and decision making. A breakdown in situational awareness is widely recognised as the leading contributor to human error (Kilingaru et al., 2013; Salas & Maurino, 2010).

There is continuous interest and debate among human factor practitioners in terms of conceptualising and measuring situational awareness. Understanding situational awareness is critical to provide a better understanding to practitioners who seek to improve the human-machine performance (Vidulich & Tsang, 2012).

Situational awareness is a colloquial aviation safety construct commonly used worldwide as a critical human factor concept and prerequisite for safe flight, as it depicts a clear presence of mind, vigilance and alertness. Furthermore, situational awareness is used extensively as a precursor to proper airmanship and flight safety. Central to this study, a multitude of definitions exist (Cooke, 2012; Kern, 2011) and the literature represents a great deal of discrepancy regarding the use of the concept 'situational awareness' (Hokeness, 2013).

Situational awareness is fundamentally a cognitive concept pertaining to the operator's accurate understanding of the present situation – hence it is closely linked to decision making and human error (Vidulich & Tsang, 2012). In explaining this phenomenon, the researcher pursued an understanding of the underlying variables of situational awareness. She contextualised situational awareness as related to emotional awareness with the classical definition that is still applicable in aviation safety, according to three levels (Endsley, 2000):

Level 1: Perception of environmental elements within a volume of time and space
Level 2: Comprehension of the current situation
Level 3: Projection of information in the near future

Endsley (2000) also describes situational awareness at three levels, known by aircrew as "PCP". This acronym is a familiar aviation concept and is still highly applicable in aviation schools of thought.

- Level 1: **P**erceiving the status, attributes and dynamics of relevant elements in the environment
- Level 2: **C**omprehending the significance of these elements
- Level 3: **P**rojecting current assessment to future status

Reason's (2000) model explains that aircrew are surrounded by a wealth of sensory information from which they must extract critical information. Displays in the cockpit and control towers provide a complex visual experience for which accurate visual perception is critical (Curtis, Jentsch & Wise, 2010). A lack of situational awareness is one of the most critical and challenging features leading to human error. In a study of accidents among major airlines, 88% of those involving human error could be attributed to degraded situational awareness (Endsley, 2000; Van de Merwe, Oprins, Eriksson & Van der Plaat, 2012).

The human factor perspective explains that situational awareness is the continuous interaction and relationship between aircrew, including various artefacts relating to the five SHELL components (Figure 2:1). Adding to this, Kern (2009) explains emotional awareness related to situational awareness known as "NIFITI":

- **N**ame **I**t. This is the emotional awareness stage where the environment is identified and expressed in a common aviation language, for example, "I do not feel comfortable" or "I feel stressed about the oil pressure".
- **F**rame **I**t. Contextualise the potential problem and decide on potential action to mitigate the challenge; for example, decide to consult the oil pressure checklist.
- **T**ame **I**t. To act and correct the situation pro-actively before it spins out of control; for example, decide to divert the aircraft to a closer airfield for a technical opinion and oil pressure analyses.

In relation to threat and error management, situational awareness is referred to as a cluster of specific outcomes including preparation, planning, vigilance, workload distribution and distraction avoidance (Kanki et al., 2010). Furthermore, situational awareness is explained within the distributed cognition perspective (Stanton, Salmon, Walker & Jenkins, 2010). Hazardous attitudes such as stress, biases and work overload could result in a potential cognitive bottleneck, influencing perception and resulting in human error (Vidulich, Wickens, Tsang & Flach, 2012).

However, human factor studies support the paramount importance of situational awareness for optimum performance and aviation safety (Nicholsen, 2010; Pasztor, 2010; Stanton et al., 2010). Emotions such as stress and anxiety are cognitive stressors that influence perception, decision making, cognitive processing and performance, and that reduce situational awareness (Tichon, Mavin, Wallis, Visser, & Riek, 2014).

Literature provides sufficient evidence and consistency between the prevalence of human factors related to reduced situational awareness and causing human error (Hokeness, 2013). To date, human factor research has focused largely on operator (pilot/ATC) trust and reliance, while ignoring the role of emotion in safe flight (Hughes, Rice, Trafimow, & Clayton, 2009).

Aviation research supports the view of the researcher and highlights limitations within current human factor models. So far, little research explored and investigated the relationship between emotional awareness and situational awareness to reduce human error (Jeon, Walker & Gable, 2014). Kern (2009) argues effective threat and error management requires emotional awareness. Importantly, training programmes should be more prescriptive and include practical methods to enhance aircrew emotional awareness (Matthews, Strater, & Endsley, 2004).

CHAPTER 3: LITERATURE REVIEW ON EMOTIONAL AWARENESS

3.1 INTRODUCTION

The researcher explored literature and trends that explain the importance of emotional awareness as central to the Human Factor perspective (Jeon, Walker & Gable, 2014; Tshabalala, 2011). In aviation, safe performance is dependent on emotional awareness to detect early warning signs of potential human error, so as to pro-actively act and rectify the threat. Emotional awareness creates an array of personal resources for problem solving, decision making, and social skills, including psychological resources such as resilience and motivation, thereby enhancing situational awareness (Grant, 2013; Hefferon & Boniwell, 2011).

3.2 CONCEPTUALISE THE INDEPENDENT VARIABLE: EMOTIONAL AWARENESS

Research literature provides evidence of the purpose of emotion and it considers emotion more powerful than thoughts (Lehr, 2014). Emotion triggers conscious and unconscious effects related to the environment as well as important factors to consider (Behrmann, 2015). In relation to situational awareness level 1 perception, emotional awareness communicates important messages about ourselves and the environment (Reason, 2000; Hefferon & Boniwell, 2011). Ekman (2003) identifies six hazardous human emotions, namely anger, disgust, fear, joy, sadness and surprise. Emotion is also defined as a psychological state in which subjective feelings or characteristics and patterns of physiological arousal influence thought and behaviour. In turn, emotional awareness is defined as the extent to which an individual consciously perceives emotion and distinguishes between different bodily feelings (Alpullu, 2013; Davidson & Begley, 2012). Relating to situational awareness, Stein and Book (2011) explain emotional awareness as the ability to tune into the world, read situations and connect with others. Emotional awareness is a prerequisite for emotional regulation and it involves the ability to monitor and differentiate between emotions, locate their originators and acknowledge the value and importance of their messages (Camodeca & Rieffe, 2013; Stein & Book, 2011; Tshabalala, 2011).

For the purposes of this study, emotional awareness is divided into two components, namely the extent to which one is aware of one's emotions and the extent to which one can identify and describe one's own emotions (Moon & Berenbaum, 2009). According to Coates (2008), negative past experiences could result in emotional suppression or repression for survival. Humans ignore emotions selectively or try to control them. Suppressed emotions become imprisoned in our subconscious or unconscious minds.

Furthermore, emotion influences cognitive processing and is the key determinant of behaviour, performance and decision making. Negative emotions such as stress and anxiety are cognitive stressors that influence decision making and result in degraded performance (Tichon et al., 2014).

People employ three strategies to cope with stress: problem solving, avoidance and social support (Amirkhan, 1998). Negative emotions influence safe performance by focusing on what is wrong instead of what is right (Fredrickson, 2001; Straus & Allen, 2006). Positive emotions build personal resources such as problem solving, social skills and psychological resources such as resilience and goal orientation (Hefferon & Boniwell, 2011). A behavioural approach study by Newby and Narain (2016) to determine the role of emotions in aviation safety describes unsafe behaviours as driven by emotion. Their study refers to 12 hazardous attitudes (Table 3.1) tabulated in the so-called Dirty Dozen as common causes of human error. Fakoussa (2012) refined those attitudes to only six.

Table 3.1 The Dirty Dozen

Original Dirty Dozen	Dirty Dozen by Fakoussa
Lack of communication	
Complacency	Lack of awareness
Lack of knowledge	
Distraction	Lack of attention
Lack of teamwork	
Fatigue	Lack of sleep/breaks
Lack of resources	
Pressure	Lack of stress resistance/self-confidence
Lack of assertiveness	
Stress	Lack of relaxation
Lack of awareness	
Norms	Lack of creativity

Source: Newby & Narain (2016, p. 7)

Adding to these hazardous attitudes, results from a survey administered among the global aviation community (Newby & Narain, 2016) to define the role of emotion in aviation safety, identified five top emotions (see Table 3.2).

Table 3.2 The top five emotions identified

Emotion	Interpretation
Fear	Something specific in the future is likely to harm me and the predisposition is to run away or avoid it.
Care	The person/place/thing is the value to me and the predisposition is to protect.
Arrogance	I believe I am smarter than others and as a result I am also better than them. My tendency will be to dismiss their ideas and suggestions as coming from an inferior being.
Compliance	I will go along with this initiative because I do not have the freedom to decline and the predisposition is to go through the actions.
Complacency	I believe I know enough to get by and as a result do not put effort into checking or learning.

Source: Newby & Narain (2016, p. 9)

Related to aviation and emotion, Brown and Moren (2003) studied the emotion of shame and coping responses and they proposed that emotional dynamics are involved in aircrew stress coping or avoidance strategies (see Figure 3.1). They also suggested emotional awareness training for aircrew, to become aware of their emotions (shame), speak up and communicate important information when they feel uncomfortable about a situation.

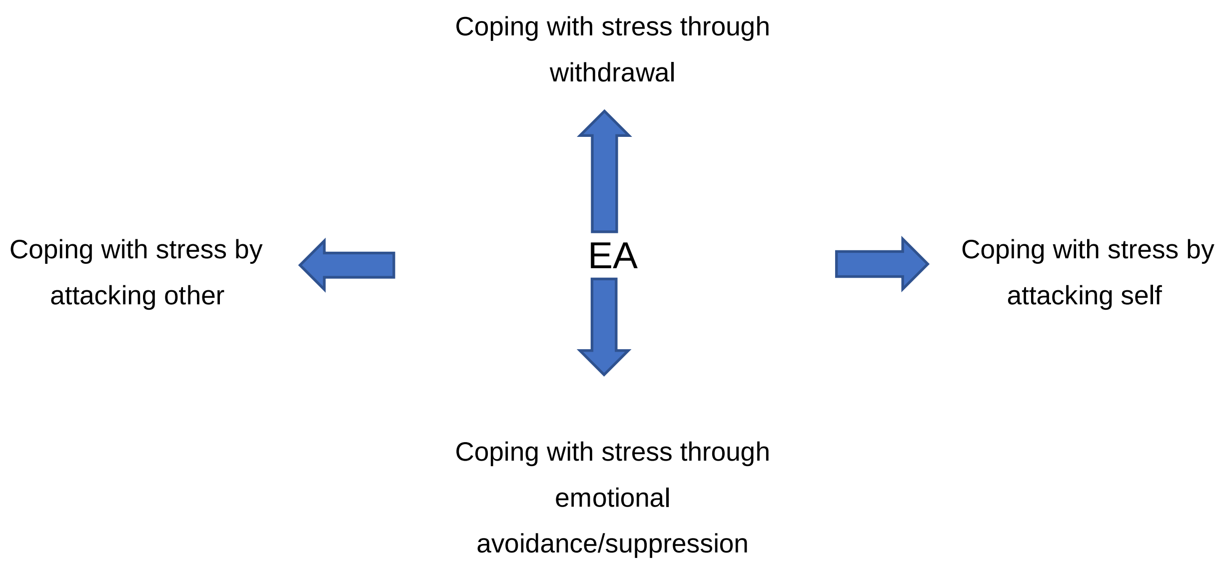


Figure 3.1 The compass of emotional awareness avoidance responses
Source: Adapted from Brown & Moren (2003, p 273)

As discussed, human factor research limitations directed the research problem and aim of this study, namely that aircrew behaviour is driven by emotion and, to avoid human error, aircrew should be emotionally aware. However, studies identifying the relationship between emotional awareness and human error are limited (Brown & Moren, 2003; Dobson, 2013; Killian, 2012; Larkins, 2010; Newby & Narain, 2016).

3.3 EMOTIONAL AWARENESS IN RELATION TO EMOTIONAL INTELLIGENCE

Considering the three main criteria for a nomothetic relationship in social research (Babbie, 2013), the researcher hypothesised a relationship between emotional awareness and human error. Supporting this argument, Stein and Book (2011) conceptualised emotional awareness and converted information from the environment for effective decision making. As shown in Table 3.3, emotional awareness is a construct of emotional intelligence (EI) (Salovey & Mayer, 1990). For this study, emotional awareness pertains to innate intelligence and is concerned with conscious and cognitive activity. Additionally, emotional awareness is the acquisition of knowledge and decision making through emotions, while unconscious activity plays a vital role because emotions emanate from it (Lehr, 2014). For aircrew to be able to maintain situational awareness, they need to be able to perceive emotion. This is vital to recognise their own emotion as well as the emotion of another aircrew member (Alpullu, 2013; Endsley & Jones, 2012; Killian, 2012). Brown and Moren (2003) explain that emotion influences thought and behaviour, which indicates a significant relationship between emotional intelligence and human performance (Bar-On, 1997; Brackett & Salovey, 2006; Bar-On et al., 2006). Because of the importance of emotional awareness and the influence it has on the aircrew's perception and decision making, emotional awareness formed the basis of this study.

Emotional intelligence researchers argue that a person's personal and professional success in life depends not only on cognitive abilities, but also on emotional skill and social traits (Killian, 2008; Stein & Book, 2011). Various theorists propose different concepts related to emotional intelligence and agree on emotional quotient dimensions (see Table 3.3) namely, emotional awareness, social awareness, self-management and relationship management (Killian, 2012; Bar-On, 2010).

Additionally, emotional intelligence moderates the relationship between stress and performance (Alpullu, 2013; Wu, 2011). Stein & Book (2011) explains emotional awareness as a sub-scale of emotional intelligence in that it represents the potential for behaviour and not the actual behaviour. A study of Reuven Bar-On's model and meta factors pertaining to emotional intelligence sub-scales directed this study to explore the relationship between emotional awareness and human error (Alpullu, 2013; Bar-On, 2010; Killian, 2012).

3.3.1 Emotional awareness: Bar-On's emotional intelligence sub-scale

Exploring the scales of emotional intelligence, this study focused on the composite emotional awareness based on findings from Bar-On (2010), which indicate emotional awareness as a building block to self-perception and an activator to emotional intelligence (Table 3.3). Relevant to our effort to conceptualise emotional awareness, research by Stein and Book (2011) provided conclusive evidence that cognitive ability identifies and describes one's own emotional experiences as well as those of others (Lane & Schwartz, 1987) by describing emotional awareness as the conscious processing of emotional information (Lane, 2000). Aircrew must be prepared for any situation or emergency. In the case of the Hudson River landing, emotional awareness provided skill and strategies to adapt to and deal successfully with any situation. Therefore, the researcher postulates that there is a relationship between emotional awareness and human error (BEA, 2016).

Table 3.3 EQ-I 2.0 Model. Scales and assessment

EQ-I 2.0 scales	EI competency assessed by each scale
Self-perception	Emotional awareness Self-regard Self-actualisation
Self-expression	Emotional expression Independence Assertiveness
Interpersonal	Interpersonal relationships Empathy Social responsibility
Decision making	Impulse control Reality testing Problem solving
Stress management	Flexibility Stress tolerance Optimism

Adapted from Stein and Book (2011, p. 23)

Recognising the importance of emotional awareness to notice one's own thought and feelings, Coates (2008) states the significance of being able to observe the constant interaction between thought and emotion. Brown and Moren (2003) argue that when aircrew fail to identify their emotions, this might result in amplification, suppression or maintenance of an inappropriate emotion, resulting in human error. Applied to aviation, emotionally aware aircrew will observe stress within themselves or other aircrew members and display calmness. Emotionally aware aircrew may reduce their stress, thereby enhancing confidence and performance.

Considering the importance of emotional awareness in relation to aviation safety, the researcher argues that emotional suppression is detrimental to perception and may lead to human error. Emotional awareness is therefore paramount to recognise subtle emotional cues and to be equipped for dealing with one's circumstances (Hefferon & Boniwell, 2011). Kern (2009) states that low emotional awareness may cause highly trained and skilled aircrew to err. Applied science and human factor research recognise how important it is for emotionally aware aircrew to accurately perceive stress to regulate and manage their environment (Han & Johnson, 2012).

Human factor science argues that the ability to be consciously aware of emotion is an important and unique competency. Being aware of emotion is important to recognise the situational nature of the environment and to modulate and manage reactions to stressful events (Morris et al., 2010). Adding to this, emotion contains important messages that cannot be ignored (Newby & Narain, 2016). Safe performance requires aircrew to be aware of their emotional states and to operationalise underlying messages related to their environment. Aircrew need to be skilled in emotional literacy and emotional awareness lexicon to distinguish and express their emotion (Brown & Moren, 2003).

A study conducted by Reyes-Dominguez (2010) supports this hypothesis and suggests that there is a relationship between emotional awareness, success and increased performance. Additionally, emotional awareness has been associated with signs of positive mental health, job satisfaction, organisational commitment, productivity and trust (Schutte & Malouff, 2012). The most prevalent Human Factor traits currently studied by positive psychologists are self-regard and self-acceptance, based on emotional awareness. Human factor research agrees that emotional awareness could affect and regulate safe performance, decision making and problem solving to reduce human error (Hefferon & Boniwell, 2011; Newby & Narain, 2016; Bar-On, 2010).

3.4 THE RELATIONSHIP BETWEEN EMOTIONAL AWARENESS AND HUMAN ERROR

This study originated from the human factor approach to operationalise the phenomenon ‘human error’ as how aircrew judge a situation based on their perceptions. The scope of human factor training directed this study to explore the relationship between emotional awareness and human error. To gain a deeper understanding of human factor training limitations, the researcher explored literature pertaining to aviation and related to safe performance within the application of various CRM modules.

The SAA’s human factor training includes the following five most common hazardous behaviours related to human error (Odendaal, 2012):

1) Anti-authority (don’t tell me what to do!)
2) Impulsivity (do it quickly!)
3) Invulnerability (it won’t happen to me.)
4) Macho (I can do it!)
5) Resignation (what’s the use?)

ICAO (2013) human factors training prescribe EI training and the importance of emotional awareness in terms of ego, complacency, fatigue, stress, experience, gender and cockpit gradient as safety barriers. Several empirical studies on aircrew and stress indicated strong relationships between emotion, performance and human error (Brink, 2009; Tshabalala, 2011). Emotional awareness affects human judgment and drives behaviour and decision making. Adding to this, Goleman (1998) argued that emotional upsets interfere with one’s mental life. Aircrew caught in a destructive emotional state do not perceive and comprehend information correctly, which results in human error (Endsley & Jones, 2012). Negative emotions direct attention towards one’s own preoccupations and interfere with an attempt to focus elsewhere, leading to situational awareness deterioration and ultimately to human error (Afolabi, Ogunmwonyi & Okediji, 2009).

Emotional awareness plays an essential role in value recognition and teamwork to enable aircrew to regulate their emotions and cope within a complex and demanding environment where situations change frequently and extensively (English & Branaghan, 2012). Therefore, it can be argued that aircrew need the trait 'emotional awareness' to perceive and comprehend a situation accurately, so as to adapt and deal safely with the possible consequences of a situation.

This study's hypothesis is supported by a recent study in South Africa on civilian ATCs that revealed a positive correlation between emotional awareness and increased situational awareness. Local research suggested that aircrew suffer from stress-induced emotion namely apathy, they neglect normal safety precautions and express more risk-taking and ego-driven behaviour (Tshabalala, 2011).

Brown and Moren (2003) conceptualise emotional awareness in their study and argue that pilots are more driven by excitement than the average person. This quality is associated with a tendency to avoid self-blame and to focus on excitement, self-confidence or ego to cover the shame effect (Brown & Moren, 2003). They propose that emotional dynamics such as shame prevents aircrew from speaking up. Low emotional awareness results in failure to communicate relevant information in the aviation system (Bienefeld & Grote, 2012). This argument is based on emotional awareness and the shame effect, and it results in apprehensiveness to communicate, due to fear of an attack on one's personal competence. Kern (2011) argues that safety is affected by negative emotions, which results in hazardous attitudes and turns aircrew into their own worst enemy. Kern (2009) studied aviation accidents and concluded that the reason highly skilled aircrew lost situational awareness before an accident, is because they were not emotionally aware of what was going on within themselves.

3.5 COPING WITH EMOTIONAL STRESS IN AVIATION

The extensive cognitive demands made on aircrew are indicated through various performance and stress-related studies (Brink, 2009; Larkins, 2010; Tshabalala, 2011). How aircrew cope with stress is a major human factor research focus. Schwarz et al., (2016) analysed stress related to air traffic management and concluded that human performance is the key success factor to manage safety. Studies argue that stress has a negative impact on working memory capacity, productivity and performance (Kanki et al., 2010; Tshabalala, 2011). A study by Wu (2011) confirms a negative relationship between emotional stress and performance. His study explains that emotionally aware aircrew are able to observe emotions such as stress and anxiety pro-actively and regulate emotions to manage a situation before human error occurs.

A study in which employees were asked to define work-related stress illustrated an obvious inability to describe the emotions related to stress. This inability to recognise emotional discomfort and the lack of a psychological vocabulary resulted in psychosomatic symptoms. These results illustrate the importance of emotional awareness for stress management and regulation to prevent human errors (Grieve et al., 2006).

Research studies indicate a correlation between stress and a wide range of negative emotions such as aggression, depression and anxiety (Schwarz et al., 2016). The relationship between emotional stress, arousal and performance was established by Yerkes and Dodson in 1908. The Yerkes-Dodson law states that performance increases when arousal increases, but only to a moderate level, before it reaches an optimal performance level that is required for aircrew to operate safely. Beyond the optimal level, performance starts to decrease and may lead to human error. As illustrated in Figure 3.2, aircrew become tense and lose concentration, and their performance degrades, which leads to human error (Grieve et al., 2006).

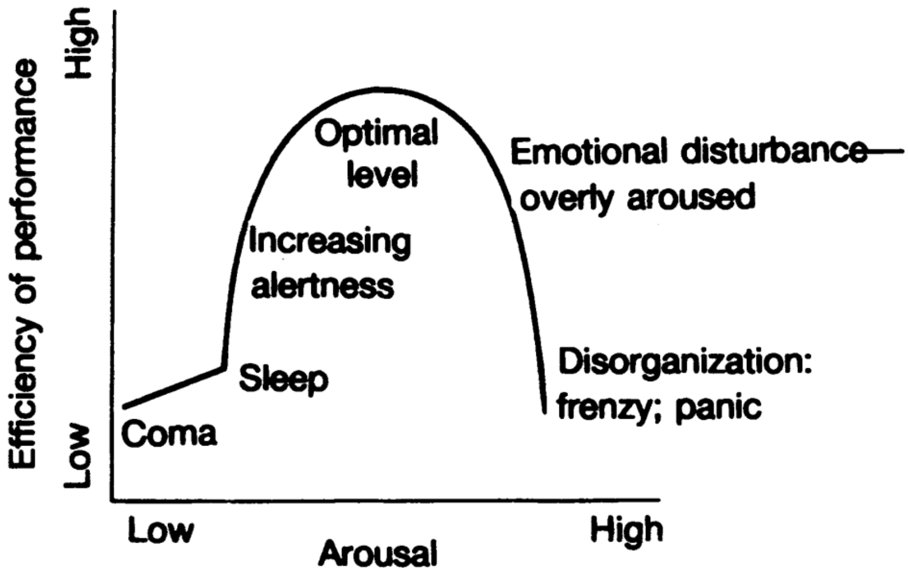


Figure 3.2 The optimal performance curve
Source: Teigen (1994, p. 534)

The Yerkes and Dodson stress curve indicates the relationship between stress and performance (see Figure 3.2). Dobson (2013) studied 193 aviation accidents and the results indicated a relationship between negative emotions such as stress and human error. His study found that stressed aircrew erred in performing unnecessary emergency landings due to emotions that affect their judgment and decision making.

You, Dai, Yang & Chang (2009) supports these studies and argues that enhanced emotional awareness should reduce human error. In turn, Causse, Dehais, Péran, Sabatini and Pastor (2013) conducted behavioural research on the effects of emotional awareness on aircrew. Their data presented a temporary impairment of rational decision making due to negative emotions such as stress.

The researcher discussed the importance of emotional awareness related to the influence of stress and negative emotion on safe performance. As suggested in the investigation of the Germanwings accident, aircraft accidents are usually the culmination of a chain of events and not a single human error occurrence (BEA, 2016). To reduce human error, it is essential to understand the how emotion affects aircrew and eventually results in decision shortcomings. Furthermore, human error is linked to emotional states that result in the failure to communicate, poor decision making and degraded situational awareness (Bienefeld & Grote, 2012; Walker et al., 2013). Studies support the view that poor judgment results from a breakdown in emotional awareness, leading to poor decision making associated with human error.

3.6 MILITARY PILOTS AND EMOTIONAL AWARENESS

A study by Meško et al. (2013) on Slovene military pilots produced a profile of a typical military pilot. The study indicated that the typical military pilot should have emotional control, emotional stability, extrovertedness and high impulse control. Suppressing emotion pertains to perceptual distortions and inability to process information accurately, which leads to human error (Marquardt, Robelski, & Hoeger, 2010). Joseph, Reddy and Sharma (2013) conducted a study on 205 Indian army pilots and found a correlation between human error and emotional awareness to regulate stress, anxiety, impulsivity and low self-confidence.

Realising that knowledge and skills are not enough for safe performance, a review of the available literature conceded that the human factor remains the weak link in the aviation system and human error is the main cause of accidents (Carlson, 2013). Literature supports the researcher's argument that emotional awareness influences safe performance. The researcher asked the question whether emotionally aware aircrew who operate in stressful environments can successfully perform to operational requirements. This study proposes emotional awareness training to teach aircrew members the necessary emotional skills to manage and regulate emotions such as stress and workload so as to reduce human error (Canan, 2014; Ion, 2011).

According to Brown and Moren (2003) a paradigm shift is required and they confirm that safe behaviour is driven by emotions. Maier (2014) conducted a study on ATCs and found that emotional awareness enhanced their reaction and ability to handle stress effectively.

The current researcher proposes that aviation will benefit from human factor training directed at emotional awareness. Aircrew members need skills to regulate emotional barriers with regard to response strategies and flexibility for any circumstance (Luuk, Luuk & Aluoja, 2009; Sanchez, 2012).

Dewe, O'Driscoll and Cooper (2010) note that the level of attention that organisations pay to addressing emotion-related issues is still relatively low when compared to their investments in financial budgeting, marketing and technological development. Hollnagel, (2013) argues that organisations should focus on emotional wellness and create a positive spiral by enhancing aircrew's emotional awareness and resilience, and by encouraging aircrew to speak up and learn from human errors and past experiences.

3.7 MILITARY AIRCREW SELECTION

Proposed selection requirements for aircrew and ATCs include tests for specific emotional constructs such as level-headedness. Additionally, aircrew response should indicate situational awareness, mental alertness, multi-tasking abilities and attention (Mnguni, 2011). As competency in emotional awareness includes emotional regulation strategies, stress management, decision-making and cooperation within a team, this study might be beneficial and contribute to future aircrew recruitment (Drury, Ferguson & Thomas, 2012; Subic-Wrana et al., 2014).

3.8 APPLIED HUMAN FACTOR STUDIES

Aviation Psychology and Applied Human Factor studies contribute towards understanding the human science (ICAO, 2013). Although results from human factor research and literature provide some understanding towards aircrews' safe performance (Ortner & van de Vijver, 2015), advances in technology and applied sciences in human-machine integration are falling behind. Aviation safety is reliant on research, applied human factors and behaviour-based assessment to understand aircrew performance. Continued human factor research in aviation is paramount in an attempt to overcome the human error and environmental threats, and to formulate safe performance indicators as guidelines for effective human factor training.

3.9 CONCLUSION

There is much more to be learned from the synthesis between the human error phenomenon related to emotion in aviation. Literature review and aviation studies leave many questions, which at this stage remain unanswered. Researchers and aviators concede the importance of continuous human factor research related to various factors such as gender, environmental pressures, aircraft type and safe human performance in aviation (BEA, 2016; Karwowski, 2012).

3.10 CHAPTER SUMMARY

Aviation studies and safety reports consistently implicate human error as the primary cause of accidents. If one considers the dire consequences of human error, a zero-human error tolerance should be implied. Literature review and human factor research also indicate that the human condition remains the weak link in the aviation system and the main cause of accidents. Knowledge and skills are not enough to prevent human error. The researcher proposes that emotional awareness as a human factor trait should be included in training to teach aircrew the emotional skills to manage and regulate their emotions and enhance safe performance.

With aviation as background, the researcher conducted literature studies and conceptualised the constructs within the scope of situational awareness and human error related to emotional awareness. Following the research aims, the researcher performed a comparative examination of existing literature and research concepts. Furthermore, the emotional awareness and human error phenomena were conceptualised within the Human Factor paradigm. The relevance of the current study was illustrated and the researcher argued theoretically that emotional awareness can be related to human error.

The following chapter outlines the research design and methodology that were used for this study.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

This study focused on human error in aviation as aviation is one of the most complex man-made systems, leaving “no room for error” (Kern, 2011). Adding to this concern, air traffic is set to double between 2020 and 2025 (Salas & Maurino, 2010). The aviation system is interdependent and it demands a zero-error tolerance margin. A breakdown between any one of the interacting components causes a drift into error and may have dire consequences (Dekker, 2011).

This constant interaction between human and aircraft requires superior performance. In aviation, situational awareness is expressed as a precursor to airmanship and flight safety. Although ill-defined, situational awareness (Reason, 2000) is a colloquial term used worldwide as a foundation safety concept to depict a clear presence of mind, vigilance and alertness (Tehrani & Molesworth, 2016). The researcher concerned herself with this classical safety term, as a multitude of definitions and interpretations made it practically impossible to measure situational awareness (Cooke, 2012; Kern, 2011).

The researcher was interested in measuring emotional awareness influencing performance and human error. Based on the general aim of the current research to explore a relationship between emotional awareness and human error, the practical application of this study aimed to discover a taxonomy of emotional awareness traits. Therefore, the researcher explored, analysed and investigated this construct for a comprehensive understanding and synthesis to apply to future CRM training. The researcher hypothesised that a significant relationship exists between emotional awareness and human error.

4.2 SPECIFIC AIMS OF THE EMPIRICAL STUDY

The general aim of this study was to explore limitations within the applied science of human factors to reduce human error. Aviation concepts were formulated to understand the human factors related to safe behaviour – specifically emotional awareness and human error.

To achieve the general aim of this study, the following specific aims were formulated to guide the empirical study:

- Research aim 5: Operationalise human error measurement in aviation.
- Research aim 6: Operationalise emotional awareness measurement with the Boundary Questionnaire.
- Research aim 7: Operationalise the relationship between emotional awareness and human error in aviation.

4.3 FORMULATION OF THE HYPOTHESES

A hypothesis is a tentative statement about the world that involves a conjecture about relationships that have been predicted but not verified yet. Hypothesis testing is done to determine what is true and what would explain certain observations or phenomena. A hypothesis is an *a priori* statement of expectation that includes who is involved, to what treatment or intervention they will be exposed, the outcome measures to be used, and the comparison group. The research in hand hypothesised a possible relationship between emotional awareness and human error, and explored significant differences between aircrew's emotional awareness and human error related to aviation. The researcher formalised additional hypotheses of relationships between emotional awareness and human error groups, related to aviation experience and mustering.

The empirical study focused on the variables emotional awareness and human error:
Step 1: Emotional awareness - EA (independent variable)

Step 2: Human error - HE (dependent variable)

Step 3: Aviation experience and mustering groups (moderator variables)

Aviation safety research and aircraft accident investigations support the argument raised in this study that human error remains the primary cause of aircraft accidents (Karanikas, 2016). To operationalise the human factor paradigm and contextualise emotional awareness, the researcher formulated the general aim of this study to explore the relationship between emotional awareness and human error. In addition, she extended her study to contribute to the social sciences, aviation psychology and applied human factors. The researcher hypothesised possible significant relationships between emotional awareness, human error and the variables, aviation experience and mustering.

- (H0) There is no significant relationship between emotional awareness and human error.
- (H1) There is a significant relationship between emotional awareness and human error.
- (H2) There is a significant relationship between emotional awareness, human error and experience.
- (H3) There is a significant relationship between emotional awareness, human error and mustering.

4.4 RESEARCH APPROACH

The current research was designed in accordance with the formulised aims articulated in the problem statement. The design was the plan on how to answer the formulated research questions. Msweli (2011) defined the deductive research design approach by asking questions that require the explanation of incidences that can be quantified (e.g. 'how' and 'what' questions). A deductive research design was applicable to this study since the questions were “where,” “how many” and “how much”. The deductive method was the most applicable method to derive answers for a quantitative research approach (Creswell, 2014).

A research design ensures that the evidence obtained enables the researcher to answer the initial question as unambiguously as possible. The researcher considered the design for this study as a logical method to answer the research question in a non-complicated and understandable manner. The research design was viewed as a plan for the research that was constructed to maximise the validity of its findings (Mouton & Marais, 1990). Hofstee (2006) recommended that one should obtain detailed information on all research designs and their applicability before committing to the study. Moreover, a phenomenological research is a design of inquiry rooted in aviation psychology, in which the researcher describes the experiences of individuals regarding a phenomenon as described by participants (Creswell, 2014). The current research was concerned with the aviation context. Theory and empirical research were interwoven and explored the phenomenology of human error related to emotional awareness.

4.4.1 The paradigm perspective

The research approach followed the assumptions of social sciences and explored existing frames of references related to emotional awareness and human error. Guided by existing paradigms, the researcher considered the value of stepping outside existing paradigms, exploring new perspectives, theories and realities within natural science. By describing the phenomenon human error within the context of aviation, the researcher aimed to explain how emotional awareness influences aircrew behaviour and reduces human error.

4.4.2 The positivist perspective

The basic positivist paradigm assumes that the social world is no different from the natural world. What is relevant to this study in the context of aviation, is that the positivist perspective is confronted with the basic question of how the aviation system influences aircrew behaviour. Human factor studies and knowledge from accident observations revealed anomalies within the perspective of the human error theory that are related to aviation safety expectations that are not met. Social research paradigm limitations guided this study to explore human error as it is closely related to perceiving reality objectively (Babbie, 2013).

The positivist model stresses the importance of precise and reproducible measurements. It stems from the belief that research can only improve by gaining knowledge of causes and consequences of behaviour (Loseke, 2013). The positivist approach provided research knowledge regarding aircrew’s emotional awareness and behaviour within the aviation context to contribute to social science and aviation safety (Creswell, 2014; Loseke, 2013).

Adding to the aim of this study, the positivist assumption was selected as a scientific method to conceptualise the need for safe aviation behaviour and to identify and assess the causes that influence outcomes (Babbie, 2013). In the present study, the researcher was interested in exploring the relationship between emotional awareness and human error.

Babbie (2013) explains that knowledge through a positivist lens is obtained from careful observation and measurement of the objective. Positivist research is based on the belief that the scope of the programme evaluation is limited to those aspects of social programmes that can be objectively observed and tested, using a variety of methodologies and procedures. In this study, a non-experimental (quantitative) approach was followed to explore the relationship between the variables emotional awareness and human error (Creswell, 2014).

Positivistic social scientists have erred in their assumptions that human always act rationally. The influence that Human Factor traits have on perceiving reality and human behaviour is underestimated. Human factors such as stress, biases and attitudes often result in non-rational behaviour and human error.

This study questioned the principle of rational behaviour related to human factors and environmental influences within the aviation system. By finding common ground on subjective experiences, scientist agree that emotion influences our perceptions of individual reality, but objective reality is confirmed by social agreement. The present study is based on a collaboration of social sciences that explore aircrew performance and human error within the concept of agreed objective reality (Babbie, 2013).

4.5 THE QUANTITATIVE RESEARCH APPROACH

Babbie (2008) argues that there is no limit to what can be studied. The topic for this research is relevant to all forms of social research, although its implications are clearest in the case of nomothetic, quantitative studies.

When we observe a social phenomenon in a systematic and scientific way, the information gathered is referred to as data. The data is organised in such a way that it can be analysed and interpreted by means of quantitative methods (Antonius, 2003). Creswell (2014) further explains that quantitative research is an approach for testing objective theories by examining the relationship among variables. These variables can be measured with instruments and the numbered data can be analysed using statistical procedures.

Quantitative research also involves the collection of primary data from large numbers of individual units with the intention to project the results to a wider population – for the purposes of this research study, to aviation. The quantitative research approach was used to examine statistically significant differences between emotional awareness and human error variables (Coldwell & Herbst, 2004). The researcher decided to use an exploratory strategy of enquiry (*Documents Analysis and Expert Review*) to establish an understanding of emotional awareness traits that are related to aviation human error.

4.6 RESEARCH VARIABLES

Hopkins (2008) explains that quantitative research aims to determine the relationship between an independent variable and a dependent variable or outcome variable in a population. Every variable should be exhaustive and must be able to classify every observation in terms of one of the attributes composing the variable. Similarly, Babbie

(2008) argues that attributes composing a variable must be mutually exclusive and must be able to classify every observation in terms of that one attribute only.

4.6.1 Independent variable

In the attempt to conceptualise emotional awareness, no single definition could be established; instead, a label for the superordinate categories construed moods, feelings and emotions that influence judgement and behaviour (Kaufmann & Baumann, 2015). Multi-Health Systems (MHS) explains emotional awareness as a primary construct of emotional intelligence (Stein & Book, 2011). Important for this study, MHS defines emotional awareness as the ability to recognise and understand feelings and realise their impact on decision-making and problem-solving abilities. Aircrew need emotional awareness to regulate their thought processes that pass through the emotional centre of the brain and convert important outside information via the senses into responses or behaviour (Stein & Book, 2011).

Research aim 4 conceptualised emotional awareness in relation to aviation human factor studies, namely that aircrew depend on cues from themselves and the environment to perceive the situation accurately (Brown & Moren, 2003). Aviators acknowledge that suppressing emotion limits them from detecting critical environmental changes (Tietz, 2016). The Boundary Questionnaire developed by Dr Ernest Hartmann was used to measure the independent variable, emotional awareness, and to indicate the way different people experience their feelings. Hartmann (Jawer & Micozzi, 2011, p. 20) explains the boundary type of people by stating that “each individual can be characterized on a spectrum of boundaries from thick to thin”. SAAF aircrew members were tested for their individual emotional awareness boundary types.

4.6.2 Dependent variable

The dependent variable was human error in the military aviation environment, and it was categorised according to severity in terms of hazards, incidents and accidents (Yantiss, 2011). The SAAF regulates compulsory incidents and accidents reporting within a just culture based on the aviation safety policy (SACAA, 2016). This safety philosophy makes provision for open reporting and is a relatively true reflection of human error incidences recorded over the past ten years. The human error reporting classifications were coded for no recorded human error, hazards, incidents and accidents (Yantiss, 2011).

4.6.3 Moderator variables

Guided by Department of Defence Human Resource policy regarding aircrew recruiting and training, the researcher expected some influence from moderator variables. For the purposes of this research, the following moderator variables were explored as they were expected to influence the relationship between emotional awareness and human error; aviation experience and mustering groups (Creswell, 2014; Gibbon, 2014b).

4.7 EXPLORATORY STUDIES

Babbie (2013) argues that social research is the systematic and empirical exploration of human social life. Additionally, Loseke (2013) states that social research is detective work to explore the mysteries of social life. Loseke adds that researchers employ exploratory research when little is known about a specific topic and previous theories or ideas are not applicable. The researcher was interested in a relationship between emotional awareness and human error within the science of applied human factors. The exploratory study clarified the research problem and gathered information that was used to formulate the research questions.

Investigating human factors in aviation is relatively new and has only been done over the past two decades. Exploratory studies are valuable in social science and they are used mostly for three purposes: (1) to satisfy the researcher’s curiosity; (2) to test the feasibility of a more extensive study; and to (3) develop and employ methods for the study (Babbie, 2013). The purpose of this research was to explore the field of the applied human factor sciences to obtain a better understanding of human errors related to emotional awareness.

4.8 RESEARCH METHOD

Literature studies guided this research to explore aircrew performance and their perceived reality in relation to emotional awareness. A non-experimental quantitative research design was followed and a possible relationship was examined between the independent variable emotional awareness (measured with Hartmann's Boundary Questionnaire) and existing pre-recorded human error data. The researcher obtained quantitative human error data that had been recorded over a ten-year period. Variables were conceptualised to specify the exact meaning of each emotional awareness and human error concept. Measurement indicators were described to measure specific behaviour characteristics of the emotional awareness concept related to human error. The independent variable (emotional awareness) was conceptualised in the literature review in Chapter 2, and operationalised with the Boundary Questionnaire (Zborowski, Hartmann, Newsom & Banar, 2003). The Boundary Questionnaire was administered to 173 aircrew members to measure emotional awareness sub-constructs, and to operationalise and explore the relationship with human error in aviation (Creswell, 2014).

4.9 AIRCREW SAMPLE

Babbie (2008) states that units of analysis are the phenomena examined to describe such units and explain their differences. There are two different units of analysis involved, namely individuals or collectives (Antonius, 2003). The unit of analysis refers to the "what" of the study, in other words, what object, phenomenon, entity or process the researcher was interested in investigating. In this study, the unit of analysis was aircrew, which collectively refers to pilots, navigators and air traffic controllers (ATCs).

Cluster sampling used to be the preferred method to study similar flying groups (mustering) individually at a given time (Verhoeven, 2011). Probability or representative samples were collected because the researcher was interested in inferential statistics to discuss the characteristics of aircrew based on the specific aims (Loseke, 2013). In this study, all aircrew members had an equal opportunity to participate in the study, pending their individual availability on the day the questionnaire was administered. Central to the positivist-informed research, statistical generalisation from the aircrew sample can be related to the general aviation population, as the study aimed to explore the general human factor laws of aircrew behaviour and human error in aviation (Loseke, 2013).

A stratified random sample was selected according to SAAF mustering groups in such a way that every aircrew member had an equal chance of being included; therefore, this study's sample presents a miniature aviation population (Anderson, Sweeney & Williams, 2015; Loseke, 2013) consisting of combat pilots, fixed-wing pilots, helicopter pilots, navigators and ATCs – referred to as aircrew mustering.

A cross-sectional study involves the observation of a sample of a population (aircrew) or phenomenon (emotional awareness) at one point in time, such as the Boundary Questionnaire survey. Relevant to this study, exploratory studies are often cross-sectional (Babbie, 2013). Research suggests that the overall matching process could be most efficiently achieved through the creation of a quota matrix constructed of all the most relevant characteristics, as was performed with the selected Boundary Questionnaire categories applicable to aircrew. This research focused on the emotional awareness traits related to human error.

4.10 MEASURING INSTRUMENT FOR EMOTIONAL AWARENESS

A survey design provides a quantitative description of human error trends and aircrew emotional awareness attitudes. For this study, the Hartmann Boundary Questionnaire results of the aircrew participants were captured, analysed, inferred and generalised to the aviation population (Creswell, 2014). The researcher selected a questionnaire, as it is one of the most widely used methods for non-experimental research designs across disciplines to collect large amounts of survey data from a representative sample. Additionally, a questionnaire is considered one of the most important research designs, and survey instruments are frequently used to collect data (Kalaian & Kasim, 2012).

Furthermore, a survey involves asking many people the same questions (Antonius, 2003). Important for this study, the survey provided a quantitative description of trends, attitudes or opinions of aircrew by studying a sample. The present study used the Hartmann Boundary Questionnaire with the intent of generalising findings from this aircrew sample to the larger aviation population (Wadsworth, 2011).

4.11 THE EMOTIONAL BOUNDARY QUESTIONNAIRE

The Boundary Questionnaire measures emotional awareness boundaries and refer to degree of separateness or connection between mental functions and processes. High emotional awareness is associated with open mindedness, creativity, and imagination versus reality, high emotional boundary people have fluid sense of identity and tend to merge or lose themselves in relation to others. Aircrew with low emotional awareness differentiate clearly between reality and imagination and self and others and tend to prefer well defined structures (Hartmann, 1991).

The Boundary Questionnaire was used as the emotional awareness measuring instrument. Jawer and Micozzi (2011) explains the applicability of the Boundary Questionnaire by arguing that ‘thick’ boundary people are less conversant with feelings and most often maintain a calm demeanor while avoiding, denying or distancing themselves from strong feelings. The authors describe emotions as feelings that flow like water in continuous motion. Describing that with people whose boundaries are thin, the flow is quicker and more direct, resulting in better emotional awareness and a sense of reality.

Since the researcher was interested in applying emotional awareness to safe behaviour in aviation, she recognised the expression by Beck (1996) that emotional awareness enhances our observation, perception and understanding of the environment. Supporting his argument, thick emotional awareness boundary people commonly brush aside emotional upset in favour of coping with a situation and maintaining a calm demeanour.

The researcher argues that aircrew members practise similar strategies to avoid, suppress and deny strong feelings so as to cope in the aviation environment.

Applicable to the scope of this study for the military environment, Hartmann selected naval officers to design the Boundary Questionnaire, with the prediction that they would be low on emotional awareness. Hartmann reasoned that officers' mental structures would be compatible with the hierarchical-structured social organisation of the military and with the exact, precise and unambiguous style of its operation procedures. Against this military and operational background, the researcher decided to use the Boundary Questionnaire as a valid instrument (Harrison, Hartmann & Bevis, 2008).

During the literature review phase, the researcher examined the application of the Boundary Questionnaire, as it correlates ego boundary thickness related to the emotional awareness constructs applicable to the military environment. The psychometric validity of the Boundary Questionnaire was investigated, as well as whether the scale could differentiate between aircrew in a consistent manner. Internal consistency of the overall Boundary Questionnaire, as well as of the world and personal total sub-scores, was demonstrated. The results are discussed in the context of emotional awareness boundary development. Studies found the "Big Five" taxonomy applicable to measure aircrew behaviour and for aircrew selection, regardless of mustering (Fitzgibbons, Schutte & Davis, 2004). Measuring emotional awareness sub-constructs related to the scope and aviation background of this study, the 70 tabulated items of the Boundary Questionnaire were administered to the aircrew (see Table 4.1).

Table 4.1 Emotional awareness categories (70 items) in the Boundary Questionnaire

Category	Description
Category 1 (14 items)	Boundaries related to sleep and waking
Category 3 (16 items)	Boundaries related to thoughts, feelings and moods, e.g. merging of thinking and feeling
Category 5 (12 items)	Interpersonal boundaries
Category 7 (11 items)	Neatness, exactness, precision
Category 8 (17 items)	Boundary preferences (e.g. structured or unstructured)

Source: Jawer & Micozzi (2011)

The literature review, behavioural models and EQi-20 guided the researcher towards specific Boundary Questionnaire categories applicable to performance in aviation. Considering expert opinions, the researcher pre-select data from five emotional awareness categories (see Table 4.1). As the focus of this study was aircrew emotional awareness related to human error, the tabulated Hartmann Boundary Questionnaire categories were operationalised.

4.11.1 Reliability of the Boundary Questionnaire

Reliability is described as involving the consistency of measurements. Additionally, reliability refers to the dependability of the measurement instrument or the extent to which the instrument yields the same results on repeated ocasions (Durrheim, 2006; Babbie, 2005). Msweli (2011) argues that reliability of measure can be assessed in a test and re-test, or to compare scores of a test administered to a single group to determine whether they measure the same construct or trait. However, reliability does not ensure accuracy any more than it does precision (Babbie, 2013). The researcher realised the effect of a possible bias to make the research findings look good. She was however guided by ethical procedures to counter any influence or bias. Reliability is related to the number of items and the strength of correlations between them (Anderson et al., 2015). The researcher considered the concept of reliability (Riley, Wood, Clark, Wilkie & Szivas; 2007), as more items increase the scope for error. Hence, scores were calculated for only five selected constructs (70 items) that were found reliable. Since random errors occur during research, reliability of the results is an indication of how free the research was from random errors. To test reliability, the research was considered replicable if it led to similar results (Verhoeven, 2011).

As internal consistency is the purest form of reliability, reliability analysis was performed on the selected Boundary Questionnaire constructs with initial data by using Cronbach Alpha coefficients to assess the internal consistency (Anderson et al., 2015). Cronbach's alpha was calculated for each of the scores used as part of the reliability test (Table 4.2). The Cronbach Alpha value for Boundary Questionnaire reliability was interpreted as follows:

Table 4.2 Cronbach Alpha values for Boundary Questionnaire reliability

BQ Constructs	Cronbach	Reliability
Cat 1	.749	Acceptable
Cat 3	.729	Acceptable
Cat 5	.731	Acceptable
Cat 7	.754	Acceptable
Cat 8	.703	Acceptable

4.11.2 Validity of the Boundary Questionnaire

Validity refers to the extent to which an empirical measure adequately reflects the real meaning (Babbie, 2005). Validity for this quantitative research was concerned with establishing how good the pre-selected 70 Boundary Questionnaire items measured emotional awareness. Msweli (2011) names five forms of validity, namely construct validity, predicative validity, content validity, internal validity and external validity. Conceptualisation, operationalisation and checking validity are related tasks in the positivist tradition (Durrheim, 2006). Using an existing instrument such as the Boundary Questionnaire, the researcher explored information about the construct validity and reliability of the instrument (see Table 4.1). Internal validity was conceptualised as a classical form of logical argument called the syllogism. To test construct validity within the Boundary Questionnaire, factor analysis was performed to reduce the number of variables within the scope of work.

In the context of aviation, external validity was confirmed as findings and conclusions could be generalised beyond the confines of the design and the military setting (Durrheim, 2006).

The literature review established a theoretical justification for the comparison of content and face validity (Msweli, 2011). Furthermore, the "Big Five" taxonomy justified the selected Boundary Questionnaire items applicable to aircrew and human error (Fitzgibbons et al., 2004). The researcher believes findings produced by the design can be sustained as they indicate a relationship between emotional awareness and human error in aviation. To test validity of the constructs in the Boundary Questionnaire, factor analysis was performed to confirm content and construct validity and reduce the number of variables.

4.12 FACTOR ANALYSIS

Factor analysis is commonly used in the behavioural sciences to discover the underlying dimensions of a variable. Factor analysis is the preferred technique to mathematically reduce a large data set to smaller clusters of variables.

4.12.1 Exploratory factor analysis

Exploratory factor analysis explains the variation and co-variation in the data set. The literature review and previous Boundary Questionnaire studies indicated the following factor analysis:

I: primary process thinking (blurry boundaries in the mind);

II: a preference for explicit boundaries;

III: identification with children;

IV: fragility;

V: percipience/clairvoyance;

VI: trustful openness;

VII: organised planfulness;

VIII: belief in inpenetrable intergroup boundaries (no mixing between demographic groups);

IX: flexibility;

X: overinvolvement in fantasy;

XI: preference for simple geometric forms;

XII: isolation of affect (thinking and feeling kept strictly separate); and

a final factor with no particular theme.

Hartmann speculates that the concept of boundaries relates to Eysenck's P (measured by the EPQ-R).

4.12.2 Factor analysis steps

Although factor analysis is not alchemy, meaningful research provides meaningful results. The researcher performed factor analyses by following these steps (Field, 2013):

Step 1: Calculate the maximum amount of common variance matrix from the data set.

Step 2: Compute a factor correlation matrix.

Step 3: Extract eigenvalues from the factor correlation matrix.

Step 4: Obtain eigenvalues from each eigenvector based on the characteristics equation.

Step 5: Generate the factor loadings by normalising the eigenvectors.

Step 6: Determine the amount of variance that was not accounted for in each variable.

Step 7: Perform factor extraction, Kaiser criterion and parallel analysis.

Step 8: Create the final matrix of factor loadings (F) from the factors extracted by using principal factor extraction and maximum likelihood with oblique direct oblimin factor rotation.

Step 9: Name the extracted emotional awareness factors. The factor loadings were used as the basis for imputing labels to the explanatory dimensions of the emotional awareness sub-constructs.

4.13 VALIDATION OF THE BOUNDARY QUESTIONNAIRE

The literature review confirmed the Boundary Questionnaire as a valid and reliable instrument in the field of psychology for measuring emotional awareness constructs. Considering the statement of Jawer and Micozzi (2011), the scales of the Boundary Questionnaire are culturally non-specific and can be used effectively for cross-cultural measurement; therefore, it is acceptable for research in South Africa and suitable for this study. It is important to note that although the Boundary Questionnaire is based on a solid theoretical and academic foundation and used in research worldwide, the researcher could not find evidence that it had been administered in South Africa before.

4.14 RESEARCH PROCEDURE

The Boundary Questionnaire survey data was obtained over a two-year period during annual Crew Resource Management (CRM) training courses. All aircrew who agreed to this study had equal opportunity to participate in this research. The survey was adminstered at 8am each morning and took approximately 40 minutes to complete in a quiet environment (a conference hall setting). The researcher personally supervised the participants during this time and was available to answer any questions.

4.15 DATA COLLECTION

Data collection entails obtaining the data in accordance with the research design (Creswell, 2014). The paper-based, self-completion survey consisted of 70 questions pre-selected for this study. This study was a non-experimental quantitative study aimed at establishing the causality between the two variables emotional awareness and human error. Babbie (2008) explains the effects of an independent variable on a dependent variable by taking the form of an experimental stimulus, which is either present or absent. The survey methodology measured emotional awareness by asking aircrew questions and examining the relationships among them (Coldwell & Herbst, 2004).

4.15.1 Rating Scales for Emotional Awareness

The Likert scale is used to measure attitudes towards a coherent whole (Coldwell & Herbst, 2004). In this case, the Likert scale was used to measure positive-negative tendency towards unipolar scales for 70 emotional awareness items. Aircrew had to choose between five positive and negative modes. The questionnaire measured five scales, and each item was judged with numerical data ranging from one to five ((1) denoting "strongly disagree" and (5) denoting "strongly agree"). Five degrees of relative attitudes were rated as per the following five unipolar Likert scale ratings:

5 = Strongly agree
4 = Agree
3 = Uncertain
2 = Disagree
1 = Strongly disagree

Aircrew responses illustrated valid dimensions that conveyed the direction of aircrew attitudes towards the 70 emotional awareness items. Parametric tests require a normal distribution of variable scores employed for continuous (interval and ratio) data scores, also described as continuous (Allen et al., 2009). If data distributions are skewed, non-parametric tests will be employed.

4.15.2 Rating Scales for Human Error Data

Human error data was categorically coded per numerical values ranked as ordinal data rating scales on four different human error category values according to the severity of the incident (Stolzer, Halford & Goglia 2011):

0 = (zero human error data recorded, HE0)
1 = (human error, hazards recorded, HE1)
2 = (human error, incident recorded, HE2)
3 = (human error, accident recorded, HE3).

Human error incidences were ranked according to severity (0 – 3).

4.16 DATA ANALYSIS

The data files were prepared on an Excel spreadsheet (hard copy data) before converting the scores to the statistical programme for the social sciences (SPSS) format. SPSS (2016) was used to enter and analyse the data. The statistical processing of the data was presented in terms of quantitative methods (Pallant, 2007). Each response was assigned a numerical code and tabulated for research analysis.

4.16.1 Statistical Inference

Socio-behavioural scientists are interested in determining whether the relationships found in data can be inferred as applying in general to the population from which the sample was drawn (Babbie, 2013). In this study, the population refers to the values of the variables rather than to the individual. The sample is considered a subset of the data values. To establish a possible relationship in the sample, the researcher calculated the probability of a statistically significant relationship between human error and emotional awareness sub-scales (Cramer, 2003).

4.16.2 Biographical Questionnaire

Aircrew information related to name, age, gender, mustering, years of aviation experience and human error incidents were gathered using the biographical questionnaire, after which the data was coded for the SPSS (2016) in a data file (Antonius, 2003; Gibbon, 2014b) (mustering data and years' aviation experience in the SAAF according to groups, more than ten years and less than ten years). Aircrew mustering refers to combat, helicopter, fix-wing, navigator or ATC. Coding and scoring of the Boundary Questionnaire was done according to the accepted procedures. In addition, the data was screened and cleaned of any errors and missing information and the variables were verified. Five questionnaires that were without any demographic information data were discarded, since these unidentifiable surveys had no value for this specific research related to human error. The researcher defined the variables, and provided variables with value labels.

4.17 METHODS TO ENSURE ETHICAL RESEARCH PRINCIPLES

Hofstee (2011) suggests naming all the potential ethical problems in advance and obtaining formal approval to conduct the study. The present study was conducted based on three ethical principles, namely (Durrheim & Wassenaar, 2002; Msweli, 2011)

- respect the autonomy of all individuals participating in the research;
- no maleficence, in other words not harming any person who is part of the research in any way; and
- beneficence, to contribute to science.

The researcher contacted Jawer and Micozzi by e-mail to obtain consent for this research and to confirm its validity and reliability in the aviation context. Approval from Dr Hartmann to use the Boundary Questionnaire was also obtained. Ethical clearance was obtained from the researcher's educational institution, UNISA, prior to the research. UNISA procedures to secure sensitive and confidential information were also confirmed and discussed with the supervisors. Furthermore, since this study took place within the parameters of the SAAF, approval was obtained from the Chief of the Air Force and the Chief Director Force Preparation.

Considering Hofstee's (2011) argument that there is potential for harm in research, all reasonable attempts were made to counteract it. The researcher complied with all ethical requirements and considered ethical procedures during the study. Additionally, she identified and considered all possible ethical threats, such as privacy, storage of data and subjectivity (Creswell, 2014).

Prior to the administration of the Boundary Questionnaire, the researcher explained the aim and ethics of the study to participants, and a consent form was completed voluntarily by all aircrew prior to the test (Durrheim & Wassenaar, 2002). The researcher provided a briefing regarding the nature and aim of the research study and the Boundary Questionnaire test, after which aircrew could decide to participate or not. The strict confidentiality and security of all research data were guaranteed and the findings of the study were reported in accordance with ethical guidelines (Msweli, 2011). The researcher prepared feedback to aircrew, considering Pope's (1992) statement that effective and constructive feedback to participants is a challenging skill to master. Feedback of the results was provided only on request during a one-to-one discussion.

4.18 RESEARCH METHOD

To test the different hypotheses, the small sample size and probability distribution might require the data to be visually presented by scatterplots following non-parametric techniques to test for differences between groups. The descriptive variables provided statistics such as the mean, median and standard deviation (Pallant, 2007). To limit the effect of outliers, non-parametric tests require ranks rather than the actual data to explore possible relationships between aviation experience, mustering groups, emotional awareness and human error (Vermeulen & Mitchell, 2007).

4.19 CONCLUSION

This chapter described the research approach, research design and quantitative methodology followed. Non-parametric data analysis methods and methods for factor analysis were also discussed. Chapter 5 will report results and discuss empirical testing, aircrew descriptive statistics and results obtained from quantitative data.

CHAPTER 5: RESEARCH RESULTS

5.1 DATA DESCRIPTION

Descriptive statistics were calculated to describe the samples and participants' responses on the individual item scales of the emotional awareness dimensions. Data files were prepared on an Excel spreadsheet from the original hard copy surveys before converting them to SPSS format. The statistical processing of the data was presented in terms of quantitative methods (Pallant, 2007), and the reverse coding and scoring of the Boundary Questionnaire were done programmatically. Data was screened and cleaned of any errors and all missing information in the variables was verified. Incomplete questionnaire answer sheets were disregarded. Likert response scales were coded for the SPSS as a numerical representation of variables. This data was subsequently processed.

5.2 DISTRIBUTION OF DATA

Descriptive statistics, correlation and inferential statistics were calculated for all scores of the independent variable, emotional awareness, and the dependent variable, human error. Gender was coded as a numerical representation of variables for 173 aircrew members.

5.2.1 Gender distribution

As females made up only 9% (see Table 5.1) of the aircrew sample, gender was not analysed further. This finding is however a reflection of the traditional male dominance in the field of aviation.

Table 5.1 Sample distribution of aircrew in terms of gender

Gender	Frequency	%
Female	14	9
Male	159	91
Total	173	100

Although not the focus of this study, respondents assigned themselves to one of four ethnicity categories, namely African (25.43%), coloured (8%), white (63%) or Indian (3.47%). Because of the skew distribution of the aircrew sample as presented in Table 5.2 no further analysis was undertaken.

Table 5.2 Sample distribution of aircrew in terms of ethnicity

Race	Frequency	%
African	44	25.0
Coloured	14	8.0
Indian	6	3.0
White	109	63.0
Total	173	100.0

5.2.2 Aircrew in terms of mustering

Respondents assigned themselves to one of the following four mustering categories: ATC, combat pilot, fixed-wing pilot and helicopter pilot. The sample consisted of 23 combat pilots, 63 fixed-wing pilots, 61 helicopter pilots, seven navigators, and 13 ATCs (see Table 5.3). The mustering of the aircrew sample is presented in Figure 5.1.

Table 5.3 Sample distribution of aircrew in terms of mustering

	Mustering	Frequency	%
	Helicopter pilots	61	35.26
	Fixed-wing pilots	63	36.42
	Combat pilots	23	13.29
	Air Traffic Controllers	13	7.51
	Technicians	6	3.47
	Navigators	7	4.05
Total		173	100

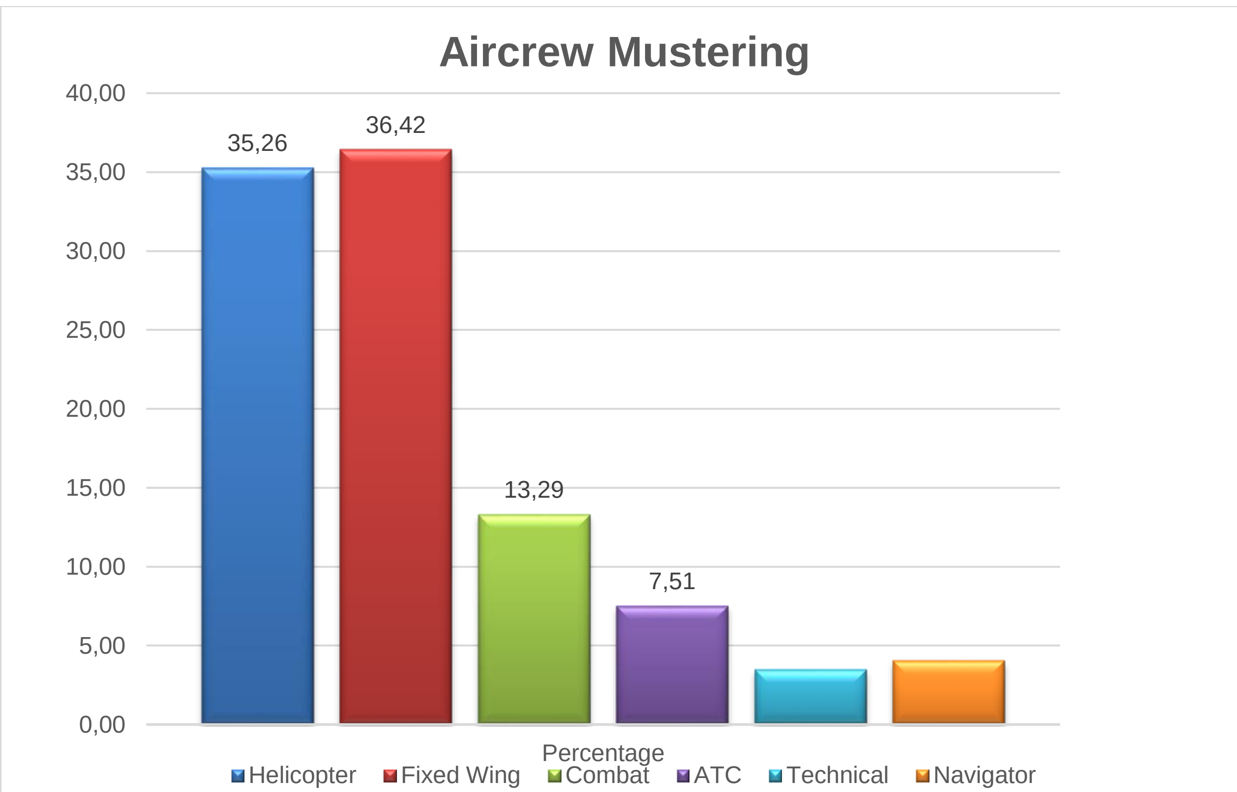


Figure 5.1 Percentage distribution in terms of aircrew mustering

As the technical and navigator component is very small (less than 5%), these will not be used as separate groups in further analysis.

5.2.3 Aircrew in terms of age

The aircrew assigned themselves to one of the following four age categories - between 20-30, 31-40, 41-50, or 51-60 years. The two largest age category groups were 20-30 (37.57%) and 31-40 (46.82%). The age distribution of the sample is presented in Figure 5.2.

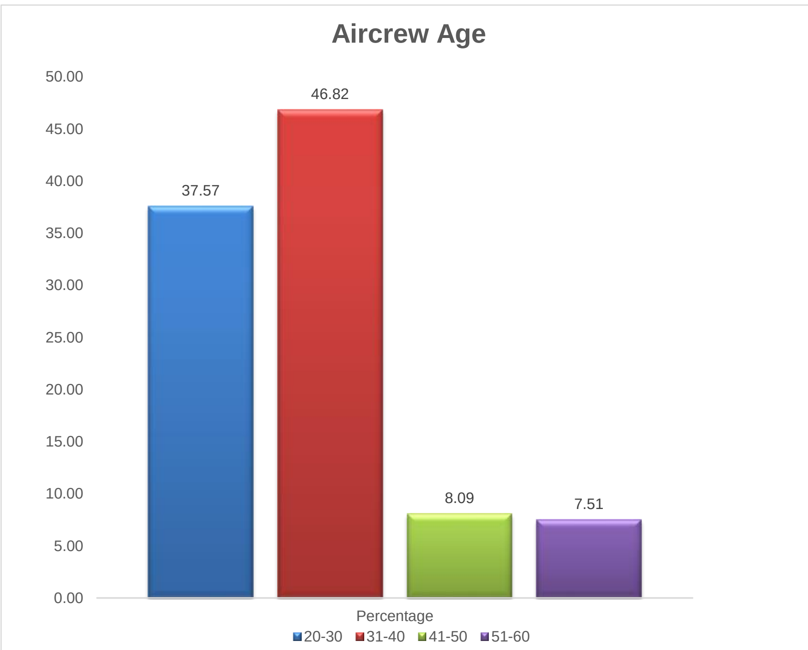


Figure 5.2 Percentage distribution in terms of aircrew age

5.2.4 Aircrew in terms of aviation experience

The respondents assigned themselves to either of two aviation experience groups: (1) less than ten years' experience or (2) more than ten years' experience. This resulted in two groups of approximately 50% each (see Figure 5.3).

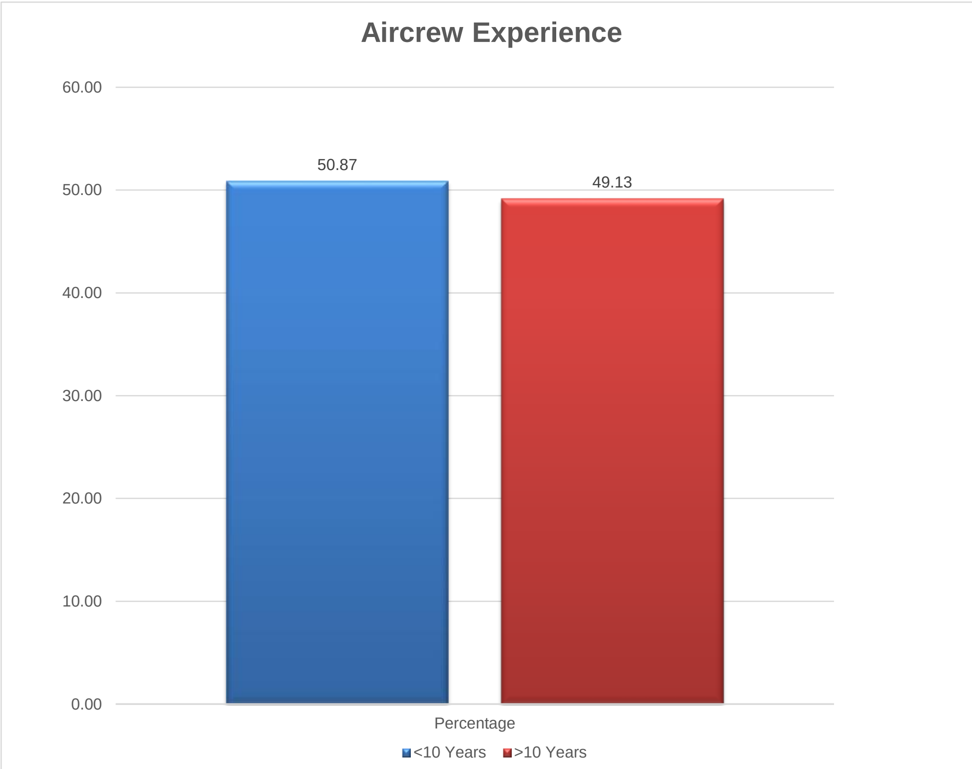


Figure 5.3 Percentage distribution in terms of aircrew experience

5.3 VARIABLES FOR THIS STUDY

The researcher recorded human error data that had been captured over the period 2005 to 2015 and categorised and analysed this date according to severity (Yantiss, 2011).

5.3.1 Dependent variable: Human error (HE)

Human error data was categorised into numerical values according to severity:

0 = (no human error data recorded, HE0)

1 = (HE, hazards recorded, HE1)

2 = (HE, incident recorded, HE2)

3 = (HE, accident recorded, HE3)

Table 5.4 indicates the percentage human error incidences, HE0+HE1+HE2+HE3, for the total aircrew (N = 173). The results were as follows: Zero error recorded or *HE0* group was the largest group (65%), followed by *Accident* (HE3) recorded (21.4%). The remaining two groups, *Hazards* (HE1) recorded (5.2%) and *Incident* (HE2) recorded (8.7%) each represented less than ten percent. The human error incident classification is presented in Figure 5.4. The human error dataset indicates a negative leptokurtic distribution as well as a negative kurtosis with a value of +1.143. This distribution could perhaps be attributed to aircrew not reporting occurrences so as to avoid embarrassment, or for fear of consequences. The present study is grounded in the assumption that aircrew do not volunteer to admit human error and that they do not formally submit hazard and incident reports according to risk management procedures. Therefore, the HE1 and HE2 data values for the period 2005 to 2015 are probably inadequate and do not include all human error incidences – which is a clear limitation of this study. Owing to the magnitude of an aircraft accident (HE3), accidents are reported immediately; therefore, accident data values in this study are considered accurate and reliable.

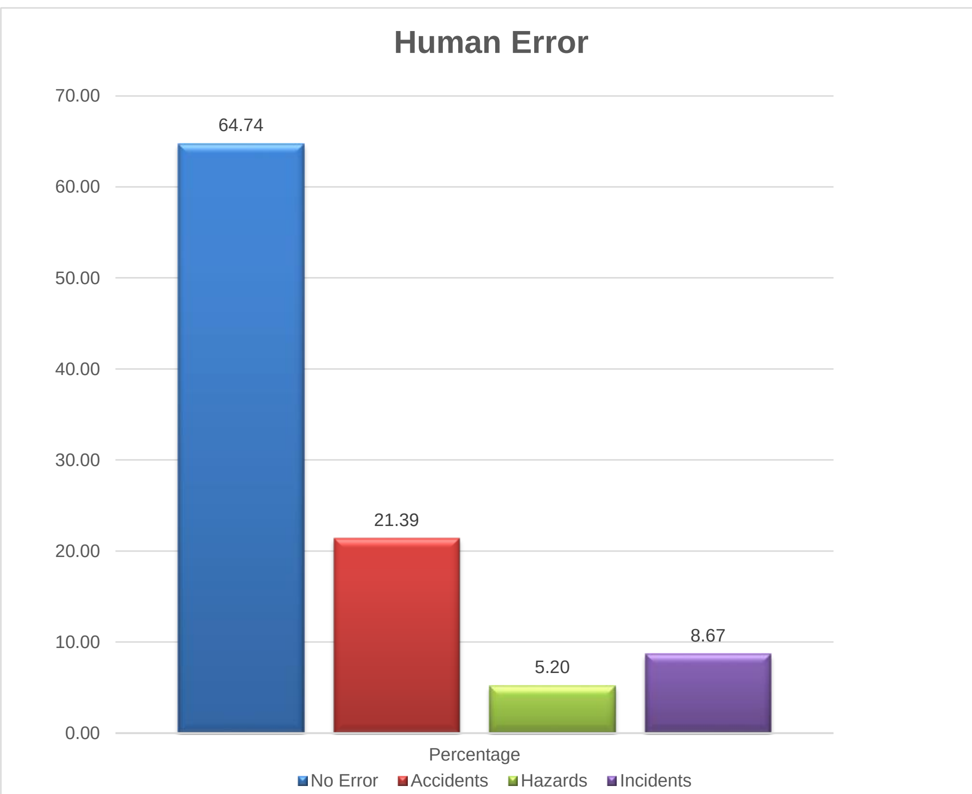


Figure 5.4 Percentage distribution of aircrew human error

Table 5.4 Distribution for aviation human error

	HE	Frequency	%
	0 HE	112	65
	1 Hazards	9	5.2
	2 Incident	15	8.67
	3 Accident	37	21.39
Total		173	100

This study aimed to explore the relationship between emotional awareness and human error, because human factor studies that relate to aviation accident reports indicate that more than 90% of all accidents can be attributed to human error (ICAO, 2002). Human error data such as the above therefore propelled this research to explore the relationship between aviation human error and emotional awareness (Msweli, 2011).

5.3.2 Independent variable: Emotional awareness (EA)

While conceptualising emotional awareness influences on all three taxonomy levels – cognitive space, information processing and decision making (Brown & Moren, 2003) – the researcher hypothesised a relationship between emotional awareness and human error.

5.4 RESPONSE FREQUENCIES FOR CATEGORIES

Based on the literature, the researcher selected five Boundary Questionnaire categories to test this study's hypothesis (H0) and to determine whether there is a significant relationship between emotional awareness and human error. Due to the scope of this study and the limited sample size, only the following five categories were selected for analysis: degrees of differences between sleeping and waking; thoughts and feelings;

interpersonal boundaries; neatness, exactness and precision; edges, lines and clothing (Jawer & Micozzi, 2011).

5.4.1 Boundary Questionnaire Category 1: Sleeping, waking and dreaming

Category 1 of the Boundary Questionnaire measures degrees of different perceptions and awareness. An emotionally ‘unaware’ aircrew member does not experience synesthesia and is absolutely clear about when s/he is awake, asleep or dreaming; s/he experiences no in-between states. In contrast, aircrew who are extremely emotionally aware may become deeply immersed in daydreaming and imagination so that the boundary between real life and fantasy may become unclear (Hartmann, Harrison & Zborowski, 2001). Figure 5.5 indicates the distribution of aircrew responses in percentages for Category 1 of the Boundary Questionnaire.

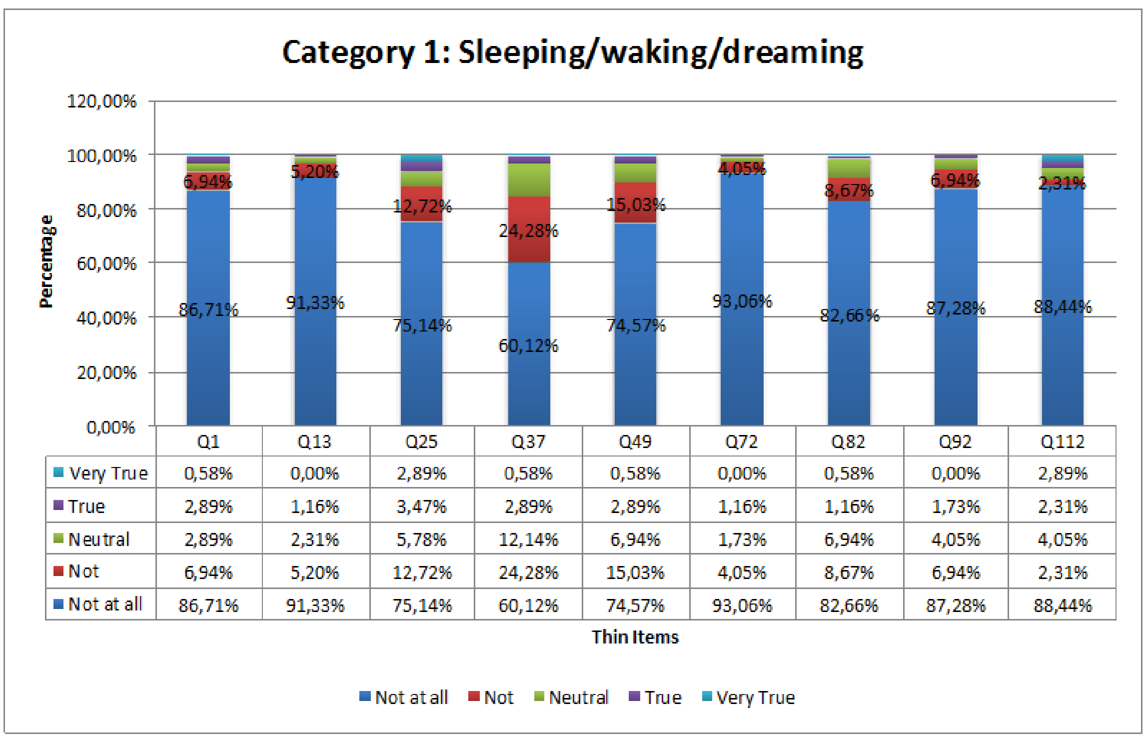


Figure 5.5 Percentage distribution for items: sleeping and waking

Figure 5.6 illustrates the distribution of responses by aircrew for inverse items in Category 1, which represent degrees of difference between sleeping, waking and emotional awareness.

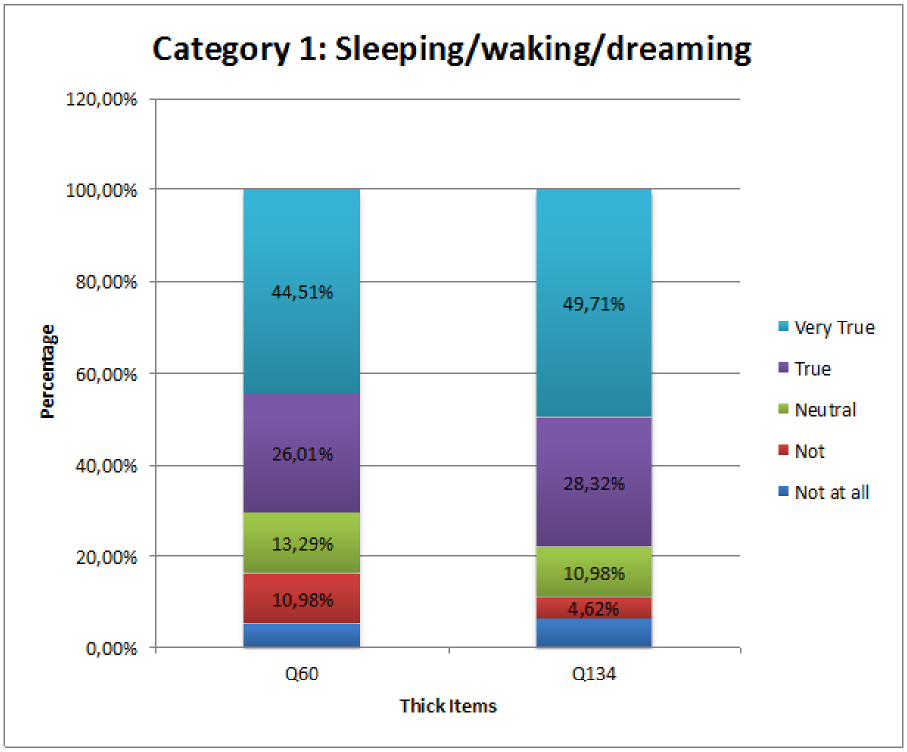


Figure 5.6 Percentage distribution for inverse items: sleeping, waking and dreaming

5.4.2 Boundary Questionnaire Category 3: Thoughts and feelings

Aircrew who keep thought and feelings separated have a sharp sense of focus in all senses at a given time and can focus on one thing while ignoring others ("I don't let my feelings get in the way of my thinking"); they have a clear sense of the separation of past, present and future ("that was then, this is now"), and have a very definite sense of personal space ("this is my space, this is yours"). Figure 5.7 shows the distribution of aircrew percentages for Category 3 items measuring degrees of difference in "thought and feelings".

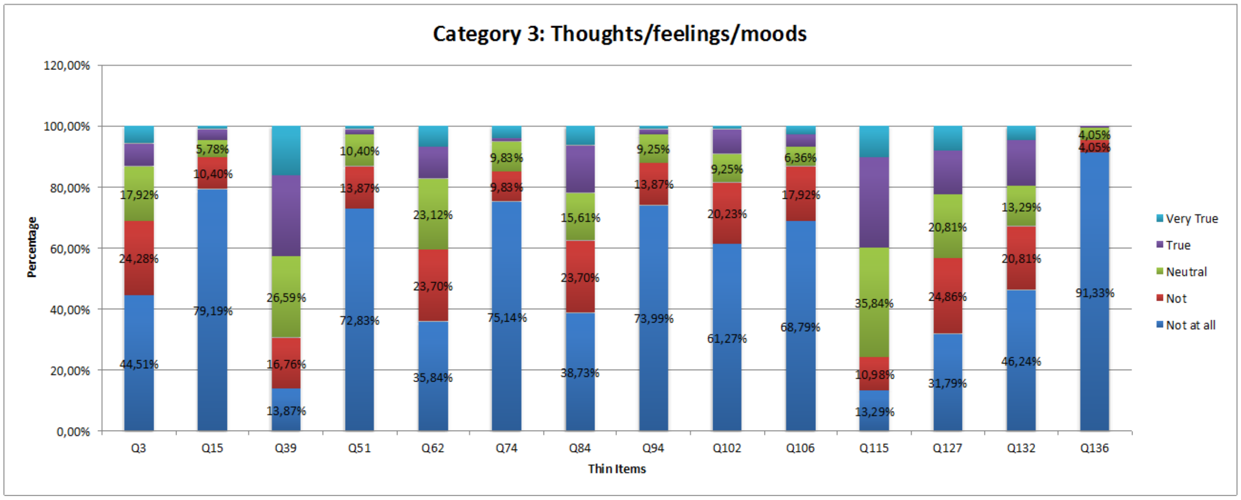


Figure 5.7 Percentage distribution for items: thoughts, feelings and moods

On the other hand, Figure 5.8 indicates the responses of aircrew for Category 3 lexical descriptors for the inverse items that measure the degrees of difference for thought and feeling preferences.

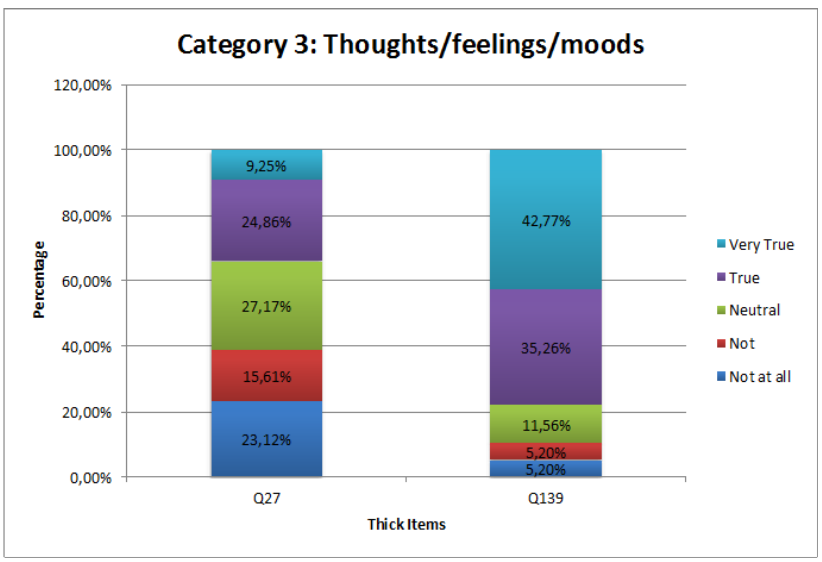


Figure 5.8 Percentage distribution for inverse items: thoughts, feelings and moods

5.4.3 Boundary Questionnaire Category 5: Interpersonal

Interpersonal boundaries of the mind refer to a personality trait that concerns the degree of separateness ("thickness") or connection ("thinness") between cognitive processes and identity (Zborowski, Hartmann, Newsom & Banar, 2003). Aircrew with extremely low emotional awareness have a sharp sense of focus and can easily concentrate on one thing while ignoring others. They have a definite sense of space around them. Figure 5.8 illustrates the Category 5 distribution of aircrew percentages for items that measure degrees of difference for the "interpersonal" preferences of aircrew members.

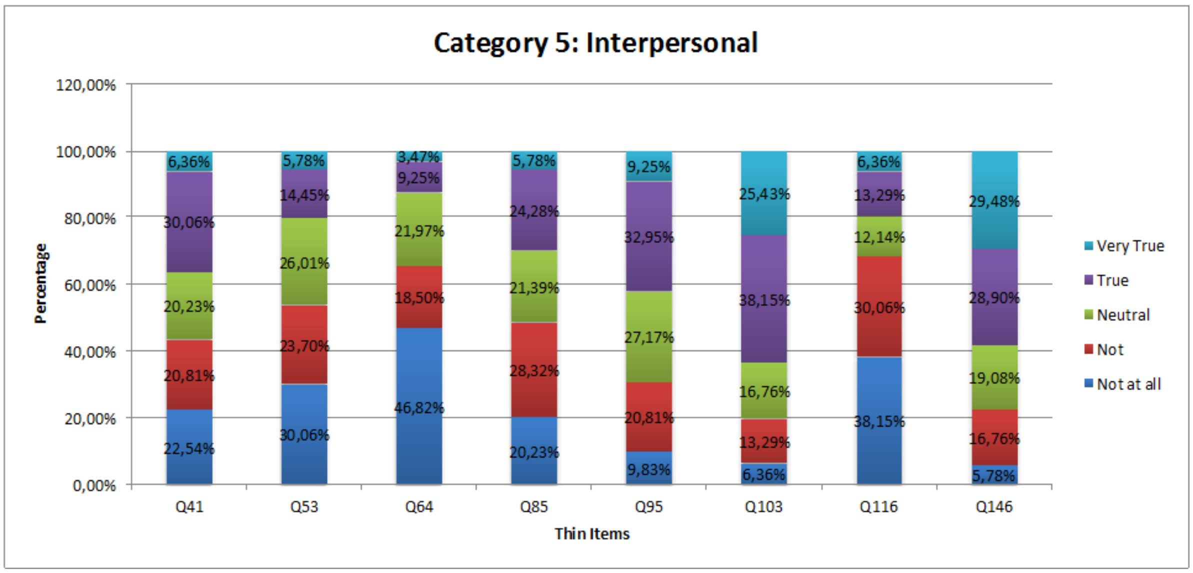


Figure 5.9 Percentage distribution for items: interpersonal

Figure 5.9 shows the distribution of aircrew percentages for Category 5 inverse items that measure differences in "interpersonal" states. Similarly, a group of naval officers were found to score relatively low on emotional awareness and their results correlated with "defensiveness" traits (Hartmann, 2006).

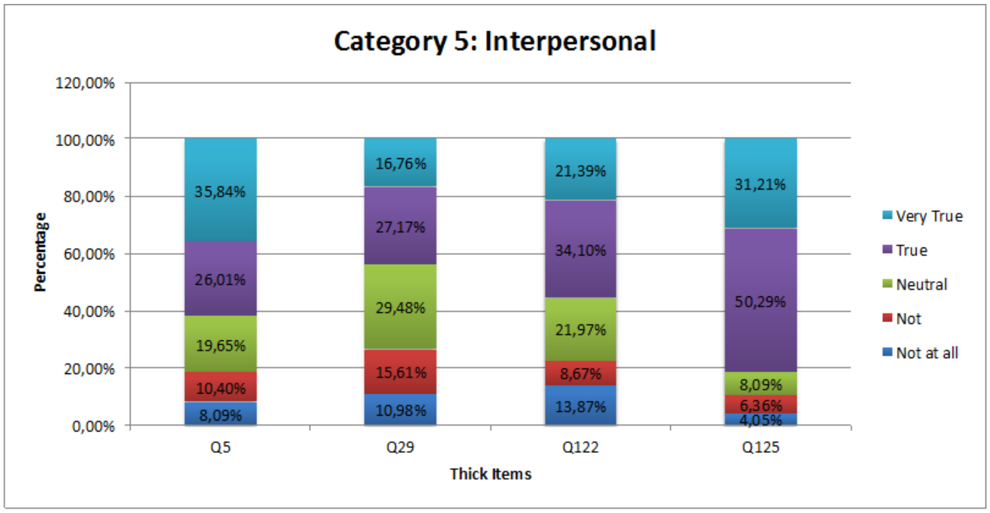


Figure 5.10 Percentage distribution for inverse items: interpersonal

5.4.4 Boundary Questionnaire Category 7: Neatness, exactness and precision

The term ‘precision’ was introduced for 'virtual' realities (applicable to space and time), whereas the term ‘exactness’ was proposed for 'social' realities or realities by consensus (Sell, 2000). Moreover, flying is a sensory task and involves accuracy in perception as well as judgment in dealing with the environment and a multitude of inputs (Salas & Maurino, 2010). To reduce human error, aviation studies relate emotional awareness to degrees of difference with responses for “accuracy, exactness and precision”, thereby limiting the chances of different concepts becoming confused with each other (see Figures 5.10 and 5.11).

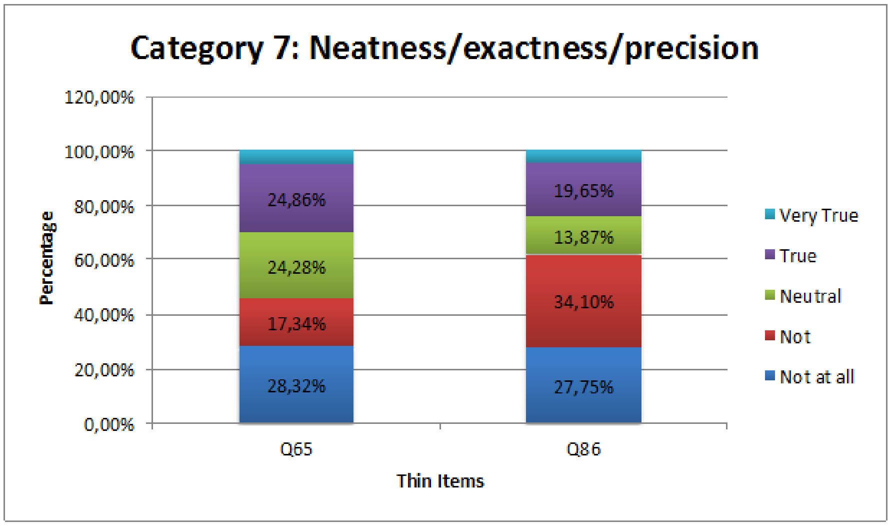


Figure 5.11 Percentage distribution for items: neatness and exactness

Figure 5.11 shows the distribution of aircrew responses for Category 7 items that measure degrees of difference for inverse items measuring exactness.

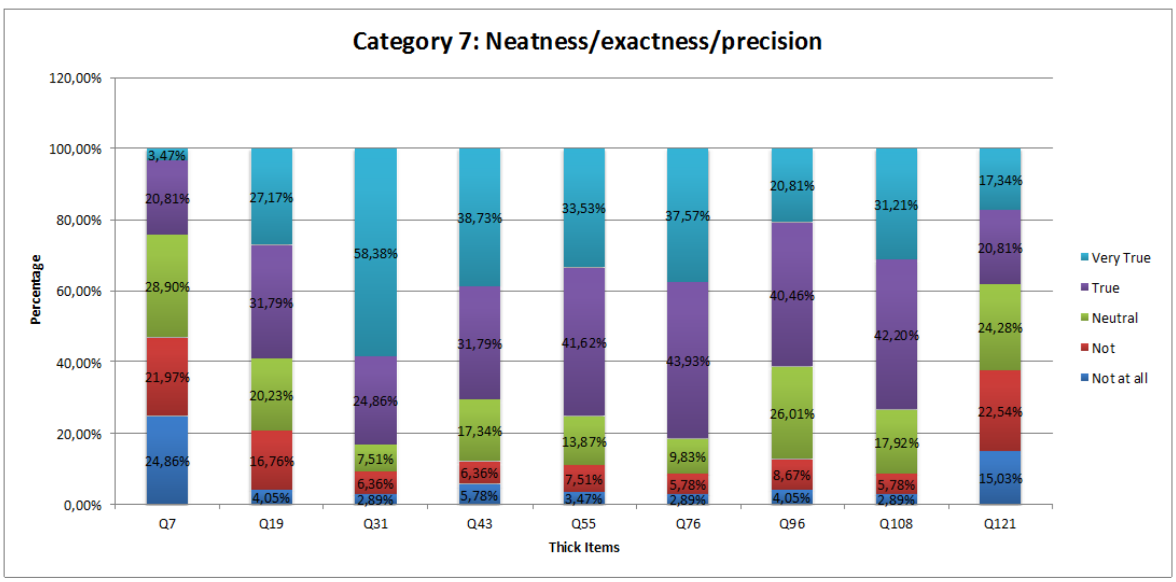


Figure 5.12 Percentage distribution for inverse items: neatness and exactness

5.4.5 Boundary Questionnaire Category 8: Edges, lines and clothing

Category 8 of the Boundary Questionnaire is important for this study to operationalise emotional awareness and human error. Evidence suggests that balancing emotional awareness between self and the environment indicates a preference for neat, organised and structured vs. unstructured traits (Figure 5.12). It also differentiates between boundaries of sharp vs. fuzzy lines (Hartmann, Harrison & Zborowski, 2001). Figure 5.12 shows the distribution of aircrew responses for Category 8 items that measure degrees of different preference for neatness or exactness.

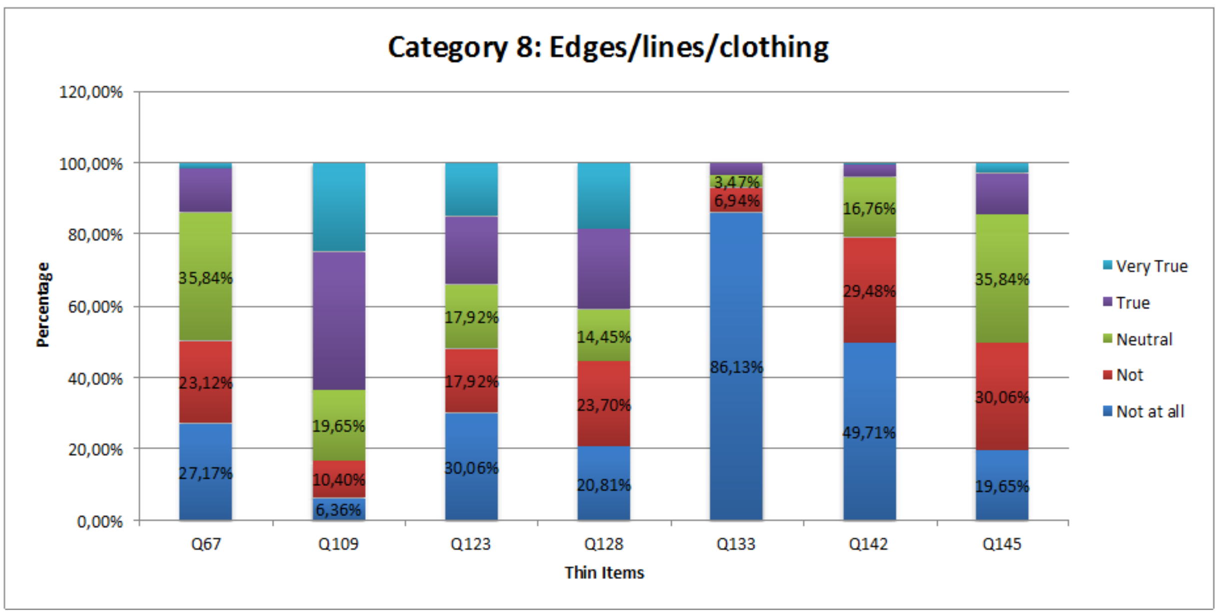


Figure 5.13 Percentage distribution for items: edges and lines

5.5 RELIABILITY ANALYSIS

The researcher expected and addressed random errors such as missing data and questions not completed. In this study, reliability analysis was conducted using Cronbach alpha coefficients to assess the overall internal consistency of the Boundary Questionnaire as measuring instrument. Cronbach's alpha scores were calculated for each of the eight Boundary Questionnaire constructs (Table 5.5). The Cronbach alpha values suggested that the categories were internally consistent and reliable.

Table 5.5 Reliability of BQ constructs

BQ Constructs	Cronbach	Reliability
Cat 1	.749	Acceptable
Cat 3	.729	Acceptable
Cat 5	.731	Acceptable
Cat 7	.754	Acceptable
Cat 8	.703	Acceptable

5.6 FACTOR ANALYSIS APPLIED TO THE FIVE BOUNDARY QUESTIONNAIRE CATEGORIES

The researcher was concerned with the number of emotional awareness sub-constructs that were represented and how well each item represented these domains.

First of all, the factor structure of all 70 selected Boundary Questionnaire items was examined (see Annexure B). The interrelationships among the Boundary Questionnaire variables were subsequently summarised to conceptualise the component 'emotional awareness' and group it into meaningful factors. Importantly, conducting a Principal Component Analysis (PCA) was not advisable as the technique assumes uncorrelated factors (Preacher, Zhang, Kim & Mels, 2013), consequently an exploratory factor analysis was conducted.

5.6.1 Exploratory factor analysis (EFA)

Since exploratory factor analysis (EFA) methods have widespread use in psychological research, the researcher conducted EFA to establish linear variates within the data and to discover degrees of difference in aircrew's emotional awareness (Babbie, 2013). EFA was performed by analysing the covariance matrix as it produces a better-defined factor structure (Field, 2013; Preacher, Zhang, Kim & Mels, 2013).

EFA was performed using the maximum likelihood (ML) method of extraction to identify underlying emotional awareness variables. The information gained from the interdependencies between the observed variables was used to reduce the set of variables in the dataset and group the remaining traits to find the relevant latent emotional awareness factors. Results are reported in detail in the following sections.

5.6.2 KMO measure of sampling adequacy

A Kaiser Meyer-Olkin (KMO) measure of sampling adequacy was performed to determine how much variance was common variance between variables. A rotation with Kaiser normalisation was performed to aid the interpretation of the dimensions. Variables were sorted by their loading size. The diagonal elements should all be greater than 0.7 for a given pair of variables to ensure factor analysis yields distinct and reliable factors (Field, 2013; Pallant, 2006). In this study, values between 0.7 and 0.9 were used. The output magnitude loadings from the five selected Boundary Questionnaire categories ranged between 0.703 and 0.749. The dimension solution explained between 19% and 31% of the common variance, with the individual dimensions ranging between 7% and 19% (see Table 5.6).

Table 5.6 Variance accounted for by the emotional awareness constructs

BQ category	Direct oblimin rotation converged in iterations	KMO	Eigen-value	% of variance for each factor	Total variance explained
Category 1	26	.749	3	7	25
			1	18	
Category 3	26	.729	1	7	31
			2	18	
			1	6	
Category 5	28	.731	1	12	28
	17		1	9	
			1	7	
Category 7	*4*	*.754*	*2*	*19*	*19*
Category 8	*27*	*.703*	*2*	*14*	*23*
			1	*9*	

(N = 173)

Initially, the researcher performed a promax oblique rotation, despite being aware that the sample size of 173 was barely adequate and these factors all had eigenvalues greater than 2. The data was then fitted to a factor pattern structure using oblimin rotation with Kaiser normalisation to aid the interpretation of the dimensions. Factor extraction was performed by means of Principal Axis Factoring. Where the factors correlated, sums of squared loadings could not be added to obtain a total variance. The individual dimensions only contributed between 5.6% and 19.8% variance each (Appendix A).

5.6.3 Factor analysis with direct oblimin rotation with Kaiser normalisation

As the pattern matrix is a simpler method to interpret, the researcher selected the factor loadings of the pattern matrix to decide on the factors to retain (Field, 2013). Promax rotation is used for large datasets and when the researcher expects the factors to be independent (Field, 2013). In this case, the direct oblimin rotation method was selected due to the limited sample of 173 aircrew and as the factors are bound not to be independent as the items were developed to measure one underlying construct. Oblique factor rotation was performed to discriminate between factors by effectively rotating the axes such that variables loaded maximally on only one factor (Appendix B). With direct oblimin, the degree to which factors can correlate is determined by the value of the delta constant which was kept at the recommended zero default setting (Field, 2013). The closer the communalities are to 1, the better the factors are at explaining the data (Pallant, 2006). These factors all had eigenvalues larger or close to 0.7, which is within the acceptable limit for small samples (Field, 2013) as can be seen in Appendix B.

5.6.4 Factor extraction

Item cluster extraction (ML) was performed. First, the linear components within the dataset were determined by calculating the eigenvectors of the 70 Boundary Questionnaire items. Then the eigenvalue greater than one option was selected. The eigenvalues associated with each factor represented the common variance explained by that factor. Communality before extraction is the proportion of common variance, whereas communality after extraction is the amount of variance in each of the factors identified –

which can be explained by the retained factors (Field, 2013). The researcher used the factor correlation matrix to assume some independence between the factors. The fact that correlations existed, provided evidence that the emotional awareness constructs were interrelated (Appendix B).

5.6.5 Naming of factors

The researcher analysed the content of the items after rotation that loaded highly on the same factor to identify common themes. The factor loadings were used as the basis for inputting labels to the explanatory dimensions of the new emotional awareness sub-scales. The eight extracted factors were labelled to provide a description of the underlying meaning of each emotional awareness sub-construct to enhance the interpretation of the results. The researcher named the extracted factors independently without reference to any personality model or EQ-i20 traits as emotional awareness sub-scales: involved, blend, imaginative, precise, flexible, structured thought, unstructured thought and openness (Table 5.7).

Table 5.7 Factor naming and emotional awareness trait description

BQ Category	EA sub-scales	BQ items retained	Sub-scale description
Category 1: Sleeping, walking, dreaming	Openness	72, 92, 130	Friendly, relaxed, confident, extraverted and open to experience
	Unstructured	1, 25, 37, 60, 82, 112, 119	Disorganised and careless
Category 3: Thoughts, feelings, moods	Involved	15 ,51 ,84, 94, 102, 106	Conscientious and focused attention
	Blend	3,62	Agreeableness and cooperative
	Imaginative	74,127,132	Creative and innovative, resources required for problem-solving abilities
Category 7: Neatness, exactness, precision	Exactness	43,55,76,96,108,121	Resourcefulness, complex questioning and detail oriented for decision making
Category 8: Edges and lines	Flexible	67,142,145	Emotional stability, agreeable and cooperative
	Structured	44, 137	Conscientious, organised and careful

As a sample size of 200 or more is required to reliably use a scree plot as a factor selection criterion (Field, 2013), an SPSS scree plot graph is not depicted (the current study had a limited sample size of 173). Once the factors had been extracted (ML), the degree to which variables loaded on the factors was determined. Factor rotation was used to discriminate between factors and the axes were rotated such that variables were loaded maximally to only one factor (Field, 2013). Factor analysis was hence performed to generate new emotional awareness scales in the aviation context from the item pool. These scales will be discussed in more detail in the next section.

5.7 DESCRIPTIVE STATISTICS FOR THE EMOTIONAL AWARENESS SUB-SCALES

The mean, standard deviation, variance, skewness, kurtosis, minimum and maximum statistics were calculated for each emotional awareness sub-scale. Normality of the data was assessed in terms of the data distribution and skewness. Data was leptokurtic distributed, and skewness of zero indicated range restriction, possibly due to aircrew selection for the military environment (see Table 5.8).

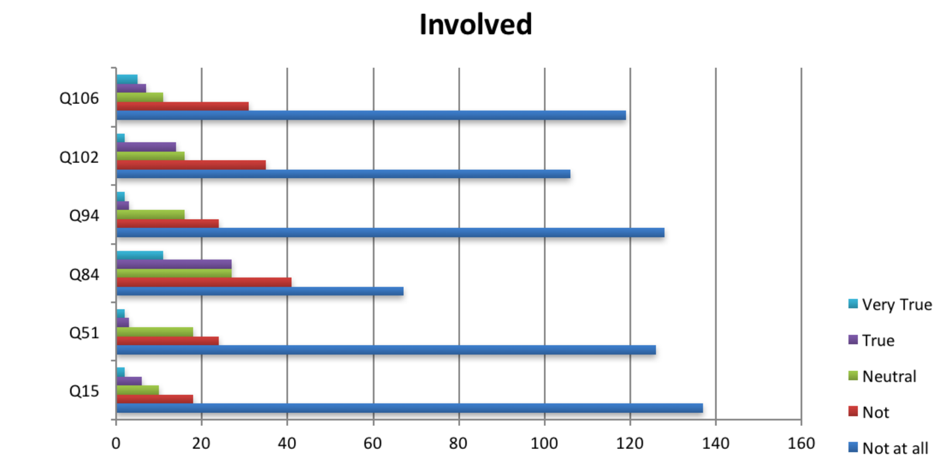
Table 5.8 Descriptive statistics for the emotional awareness sub-scales

EA sub-scales	N	Mean	Median	Std deviation	Skewness	Std error of skewness	Kurtosis	Std error of kurtosis
Involved	173	.630	.5000	.649	1.530	.184	3.67	.366
Blend	173	1.178	1.000	1.091	.774	.184	-.014	.366
Imaginative	173	1.017	1.000	.8955	.862	.184	.309	.366
Exactness	173	1.233	1.167	.6695	.373	.184	.975	.366
Flexible	173	1.210	1.333	.7601	.373	.185	.337	.367
Structured	173	1.052	1.000	.9087	1.143	.185	1.509	.367
Unstructured	173	.4918	.2857	.5077	1.315	.184	1.668	.366
Openness	173	.1590	.0000	.42058	3.197	.184	10.480	.366

(minimum = 0, maximum = 4, range = 4)

5.7.1 Emotional awareness sub-scale: Involved

The emotional awareness sub-scale scores exhibited a leptokurtic distribution (Table 5.8) with a mean of 0.630 and standard deviation of 0.649. The data indicates the presence of a positively skewed distribution with a skewness value of 1.53 (Figure 5.13).



	Q15	Q51	Q84	Q94	Q102	Q106
Very True	2	2	11	2	2	5
True	6	3	27	3	14	7
Neutral	10	18	27	16	16	11
Not	18	24	41	24	35	31
Not at all	137	126	67	128	106	119

N=173

Figure 5.14 Frequency distribution for emotional awareness sub-scale: Involved

The leptokurtic kurtosis value of 3.67 indicates high item responses for “not at all true” and “not true” measuring ‘involved’ items 15, 51, 84, 94, 102 and 106. To estimate the degree of association between the quantitative variables, the researcher viewed the relationships between each selected item and ranked human error data in scatterplots, to decide on the best choice of measuring association. The scatterplots (Figure 5.14) visually present item responses for the independent variable, emotional awareness, on the y-axis and for the dependent variable, human error, on the x-axis.

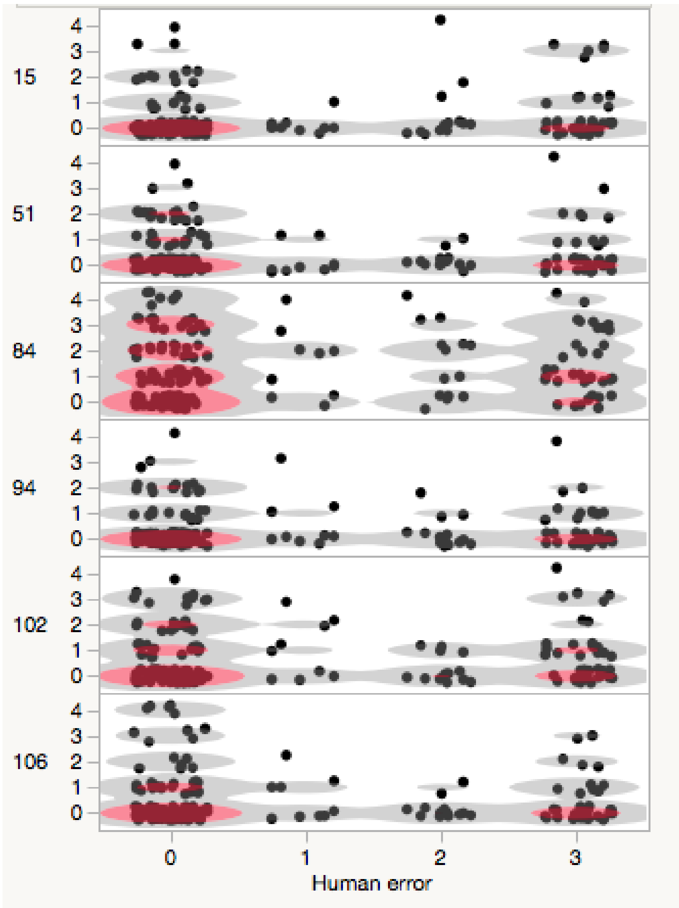


Figure 5.15 Matrix scatterplot for human error and sub-scale: Involved

The scatterplots are divided into 24 quadrants. Therefore, the assumption of the homogeneity of variance-covariance matrices was met for the discrimination classes of emotional awareness variables and human error. The data points group themselves closer together at the human error point, as the correlation increases in strength. These plots show some evidence of linearity between the sub-scale items 'involved' and 'zero human error'.

5.7.2 Emotional Awareness sub-scale: Blend

The dataset for the emotional awareness variable 'Blend' was leptokurtic distributed (Table 5.16) with a mean score of 1.17 and standard deviation of 1.09. The dataset indicates a positive skewed distribution with a value of 0.774 and slight negative kurtosis as indicated, with a value of -0.014 that indicates lower item responses for “not true” and “not at all true” (Figure 5.15).

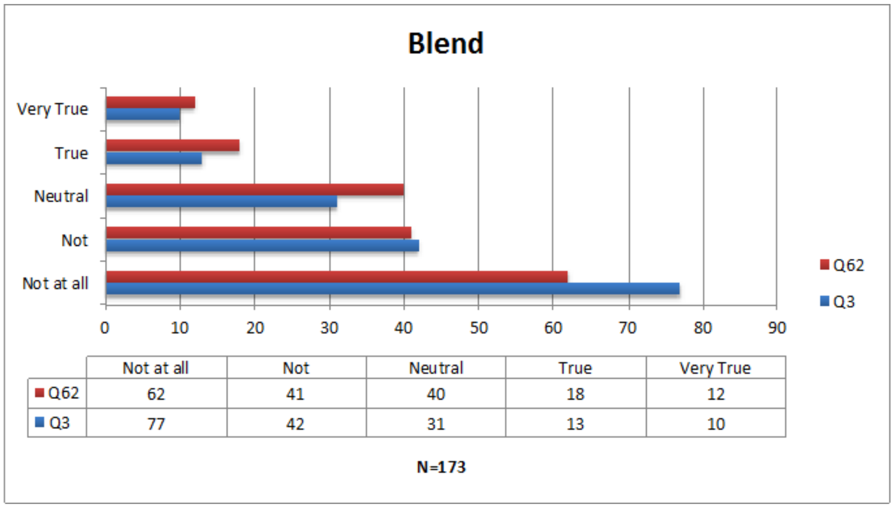


Figure 5.16 Frequency distribution for emotional awareness sub-scale: Blend

This leptokurtic distribution indicates a balance between “open” and “closed” item responses for the trait, “blend”. The scatterplot relating human error and items for the sub-scale ‘Blend’ (Figure 5.16) is indicative of a linear relationship for both items. The scatterplot (Figure 5.16) presents item responses for items 3 and 62. Item preferences were evenly distributed in relation to human error. The scatterplot presents no obvious linear relationship for item responses 3 and 62, and a low correlation with human error.

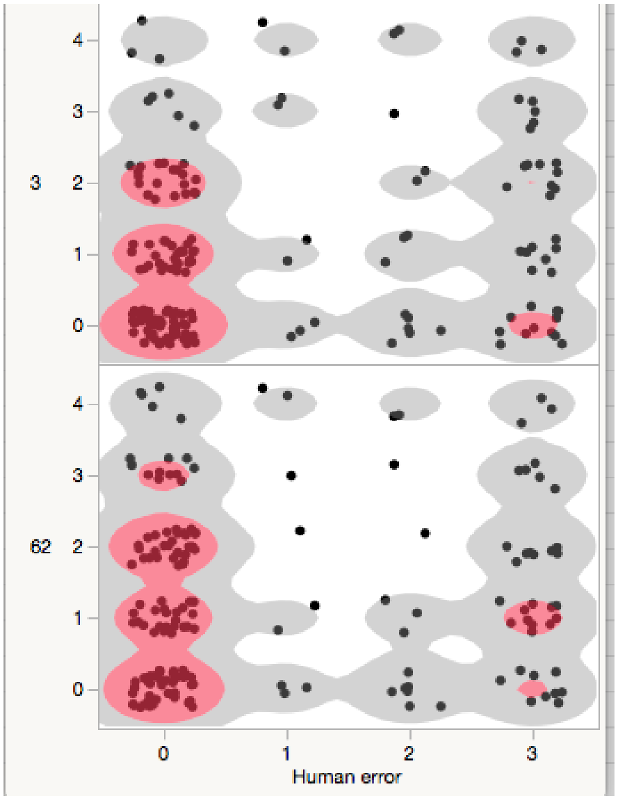


Figure 5.17 Matrix scatterplot for human error and sub-scale: Blend

5.7.3 Emotional Awareness sub-scale: Imaginative

The data distribution was leptokurtic for the emotional awareness variable, ‘imaginative’. Table 5.9 with a mean of 1.01 and standard deviation of 0.895 for N = 173. The data reflects a positive skewed distribution with a value of 0.862 and slight positive kurtosis as indicated by a value of 0.366, which indicates high item responses for “not true” and “not at all true” (Figure 5.17).

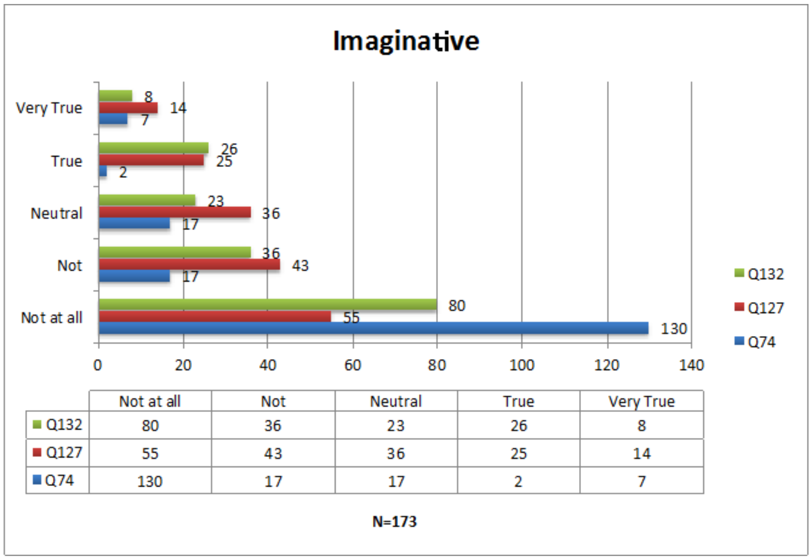


Figure 5.18 Frequency distribution for emotional awareness sub-scale: Imaginative

Scores were not normally distributed. This leptokurtic distribution may be attributed to a military profile representing the operational environment requirement of accuracy and precision (congruent to previous studies), as opposed to ‘imaginative’ aircrew (Mnguni, 2012).

The scatterplot for human error (x-axis) and the sub-scale item ‘imagination’ (y-axis), (Figure 5.18) presents a linear representation for “not at all” for item 74 “I can easily imagine myself to be an animal or what it might be like to be an animal”. The data points are grouped closer together as the correlation increases in strength.

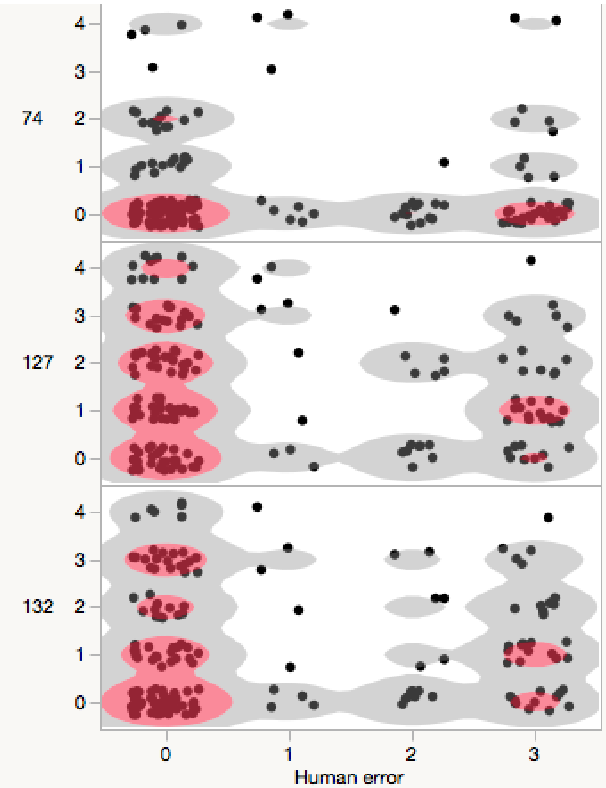
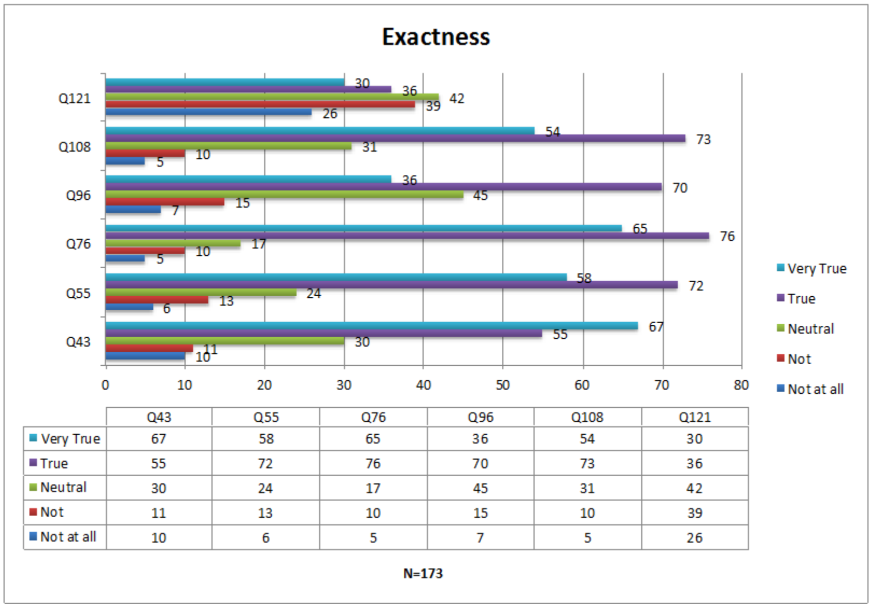


Figure 5.19 Matrix scatterplot for human error and sub-scale: Imaginative

5.7.4 Emotional Awareness sub-scale: Exactness

The dataset was leptokurtic distributed for the emotional awareness trait 'exactness'. Table 5.9 with a mean of 1.23 and standard deviation of 0.669 for N = 173 aviators. The dataset indicates a slight positive skewed distribution with a value of 0.373 and positive kurtosis value of 0.975, which indicates high item responses for "very true" and "true" (Figure 5.19).



	Q43	Q55	Q76	Q96	Q108	Q121
Very True	67	58	65	36	54	30
True	55	72	76	70	73	36
Neutral	30	24	17	45	31	42
Not	11	13	10	15	10	39
Not at all	10	6	5	7	5	26

Figure 5.20 Frequency distribution for emotional awareness sub-scale: Exactness

This leptokurtic distribution might be attributed to range restriction, because the selection process of military aircrew prefers ‘attention to detail’ traits, vital for a safe operational environment (Mnguni, 2012). The human error scatterplot and sub-scale item ‘exactness’ (Figure 5.20) present 70 emotional awareness item responses for items measuring the sub-scale ‘exactness’, item 43, “I am good at keeping accounts”, item 55, “I like things to be spelled out precisely and specifically”, and item 76, “When I am in a new situation, I try to find out precisely what is going on and what the rules are”.

The scatterplot represents responses for items 43, 55 and 76 that correlate with human error categories (x-axis). The items 96, 108 and 121 do not group within any specific quadrant and indicate no linear representation on item responses (Figure 5.20).

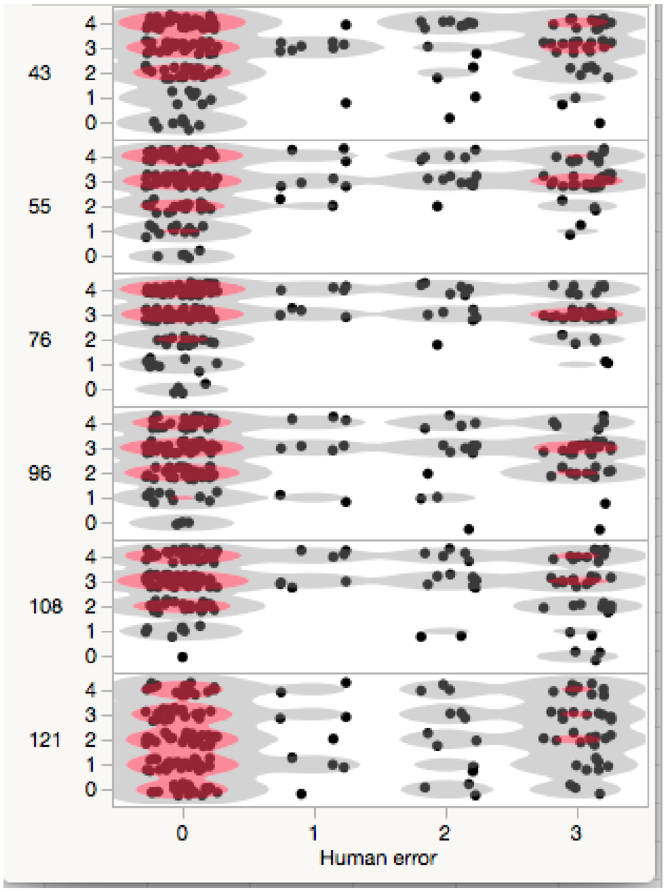
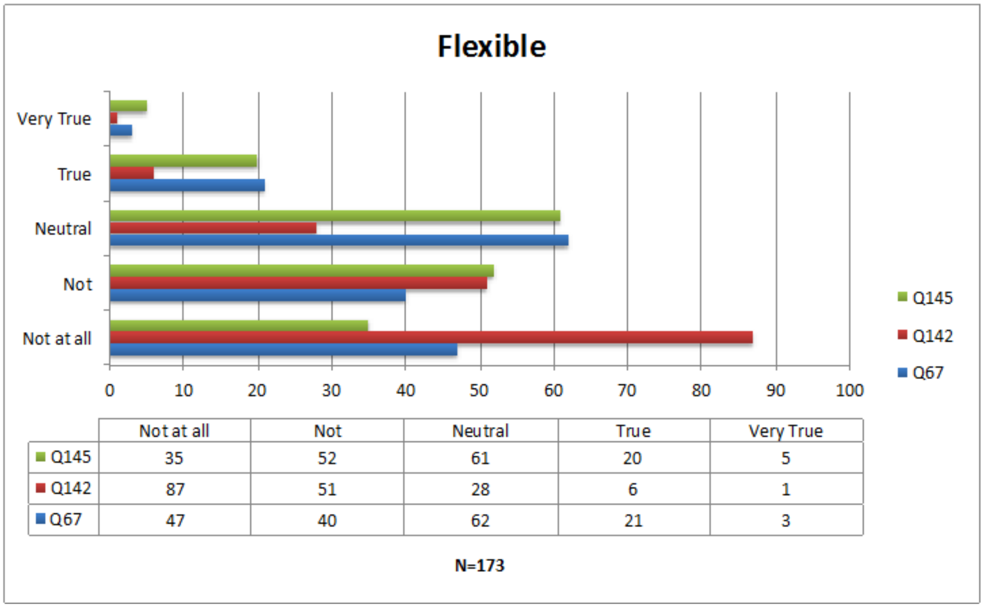


Figure 5.21 Matrix scatterplot for human error and items measuring: Exactness

5.7.5 Emotional Awareness sub-scale: Flexible

The distribution of scores for the emotional awareness sub-scale ‘flexibility’ was leptokurtic with a mean of 1.21 and standard deviation of 0.760 for the sample. The data indicates a slight positive skewed distribution with a value of 0.373 and slight positive kurtosis as indicated in Table 5.9, with a kurtosis value of 0.337, indicating a preference of item responses for “not at all flexible”, “not flexible” and “neutral” in the case of items 67, 142 and 145 (Figure 5.21).



	Not at all	Not	Neutral	True	Very True
Q145	35	52	61	20	5
Q142	87	51	28	6	1
Q67	47	40	62	21	3

Figure 5.22 Frequency distribution for emotional awareness sub-scale: Flexible

This leptokurtic distribution might be attributed to an uncompromising personality profile that is preferred during selection that suits the demands of the military environment. The scatterplot (Figure 5.22) presents emotional awareness item responses for three items measuring the trait ‘flexibility’. The scatterplot presents visual responses for items 67, 142 and 145 (y-axis) and human error (x-axis). The human error category presents no linear relationship with any item responses.

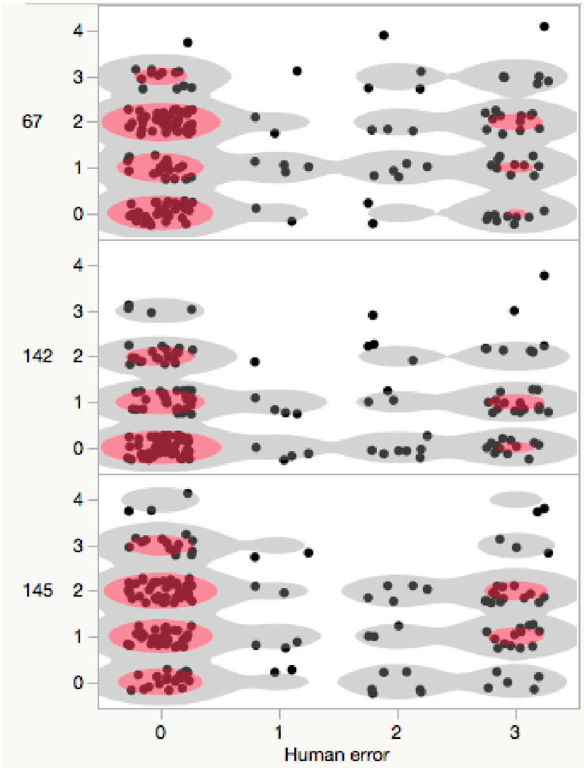
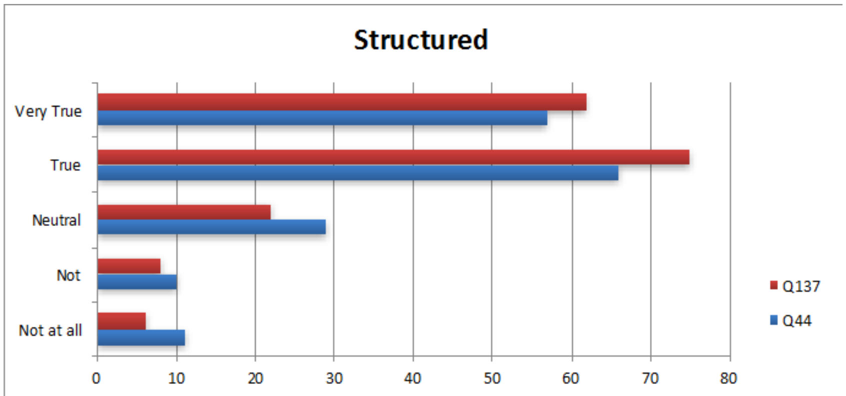


Figure 5.23 Matrix scatterplot for human error and items measuring: Flexibility

5.7.6 Emotional Awareness sub-scale: Structured thought

The distribution of the responses for the items representing the emotional awareness trait 'structured thought' (Table 5.9) was leptokurtic with a mean of 1.05 and standard deviation of 0.908 for the sample of aviators. The data indicates a positive skewed distribution with a value of 1.143 and slight positive leptokurtic kurtosis with a value of 1.509 (Figure 5.23).



	Not at all	Not	Neutral	True	Very True
Q137	6	8	22	75	62
Q44	11	10	29	66	57

N=173

Figure 5.24 Frequency distribution for emotional awareness sub-scale: Structured thought

This leptokurtic distribution might be attributed to a structured personality profile that is preferred during in the organised military environment. The scatterplot (Figure 5.24) presents a high frequency of item responses for ‘exactness’ related to human error and item 44, “I like stories that have a definite beginning, middle and end” and item 137, “I like clear, precise borders”. Responses for “true for me” present a linear relationship between human error (x-axis) and ‘structured thought’ (y-axis) in the case of items 44 and 137.

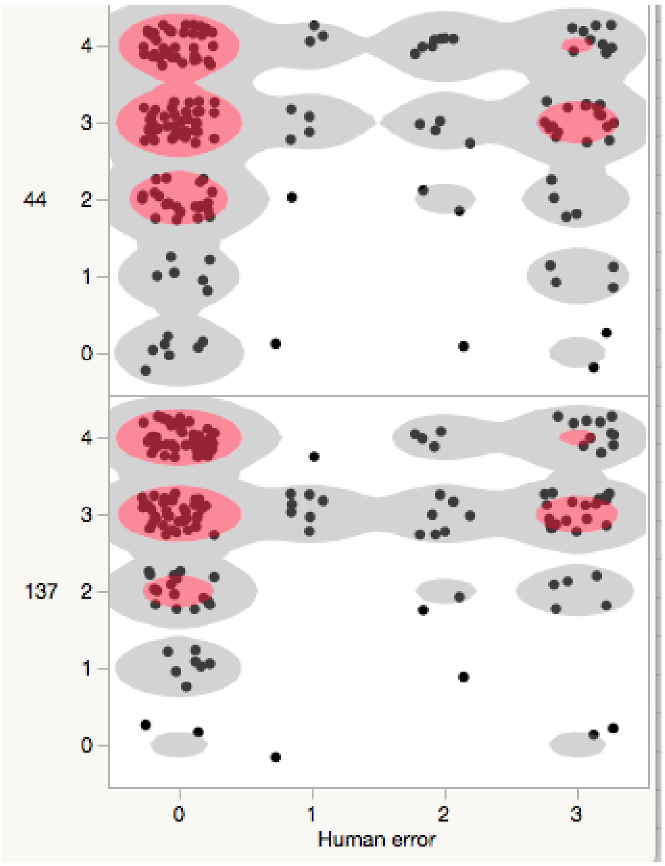
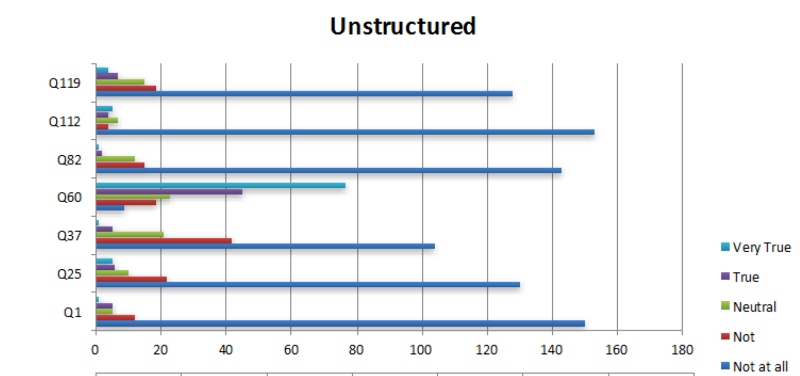


Figure 5.25 Scatterplot for human error and items 44 and 137: Structured thought

5.7.7 Emotional Awareness sub-scale: Unstructured thought

The scores for the emotional awareness variable, ‘unstructured thought’ (see Table 5.9) were leptokurtic with a mean of 0.491 and standard deviation of 0.507 (N = 173). The data indicates a positive skewed distribution with a skewness value of 1.315 and slight positive kurtosis with a value of 1.668, indicating item response preferences for “not true” and “not at all true” for the items measuring ‘unstructured thought’ (Figure 5.25).



	Q1	Q25	Q37	Q60	Q82	Q112	Q119
Very True	1	5	1	77	1	5	4
True	5	6	5	45	2	4	7
Neutral	5	10	21	23	12	7	15
Not	12	22	42	19	15	4	19
Not at all	150	130	104	9	143	153	128

N=173

Figure 5.26 Frequency distribution for emotional awareness sub-scale: Unstructured thought

This again might indicate the presence of range restriction as a result of military selection requirements.

The scatterplot (Figure 5.26) indicates a relationship between high 'structured thought' preferences and human error (x-axis) for Items 72, 92 and 130. These preferences indicate a relationship between 'unstructured' aircrew and no recorded 'human error', signifying a balance between 'structured' and 'unstructured' thought.

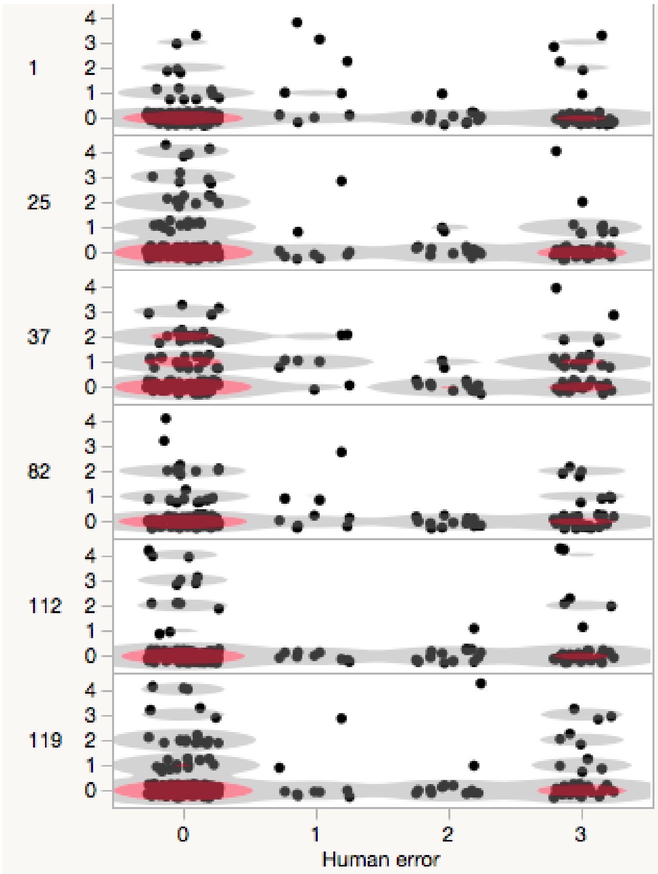
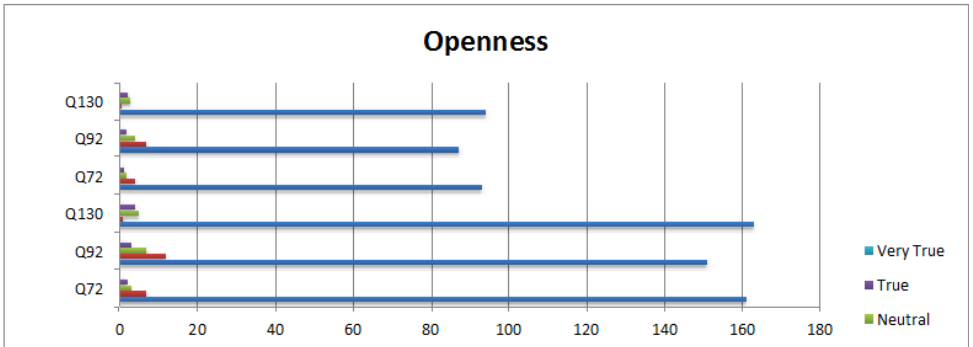


Figure 5.27 Scatterplot for human error and unstructured thought

5.7.8 Emotional Awareness sub-scale: Openness

For the sub-scale, ‘Openness’ (mean = 1.6; standard deviation = 0.420; N = 173) the dimensions clustered around the scores indicating the opposite of ‘openness’. The data represents a positive skewed distribution with an extreme skewness value of 3.197 (opposed to the previous sub-scales) and extreme positive leptokurtic kurtosis with a value of 10.48, which indicates very high item responses for “not at all true” (Figure 5.27).



	Q72	Q92	Q130	Q72	Q92	Q130
Very True	0	0	0	0,00	0,00	0,00
True	2	3	4	1,16	1,73	2,31
Neutral	3	7	5	1,73	4,05	2,89
Not	7	12	1	4,05	6,94	0,58
Not at all	161	151	163	93,06	87,28	94,22

N=173

Figure 5.28 Frequency distribution for the emotional awareness sub-scale: Openness

Comparing these results with Hartmann's study on Naval officers, this distribution may be attributed to rigid emotional boundaries that are suitable for military profiles within the operational environment (Jawer & Micozzi, 2011).

Supporting this, on the scatterplot (Figure 5.28) the data points cluster closer together as the correlation increases in strength. Responses for "not at all" items (72, 92 and 130 on the y-axis) indicate negative 'openness' preferences, corresponding with the x-axis, no recorded 'human error' group and some groupings for the accident (x = HE3) group.

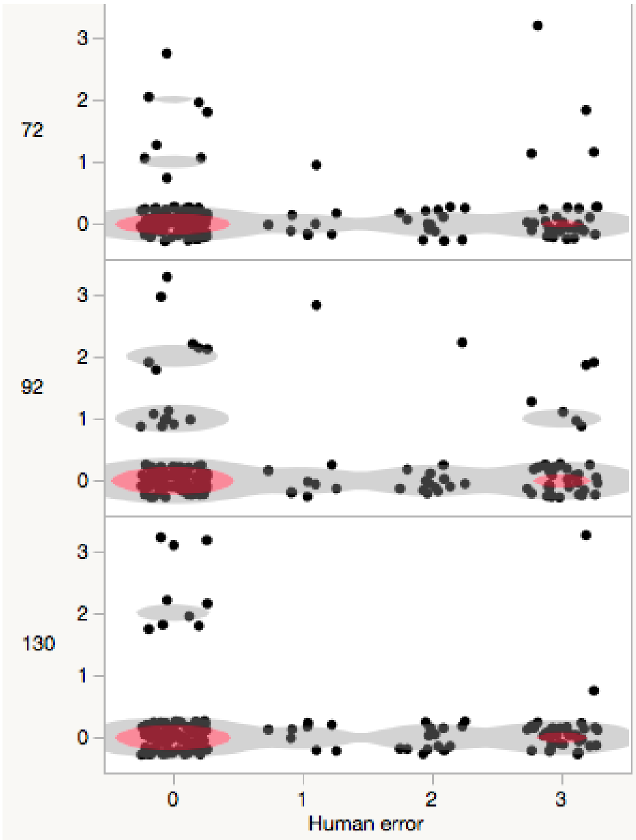


Figure 5.29 Scatterplot for human error and Emotional Awareness: Openness

As presented above, the frequency distributions were skewed and parametric assumptions were not met. Measures of monotonic association between emotional awareness traits and human error were determined. Furthermore, viewing the human error scatterplot distributions, indicated no clear relationship with hazards (HE1) and incidences (HE2). Furthermore, the small sample size and use of ordinal scales necessitated the use of non-parametric techniques.

5.8 NON-PARAMETRIC TESTS BETWEEN GROUPS

As presented, the frequency distributions were skewed and parametric assumptions were not met. Data from each aircrew member was counted only once and the data did not influence each other as assumed by non-parametric tests. To limit the effect of outliers, non-parametric tests were conducted with ranks, exploring possible relationships between experience, mustering, emotional awareness and human error groups.

5.8.1 Kruskal-Wallis test for emotional awareness sub-scales and human error

Exploring the relationship between human error and emotional awareness, the Kruskal-Wallis test was conducted. The emotional awareness and human error mean rank scores were calculated for non-parametric analysis (see Table 5:9).

Table 5.9 Ranks for human error groups

		Ranks	
EA sub-constructs	HE groups	N	Mean Rank
Involved	0	140	86.81
	1	7	85.14
	2	6	79.25
	3	20	91.30
	Total	173	
Blend	0	140	83.17
	1	7	118.29
	2	6	114.75
	3	20	94.53
	Total	173	
Imaginative	0	140	85.39
	1	7	109.00
	2	6	44.25
	3	20	103.40
	Total	173	
Exactness	0	140	87.67
	1	7	72.86
	2	6	59.25
	3	20	95.60
		173	
Flexible	0	140	85.17
	1	7	77.00
	2	6	82.92
	3	21	100.13
		173	
Structured thought	0	140	85.50
	1	7	93.21
	2	6	74.58
	3	21	94.68
		173	
Unstructured thought	0	140	86.03
	1	7	97.00
	2	6	52.08
	3	21	100.80
	Total	173	
Openness	0	140	86.72
	1	7	85.29
	2	6	71.50
	3	21	94.20
	Total	173	

Note: zero = 0, hazrep = 1, incident = 2 and accident = 3.

The Kruskal-Wallis test was performed to establish if there were any significant differences between emotional awareness traits and four human error groups. To counter the probability of a Type 1, error the significance value was set at a 95% confidence interval level ($p \leq .05$). For this study, r values larger than .30 (medium effect) were regarded as practically significant.

The goodness of fit test was used to test if the frequency distribution from the categorical data represents a good fit to the hypothesised probability. Chi square values were calculated (Table 5.10) and a significant difference for the emotional awareness trait 'imaginative' ($p = .043$) was found**.** No other significant difference between the four human error groups and the emotional awareness sub-factors were found.'

Table 5.10 Kruskal-Wallis test: Emotional awareness and human error

	Involved	Blend	Imaginative	Exactness	Flexibility	Structured	Unstructured	Openness
Chi-square	.308	6.06	8.173	3.03	1.927	1.1	4.88	2.240
df	3	3	3	3	3	3	3	3
Asymp. sig	.958	.109	.043	.386	.588	.775	.181	.524

*** correlation is significant at the level p ≤ .05 (2-tailed).*

5.8.2 Kruskal-Wallis test for relationships between EA, HE and mustering

To explore the relationship between human error and emotional awareness and mustering, the Kruskal-Wallis test was conducted for differences between independent mustering groups. The mean rank scores of 160 aircrew were ranked per four independent mustering groups (Table 5:11). The technical ($N = 7$) and navigator ($N = 6$) mustering groups were not included in the analysis for mustering, due to small sample sizes.

Table 5.11 Ranks for aircrew mustering groups

EA sub-constructs	Mustering	N	Mean Rank
Involved	1	60	80.80
	2	61	82.44
	3	23	68.37
	4	13	73.35
	Total	160	
Blend	1	60	77.46
	2	61	84.40
	3	23	63.93
	4	13	87.42
	Total	160	
Imaginative	1	60	83.04
	2	61	74.19
	3	23	84.07
	4	13	73.96
	Total	160	
Exactness	1	60	77.34
	2	61	81.12
	3	23	79.50
	4	13	75.81
	Total	160	
Flexible	1	60	74.85
	2	61	80.55
	3	23	80.73
	4	13	81.96
	Total	160	
Structured Thought	1	60	78.07
	2	61	72.48
	3	23	93.57
	4	13	83.27
	Total	160	
Unstructured Thought	1	60	85.00
	2	61	78.43
	3	23	63.39
	4	13	81.58
	Total	160	
Openness	1	60	81.86
	2	61	81.14
	3	23	67.02
	4	13	76.96
	Total	160	

Note: Combat = 3, Helicopter = 1, Fixed Wing = 2 , ATC = 4.

No statistical significant relationships were found between the mustering groups and emotional awareness traits. The values ranged between p = .236 and p = .882 (Table 5:11).

The goodness of fit test indicated that the frequency distribution of the categorical data was a good fit to the hypothesised distribution. Chi square values (Table 5:12) were all above the critical level of p = .05, confirming that no significant difference between any of the four mustering groups and emotional awareness sub-factors existed, rejecting the H4 hypothesis.

Table 5.12 Kruskal-Wallis test: Emotional awareness and mustering groups

	Involved	Blend	Imaginative	Exact	Flexible	Structure	Unstructured	Openness
Chi-square	1.94	4.05	1.636	.282	.663	3.822	3.907	4.242
df	3	3	3	3	3	3	3	3
Asymp. sig	.584	.256	.651	.963	.882	.281	.272	.236

*** correlation is significant (Sig.) at the level p ≤ .05 (2-tailed).*

5.9 NON-PARAMETRIC MEASURES OF BIVARIATE RELATIONSHIPS

Next a correlation analysis was conducted to assess the relationship between the emotional awareness sub-scales and human error. To measure association, the non-parametric Spearman rank correlation coefficients were calculated.

5.9.1 Measures of association

As the data was not normally distributed and scatterplot distributions, HE1 and H2 did not present sufficient incidences (see Scatterplot Figures; 5.14, 5.16, 5.18, 5.20, 5.22, 5.24, 5.26 and 5.28), the researcher decided to categorize human error into two groups; the zero-error group and the human error group (HE1+HE2+HE3=HE). The researcher explored possible correlations using Spearman's rank correlation coefficients.

5.9.2 Spearman's rank correlations for HE and EA

A Spearman's rank-order correlation was run to explore a possible correlation between the HE group (HE1+HE2+HE3=HE) and EA sub-scales. The Spearman correlation coefficient from the output matrix (Table 5:14) presents a correlation coefficient between the dependent group, human error $r = .49$ and EA sub-scale; blend $p = .49$. The fact that the significant value was below the standard criterion $p = .05$ presents a statistically significant relationship between human error and the independent variable emotional awareness sub-scale 'blend'.

Spearman's rank-order correlation was used to calculate the strength of relationships between the emotional awareness traits and two experience groups. The standard deviation for the variable 'experience' was measured as the average difference of human error observations and experience groups from the mean.

5.9.2.1 Spearman correlations between emotional awareness and human error

When investigating ranked human error the results (Table 5:13) indicated a positive significant correlation between the human error group and the trait 'blend' ($r = .150$; $p = .049$), confirming the need for exactness. All other sub-scales showed no significant correlation with the human error categories.

5.9.2.2 Spearman correlations between emotional awareness and experience groups

As mentioned, the aircrew's years' experience was coded into two groups. Those with less than ten years' experience and those with more than ten years' experience. Spearman's correlations were calculated to determine differences between emotional awareness traits and experience. The results are presented in a matrix (Table 5.13) and indicate that the more than ten years' aviation experience group correlated significantly (negative) with both the trait 'exactness' $r = -.158$ ($p = .038$) and with the trait 'openness', $r = -.244$; ($p < .001$), indicating experienced pilots are less 'exact' and less 'open'.

Table 5.13 Correlations between emotional awareness sub-scales, human error and experience groups *(N = 173)*

Spear-man's rho	Involved	Blend	Imaginative	Exactness	Flexibility	Structured	Un-structured	Open-ness	Ex-perience	HE
Involved	1	**.379**** .000	.475** .000	.112 .060	.142* .012	.040 .410	.267** .000	.455** .000	-.014 .000	.11 .882
Blend		1	.278** .000	.115 .371	.197* .040	.051 .794	.155** .000	.370** .000	-.155 .041	**.150*** **.049**
Imaginative			1	-.006 .941	.167* .028	-.039 .611	.251 .000	.290** .000	-.015 .029	.073 .341
Exact				1	.226* .003	.516	.247**	.355** .000	**-.158*** **.038**	-.016 .838
Flexibility					1	.244	.141	.249 .001	-.084	.065 .398
Structure						1	**.193****	**.293**** **.000**	-.017	.045 .557
Unstructured							1	.414**	-.239	.048 .529
Open								1	**-.244*** **.001**	.026 .737
Experience									1	
HE										1

*** correlation is significant (Sig.) at the level p ≤ .05 (2-tailed).*

In the above, Spearman's correlations determined the degree to which the relationships were monotonic and if there was a component of association between emotional awareness, human error and experience groups.

5.10 CONCLUSION

The literature review could not provide substantial evidence to explore human error models related to safe performance traits. As the data was not normally distributed, the researcher performed nonparametric Kruskal-Wallis tests for more than two groups; i.e. four ranked mustering and human error groups. Spearman correlations tested the strength of relationships between the ordinal variables, emotional awareness, the human error group and two experience groups.

This empirical section explored relationships between emotional awareness, human error, experience and four mustering groups. This chapter, provided descriptive data and explored possible relationships with non-parametric tests. Against the background and aviation scope of the research findings, a discussion of the results, a conclusions and applied recommendations are discussed in Chapter 6.

CHAPTER 6: FINDINGS, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

To “err is human” and making mistakes is part of the human condition. Adding to this, Cicero realised that “in the stress of battle, brave men do not feel their wounds”. Unfortunately, in the world of aviation, suppressing emotion and human error may have serious consequences. Aviation human factors studies consider human error as the main cause of aviation accidents (Arendt & Adamski, 2011; Kern, 2009; Schwarz et al., 2016). Worldwide, aircraft accident data and aviation human error analysis denote that more than 90% of accidents can be attributed to human error (Karanikas, 2016).

Human error management is considered critical for aviation safety (Munene, 2016). Adding to this argument, Wiegmann and Shappell (2003) attribute human error to task fixation and distractions. Hobbs (2008) also argues that emotional stressors lead to perception errors, memory lapses, slips and flawed assumptions, while Kern (2011) states that overconfidence, complacency and misplaced motivation result in adverse mental states. Cooke (2012) claims that the highest number of errors is due to perceptual-motor bungles and decisional errors. The researcher has realised that stress, ego states, sensory and information overload, as well as cognitive biases have an impact on aircrew performance and human error (Behrmann, 2015; Tehrani & Molesworth, 2016). The science of applied human factors indicates growing concern regarding the influence that flight deck automation has on aircrew’s perceptions and error management (de Boer & Hurts, 2017).

In aviation, mandatory human factors development becomes a multidisciplinary field to optimise human performance and manage human error within the human-machine interface (Karwowski et al., 2010; Salas & Maurino, 2010). To date, the Human Factors Analysis Classification System (HFACS) (Wiegmann & Shappell, 2003) has been the most comprehensive and applied framework to categorise human factors that influence human performance. An HFACS study conducted in Kenya found that reduced situational awareness is the main contributor to human error (Munene, 2016).

Although the human factor concept evolved over the last 60 years, applying the human factor science remains limited with safe performance models and safe behavioural indicators. Adding to this, applied human factors do not address human performance limitations within Crew Resource Management (CRM). Though the science of human factors studies behaviour markers to manage human error (Baier & Zimmer, 2015), experts contest available models and argue that they are limited in scope and application (Karanikas, 2016; Schwarz et al., 2016). Considering these generalisations and theories, the researcher asked the question whether emotional awareness training can be practically applied to reduce human error.

Applied human factors science and research limitations directed this study to conceptualise emotional awareness as a practical human factors trait application to manage human error in aviation (Karanikas, 2016). Since situational awareness is too complex to measure (Govern & Marsh, 2001), literature directed this study to explore the relationship between emotional awareness and human error. The general aim was formulated to explore a possible relationship between emotional awareness and human error (Baier & Zimmer, 2015; Landry, 2012).

Chapter 6 discusses the research findings, conclusions, limitations and recommendations for future aviation human factor studies. The researcher suggests practical human factors application to CRM training in order to skilfully manage human error.

6.2 BACKGROUND

The concept of emotional awareness is a traditional psychological trait theory and personality measure that is considered an important dimension of personality. Emotional awareness levels explain the degree of separateness and connection between thought and processes. People with low emotional awareness tend to see the world in structured "black-and-white" terms, whereas those with higher emotional awareness tend to be more unstructured and see different shades of grey (Jawer & Micozzi, 2011; Stein & Book, 2011).

Results from a study by Hartmann suggested that individuals who score lower on emotional awareness include military officers and persons suffering from alexithymia[1] (Hartmann, 1991). Studies suggest that low emotional awareness is more helpful at times of war, threat, or danger. Groups that feel threatened tend to suppress emotion. Generally, emotional awareness is more valuable when there is less danger and the individual can "let go". Along military lines, it is possible to think of war and peace in emotional awareness terms.

Literature review and studies directed this empirical research towards measuring emotional awareness levels as the independent variable with Hartmann's Boundary Questionnaire. The Boundary Questionnaire was administered to 173 aircrew members to operationalise emotional awareness and explore a relationship with human error in aviation.

6.3 REVISITING THE AIMS OF THIS STUDY

The researcher identified a gap in the science of aviation psychology and applied human factors in aviation when she attempted to conceptualise the safety term situational awareness for safety training purposes. She subsequently posed the question whether a significant relationship existed between emotional awareness and human error. The researcher believes that findings from this study will contribute to future human factor research and propel a new perspective applicable to safety training. Human error data and research results directed the hypothesis of this study to explore the relationship between emotional awareness and human error in an attempt to discover differences

[1] Alexithymia is a trait characterised by an inability to recognise, understand or manage emotions or to understand facial cues. Individuals appear detached from others.

between aircrew who perform well versus those who do not. The researcher based her study on safety data, research findings, recommendations and limitations, and formulated specific and general research aims to encourage future applied human factors studies. The general aim of this study was to explore a significant relationship between emotional awareness variables related to human error. The practical purpose of the study was directed at improving aviation safety and manage human error. Limitations guided this study to apply human factors training to CRM training so as to enhance safe aviation performance.

6.3.1 General aim

As discussed in Chapter 1, the general aim of this study was to explore the relationship between aircrew's emotional awareness and human error. The researcher formulated five specific research aims, to operationalise and conceptualise aviation concepts related to human error.

6.3.2 Specific aims

To achieve the general aim of this study, the following four specific aims were explored as indicated in Chapter 1:

Research aim 1: Conceptualise the aviation human factor paradigm.

Research aim 2: Conceptualise human error management in aviation.

Research aim 3: Conceptualise emotional awareness related to aviation.

Research aim 4: Conceptualise the theoretical relationship between emotional awareness and human error.

6.3.3 Empirical aims.

The empirical study operationalised the following aims:

Research aim 5: Operationalise human error measurement in aviation.

Research aim 6: Operationalise emotional awareness measurement with the Boundary Questionnaire.

Research aim 7: Operationalise the relationship between emotional awareness and human error in aviation.

6.4 INTEGRATED FINDINGS

While conceptualising the research aims the researcher found sufficient evidence that aircrew must have multi-tasking abilities, high levels of attention and response speed to perform safely (Schwarz et al., 2016; Pecena et al., 2013).

6.4.1 The aviation human factor conundrum

Various studies have identified human error as the primary factor responsible for aircraft accidents, and it is exacerbated by a variety of environmental pressures (Kanki et al., 2010). Aviation safety research and aircraft accident investigations support the viewpoint that human error remain the primary causes of aircraft accidents (Karanikas, 2016). Additionally, Hobbs (2008) argues that emotional stressors lead to perception errors, memory lapses, slips and flawed assumptions. Unfortunately, aircrew are also competitive by nature, and they often try to impress and outperform their peers (Schwarz et al., 2016; Rash et al., 2011).

Barker (2011) argues that although aviation automation increases safe performance, overreliance on technological solutions often results in reduced situational awareness and thus causes human error (Lintern, 2011; Vidulich & Tsang, 2016). Environmental factors and emotional stressors all make an additional demand on effective human error management of workload, interpret aviation data correctly and perform safely.

Additionally, this study explored aviation research results (Vermeulen & Mitchell, 2007) to assess perceptions related to the human factors that cause error. Their findings support this study and suggest that aviation safety training should be adapted to educate aircrew to adjust gender stereotyping attitudes. The researcher proposes that emotional awareness training should be applied as part of CRM training. Additionally, aircrew must be informed of gender stereotyping and awareness must be created of the potential impact that flawed perceptions have on safe aviation performance and human error.

6.4.2 Research aim 1

The first research aim addressed the human factor paradigm, and highlighted human limitations. Furthermore, it is often said that aircrew members are generally unfamiliar with the human factors concept and do not always comprehend the man-machine synthesis in a technologically advanced environment (Schwarz et al., 2016). Unfortunately, aircrew members are usually not familiar with emotional recognition and regulation (De Boer & Hurts, 2017). Human factors concepts should be integrated with Crew Resource Management training.

6.4.3 The value for aviation psychology and applied human factors

The aviation industry is challenged by acute pressures in a dynamic environment (Vidulich & Tsang, 2016) and Kern (2009) acknowledges the continuous struggle of human performance experts to find a cure for the ‘human error disease’. In support of Kern’s arguments, Tshabalala (2011) argues that negative emotions such as stress reduce safe performance. His study related to ATCs and he examined work stress and emotional coping abilities in the stressful aviation environment that contribute to human error. Similarly, Brink (2009) found statistically significant relationships between high levels of stress and low emotional awareness while studying 64 South African air traffic controllers (ATCs). Unfortunately, aircrew has limited emotional understanding regarding influences on performance (De Boer & Hurts, 2017; Schwarz et al., 2016).

Emerging technology adds to environmental pressures (Vidulich & Tsang, 2016). Casner and Woods (2014) argue that increased automation in cockpits leads to pilots having a higher percentage of task-unrelated thoughts. Aircrew are hence becoming more vulnerable to automation-induced complacency (De Boer & Hurts, 2017; Woods & Sarter, 2000). Supporting this study, Barker (2011), implores the hidden human factors threat and proposes that CRM should counter the effect of such automation-induced complacency. De Boer and Hurst (2017) argue that aviation automation reduces performance and decision-making abilities, and raised a terrifying question– is the autopilot considered friend or foe?

6.4.4 Research aims 2 and 3

The researcher explored the emotional intelligence sub-construct, emotional awareness and human error and proposed an emotional awareness trait taxonomy to facilitate safety training. As prescribed by ICAO, aircrew expect emotional intelligence training to provide them with the necessary skill to reduce human error. The researcher proposes emotional awareness training as traditional emotional intelligence training does not operationalise safe behaviour and provide skill to manage human error. Furthermore, applied human factors training should be regulated and facilitated by health professionals to enable aircrew to perceive their environment in combination with emotional awareness and to accurately voice early warnings such as “I don’t feel comfortable” (Brown & Moren, 2003, p. 270).

6.4.5 Research aim 4

The International Civil Aviation Organisation (ICAO, 2013) regulates safety training and proposes recruitment requirements for aircrew. Excellent multi-tasking abilities, extraordinary levels of attention and response speed are among the top ten cognitive abilities (Mnguni, 2011). Internationally, research is concerned with specific safe behaviour markers and personality constructs, such as level-headedness and mental alertness to enhance situational awareness (Tehrani & Molesworth, 2016). Aviation research studies propose safety training methods and behaviour markers to predict safe aviator profiles and to instil safe behaviour that will create human safety nets. Although limited, aviation safety trends aim to enhance safe aircrew performance. Collaboration in various social and behavioural sciences, including aviation psychology and applied human factors, aims to inform CRM, Team Resource Management (TRM) and Line-Oriented Flight Training (LOFT) strategies.

Kern (2009) realised the limitations within the safety management system, as it focuses on groups, and claims that therein lies the problem. He urges that applied sciences should focus on the individual *per se*, so as to understand his/her psychological predispositions and the skill necessary to enhance situational awareness. Kern also claims that “to avoid error”, we should empower aircrew to predict their own performance based on enhanced emotional awareness.

Linking Kern’s statement with the classical situational awareness model, an accurate perception is critical for decision making and to perform safely within the given environment (Reason, 2000). Kern (2009) argues that although social scientists have added greatly to the sum of our knowledge, they made it more difficult for the individual to merge all this information into a *gestalt* of performance in the real world. More so, the military environment is not homogenous. Aircrew need to perform safely despite additional pressures from the operational environment, and they should cope with accurate mission timing, challenging geographical environment and weather conditions – all of which add to workload and pose a threat to safety (Ojedokun & Idemudia, 2014). Considering these variables, an additional load is placed on military aviators to maintain their situational awareness and mitigate errors.

A plethora of research findings, including military studies, indicate scant literature related to safe performance indicators to guide CRM programmes. Current literature also reflects an almost exclusively US military perspective (Kanki et al., 2010). Cooke (2012) argues that South African aviation studies are limited to enhancing a safety culture. He presents the notions of behavioural change through an understanding of human error and argues that the cognitive system approach is limited to developing a scientific model aimed at behavioural change and developing safety-based thinking and behaviour. Similarly, the South African Air Force must manage acute pressures in a constantly changing and dynamic domain and aircrew must perform operations safely within this environment.

CRM safety training is recognised as a controllable variable in the aviation safety system (ICAO, 2013). The link between applied human factors and CRM training to instill safe behaviour is widely recognised (Kern, 2011). Aviation practitioners agree that applied human factors and CRM training require a renewed effort to embed safe behaviour in aircrew and ensure lower accident rates (Salas & Maurino, 2010). Adding to these limitations, resilience engineering is an underdeveloped science in South Africa; it is not effectively integrated within CRM training, and therefore does not provide aircrew with the necessary skills to detect and manage risk pro actively.

Although researchers agree that emotion influence aircrew performance, and that this may result in human error, this concept is not fully addressed in CRM training (Kern, 2011). Behaviour-based assessment provides evidence of emotional content and suggests that emotional suppression is detrimental to our well-being and safety (Hefferon & Boniwell, 2011; Stein & Book, 2011). Agreeing with Kern (2011), Behrmann (2015) describes the influence of hazardous attitudes and cognitive biases, which may well turn us into our own worst enemy.

Clearly, the scope of human factor science should be broadened. One prominent reason remains why aircrew do not speak up, but remain silent despite devastating consequences (Dekker, 2011). A study by Ramesar, Koortzen and Oosthuizen (2009) revealed a significant relationship between emotional intelligence and stress management and explains how stress erodes mental abilities. Available literature studies dealing with the effect of emotion on safe performance emphasise current research limitations. These limitations were the underlying reasons why the researcher wanted to explore the manner in which emotion affects situational awareness related to human error.

Emotional competence and emotional intelligence have parallel definitions, and both incorporate aspects of thinking, feeling and emotional awareness. Furthermore, social intelligence overlaps closely with emotional intelligence constructs (Ortner & van de Vijver, 2015). The evolution of the definition of emotional intelligence is echoed in various definitions of emotional constructs. Importantly, this study agrees with Bar-On (1997) who defined emotional intelligence as an array of non-cognitive capabilities, competencies and emotional skills. In the current study, the researcher was specifically interested in the array of emotional abilities related to situational awareness and human error in aviation.

The researcher therefore explored numerous behaviour-based models and theories (Ortner & van de Vijver, 2015) and found that literature and research studies directed this study towards many applied human factor models. Based on Reason's (2000) classical Swiss Cheese human error model and situational awareness theory, human factor classification was extended by developing the HFACS model (Wiegmann & Shappell, 2003) to identify latent and active factors that may lead to human error. Furthermore, the researcher consulted information-processing models (Behrmann, 2016) and emotional intelligence models (Bar-On, 1997). She explored many scientific models and was guided by classic behaviour-based taxonomies, including the Boundary Questionnaire, Big Five and MBTI, to develop a taxonomy of emotional awareness constructs related to safe performance. These constructs were conceptualised, operationalised and explored in relation to situational awareness and human error. Theoretically, the researcher derived at emotional awareness constructs related to aviation performance and situational awareness. Specific scales applicable to situational awareness are emotional awareness, stress management, flexibility for good judgement, openness, impulse control, problem solving, assertiveness and independence.

Aware of the limitations of CRM, the researcher argued that aircrew must be coached in terms of emotional awareness. Additionally, the researcher suggested that CRM must be applied to the unique demands of the environment and focused at individual experiences that have an impact on safe performance (Bienefeld & Grote, 2012).

According to Brown and Moren (2003) it requires a paradigm shift for most of us to accept that our behaviour is driven by emotions of which we are mostly unaware. Considering the importance of emotional awareness, the researcher realised the need for applied human factors to enhance aviation safety by applying CRM skills.

Research findings by Bar-On (2010) acknowledge the importance of emotional awareness for safe behaviour, and indicate that although emotional intelligence is an integral part of positive psychology, self-awareness is the most prevalent human factor to consider (Stein & Book, 2011).

Adding to these studies, the researcher explored the role of emotion on human performance and human error. This study therefore explored a behaviour taxonomy for human factor training embedded in CRM (Stein & Book, 2011).

The literature review and aviation research limitations amplify the need for aviation human factor research that is aimed at safe behaviour. Worldwide, aviation studies express the need for applied human factor studies to provide aircrew with the necessary psychological skills to practically enhance safe flights (Cooke, 2012; Kern, 2009). Considering these limitations, the researcher explored the effect that emotion has on human performance and human error and to arrive at a safe-behaviour taxonomy for CRM (Stein & Book, 2011).

The value of applied human factors in aviation has only recently been acknowledged (Harris, 2012; Kanki et al., 2010). Research in the applied human factor domain aims to gain an understanding of human factors and apply such human factor knowledge to aviation. Human factor studies all over the world aim to enhance aircrew performance by means of CRM training. The literature review and aviation studies support the researcher’s argument that human error has an emotional platform (Kern, 2011; Lintern, 2011).

The ICAO (2013) prescribes applied human factors and CRM training to address human factor limitations and argues that it is essential to create emotional awareness relating to unsafe hazardous attitudes. Emotional awareness skills enhance strategies for stress management to cope with environmental demands, manage emotion and reduce human error.

The applied human factor science identified an array of human influences within the HFACS framework (Wiegmann & Shappell, 2003) that challenge safe human performance. Examples of these human factors include stress management, adult ADHD, impulsiveness, destructive emotion, ego states and distrust, which add to false mental models and limit CRM strategies, thus resulting in human error (Schwarz et al., 2016). To perform optimally within a limited time in a stressful aviation environment, cockpit or control tower, and to make good decisions, aircrew and ATC need CRM skills to ensure an uncontaminated psychological demeanour (Harris, 2012; Kern, 2011; Stein & Book, 2011).

This study proposes the safety requirement for applied human factors and safe behaviour-based research to understand the world of aviation, integrated with human factors for safe performance. Added to these, the psychological demands on aircrew, life experiences, personality types and limited emotional understanding, influence safe performance.

Applied human factors within the scope of CRM provide a platform for potential learning that is conducive to emotional understanding, shared lessons learned and openness towards human factor principles. The researcher is of the opinion that emotional awareness training will contribute to enhanced decision making, emotional clarity and problem solving. Research provides evidence of the influence of emotional awareness and its contribution towards safer skies.

Aviation safety is a worldwide concern that needs to be addressed within the aviation psychology and applied human factor domains. Researchers realise the value and importance of emotion as human factors trait, as well as the effect of hazardous attitudes have on safe performance, and therefore agree that it must be included in CRM training. Thus, the researcher formulated a research proposal and hypothesised a relationship between emotional awareness and human error. She planned an etiology and exploratory research design for the aircrew descriptives to be effective, and organised the data to be explored for the different research hypotheses. The researcher spent the necessary time on exploratory research before she conducted the descriptive phase.

Acknowledging the need for emotional awareness, the researcher hypothesised that emotional awareness training must be incorporated as applied human factors into CRM training. She believes that emotional awareness will enhance aircrew's situational awareness abilities and reduce future human error. Furthermore, aviation incidents and life occurrences such as divorce, depression or death in the family have a negative impact on aircrew's behaviour and necessitate additional interventions. This fact illustrates obvious limitations to annual CRM training. Individual human factor coaching will contribute positively and enhance aircrew's emotional awareness and ability to manage and regulate emotion – ultimately contributing to aviation safety.

6.5 THEORETICAL CONCLUSION

Literature could not provide substantial evidence to explore human error models and questionnaires to guide safe aircrew behaviour traits. Research results and construct validity can only be tested based on a well-contextualised theoretical model. The researcher conducted a comprehensive literature study followed by a meta-analysis of the Boundary Questionnaire to measure emotional awareness traits. She pursued the initial research aims to explore the value of emotional awareness and suggests emotional awareness training to manage human error. The researcher believed her study was consistent with the theoretical model and findings, and possessed content and construct validity to the extent that the findings were consistent with the theory of the constructs emotional awareness and human error.

The fourth aim of this study explored and conceptualised the theoretical relationship between emotional awareness and human error in aviation. She also questioned whether a relationship existed between the emotional awareness sub-constructs related to human error. Adding to these findings, literature studies were consistent by validating the "Big Five" taxonomy applicable to aviation, human error and aircrew selection, regardless of mustering (Fitzgibbons et al., 2004). Results correlated positively with training performance and found that agreeableness and conscientiousness were crucial performance traits. Fitzgibbons et al. (2004) made use of the NEO Personality Inventory with the "Big-Five" scales neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. They reported a high correlation ($r = .73$) between thinness of boundaries and openness to experience. Adding to these findings, the researcher theoretically explored and contextualised the "Big Five" traits and coupled them with the engendered emotional awareness sub-constructs. These personality traits related consistently with the emotional awareness sub-constructs. The researcher argued that emotional awareness would increase aircrew's performance to emotionally sense threatening flight conditions that might jeopardise flight safety, and thus to correct their perception and manage human error.

Although human factors research and literature contributed significantly to aviation safety, practitioners argue that the academic debate does not help aircrew to understand and practically apply human factors. This challenge amplifies the need for a new error management approach and applied CRM training. Training must equip aircrew with the ability and self-knowledge to improve their emotional awareness to skilfully manage human error (O'Connor & Campbell, 2010; Salas & Maurino, 2010). Additionally, experts argue that applied human factors training is limited in providing aircrew with the necessary emotional skill to sense and perceive themselves accurately in relation to the environment. Emotionally aware aircrew should regulate and manage emotional threats accordingly and in time to manage human error (Harris, 2011; Schwarz et al., 2016).

Specific research aims were addressed to explore the relationship between emotional awareness and human error. Adding to Endsley's (2000) well-known definition of situational awareness, the researcher argues that aircrew must not only "perceive the elements of the environment" accurately, they should also direct attention inwards, and perceive and integrate emotional information with visual environmental information. In order to explore emotional awareness related to human error, specific research aims were conceptualised and operationalised in the current study. These aims involved gaining perspective in the field of aviation safety, industrial psychology and applied human factors, to develop emotional awareness as a skill to manage human error.

6.6 EMPIRICAL CONCLUSION

Positivism assumes that there is only one truth – an objective reality that exists independent of human beings (Sale, Lohfeld & Brazil, 2002). Chapter 3 presented the empirical phase of this study within a positivist framework. The basic stance of this paradigm was argued to be both reductionist and deterministic. The investigator assumed the investigated "object" to be an independent entity, and studied aircrew in isolation from any influence (Guba & Lincoln, 1994). A positivist reality was assumed, driven by immutable natural laws and mechanisms. From this perspective, this study provided proportionate evidence to be generalised to aviation.

Literature studies support arguments that human error remain the primary cause of accidents (Karanikas, 2016). To contribute to aviation research, the researcher extended her study by exploring possible relationships between emotional awareness, human error, aviation experience and mustering. Identified applied human factors studies affirmed the need for aircrew to recognise their emotions and the relationship between emotional awareness (de Boer & Hurts, 2017) and human error. The conceptual framework that constitutes the basis for this study was developed within the aviation human factor paradigm. The independent variable; emotional awareness and the dependent variable; human error was conceptualised in accordance with research aims 2 and 3.

Variables were conceptualised to specify the exact meaning of each emotional awareness and human error concept. Measurement indicators were described to measure these concepts and relate them to the dimensions of human error (research aim 5). The Boundary Questionnaire was administered to 173 SAAF aircrew members and results were related to human error data captured for the past ten years.

The researcher selected five Boundary Questionnaire categories applicable to this field, to study aviation-related behaviour. Aircrew results from Boundary Questionnaire chapters 1, 3, 5, 7 and 8 were selected and operationalised for research analysis (research aim 6). To unravel the independent variable, emotional awareness, the researcher conducted factor analysis to explore emotional awareness sub-constructs related to human error. Factor analysis explored the underlying themes of the construct emotional awareness to derive a taxonomy of behaviour indicators. The researcher explored specific relationships between the eight emotional awareness factors related to human error (research aim 7).

This study explored three empirical research questions. It was asked if there were any differences between human error incidences related to aviation experience and mustering. A non-experimental quantitative research design was adopted to measure a possible relationship between the variables emotional awareness and human error by administering the Boundary Questionnaire. The researcher obtained quantitative human error data related to aircrews' self-reported human error. Emotional awareness and human error data analyses were performed, in relation with the moderator variables of aviation experience and mustering. According to Chapter 2 (the literature study), variables were conceptualised to specify the exact definitions and meanings of the different emotional awareness and human error concepts. Measurement indicators were described to measure the emotional awareness concepts related to the dimensions of the ill-defined construct of situational awareness in aviation. The research found few significant relationships between the emotional awareness traits, human error and the moderator variables. Only experience (in aviation) correlated significantly (negative) with both the sub-scale 'exactness' and with the sub-scale 'openness', indicating less experienced pilots tend to be more precise and like rules to be spelled out and more open to alternate experiences.

Research question 7 dealt with the relationship between emotional awareness and human error. The emotional awareness construct was explored and analysed as sub-constructs and related to individual aircrew human error incidences. The researcher found that there was no significant relationship between emotional awareness and human error. A positive significant correlation between human error and the 'Blend' sub-scale was found confirming the need for exactness. All other sub-scales showed no significant correlation with the human error categories. The results of the Kruskal-Wallis test were significant for human error and the 'Imaginative' trait. Results presented in Chapter 5 indicate the significant difference for aircrew who are considered 'imaginative' ($p = .043$). The implications of this are discussed in section 6.11. The current study provides a platform for further research to explore why imaginative aircrew are prone to err and the results highlight the need for a safe behaviour trait taxonomy applied to aviation. These results are consistent with previous aviator profile studies that used the MBTI as measuring instrument and congruent with findings from a study conducted in South Africa by Bar-On (2010) on emotional intelligence to explore the factors related to success and well-being.

All the research aims were addressed, conceptualised and operationalised as directed by the proposed research question, to explore the relationship between emotional awareness and human error in aviation. The study found no significant relationships between the emotional awareness sub-constructs and human error – with one exception, namely the sub-construct ‘Imaginative’ – and the researcher discussed the value of this finding in terms of human error management. Furthermore, relationships were conceptualised and variables operationalised for future applied human factor studies.

6.7 RESEARCH LIMITATIONS

The researcher conceptualised and operationalised the research aims and identified several research limitations that might have influenced the quantitative data and limited the scope of this study. These limitations must be considered for interpretation.

6.7.1 The Hartmann Boundary Questionnaire

The Boundary Questionnaire measures emotional awareness boundaries and refer to degree of separateness or connection between mental functions and processes. High emotional awareness is associated with open mindedness, creativity, and imagination versus reality, high emotional boundary people have fluid sense of identity and tend to merge or lose themselves in relation to others. Aircrew with low emotional awareness differentiate clearly between reality and imagination and self and others and tend to prefer well defined structures (Hartmann, 1991; Zborowski, Hartmann, Newsom & Banar, 2003).

The literature review guided the researcher to select only five Boundary Questionnaire categories applicable to this field in order to study aviation-related behaviour. Aircrew results from Boundary Questionnaire chapters 1, 3, 5, 7 and 8 were selected and operationalised for research analysis.

6.7.2 Limitations of human error data

A plethora of research studies support the view of the researcher regarding limited applied human factors literature within aviation literature (see Chapters 1 and 2). Researchers agree that although human error data is available, human factors application is poor and poses a threat to aviation safety. In addition, aviation practitioners are not integrated within the aviation system, thus limiting application within the field. These limitations influence every aspect of safe human performance and providing emotional awareness skill to manage human error (Karanikas, 2016). Aircrew furthermore under-report human error, which results in false low incidence reports and skewed safety data that subsequently influence interpretation. It is important to note that aircrew's silence may be attributed to flawed safety cultures, fear of punishment and avoiding shame. Limited human factors application may also fail to encourage reporting and facilitate effective CRM.

6.7.3 Range restriction

The researcher expected that aircrew recruitment and selection according to a predetermined profile may have influenced the aircrew sample. Skewness of emotional awareness data may be the effect of recruitment and selection that is directly or indirectly subjected to a preference for selecting medium to thick emotional awareness boundary profiles.

6.7.4 Aircrew medical evaluation

Since prescribed annual flight fitness ratings are subjected to psychological evaluation and have an impact on aircrew careers, the researcher expected the medical evaluation of aircrew to have influenced and limited her data and research results. Aircrew members do not always disclose self-knowledge honestly (ICAO, 2013). Furthermore, aircrew self-reported a sense of heightened caution when they completed the Boundary Questionnaire regarding emotional awareness limitations. Aircrew admitted that they were protecting their fit-to-fly ratings at all cost. They also acknowledged a predisposition and concern about psychological measuring instruments (especially emotion) adding to their fear to be evaluated or judged. Although the researcher complied with ethical procedures, she believed aircrew to have completed the Boundary Questionnaire with caution to prevent harm to their own medical validations. The researcher admitted that there were limitations in human error and emotional awareness data, as the questionnaire was subjected to a degree of safe and neutral answers that affected research results and meaningful interpretation.

6.7.5 Emotional awareness training

The researcher also expected neutral responses, due to the perceived influence on annual medical ratings. Personal perceptions and biases might have influenced aircrew's attitudes and caused suppressed emotional awareness or flawed responses.

These limitations and evidence of suppressed emotional awareness influencing aircrew performance (Schwarz et al., 2016) contribute to the need for applied human factor research related to human error (Vidulich & Tsang, 2016). In South Africa, applied aviation psychology is lagging. Industrial psychologists need to apply human factors for ethical CRM training and enhance human error management.

6.7.6 Small female sample

Gender bias encouraged the researcher to explore aircrew's gender differences in relation to human error. Exploring literature and previous studies, no gender differences were found related to human error (Walton & Politano, 2016). Similarly, no evidence was found in a study by Vermeulen and Mitchell (2007) to assess gender differences related to human error. Although the female sample in the current study was too small to analyse (9%), previous studies found a significant difference between gender and emotional awareness related to aviation human error. Recommendations from this study will be discussed in the following section.

6.10 RECOMMENDATIONS FOR ORGANISATIONAL PRAXIS

The aviation system provides a valuable platform and research opportunity for applied aviation psychology and human factors science. The researcher found that human factor training was limited in South Africa and not integrated with human error management programmes. She also realised the opportunity that crew resource management provide for applied human factors research and development. Experience shows that aircrew are more open during human factors training discussions when they freely share emotional experiences and participate in role play scenarios. Knowledge gained from safety reports, incidents and accidents should be continuously incorporated into human factor interventions to develop and align them with future CRM training. Adding to this, psychologists and industrial psychologists should use human factors and error information to explore aircrew performance. This integrated approach provides scientific scope for applied human factors science to develop within the challenging human-machine synthesis within the technologically advanced aviation environment.

Although research question 4 was explored within the literature review and studies suggest that women are emotionally aware, gender data was not sufficient to be studied empirically. Results from this study are consistent with the utility of differentiating androgyny into positive and negative categories of gender role identity and suggest that androgynous people are psychologically advantaged. Gender role behaviour supports the additive androgyny hypothesis that androgyny predicts higher emotional awareness related to safe behaviour (Bernstein & Volpe, 2016; Lam & McBride-Chang, 2007). An emerging trend in respect of androgyny in aviation indicates that female aviators with higher testosterone levels show more masculine personality traits, equal to male aviators (Walton & Politano, 2016). Future research might be directed toward the ideal combination of gender-related behavioural traits for optimal performance and provide best gender CRM practices.

Research aims were directed at exploring and operationalising the relationship between emotional awareness and human error. Supporting the primary aim of this study, the researcher proposed additional human factor training to previous human error models (Reason, 2000). For safe performance, the researcher suggested that aircrew must not only direct their attention outward to perceive information from the environment accurately, but they should also integrate emotional awareness cues. Emotional awareness provides important tell-tales related to the outside world, for a comprehensive and real-time aviation picture.

In positivism, reality is assumed to exist, driven by immutable natural laws and mechanisms. From this perspective, this study provides proportionate rewards to aircrew, generalised to aviation.

6.11 RECOMMENDATIONS

It is only over the past decade that human factors in aviation have been formally recognised and applied within crew resource management. The international regulatory body, the International Civil Aviation Organisation (ICAO) prescribes compulsory CRM training annually, to provide aircrew with the necessary knowledge, skills and attitude to manage human error (O'Connor & Campbell, 2010; Salas & Maurino, 2010).

The value of emotion awareness training to guide safe behaviour (Jawer & Micozzi, 2011) propelled this study to explore the relationship between emotional awareness and human error. The researcher proposes that low emotional awareness as human factor, influence aircrew safe performance negatively. Aircrew need to realise that their hazardous emotional states influence aviation safety (Reason, 2000) and degrade effective Crew Resource Management and performance (Munene, 2016). Following this predisposition, a flawed perception influences comprehension of available information and data configuration, as well as behaviour and decision making, resulting in system indications not being monitored, late responses and re-active behaviour. This study proposes that, information derived from emotional awareness must be integrated with real-time environmental information to enhance problem solving and decision making.

6.11.1 SACAA Regulation: Applied human factors and CRM

Although this study focused mainly on SAAF aircrew within the confined military space, research findings and recommendations can be applied in future human factor studies and generalised to the entire aviation population. As supported by this study, human factors scientists agree that aircrew members rationalise and suppress their emotions, and this may cause human error. Similarly, Brown and Moren (2003) argues that false beliefs and flawed self-perceptions cause low emotional awareness, leading to suppressed stress to avoid embarrassment. Supporting these statements, aircrew profile studies concur that interpersonal and emotional aspects must be incorporated into applied CRM training (Landman et al., 2017).

Human factors studies realised that aircrew members lack emotional skill to sense emotional tell-tales and realise human error in time (Harris, 2011). Studies by NASA argue that safe performance can be construed as a product of skill, attitude and personality factors (Fitzgibbons et al., 2004). It is evident from these studies that emotional awareness is required to enhance safe performance. These arguments provide compelling evidence in support of the need for applied human factors in South African airspace.

To predict and reduce human error in aviation, this study explored emotional awareness as behavioural indicator to predict human error as operationalised in Chapter 4. Logically arranged human error data was recorded according to aircrew experiences and related to each of the emotional awareness traits: imagination, involved, exactness, structured thought, unstructured thought, openness, blend and flexibility. The researcher proposed these emotional awareness sub-constructs as taxonomy behavioural traits and human error predictors for aircrew profiling and CRM training to enhance aviation safety.

The researcher identified a gap within applied human factors and CRM that has not been facilitated by aviation industrial psychologists and recommended emotional awareness training to reduce human error. The researcher also proposed a taxonomy of emotional awareness traits as behavioural markers to direct aircrew selection and CRM.

Although the researcher was mainly concerned with emotional awareness related to human error, this study highlighted the limitations of CRM training. Aircrew realised the value of human factors training but are concerned with non-professional CRM facilitators tackling and teaching psychological constructs such as emotional intelligence, without realising the ethical and dire consequences of flawed application. Aircrew members admit the value of applied CRM principles and realise the ineffectiveness of old school practices such as aversion therapy as primary training method (i.e. displaying fatal aircraft accidents). Applied human factors is recommended to explore aircrew behaviour related to emotional awareness and human error management, and to provide skill to enhance safe behaviour.

6.11.2 Predictive behavioural models for pro-active safety management

Emotional awareness variables were structured as eight sub-scales to performance measurement for future aviation safety assessment and training. The research in hand proposed applied human factor training, integrated with industrial psychology involved not only with aircrew selection, but also with safety training and human error analysis. Human factor training must address emotional awareness as trait to be aware of stress, distrust, anxiety and negative emotional states. Besides these human predispositions, life happens and individuals are faced with additional stressors such as family difficulties, external deployments, career uncertainty, expiring contracts, aviation incidents, accidents and colleague fatalities. All these emotions influence safe performance by affecting the individual's coping strategies and unless pro-actively managed, the stressors pose a threat to aviation safety. The researcher suggested that emotional awareness as Human Factor trait be included in CRM training to manage human error. In addition, the researcher realised the need for personal directed coaching. Interactions with aircrew highlighted the need for practitioner support to gain emotional awareness and manage stressors within a demanding environment.

The ICAO (2013) prescribes the application of human factors such as EI training to CRM to teach skill for safe performance. Although applied aviation psychology is limited in South Africa, the researcher proposes continuous human factors interventions, referred to as “positive intervention programmes” (Ehmke, 2012). The value of this approach was presented to aviation human factors practitioners during an aviation psychology symposium held in South Africa in 2015.

6.11.3 Re-active safety management

Aircraft accident investigations (AAI) provide valuable information regarding the human error chain. For maximum value, industrial psychologists and human factor practitioners must analyse human factors related to human error. The impact of an aircraft accident in 2011 on an aviator illustrates the need for practitioner interventions, as the young female commander afterwards quit her flying career.

Furthermore, the researcher recommends critical incidence stress management and aircrew support such as the *Mayday-sa Aviator Support Group* (www.mayday-sa.org.za) as they acknowledge the impact of a significant aviation event on aircrew performance and aviation safety.

Search and Rescue (SAR) often exposes aircrew to fatal accidents, which causes trauma. Feedback from aircrew confirmed the negative impact of these emotional experiences. Although aircrew do not speak up, they often continue with their flying duties without critical incidence interventions to address the emotional trauma.

6.11.4 Emotional Awareness as Human Factor trait included in CRM training

A decade of traumatic aviation experiences and numerous confidential reports from aircrew confirm the dire need for applying human factors, providing emotional support, coaching and recommend human factor practices. Qualitative data derived the value of human factor interventions and coaching for CRM. This amplifies the need for applied human factors and further research and development to understand and enhance safe performance.

For maximum value, the researcher proposes an applied health practitioner approach and continuous involvement to explore the field of aviation. Specific coaching must be provided in addition to CRM, life events and psychological support, and this should not threaten aircrew's medical status. Annual CRM training should not be referred to as a mere "tick-in-the-box" requirement to fly, prescribed by international aviation regulations. The researcher consequently proposes emotional awareness as human factor trait to be included in CRM training by introducing interventions applied for specific aircrew mustering.

6.12 FINAL CONCLUSION

This chapter dealt with the conclusions, limitations and recommendations of this research in the field of human factors. Although aviation safety relies on flawless and smooth interaction between man, environment and machine, we are faced with a flawed human design prone to human error. Adding to this conundrum, operational tempo and environmental demands do not only pose a threat to safe performance, but also to human lives.

The research aims were contextualised to deal with the research question and the general aim, namely to explore emotional awareness related to aviation human error. The study in hand explored literature and previous research results, and provided a platform for an alternative approach to human error. The value of emotional awareness as human factor trait was explored and linked to safe aircrew performance (Reason, 2000).

Worldwide, aviation human error remains a threat and aircrew remain silent, failing to speak up when they feel uncomfortable or concerned. Added to these are underlying shame, ego limitations, and fear of revealing human vulnerabilities, all of which influence reporting and reliable human error data. An integrated ethical approach that involves health practitioners and aviation specialists must direct future CRM training, in order to explore human limitations and identify safe performance indicators. The researcher proposes that emotional awareness training be incorporated with CRM, configured for the unique expectations of mustering and operational environment.

Based on the specific research aims, this study explored the relationship between emotional awareness and human error. The researcher explored the well-known definition for situational awareness by Endsley (2000) and realised the importance of emotional awareness, in addition to information from the outside world. To perceive environmental elements accurately it is necessary that aircrew integrate information with emotional awareness, as the latter provides valuable cues in addition to environmental information, to accurately comprehend information.

In the dynamic world of aviation, the researcher aimed to create research space to explore the relationship between emotional awareness and human error. Although this study did not provide evidence of a significant relationship between emotional awareness and human error, literature and human factors studies confirm the importance of emotionally aware aircrew to regulate emotions in the aviation environment. The researcher proposes future research with aviation industrial psychologists to synthesise and apply emotional awareness knowledge in an attempt to reduce aviation human error. Future research must be based on systematic aircrew enquiry to guide the selection of members and CRM training to develop skills for safe behaviour. The present study explored human factors and realised the need for future studies, applied human factors and interventions to facilitate emotional skill. Collectively, human factor specialists must explore the field of aviation and develop safety training strategies and interventions with one seamless goal – to manage human error.

The real value of applied human factors for effective crew resource management has not been discovered yet. Although compulsory, it is no secret that most aircrew consider their annual CRM training as a mere formality – a *“tick in the box”* to indicate that they are “fit to fly” or a ticket to perform air traffic control duties. Contrary to this belief, annual CRM training is not ticking the safe box. Aircrew need emotional understanding to manage human error. Industrial psychologists must address CRM limitations, conduct research and collaborate to ensure pro-active safety measures. Aviators are deprived of self-insight to understand and manage their own emotions and emotional states, which affect decision making and problem solving.

There is still much to discover within the domain of human factors and error management in aviation. To explore human factors application, reliable human error data is required. Therefore, regulators must encourage honest human error reporting to regulate applied human factors by means of Crew Resource Management, as advocated by the non-punitive just safety approach within an open, learning and flexible culture (SACAA, 2016)

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APPENDIX A: Oblique Factor Rotations

BQ Category 1: Pattern Matrix

	Factor						
	1	2	3	4	5	6	7
q1							
q49			.714				
q27		.493					
q92		.447					
q119	.342		-	-.418			
q60	.566		.313				
q134	.534			.542			

Extraction method: Maximum Likelihood
Rotation method: Oblimin with Kaiser Normalization
Rotation converged in 19 iterations

BQ Category 3: Pattern Matrix

Pattern Matrix

	Factor						
	1	2	3	4	5	6	7
q3			.781				
q15		.547					
q39						.557	
q51		.597					
q62			.693				
q74		.325		-.355			
q84		.436			.718		
q94	.561	.618					
q102	.367	.510				-.376	
q106		.401			.399	-.372	
q115					.392		
q127		.921					
q132		.702					
q136	.985						
q27r							
q139r					.730		

Extraction method: Maximum likelihood
Rotation Method: Oblimin with Kaiser Normalization
Rotation converged in 26 iterations

BQ Category 5: Pattern Matrix

Pattern Matrix							
	Factor						
	1	2	3	4	5	6	7
Q41		-.343		.460			
Q53	.761						
Q64	.412						
Q85	.385		.630				
Q95			.576				
Q103				.523			
Q116							
Q146			.425				
Q5		.347		.365			
Q29		.418					
Q122		.490					
Q125		.653					

Extraction method: Principal Axis Factoring
Rotation Method: Oblimin with Kaiser Normalization
Rotation converged in 6 iterations

BQ Category 7: Pattern Matrix

	Factor		
q65			.482
q86			.430
q7r	.979		
q19r			.422
q31r			
q43r	.479	.413	
q55r	.562	.509	
q76r	.610	.597	
q96r	.647	.676	
q108r	.394	.436	
q121r	.438	.454	

Extraction method: Maximum Likelihood
Rotation method: Oblimin with Kaiser Normalization
Rotation converged in 19 iterations

Category 8: Pattern Matrix

Pattern Matrix							
	Factor						
	1	2	3	4	5	6	7
q109						.431	
q133				.437			
q142	.484				-.635		
q145	.779						
q67	.735			.453			
q128							
q44r		.603					
q77r	.561		.543				
q87r	.367		.657				
q97r		.378					
q137r		.459		-.466			
q140r					.369		
q144r			.347				
q8r		.419					
q20r				-.759			

Extraction method: Principal Axis Factoring
Rotation Method: Oblimin with Kaiser Normalization
Rotation converged in 10 iterations

APPENDIX B: Factor Loadings

Reproduced factor loadings for exploratory factor analysis after oblimin rotation for the underlying emotional awareness sub-constructs

BQ items	*BQ questions*	*Factor1*	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
	BQ Category 1: Sleeping/waking and dreaming SDW								
1	When I wake up, I am not sure whether I am awake for a few minutes	**.311**			.315				
25	My daydreams don't always stay in control	**.499**			.529				
37	I spend a lot of time daydreaming or fantasizing	**.348**				.378			
82	In my daydreams people merge into one another	**.492**							
112	I have day mares	**.534**							
119	My dreams are so vivid that I cannot tell them from waking reality.	**.342**							
60	My thoughts blend into one another	**.566**			.455				
	% of variance pre-rotation	**25%**							
	% of variance post-rotation	**25%**							
	Eigenvalue	**3.51**							
	Cronbach's Alpha	**.749**							
	BQ Category 1: Sleeping/waking and dreaming (SDW)								
		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
72	I have dreams, daydreams/nightmares in which I see isolated body parts		**.493**						
92	In my dreams, people merge into each other	.492	**.560**						
130	In my dreams, I have been a person of the opposite sex.		**.772**						
	% of variance pre-rotation		**25%**						
	% of variance post-rotation		**25.%**						
	Eigenvalue		**2.67**						
	Cronbach's Alpha		**.749**						
	BQ Category 3: Thoughts and feelings (TFM)								
		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
15	Sometimes I don't know if I'm thinking or feeling	.563	.563	**.676**					
51	At times, I feel happy and sad	.612	.612	**.742**					
84	I get over-involved in things	.452	.452	**.488**					
94	When I read something, I get so involved that it's	.611	.618	**.561**					

	difficult to get back to reality								
102	When I get involved, it is sometimes hard when I stop and the world begins	.471	.367	**.510**		.373			
106	When I listen to music, I get so involved it is difficult to get back to reality	.345	.345	**.401**		.399			
	% of variance pre-rotation			**22%**					
	% of variance post-rotation			**31%**					
	Eigenvalue			**3.5**					
	Cronbach's Alpha			**.729**					
		BQ Category 3: Thoughts and feelings (TFM)							
		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
3	My feelings blend into one another	.340	-.748		**.792**				
62	My thoughts blend into one another		-.710		**.717**				
	% of variance pre-rotation				**10.8%**				
	% of variance post-rotation				**31%**				
	Eigenvalue				**2.3**				
	Cronbach's Alpha				**.729**				
		BQ Category 3: Thoughts and feelings (TFM)							
		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
74	I can easily imagine myself to be an animal or what it might be to be an animal.		.325		.348	**.355**			
127	When I recall a conversation or a piece of music, I hear it just as though it was happening there again right in front of me		.746		.834	**.817**			
132	I can visualise something so vividly that it is just as though it is happening right in front of me.	.351	.641		.605	**.610**			
	% Variance explained					**9%**			
	Extraction sums % variance					**31%**			
	Eigenvalue					**3.63**			
	Cronbach's Alpha					**.729**			
		BQ Category 7: Neatness/exactness or Precise (NEP)							
		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
43r	I am good at keeping accounts and keeping track of my money.	.508	.413						**.479**
55r	I like things to be spelled out precisely and specifically.	.495	.509						**.562**
76 r	When I am in a new situation, I try to find out precisely what is going on and what the rules are as soon as possible.	.622	.597						**.610**

96r	When I am working on a project I make a careful detailed outline and then follow it closely.	.647	.676						**.676**
108r	I am a down-to-earth, no-nonsense kind of person.	.405	.436						**.436**
121r	I read things straight through from beginning to end	.443	.454						**.454**
	% of variance pre-rotation								**18%**
	% of variance post-rotation								**19%**
	Eigenvalue								**3.6**
	Cronbach's Alpha								**.754**

BQ Category 8: Edges and lines (LEC)

		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
67	I like paintings or drawings with soft and blurred edges	.339	.303	.402	-.643		**.735**		
142	I like fuzzy borders				-.418		**.484**		
145	I like wavy or curved lines better than I like straight lines.			.313	-.695		**.779**		
	% of variance pre-rotation						**16%**		
	% of variance post-rotation						**23%**		
	Eigenvalue						**3.60**		
	Cronbach's Alpha						**.703**		

BQ Category 8: Edges and lines (LEC)

		Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*	*Factor7*	*Factor8*
44r	I like stories that have a definite beginning, middle and end.					-.552		**.603**	
137r	I like clear precise borders.		.336	.338				**.459**	**.309**
	% of variance pre-rotation	**25%**	**10%**	**22%**	**10.8%**	**18%**	**16%**	**73%**	**18%**
	% of variance post-rotation	**13%**	**5.6%**	**20%**	**5.08%**	**10.3%**	**10.3%**	**26%**	**10%**
	Eigenvalue	**3.5**	**2.7**	**3.5**	**2.3**	**3.6**	**3.6**	**2.0**	**3.6**
	Cronbach's Alpha	**.731**	**.749**	**.734**	**.729**	**.690**	**.690**	**.713**	**.703**

Extraction method: Principle Axis Factoring

Note: SPSS suppressed loadings less than 0.3, therefore blank spaces for many loadings. Selected factor loadings appear in bold.