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How does bias / scope influence the operational outcome of pressurised incident command decisions and can it be countered?

Geoffrey Sallis

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Abstract

Effective fireground decision - making requires good situation awareness (SA) and appropriate selection from the information available to the incident commander. Individuals can display different information bias / scope in their view of the operational incident: either a liberal bias / scope towards accepting information as true with a risk of false alarm errors and / or a conservative bias / scope towards rejecting information with a risk of misses. Such decision - making bias / scope was examined over a series of five separate studies including operational fire fighters and incident commanders. The studies included a breathing apparatus (BA) exercise, two different table top operational incidents (domestic and commercial) and two exercises for flexible duty managers (FDM) in an assessable simulated fireground incident in 2012 and again in 2013. The studies were based on realistic incidents that both fire fighters and FDMs would be expected to respond to, in the final two studies each individual had to take over command and move towards a successful conclusion from an operational, environmental and social perspective. In all the studies, participants were required to answer true or false to a series of probe statements about the incident, which were analysed by a signal detection tool (QASA) to give a measure of actual situational awareness (ASA), perceived situational awareness (PSA) and bias / scope.

The first exercise was a BA exercise undertaken to identify if bias was shown by FF's when undertaking training, the data analysed by the QASA identified

that most individuals displayed a high level of ASA about the incident, but also showed either a conservative bias / scope (with miss errors) or a liberal bias /scope (with false alarm errors). The results however also show that two individuals can appear to have similar ASA, but in fact still have very different bias / scope in regard to that knowledge. Once it was established that bias was identified this was developed using table top exercises as it allowed more participants and more control over undertaking the research within normal programmed training periods. The analysis of the two table top exercises showed ASA was high in both, but fire fighters perceived their PSA in a similar way if they had high confidence in one exercise they also had high confidence in the other exercise, or vice versa. However there was no significant correlation between the ASA scores and the PSA scores, with the pattern of bias / scope tendencies being differed across the two studies; with no significant correlation. In reviewing these results the identified difference in undertaking the 2 exercises was that in the second FF's were familiar with the process and this allow a more relaxed approach, reducing pressure on the individual. While individuals showed bias patterns within the exercises undertaken, more pressurized exercises were identified to see if this bias was consistent for the individual when under pressure. Using the assessable incident commander exercises run by the FRS to test incident commander competence at a FDM level to undertake this. The exercises were used in 2012 and 2013 using the same individuals to compare their results, the outcome of these two simulated assessable fireground incident studies were;

- for ASA: there was no significant correlation: r = -.120 and p= .623;
- for PSA: there was a significant positive correlation: r =.577 and p = .012;
- for bias / scope there was found a strongly positive significant correlation across the scores: r = .592 which is significant at the .008 level.

The conclusion of the research is that individuals hold bias / scope tendencies and under pressure these tendencies are shown to be resting and will impact (condition) the individual's decisions during periods of operational command during stressful conditions. The finding of bias / scope patterns is an important one that may have implications for understanding errors in incident ground decision - making. The finding of resting bias / scope patterns in FDM is an even more important one, which will have implications for understanding errors in incident ground decision - making and how we can help to reduce them. In semi structure interviews with FDMs who had undertaken the assessable exercises, they believed that knowing their bias was a first step to altering it to allow them to improve their decision making at pressurized incidents. Which supported the ultimate goal of the current research to further the understanding of bias / scope tendency, in order to support the training of effective fireground decision - making.

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FIRST SUPERVISOR Professor Dianne Catherwood, Professor of Psychology,

Department of Natural and Social Sciences

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Abbreviations

AFRS; Avon Fire and Rescue Service
AM; Area Commander
Appliance; fire engine
ASA; actual situational awareness
BA Guide line; a fixed 60m line for fire fighters to search off so they maintained a point of reference when searching a building with reduced visibility and would not get lost due to the lack of clear vision.
BA personal line; a short 6 meter line attached to the belt of the BA set and the BA guide line so the individual does not wonder off and get lost, or fall down a hole in the building floor.
BA; Breathing Apparatus
Bias; information bias / scope
BM; Brigade Manager
BPS; British Psychological Society
CC; crew commander
CFOA; Chief Fire Officer Association
FBU; Fire Brigades Union
FDM; flexible duty manager
FF; fire fighter
FI; fire investigation
FRS; Fire and Rescue Service
Full time; whole time contract with the FRS
GC; Group Commander
GFRS; Gloucestershire Fire and Rescue Service
Hazmat; hazard materials
HR; hose reel
HSE; Health and Safety Executive
Hydra; is a simulation system developed alongside its partner system Minerva, to operate critical incident simulation such as plane and train crashes
ICS; incident command system

ICU; incident command unit
Informative; update message for the incident ground
Jet; full fire fighting hose water stream
Jumpers; wildfire fire fighters who parachute into the hard to reach fire zone, normally from aircraft, but can do from helicopters.
Minerva; is a simulation system developed alongside its partner system Hydra, to operate critical incident simulation such as plane and train crashes
Mobilised; fire engine dispatched to an incident
NDM; Naturalistic Decision Making'
OIC; Officer in Charge
OODA; observe, orient, decide, act
OPA; Operational performance assessment
PDA; pre determined attendance
Persons reported; people reported as missing within the premise
PPE; personal protective clothing
Ps; participants
PSA; perceived situational awareness
QASA; quantitative assessment of situation awareness
QUASA; quantitative unit assessment of situation awareness
R/L search pattern; right or left hand search pattern
Retained; part time contract with the FRS
RPD; Recognition – Primed Decision Making
RTC; road traffic collision
RVP; incident meeting point
SA; situational awareness
SAGAT; Situation Awareness Global Assessment Technique
SC; station commander
SCG; strategic co-ordinating group
Scope; information filter
SM; station manager
WC; watch commander

Wildfire / (wildland fire); outdoor fire among trees, bushes, bracken and grass moving over a large area.

Chapter 1

1.1. Overview of Thesis: How does bias / scope influence the operational outcome of pressurised fire incident command decisions?

1.1.1 Background to the research: The research is broadly based on 'Naturalistic Decision Making' models (Klein, 2008; Zsambok and Klein, 1997) which identify how 'Recognition Primed Decision Making' (Klein, 1997) has the ability to influence decision - making and outcomes on the fire incident ground. Effective decision - making is dependent on good or accurate situation awareness (SA). SA involves being aware of what is happening around you, in order to understand how information and one's own actions will impact on objectives, both immediately and in the near future, an innate feel for situations and events that play out due to variables the incident commander can control. SA is especially important in work domains where the information flow can be high and poor decisions may lead to serious consequences, or impact on the understanding of what is happening in the situation (Endsley, 2000). There are a number of different theoretical approaches to explain how good SA or effective decision - making occurs (Endsley, 1987; Flin, O'Connor, and Crichton, 2008), but here the focus is on the concept of information bias which reflects the extent or scope of the available information used by the decision - maker in dynamic high pressure /

stress environments (Edgar and Edgar, 2007). Bias can tend either to cognitive and perceptual tunneling on a narrow band of information (narrow scope or *conservative* bias) or alternately towards accepting and using a broader band of information (broader scope or *liberal* bias). The way an individual applies bias or scope to the situation can influence the ability to arrive at a satisfactory outcome to the situation with "miss" errors associated with conservative bias or tunneling scope and "false alarms" with liberal bias or broadening scope that may produce a "butterfly syndrome" in which irrelevant information attracts as much attention as important information. This issue will be explored here in the context of fireground exercises with operational Fire and Rescue Service (FRS) fire fighters and incident commanders.

1.1.2 Broad Aims: These are to;

1) gain further understanding of fireground command and control decision making in relation to how bias or scope influence decisions, and

2) determine, if once identified, this can contribute to training guidelines for self-awareness of how information is scoped personally in fireground situations.

In essence the basis of good SA must be a full understanding of any personal bias / scope and how personal bias scope can / will impact on understanding and implementing operational decisions.

1.1.3 Direct Aims of the Research: The aims here are to;

1) understand if or how information bias / scope by the individual influences or impacts on decisions and outcome in fireground exercises, then if bias / scope is in evidence,

2) determine whether bias / scope works in different ways across individual incident commanders, and

3) finally to then progress this work from the theoretical model into a training / assessment scenario to determine if an individual's bias / scope can be identified and whether this knowledge assists the outcome of the decisions in actual fireground conditions.

1.1.4 Hypotheses: The predictions or hypotheses are:

i) FRS personnel will display either conservative or liberal decision - making bias / scope (with related miss or false alarm errors respectively) during FRS training exercises involving simulations of fireground incidents.

ii) any such bias / scope error patterns will be consistent for individuals over situations / scenarios.

iii) experienced FRS personnel will be less prone to displaying such bias / scope errors.

iv) any such bias / scope will be reduced or moderated by providing detailed personal feedback on bias / scope and error tendencies to individuals following training exercises (i.e. individuals can use understanding about their own bias / scope to reduce errors in decision - making).

1.2 Leadership in Incident Command

Before looking at bias / scope with both fire fighters who can and will take command positions on the incident ground (figure 1.2) and incident commanders there is a need for a general understanding of the models that are used within the FRS to help the individual provide both leadership and incident command. Looking at these models provides the underpinning understanding of the FRS development of the incident commander and will also provided the background to see how the findings from this research could assist in future development to improve understanding of bias / scope in relation to incident decision - making.

Models on leadership and identified requirements for the incident commander are numerous within the FRS internationally, with the UK FRS model ‘Aspire’ (Figure 1.1) breaking these down to leadership capacities for: organising and changing, partnership working, delivering services, community leadership, setting direction, priorities and resources and personal and team skills and showing these qualities practiced within three leadership domains; operational, political and personal and team approach, with operational incident command leadership taking on the risk critical central role for delivery.

Figure 1.1. Aspire, leadership model (FRS manual V.2, Fire Service Operations; Incident Command 3rd Edition 2008).

This risk critical incident command has been characterised by the need to deal with uncertainty in a demanding, compressed time and ambiguous framework, with this being identified not just in the UK (Flin, Salas, Strub, and Martin, 1997), but also in the USA, with the United States Fire administration's objective 3.1, 'Improve the Nation's incident decision making skill's' (United States Fire Administration, 2009, p. 8.). Henry Kissinger identified / argued that that the most important role of a leader is to take on his shoulder the burden of ambiguity inherent in difficult choices; with that accomplished his subordinates then have criteria and can turn their attention to implementation, (Kissinger, 1982). Removal of ambiguity is key for FRS incident commanders in providing clear operational direction for crews and understanding how bias / scope could impact on this is crucial for the research. Organisational leadership calls for 4 major attributes: strategic thinking about the organisation's environment, mobilisation of its resources to achieve its strategy, execution of the strategy and selflessness (Useem, Cook, and Sutton, 2005). All key areas for the incident commander from an operational perspective in making decisions on any incident ground to bring it to a safe conclusion.

1.3 The Fire and Rescue Service operational environment

Fire causes more than 20,000 deaths and up to 500,000 injuries annually in the European Union (EU) (EU Centre for Fire Statistics, 2006). Tragically, these statistics include well trained fire fighters, even through all FRSs aim to provide effective training for their personnel, showing that even highly trained and well skilled fire service personnel can be at risk of making unsafe decisions under the dynamic and high pressure conditions of the fireground, with potentially fatal consequences. For example in the UK, operational fatalities in the fire and rescue service average about one fire fighter a year (Officer of the Deputy Prime Minister, 2004), which from a fire fighter population of 50,000 would indicate the risk is well managed. While a more recent report identifies that a duty related fire fighter death has occurred every 3 months for the past 30 years (Fire Brigades Union Report, 'In the Line of Duty', 2008).

The FRS respond to a variety of incidents from fires in the home and in the work place, to fire in external buildings, grass and forest fires, to road traffic collisions (heavy goods vehicles or single or multiple cars, on or off country lanes, major roads and motorways), building collapse and animal rescue. It has over recent years taken on the response for a high number of flooding incidents and has become the main responder to fast water incidents / rescues. It is also the primary responder to a number of different types of incidents, working at height (from window cleaners in distress on high rise buildings to people falling when out walking their dog near a quarry to rock climbers in some mountain ranges) or below ground (for cave rescue, or with the mines rescue teams at either working or old disused mine shafts). The type of incident, the number and age of people involved and the environment in which the incident takes place provides the degree of difficulty that the incident commander finds themselves managing to a safe conclusion. Identified within the UK FRS are four qualifications for fire incident command (Figure 1.2) that form the basis of all development and assessment for commanders who deal with the different levels of incident response. This training provides the knowledge that underpins and supports the incident commander, allowing the support structure to be developed and managed in support of the incident commander as the incident grows. The training also provides a structure that covers the command of the incident and supports the incident commanders' decisions made on how the incident is tackled to bring it to a safe conclusion (GFRS incident command model, Table 1.1, but each FRS will have its own variation on this model). The key dynamic decisions made will be dependent on the operational needs of the incident; number of staff, appliances, specialist appliances and how best to deploy them to meet the tactical objectives decided by the incident commander. The change out of the incident commander to a more senior incident commander happens where decisions that need to be made for the incident outcome are not necessarily bigger, but are different. As the decisions in relation to the incident become more dependent on the duration of the incident, or on the size of the incident and complexity. Or if the outcome of the incident becomes more significant in the sense of loss (either loss of life or the increased cost of the incident) if the emergency situation is not managed properly. Each incident commander will make the type of decision they feel is required to bring the incident to a safe conclusion, with the different command levels dealing with the nature, size and complexity of the operation.

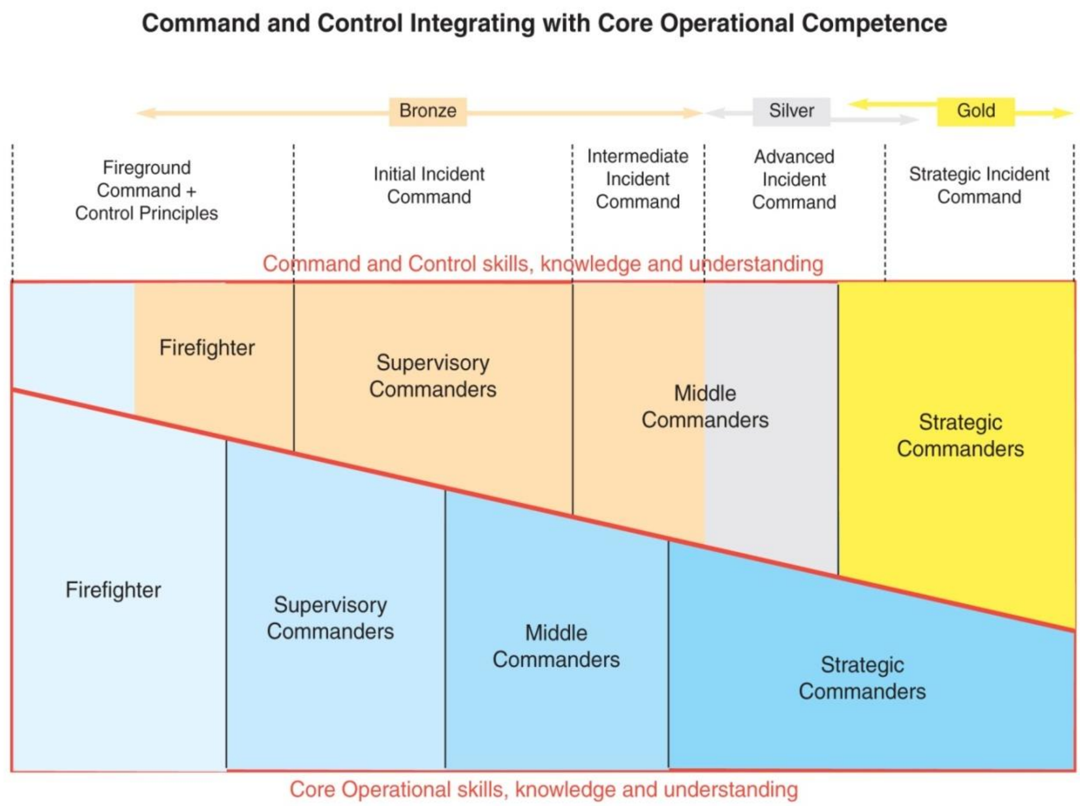


Figure 1.2. Core operational skills, knowledge and understanding.

The diagram above illustrates the relationship between core skills and knowledge and the application of these changes as a fire fighter progresses through the command structure to Strategic Commander (Command Qualifications and Command Training – Guidance Document; CFOA July 2013).

No of Appl's	Role of OIC	Commander Informed	Managers & Roles
1 - 4	CC / WC	Property fire; RTC persons trapped. Stn. Commander	• Incident Commander - Appliance Commander. • SC. if required for specialist roles (i.e. FI, Hazmat, Water, Rope, & OPA)
5	SC	Large property fire; RTC persons reported. Group Commander	• Incident Commander - Appliance Commander either CC or WC. • SC. if required for specialist roles (i.e. FI, Hazmat, Water, Rope, & OPA)
6 - +	GC	Area Commander	• IC Stn. C. + 1 x Stn. C. + 1 x Group C. • SC. perform specialist roles (i.e. FI, Hazmat, Water, Rope, & OPA)

Table 1.1. Break down of the responding commander; Gloucestershire Fire and Rescue Service (GFRS) command model 2010.

Sectorisation (sectorisation diagram Figure 1.3) is used to break down the incident into smaller and more easily manageable areas to gain maximum control of the emergency incident. The sectorisation of the incident ground will allow for the incident to be broken down into smaller areas of control.

This will allow the reduction in the span of control (number of staff reporting to an individual) for each of the sector commanders, which will then build in pyramid fashion to the single incident commander taking on the role and making the major decisions. As the incident develops the incident commander will change to provide a more senior and higher qualified commander and at a certain size (number of staff, size of incident) there will be a need for an advanced incident commander (level 3 command, shown below, figure 1.3), which will also introduce another tier of command. This next tier of command will provide the incident with an operational commander, this commander's responsibility will be dealing with the tactics for the dynamic incident and the incident ground, as well as a command support officer dealing with the resources and information flow on and off the incident ground, both reporting to the incident commander. This will then allow the advanced incident commander to manage and control the holistic incident, looking not just at bringing the incident to a safe conclusion, but also looking at the wider concerns and the impact the incident may have outside the incident ground. The four levels of command are;

1. The initial incident commander (first stage), this is the first attendance incident commander or experienced fire fighter (who would normally attend on the fire engine with the crew) who will be trained and assessed as having the ability to command and control operations at a task focused supervisory level, or to manage and

control a more serious incident that is starting to escalate normally a watch commander (WC), or crew commander (CC).

2. The intermediate incident commander (second stage) would be the responding tactical commander (responding in his provided car from the work place or home), mobilised when the incident is growing or is of a higher risk and following on from the appliance first in attendance. This commander has the ability to review the current operations and decisions made by the initial incident commander, and determine the incident status. They would have the ability and training to assume responsibility and take over command of the incident should they need to. Their tactical training and experience would ensure they operate at a middle manager level for the organisation (station commander (SC) or group commander (GC)).
3. An advanced incident commander (third stage) is the officer trained to tactically command the largest and most serious incidents, working at the incident scene or from a suitable location close to the incident from the incident command unit. They will undertake tactical co-ordination and manage both the operational side of the incident and the command support side of it (group commander (GC) or area commander (AC)).
4. The fourth stage is the strategic commander who would work with the strategic co-ordinating group (SCG), the other key players

(Police, Ambulance, Local Authority, Environmental Agency, etc.) meeting at the SCG designated co-ordinating position off the incident ground (normally Police Head Quarters) and dealing with the overall impact of the incident for the community.

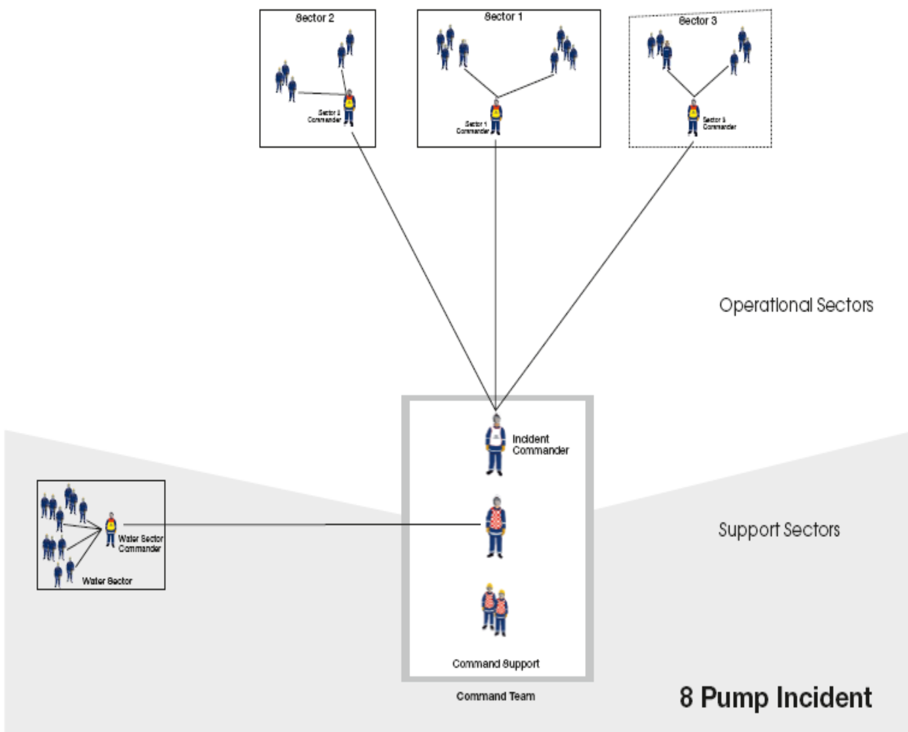


Figure 1.3. Simple sectorisation of an operational incident (FRS manual; Volume 2, Fire Service Operations, Incident Command 3rd Edition 2008).

For operational commanders the understanding of the successful outcome to operational incident management is a changing dynamic: changing from just the risk minimisation of direct harm to life or property, to the wider impact of environmental considerations, political perspective and cost minimisation now becoming key to the understanding of a successful outcome. The five characteristics of a risk critical incident (*FRS manual V.2, Fire Service Operations; Incident Command 3rd Edition 2008*) have some generic / shared considerations covering:

- Time sensitivity / tempo of activity; time pressure on decision - making is critical to the quality of the decision. With the increased pressure within the operational incident, a condensed timeframe can induce further pressure to the situation, adding to the incident's dynamic by increasing the real / perceived tempo of the decision - making considerations for the incident commander.
- Complexity; critical incidents bring with them a degree of complexity that will be perceived by the incident commander as an increasing risk to the successful outcome of the operation. With an ever increasing intrusive media and professional / political (audit, health and safety) role and growing understanding of the wider and less well defined incident risks, the incident commanders uncertainty of how to meet these ill defined requirements bring an increased pressure to outcome objectives.
- Moral pressure; the people / property dynamic of the historic FRS critical incident has now widened to include the environmental and political (either real or media induced) dimensions, bringing with it an increasing pressure on the incident commander to bring about an

early conclusion to the incident, whether this is warranted from an operational perspective at the time or not.

- Duty of Care; the wider context in which an operational incident now sits brings with it further pressure in how a positive action will be viewed following a negative outcome! The increasing uncertainty around the legal parameters and responsibilities of the individual incident commander's liability and organisational support brings with it an increasing awareness of the professional and personal impacts, should the incident not go as planned, and on whose perspective this is viewed.
- Retrospective Scrutiny; also brings a different perspective on the incident outcome and how the actions of the incident commander are analysed in the longer term, even when it is seen as a successful outcome from the FRS's point of view. A decision taken at 3 am on a cold dark February morning in relation to a time compressed incident will look different months later on a Wednesday afternoon in July viewed by other professionals from their own defined paradigm.

It could be argued that given the increasing considerations for all incident commanders, it becomes easier to understand why a critical incident will generate an increasingly intense and complex command environment. While these pressures can be seen to be increasing on the incident commander in relation to all operations on the incident ground, the impact of them adds to the pressurised environment the incident commanders find themselves in and have to be a consideration in the why and how they respond in the way they do.

1.4 Current Practice (UK Incident Command System)

The Incident Command System within *FRS manual V.2, Fire Service Operations; 3rd Edition 2008*, is the basic model for all United Kingdom based FRS. It establishes the basic doctrine of the FRS in the context of operational incident management and functional command and control processes that flow from it. The key elements of effective incident command are represented in three areas;

- Organisation of the Incident ground; providing a recognised pattern for the incident ground for resource organisation.
- Incident Risk Management; hazard identification and applications of a safe system of work for undertaking the operation
- Command Competence; skills, knowledge and understanding identified as required by the incident command and seen as the competencies to be maintained.

It is considered the system covers the 7 predictable areas within the need for command that Brunacini (1985) identifies as required for management of the incident ground;

- Action

- Command and Control
- Coordination
- Planning
- Organisation
- Communications
- Safety

These considerations allow for the UK FRS and the incident commander to work effectively within the broader multi-agency envelope, that is the growing consideration in relation to the changing dynamics of incident / environment considerations. Using the ‘Managing Incident: Decision Making Model’; (*FRS manual V.2, Fire Service Operations; Incident Command 3rd Edition 2008*) looking at the Incident needs, resource and hazard and safety information available and required; thinking about it and producing prioritised objectives for an identified outcome, from which to develop a plan; which needs to be communicated and controlled to arrive at the identified outcomes and with an evaluation loop to allow for a dynamic environment, changing information and needs to meet the identified outcome (Figure 1.4).

Within both the USA and UK FRS there is a drive from all the fire services (Flin, et. al. 1997; United States Fire Administration, 2009) to improve incident commander’s competence to undertake the role. There is more focus on a model to use in training and an operational environment and a need to be a reflective practitioner on the experiences we have. What is no't seen is an acceptance *(FRS manual V.2, Fire Service Operations; Incident Command 3rd Edition 2008)* that this is providing all that an incident commander needs to deliver an acceptable outcome for the incident to the plethora of parties involved. That is, an outcome that can maintain a consistency and be produced by all incident commanders, as the training / development model and incident command model duplicates the inputs in relation to the training and information provision on the incident ground.

It could be questioned what do the incident commanders require to ensure they are competent, if training, the incident command system and the current operational command decision - making model do not provide it. If we are using the same training inputs and command system for each of our incident commanders as they develop, why is it we do not have the same outcomes for each incident that we command.

1.5 How does the FRS undertake (support) its fire ground decision - making;

In managing an operational incident within the UK FRS there has been a move away from the purely experience based exposure (gained at operational incidents) and repetitive training (within the drill yard) to produce the good incident commander. This move has been towards the realisation that to ensure the best outcome for the incident there is a requirement for a structure on which the incident commander can develop and progress into the future their training and experience. There has been a realisation within the FRS that experience and training requires a structure or a process for the key learning points and concepts of managing and decision - making at incidents to be understood. This incident command system will then provide the knowledge base required to deliver the best outcome for the incident to be structured around. This knowledge progressed through both education and training in incident command has been added to and supported by experience gained within a learning and reflective operational environment, bringing us to the present state of play of the current operational commander template.

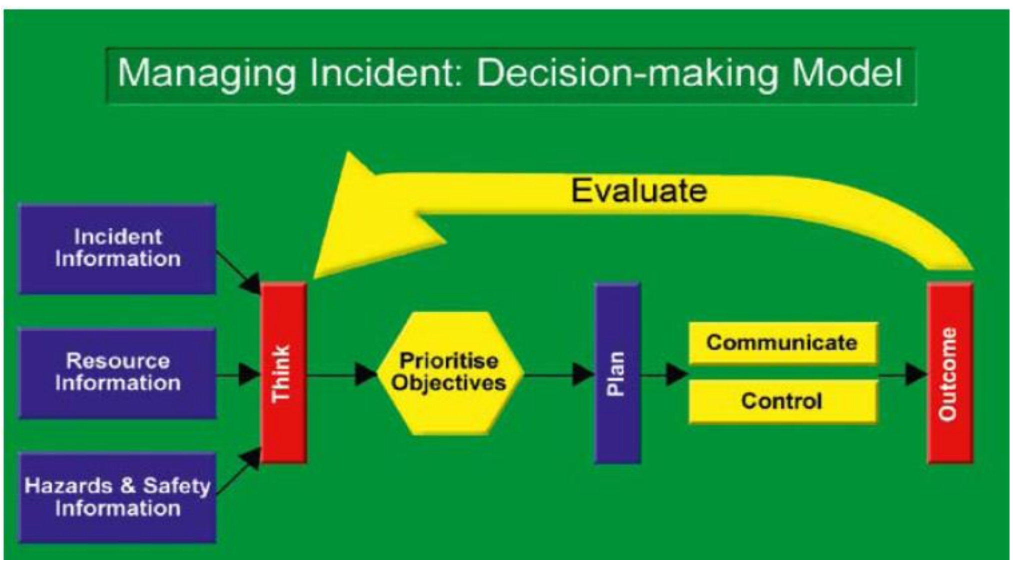


Figure 1.4. Managing incidents: decision making model (FRS manual V.2, Fire Service Operations; 3rd Edition 2008).

The model used within the United Kingdom FRS is the ‘Managing Incident: Decision - making model’ (*FRS manual V.2, Fire Service Operations; Incident Command 3rd Edition 2008*; Figure 1.4).

This model requires the incident commander to look at the incident information they have available and identify what the incident is e. g, a person trapped, a car fire, a fire in a domestic building or a fire in a high rise flat / office. Then the requirement is to progress and build this information through asking questions based on the other risk factors involved, such as;

- are there people reported missing, people who are not accounted for from the incident (family members, staff, etc.) who could still be within the premises, or would their last known whereabouts suggest that they are in a particular area / floor of the building or may have left the building?
- are there chemicals within the building and could they be involved (either with the fire now, or are there chemicals that could be involved if the fire developed on the same level, or travelled to a higher or lower level), what are the risks associated with these chemicals and could they have an impact for fire fighters even if they are not involved with the fire?
- what is the premise normal fire loading (the amount of combustible material available and involved with the fire or within the close vicinity of the fire) or has it an enhanced fire loading that could be involved

(the amount within the building that could be involved should the fire develop)?

- is there anyone available to provide more detail on risk and more current information in relation to the premises and the location the incident is within (caretaker, maintenance engineer, senior manager, welfare officer, family member etc.)

The incident commander would then review the resources the service has at the incident and those available elsewhere which could respond to the incident: for example, how many fire engines, how many members of staff / fire fighters, what is the specialist equipment already on the incident ground, what else is available and if not immediately available can it be made available? Where is this extra resource that could be used and how long would it take to be available at the incident ground, and how will its availability, or lack of its availability, impact on the current plan and could this plan be changed to maintain the outcome. Furthermore, what are the other concerns (political, criminal, legal) in relation to the incident, how do these impact on the decisions to be made and what other agencies will be required on the incident ground. Additionally, what safety information is available (premises, structure, hazards, staff competencies, time scales) to feed into the decision - making model and if this information is not available what are the issues in making it available (access, timescales)?

The incident commander is required to draw all this information together and to think about what it means in relation to bringing the incident to a safe conclusion to identify the best outcome. Using this wealth of information the incident commander has to prioritise what they see as the objectives for the incident, from which to develop a plan that will allow a safe conclusion for the incident. This then needs to be communicated (cascaded) to all staff on the incident ground, allowing them to implement their specific part of the plan, all controlled by the incident commander to arrive at the outcomes they are looking for. The whole model involves an evaluation loop to allow for a dynamic environment where new issues / information will become available and allow for changes to the plan.

Within the USA the FRS use another version of a decision - making model for incident command which was developed within the USA military and is built around Boyd's OODA loop (1987) (Figure 1.5) incorporating four essential elements: Observe, Orient, Decide and Act.

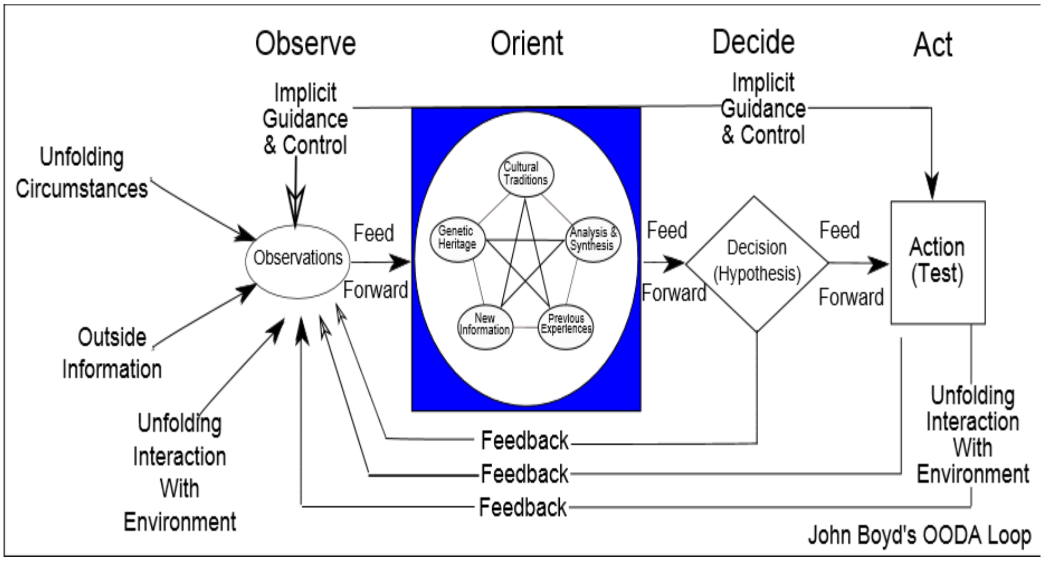


Figure 1.5. OODA loop; Boyd, J.R. The essence of Winning and Losing, June 1987 a five slide set by Boyd.

The Observe component of this model is the only input from the external environment and consequently it determines how well the orientation matches the real world. The ability of the incident commander to orient to a situation is seen as the critical element in the loop, involving experience and the ability to synergise this with new information, before deciding and acting to control the incident. The OODA Loop shows that prior to making a decision (the Decide phase), the person will first have to obtain information (Observe) and make a decision on what this means to them and what they can do about it (Orient). Greene and Swets (1966) wrote in an article called OODA and You that; the proper military mindset is to let go a little, to allow some of the chaos to become part of his mental system, and for the commander to use it to his advantage by simply creating more chaos and confusion for the opponent.

Both of these models have embedded within them the traditional decision - making processes which have been articulated in various forms, but essentially it is some variation of the following;

1. Define the problem
2. Identify the decision criteria
3. Allocate weight to the criteria
4. Develop alternatives
5. Evaluate the positives and negatives of the alternatives
6. Select the best from the list
7. Make the decision
8. Evaluate the effectiveness of the decision

In appraising the effectiveness of these models and the optimum outcome they are hoping to produce however, it may be critical to also acknowledge that stress, fear and panic take their toll at all levels of incident command. Under stress, leadership becomes more dogmatic and self centred, it regresses towards more habituated behavior, where most of the information available for making the best decision is not utilized (Putnam, 1995). Researchers similarly reported that some decisions evolved out of numerous discussions, multiple players and unanticipated events, with few sharp edged decision moments (Klein, 2008). These considerations make it clear that modeling of effective incident command needs to account for how commanders personally respond to high demand incidents over and beyond their training per se.

Incident ground decision - making does not therefore simply mean collecting information about the incident and environment to build an understanding / representation of the situation (Catherwood, Sallis, Edgar, and Medley, 2011; Gasaway, 2008; Klein, Calderwood, and Clinton-Cirocco, 2010; Omedei, McLennan, Elliott, Wearing, and Clancy, 2005). It also requires the individual to identify the decision criteria with which they're going to work, make the *appropriate selection* and allocate any weighting he / she feels is justified to the range of information on offer. This could be either from the incident ground, its contextual environment or their internal knowledge base in relation to the incident and the individual making the decision. These considerations point to the critical importance of the factor of bias or mental scope in decision - making. The application of bias / scope to the situation when under a great deal of stress will influence the incident commander's ability to arrive at a satisfactory outcome to the situation. As information selection reflects the bias or scope applied by the individual to the information and is a key factor in explaining errors of decision - making. As explained above (1.1), too narrow / conservative a bias / scope can lead to miss errors or overlooking information, while too broad / liberal a bias / scope may mean that information is processed superficially leading to false alarms (see Section 1.8 below). Either way SA may be faulty or decision - making impaired. Gasaway (2008) looked at barriers to situation awareness and impacts to decision - making, describing high stress environments as ones that contained multiple sources of information, physical / mental stress, communications issues, distractions, and interruptions among others, a necessary skill for understanding what is happening during any fire and rescue emergency incident (Gasaway, 2008). These issues are illustrated very clearly in the Storm King Mountain incident.

1.6 Incident decision - making and Storm King Mountain

In looking at the impact of these factors in relation to a single fireground incident Putman (1995) wrote on the collapse of decision - making and organisation structure on Storm King Mountain. The Storm King Mountain fire in July 1994 was a wildland fire fighting disaster where 14 fire fighters lost their lives. The analysis of this incident identifies that commanders differ in both the number of factors they use in decision - making and the value they place on each of these individual factors. It is also identified that in a situation where fear and panic is created, individual minds can regress towards a simpler, more habitual thinking that does not reflect appropriate training guidelines. Whilst individuals rarely have a full understanding of the few facts they have in relation to the incident and how they are processing them in making their decisions, possibly leading to a tendency to be over confident in their decision - making ability (Tavris and Aronson, 2011). With the background briefing on emerging issues for fire managers from the Australasian Fire and Emergency Service Authorities Council (AFAC) and

Bushfire Co-operative Research Centre (CRC) in 2009 studies (fire note 2009; p.4) also showing that our thinking tends to underestimate hazards, particularly if the hazard is increasing at a logarithmic or exponential rate. 'The human consequences of suboptimal decisions by fire leaders are compellingly clear and conversely, optimal leadership decisions are no less vital for successfully suppressing a fire' (Useem et. al. 2005, P.462). Exploring decision - making within the wildland fire scenario Yukl (1989) showed how good decision - making achieved the best possible futures and therefore identified good decision - making as a key component for leadership, with poor decision - making compounding the situation and increasing pressure, carrying a high demand for increased action and an increase with possible risk of loss of life and decision - making objective outcomes failing. These demands and risks are clearly shown by incidents such as the Storm King Mountain fire.

In this incident, Putnam (1995) felt stress, fear, and panic predictably led to the collapse of clear thinking and organisational structure, while Useem et. al. (2005) suggests that three factors – under preparation, acute stress and ambiguous authority- resulted in suboptimal decisions by team leaders on the fireline. Both identified how one could decide the crucial factors which allowed this disaster to happen and both looked at the inputs and outputs gained from the leadership of the fire fighting crews committed to resolving this incident.

The fire started high in the mountain on July 2nd, but fire fighting resources did not reach the fire until July 5th, with the acknowledged truth among experts in this type of fire fighting, that the longer the initial attack was delayed, the greater the risk to the fire fighters attending. To understand the environment these fire fighters were operating in on this mountain, one needs to understand that Wildland fires can reach 2,500 F, move across the ground affected at 25 miles an hour and leap a large gap overhead (at tree top level) without warning. At 12.30 on July 6th 3 local crews and jumpers (wildfire fire fighters who parachute into the hard to reach fire zone, normally from airplanes, but can do so from helicopters) from 5 different bases across the affected area (a high number of wildfires were being fought at this period over a wide area) were thrown together and required to work and perform as a team under increasingly unstable and dangerous wildfire conditions. As the incident on the mountain developed the fire fighters were working in 3 separate groups and at 15.00 in the afternoon of the crucial day the wind started to pick up, gusting from 30 miles an hour to 45 miles an hour. With this increase in wind speed (fanning the flames, increasing available oxygen and pushing it towards new fuel sources in the form of unburned trees and bush) there was an increasing fire activity, bringing with it a requirement for much more dynamic decision - making of the groups and their leaders. At 16.06 that afternoon an emergency radio message of ‘everyone out of the canyon’ went out and 18 fire fighters on the side of the mountain were running for their lives, at 16.13 the same afternoon only 6 had outpaced the fire and reached safety, while 12 fire fighters were destined to lose their lives in that fire on the side of the mountain. As well as these 12 fire fighters, two other fire fighters in other areas of the mountain fighting the fire in different circumstances were also destined to become victims to this fire, making a final death total of 14 fire fighters.

Useem et. al. (2005) saw the events as unfolding due to 5 suboptimal decisions which were taken, with 3 primary factors impacting that can reduce the quality of decision - making by team leaders; limited preparation, experiencing acute stress and ambiguous authority. In looking at what they feel were the 10 most consequential decisions, they concluded that 5 of these decisions were relatively optimal for the triple objectives of safety, speed and suppression, while the other 5 decisions were suboptimal. 'The disaster, rather, derived in part from an underdevelopment of leadership skills, especially for making quality decisions under demanding and ambiguous conditions' (page 477). Useem et. al. (2005) supported Yuki (1989) in identifying good decision - making as one of the key components of leadership. Historically, in the United States wildland fire fatality investigations were seen to focus on external factors like fire behaviour, fuels, weather and equipment; with the key elements of both human and organizational failures, seldom discussed in relation to the outcome of the investigations. When individual fire fighters and support personnel are singled out, it’s often to fix blame in the same way we blame fire behaviour or the fuels involved. Putnam feels this is wrong headed and dangerous, because it ignores what he thinks is an underlying cause of fire fighter deaths; the difficulty individuals have to consistently make good decisions under stress (Putnam, 1995).

The key issues are therefore whether in reaching their decisions do incident commanders always use a decision - making model to help them make their key decisions and if they do is there one decision - making model that helps and works more than another. The truth is that there are a number of decision - making models that can be used (as shown above) and each FRS is able to pick and then modify the one that they prefer, or are most comfortable with. Nevertheless, in the end it may not matter which model is ostensibly being followed, since as noted by Useem et. al. (2005) and Putnam (1995), both discuss what goes in to making a good decision, but they also recognise that in situations that create fear and panic, increased stress and pressure on leaders will follow! Within their paper, Useem et. al. (2005) identifies research that confirms that when individuals are under time pressure or perform multiple tasks at the same time, they are more likely to make suboptimal decisions. Much of the stress experienced by fire fighters is thus a direct product of the urgent and diverse demands imposed on crew leaders and incident commanders when confronted by a fast evolving fire

(Janis and Mann, 1977; Finucane, Alhakami, Slovic, and Johnson, 2000; Gilbert, 2005).

1.7 How do we progress the current understanding of the incident commander role to improve incident outcomes?

Research in the USA on the 'Naturalistic Decision Making' (NDM) model identified that in an operational environment information comes from many sources and is often incomplete. One theory from NDM is 'Recognition - Primed Decision Making (RPD) (Klein, Orasnu, Calderwood, and Zsambok, 1993), where fireground commanders argued that they were not making choices, considering alternatives or assessing probabilities, but saw themselves as acting and reacting on the basis of prior experience. Two of the key features of the RPD model are: focus on the situational assessment and checking that the action plan will work using mental simulation, but in view of the evidence from incidents such as Storm King Mountain, is this enough? The current research project is based on the consideration that another key factor may need to be addressed in explaining and supporting fireground command and decision - making: the issue of information bias. As noted above (1.1) past research (e.g. in regard to military situations: Edgar & Edgar, 2007; Edgar, Catherwood, Nikolla, and Alford, 2009) has shown that individuals differ in how much of the available information that they use and trust in making - decisions, referred to as the information bias or scope of the individual. With the way an individual applies bias / scope to the situation, when under a great deal of stress (not using a rational basis) possibly influencing their ability to arrive at a satisfactory outcome to the situation by not taking account of, or applying the correct judgment to all the information available in making their decision. Some people may apply a conservative bias / scope, trusting or using only a narrow range or scope of available information, which could be seen as narrowing of perception (tunnel vision), while others may show a more liberal or lax bias / scope, trusting or using a wider scope of information (butterfly syndrome) (Catherwood, Sallis, Edgar & Medley, 2012; Sallis, Catherwood, Edgar, Brookes, and Medley, 2013). These considerations may be important in further development of the training for effective FRS incident command.

1.8 Bias in decision – making

As noted above, effective decision - making and SA (Endsley, 2000) involves acquiring information, but also needs the appropriate selection of relevant information from the external environment or from the decision - makers own internal knowledge base (Catherwood, et. al. 2011; Gasaway, 2008; Klein, Calderwood, and Clinton-Cirocco, 2010; Omodie, and Wearing, 2005). Past research into real - world decision - making (e.g. in military situations: Edgar and Edgar, 2007) and the Naturalistic Decision - Making theoretical approach have confirmed that even when individuals have similar knowledge of a situation, they will vary in how, or how much of that information they actually choose to use in making decisions. This project adopts a novel approach to investigating why such variation occurs by studying the decision bias / scope of individuals.

It would appear that this bias or scoping can apply to either externally available information (eg. aspects that can be seen) or to information absorbed cognitively or even subconsciously (Catherwood et. al. 2012; 2011; Sallis, et. al. 2013). It does not just apply therefore to what individuals are actually seeing before them, it can also apply to the information they have in their knowledge or memory. Even if a wide range of information is taken on board, people do still mentally or internally adjust their scope or bias so they can select the information that suits the way they interpret / understand what is being presented. Regardless of the fact that the key points and the full range of information in relation to the situation are available to them for their analysis or understanding. This can explain some of the puzzling decisions / errors people make even when theoretically they have all the correct knowledge available to them.

This concept of bias derives from “signal detection theory” (Green & Swets, 1966) (see below Figure1.6). Correct judgments are hits and correct rejections, but errors are either misses or false alarms. Prior research (Edgar, et. al. 2009) indicates that individuals tend towards either a) conservative decision bias / scope, classifying less information as true, making more correct rejections but also more misses or b) liberal decision bias / scope, deciding more is true, thus making more hits but also more false alarms (Figure 1.6).

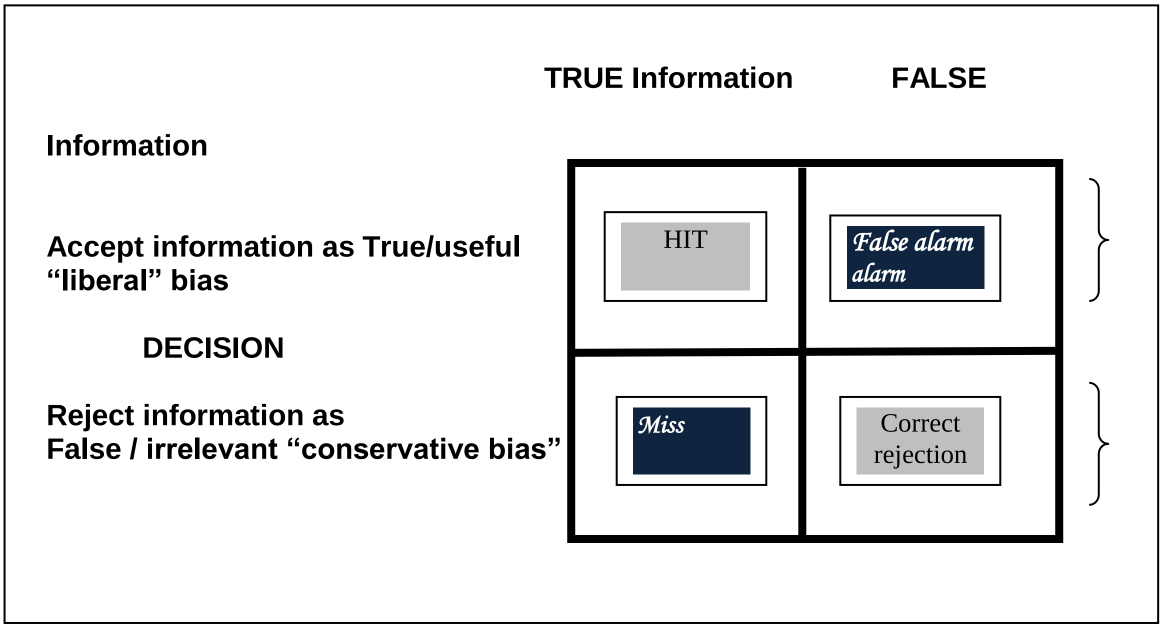


Figure 1.6. Categories of decision - making and bias (after: Green & Swets, 1966; Saveland, 2005).

People with conservative bias / scope have a tendency to trust a narrow range of available information (tunnel vision), while those with more liberal or lax bias / scope, trust a wider / shallower scope of information (butterfly effect). Bias / scope starts to explain errors in decision - making even when theoretically all the correct information is available and with hindsight in any review will be seen to be available. This concept is thus highly relevant to the fireground incident situation e.g., as noted above, in the Storm King Mountain wildfire, an experienced commander displayed a conservative bias / scope, making the miss error that overlooked weather / wind information with fatal consequences (Useem, et. al. 2005).

1.9 Aims of the current research.

The current research will focus on this key issue of information bias in FRS decision - making to determine whether FRS personnel display bias / scope during realistic simulations and exercises and if so, whether they are conservative or liberal in nature. There has been some preliminary application of this theoretical framework to fireground decision - making (Saveland, 2005), but the current research will extend this by quantifying bias / scope to enable appraisal of such tendencies across different contexts, within individuals over time and after the provision of personalised feedback about bias / scope.

The current research will also explore the effects of FRS experience on decision - making bias / scope. Experienced FRS personnel may act on the basis of prior experience using “Recognition-primed decision making (RPD)” (Klein, 2003; Klein et. al. 2010), rather than fresh appraisal of fire situations (Klein, Orasnu, Calderwood, and Zsambok, 1993). RPD is beneficial if it aids focus on correct aspects of the situation but can induce a conservative bias / scope and hence miss errors’ or liberal bias, false alarms.

An important question to be considered in the thesis is whether bias / scope is consistent or varies for individuals. Does the same person vary in the bias / scope that they use in different situations, or at different types of incident (experience), demonstrating a situational bias/ scope. Or do individuals have a natural and consistent bias / scope. In either case, will the understanding of personal bias / scope tendencies make a difference to the way individuals react under pressure and therefore to the way they manage an incident. Is it possible to alter the bias of an individual, or will it be different at different times / incidents, can knowledge of an individual's own bias change the way bias affects, or impacts on their incident decisions. Is it possible that understanding of bias can help to extend an individual's ability to manage an incident under pressure without falling back to a resting bias that may impact detrimentally on decisions made? This issue raises important questions for training which will be considered within the thesis. Do the FRS incident command system and command models already established and in use within the training and operational environment provide enough support to give the competence requirements of the incident commander. Without that same incident commander knowing and understanding more about their personal bias / scope tendencies and how they react or fail to react under pressure in relation to these. Can there really be effective training of incident command without knowing whether individuals have a conservative decision making bias / scope, classifying less information as true, making more correct rejections but also more misses, or alternately a more liberal bias / scope, deciding more is true making more hits but also more false alarms (Figure 1.6).

The specific aims (Hypotheses) of the current investigation are therefore to determine if:

i) FRS personnel will display either conservative or liberal decision - making bias / scope (with related miss or false alarm errors respectively) during FRS training exercises involving simulations of fireground incidents.

ii) any such bias / scope error patterns will be consistent for individuals over situations / scenarios.

iii) experienced FRS personnel will be less prone to displaying such bias / scope errors.

iv) any such bias / scope will be reduced or moderated by providing detailed personal feedback on bias / scope and error tendencies to individuals following training exercises (i.e. individuals can use understanding about their own bias / scope to reduce errors in decision - making).

The broad aims are thus to improve understanding of how an incident commanders personal decision - making bias / scope may influence decisions and errors in FRS operations. Then to ultimately ascertain if this knowledge made available to the individual, or this type of information can contribute to training guidelines for self-awareness of how information is sampled or scoped in fireground situations, with a view to reducing risk in actual FRS operations. The ultimate goal is to progress this work from the theoretical model into a plan to help to identify how an individual bias / scope can be identified and to see if or how this knowledge can assist the FRS decision maker.

1.10 Methodology Overview:

1.10.1 Sample of participants: Participants were operational FRS fire fighter personnel (male and female) from both full time and part time (retained) fire crew from Gloucestershire FRS. The only selection criterion was that they were within an operational FRS fire fighting role as either managers or fire fighters and that they consent to be involved. With participant consent, results for the longer-term feedback study were provided on a personal and confidential basis to each participant. The research had full endorsement of senior FRS staff at Gloucestershire FRS who have previewed task content to ensure its validity for FRS operations.

1.10.2 Ethical issues: The studies were undertaken at FRS stations or at training situations at the time of routine training / assessment exercise sessions although participation in these research studies was fully voluntary by signed consent after a preliminary briefing. Staff were fully advised that there are no requirements to participate in the research project. Some staff elected not to be involved in the studies demonstrating that consent was fully voluntary. Results were anonymised for purposes of general analysis and for reporting in any public manner. General anonymous feedback was provided to the crew and individuals involved. For ethical reasons, individual assessment sessions were administered by trained FRS managers.

1.10.3 Basic methodological / analysis approach: Each study involved a fireground simulation exercise about which yes / no or true / false probe questions were subsequently presented to each individual in a written response sheet format. The responses were analysed by a “signal detection” type method, the Quantitative Assessment of Situation Awareness (QASA): Edgar et. al. 2009) (previously known as Quantitative Unit Assessment of Situation Awareness (QUASA)) that gives two scores (from -100 to +100): i.) knowledge (or Actual Situational Awareness (ASA)) and ii.) bias on a scale from very liberal to very conservative (see Figure 1.6). The ASA or knowledge score is conceptually similar to that provided by other established measures of SA, such as the Situation Awareness Global Assessment Technique (SAGAT)(Endsley, 1987). The bias measure in QASA however gives further insights into the critical question of how knowledge or information may be selected or filtered for decision - making and whether this is being achieved in a strict and conservative way or alternately, a more lax or liberal manner. Moreover, QASA is uniquely suited for studying real-world decision - making since it allows and is able to measure, the state of an individual where true information may actually have a weaker representation than false. Thus QASA may be especially suited to studying the decision - making of individuals who are fundamentally misguided about a situation and hence at great risk of making errors. It has been used in a range of applications to date including simulated military contexts (Edgar, et. al. 2009; Rousseau, Tremblay, Banbury, Breton, and Guitouni, 2010).

Initially there was a need to understand if FF's showed a bias pattern and how this could then be developed with other exercises to test how this could impact on decisions made, which was done using a training event that simulated a command type of incident (breathing apparatus exercise). This was then developed using table top exercises which involved trial sites (fire stations during the fire fighters training periods) of interactive computer based fireground exercises with locally relevant content. A range of exercises were trialed, with each presenting a series of images and video material representing the exercise interspersed with probe questions to be answered true / false (eg. "there were 3 staircases within the search area") and how confident they were in their response (perceived Situational Awareness (PSA)). As noted above, the QASA method produce's the SA score (both perceived and actual) and the bias / scope tendency score (conservative / tunnel bias / scope vs. liberal / broaden bias / scope). Thesewere followed where possible by general qualitative feedback to the individuals / groups taking part and further training activities. While the exercise showed bias patterns for the individuals they were variable for different exercises and were not felt to reflect the pressure a developing incident brought to the individual making the decision. They did however show how bias was reflected in an individual decision making process and how this type of exercise could be used within the training environment to improve incident decision making.

An exercise that could provide the pressure to test the theory that it was a sleeping bias involved trials for individuals during response officer assessment exercises at Avon Fire and Rescue Service (AFRS) Specialist Fire and Rescue Training Centre (Avon FRS South West Command Centre) based on developing emergency fireground situations with locally relevant content. Assessment exercises over a period of time were trialed, with each being assessable for the individual in relation to their competency to undertake their role; the exercise were interspersed with probe questions to be answered true / false (eg. "the services for the premises were isolated on arrival ") and how confident they were in their response (PSA). QASA produced the SA score (both perceived and actual) and bias tendency score (conservative / tunnel bias / scope vs. liberal / broaden bias / scope). For individuals taking part on an individual assessment basis this was followed by specific qualitative feedback and followed up by interviews for the participants in the trials to reflect on the results and provide feedback on the perceived value of the method and suggest ways to develop it. The exercise were actual simulations of emergency incidents and developed with time and decisions made by the incident commander, more pressure on the incidents commander was built using interventions by other authorities replicating a real incident. While this method was preferable in bringing real incident pressures, it was based on opportunity with the FRS. The level of commitment to this type of exercise (both FDM time and other participants, plus the cost of the centre) was not controllable in undertaking developments in the longer term with identifying bias of individuals for future development.

These methods provided the basis for furthering the understanding of FRS personnel's SA and decision - making bias / scope tendencies and providing the data required to improve on these critical aspects of fireground operations making for safer fireground operations.

Chapter 2

Literature Review: Theory and Research on how bias / scope influences decision – making

2.1 Introduction: the concept of capacity limitations in decision – making

Within both the United States of America and the United Kingdom Fire and Rescue Services (FRS) there has been a drive to improve the incident commander's competence to undertake the operational incident command role. Recognition primed decision - making, naturalistic decision - making and traditional decision - making have all been associated with both command and decision - making styles, along with a need to be a reflective practitioner, reflecting on the experiences of both training events and responding to emergencies and also being part of the command team and the experience of seeing others undertake the role. Baddeley (2001) appears to challenge the assumption that more information in time-pressured, high stakes and complex situations will necessarily help, as he feels it may result in a set of new problems. In particular, too much information may lead to information overload, which is likely to degrade the decision - making quality under some circumstances, rather than enhance it. This overload is a consequence of the natural limitations of human information processing, with information overload likely to lead to sub-optimal decision - making which, in turn, may result in sub-optimal performance on the part of the incident commander: "The human consequences of sub-optimal decisions by fire leaders are compellingly clear and conversely, optimal leadership decisions are no less vital for successfully suppressing a fire", (Useem, Cook, and Sutton, 2005, P.462).

The critical factor in these issues may be cognitive capacity. Kahneman (1973) first discussed the idea of limited capacity, a theory he put forward which suggests that within the brain there is a ‘limited capacity central processor’. This processor is responsible for analysing incoming information and integrating it with information already held in the memory. The idea that the amount of information that we can attend to is limited, that the processor is of limited capacity, would mean that some of the information coming in will not be processed and this could be the reason why we are unaware of so much that is happening around us. But Kahneman did suggest that arousal may influence the capacity of the processor, where the higher the level of arousal the more information can be taken in and processed. The source of these limitations may lie in various processing systems in the brain. Baddeley (2001) proposed that there is limited capacity in working memory, while looking to understand the way information is temporarily stored and maintained in the performance of complex cognitive processing and Rasmussen (1983) identified the slowness or capacity limits of knowledge based problem solving, again working on the theory of limited capacity. With the effectiveness of decision - making in complex situations and its dependency on emotional self regulation as discussed by Omodei and Wearing (1995), when they looked at information processing competencies and decision - making in complex environments.

These proposals highlight the key issue of capacity limitations: we are unable to process everything, we just do what we have the ability to do, and so the argument goes that our brains are limited in terms of how much they can take in, process and store. A number of core brain systems reflect this limitation of capacity especially systems involved in perception, attention and memory (working and long-term) as discussed in the following section.
To further understand these ideas about capacity limits, it is useful to consider the basic psychological processes involved in making decisions and any capacity limits in these systems.

2.2. Basic psychological processes in decision - making

Basic cognitive processes relevant to decision - making include: perception, attention, working memory and long-term memory (Eysenck & Keane, 2005). All of these may be affected by capacity limitations.

In regard to limits in perception, high perceptual load (i.e. the need to process a large quantity of perceptual features or information) may elicit a narrow bias towards perceiving central features only, with peripheral information being overlooked (Forster and Lavie, 2009; Rees, Frith and Lavie, 1997). This may be especially critical in perceptually complex real world environments. For example, the tendency of air traffic controllers to overlook key perceptual features of aircraft (such as location, altitude, heading, etc.) has been found to increase with the number of aircraft to be monitored (Endsley and Rodgers, 1998).

Other inherent constraints include those related to the cognitive workload on the attentional systems that determine the scope of information for selective or privileged processing by the brain (Posner, Rueda and Kanske, 2007). Cognitive psychologists often regard attention as acting like a filter so the individual is not overwhelmed by more information than they can cope with. Posner (1980) in explaining how this might work discussed attention focus like a 'spotlight', illuminating only a small proportion of everything that is registered by the eye (visual field), with the attentional spotlight working for hearing as well as vision. Whereas within their theory Eriksen and Murphy (1987) describes it as a 'zoom lens' where attention can be focussed tightly on a narrow area, or broadened to cover a wider area, which would imply spreading the effort, a lot of effort going into a small area, or at a lower concentration over a large area. Which is suggesting control over your spotlight of attention, an ability to move it around or in and out, that you can decide what you want to attend to, selective attention, and a conscious cognitive process. Lavie (1995) suggests that the amount of perceptual information available to be processed and over which we do not have direct control, may also influence the size of the spotlight, or attention tunneling (Engel, 1971). Lavie's (1995) work proposes that anything outside of the spotlight is likely to receive little or no processing, with some evidence to suggest we do not have complete control over where the spotlight is directed. Some of this direction will be involuntary (no conscious decision to direct attention to a particular stimulus) and with involuntary attention something draws you to it, you are unable to stop it. When attention is drawn in this way it is referred to as stimulus induced shifts of attention, crucially an involuntary process, something that just happens. Posner (1980) referred to the internal voluntary control as an endogenous system and the effect of reacting to external stimuli as making up an exogenous system. Schneider and Shiffrin (1977) suggested that there were two processes at work, controlled and automatic, where the automatic process makes little, or no demand on the attentional capacity and occurs without conscious awareness; the two process theory. The distinction however is not that straight forward, as reading may be, for most, an automatic process, but is and continues to be a learned process, meaning that at some time it was not automatic, which would imply we can change the amount of control we have over attention. This would support Gopher’s (1993) suggestion that attention control is a skill that can be learned and modified to some extent.

Memory also reflects capacity limits. A basic model of memory proposes that there are three linked systems which will help explain both the strengths and limitations for both SA and also the decision - making process. The multi-store model was first described in 1968 by Atkinson and Shiffrin, but has been criticised for being too simplistic and in particular, the idea of a “working memory” (Baddeley 2001) has been added.

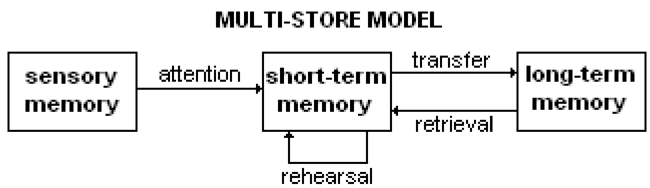


Figure 2.1. The multi-store model 1968 Atkinson and Shiffrin.

Sensory memory holds information for a very brief period of time (Eysenck and Keane, 2005) from a half to two seconds, which allows extra time to process incoming information. The ability to look at an item and remember what it looked like with just a split second of observation, or memorisation, is an example of sensory memory. It is out of cognitive control and is an automatic response. Working memory systems dictate the selective focus for maintenance of that information in an active state (Baddeley, 2003; Cowan, 1998). Working memory, (or the currently active short term memory) contains our conscious awareness, holding about seven pieces of information, plus or minus two (Miller 1956) and then only for a short period. This makes us susceptible to losing the information being held especially if distracted, so knowing how to preserve information in working memory is key to SA. The storage in sensory memory and working or short term memory generally has a strictly limited capacity and duration, which means that information, is not retained indefinitely. Long term memory offers a huge storage of information collated over our whole life, which can be accessed for SA transferring into working memory; with certain types of information easier to retrieve when it is familiar, accessed recently, salient or of particular personal value (Endsley and Garland, 2000). Nevertheless, long term memories need to be retrieved into working memory to be of use in decision - making and there are capacity limits in this regard as noted above.

All of these limitations then in perception, attention and memory may impact on decision - making and promote information bias. While high cognitive load may involve a selective or narrow focus on some aspects of a situation, this may be at the cost of reducing brain resources for processing other information (Dretsch and Tipples, 2008; Franco- Watkins, Pashler and Rickard, 2010; Roberts, Hagen and Heron, 1994; Zanto and Gazzaley, 2009), which could lead to poor filtering of information not selected for attentional and working memory focus.

Another key factor in decision - making bias is motivational (Becker, Mortensen, Ackerman, Shapiro and Anderson, 2011) or emotional state (Mosier and Fischer, 2010). Negative emotional arousal may narrow attentional focus (Derryberry and Tucker, 1994) so that only details considered central to an event are retained (Christianson and Loftus, 1991), while positive emotional arousal may promote less intensive filtering of information (Isen and Labroo, 2003) with a more lax or superficial processing bias. Even unconscious emotional cues (somatic markers) acquired during previous experiences (D'Amasio, 2000) can direct attention towards selected aspects of a situation. This influence of emotional cues has been noted in many areas of natural decision - making, including that of pilots or military commanders (Mosier and Fischer, 2010) and may be relevant in fireground decision - making. Thus these emotional-motivational factors may need to be considered in explaining bias especially in conditions that promote high stress or anxiety.

2.3 Decision - making (traditional decision making; recognition primed decision making; naturalistic decision making)

The traditional decision - making process has been articulated in various forms (Gasaway, 2009), but can be seen as a variation of eight steps (factors);

1. Define the problem
2. Identify the decision criteria
3. Allocate weight to the criteria
4. Develop alternatives
5. Evaluate the positives and negatives of the alternatives

6. Select the best from the list
7. Make the decision
8. Evaluate the effectiveness of the decision

Such models present decision - making as a linear sequence of certain deductive steps, but current psychological models of decision - making acknowledge the “fuzzier” nature of human reasoning such as the “heuristic” or knowledge - based reasoning that is more likely in natural contexts and is identified by Tversky and Kahneman’s many research studies (e.g., Tversky & Kahneman,1971). These studies indicated that in uncertain or ambiguous real-world contexts, decision - making can be swayed by such factors as personal bias and the availability (vividness) of information. Indeed, uncertainty is a constituent element of all operational decision - making and in classic decision - making theory is one of the difficulties decision makers have to overcome (Lipshitz, 2003). Weick and Sutcliffe (2007) talk about the ability to make decisions based on what individuals have described as feelings, and Kline (2003) referring to this knack, or skill as intuition. The notion of intuitive decision - making appears in numerous papers, such as those by Von Schell (1993) and Marshall (1947) concerning military decision - making.

Work by Klein (2003) on intuitive decision - making confirmed that it appears to be a skill used by fire fighters as well as the military. Klein’s definition was "the way we translate our experience into action" (Klein 2003, p. xiv). Klein described this as ‘Recognition Primed Decision - Making’ (RPD), based on the situational cues and ability to match patterns, supported by the individuals experience and judgement. For Klein RPD distinguished 2 important elements; a) mental simulation (a process that envisions what may happen) and b) how to address it. Both elements are united within a second mental model or individual understanding of how and why things happen; completed by the individuals experience and how it influences a person’s RPD. Klein also describes barriers (structures within the organisation that interfere with) to intuitive decision - making, such as service policies, procedures and information technology.

'Naturalistic Decision Making (NDM) is an attempt to understand how humans actually make decisions in complex real world settings, such as fire fighting' (Klein and Klinger 2008, p. 16). The approach aims to improve decision - making in the field by the development of tools, training and decision support. Johnson, Cummings and Omodei (2009), talk about worst case scenarios in decision - making, relating the low probability, high consequence events to these scenarios and the reaction to risk, if it is identified and how it influences the decision - making process.

2.4 Fire and Rescue Service perspective on decision – making

Gasaway (2009) looked at barriers to SA and resultant good decision - making; describing problematic environments as ones that contained multiple sources of information, physical / mental stress, communications issues, distractions, and interruptions. In looking at the impact of decision - making in relation to a single incident Putman (1995) identified that commanders differ in both the number of factors they use and the value they place on each of these factors, also identifying that in a situation where fear and panic is created, individual minds can regress towards a simpler, more habitual mode of thinking. With individuals rarely having a full understanding of the few facts they have in relation to the incident, and how they are processing them in making their decisions; which can lead to them having a tendency to be over confident in their decision - making ability (Tavris and Aronson, 2011).

To understand how the incident commander having very few facts in relation to the incident may be overcome in relation to fire fighting operations, it is necessary to understand how decision - making on the incident ground relies on maintaining SA (as described below in 2.5) and making decisions under time pressure (Saveland, 2005), an environment that the traditional decision - making process does not fully cater for (AFAC & CRC Fire note 2009). Snowden and Boone (2007) however, recognised that a changing situation (dynamic event) can become more complex and it may be necessary to apply different methods of decision - making to the circumstances. They identify four contexts: complex, complicated, simple and chaotic; with leaders needing to identify the context and adapt their behaviour accordingly, to assess the facts of the situation and establish their response on established practise. Incident ground decision - making does not simply mean collecting information about the incident and environment to build an understanding / representation of the situation (Catherwood, Edgar, Sallis and Medley, 2010; Gasaway, 2008; Klein et. al. 2010; Omedei, McLennan and Elliott, 2005). It also requires the individual to identify the decision criteria; make the appropriate selection and allocate any weighting he / she feel is justified to the range of information on offer. Either from the incident ground, its contextual environment or their internal knowledge base in relation to the incident and the individual making the decision. Identifying that a necessary skill for understanding what is happening during any fire and rescue emergency incident is SA (Gasaway, 2010). In looking at the impact of this in relation to a specific incident Putman (1995) looked at the Storm King Mountain fire and the 'collapse of decision - making and organisation structure during the wild fire in July 1994 where 14 men and women fire fighters lost their lives (discussed at 1.6). Here Putman identified that people differ in both the number of factors they use and the value they place on them and in a situation that creates fear and panic, individual's can regress towards more habitual thinking (develop cognitive process). Studies (AFAC & CRC Fire note 2009; p.4) also show that our thought process tends to underestimate hazards, particularly if the hazard is increasing at a logarithmic or exponential rate. ‘The human consequences of suboptimal decisions by fire leaders are compellingly clear and conversely, optimal leadership decisions are no less vital for successfully suppressing a fire’, (Useem et. al. 2005, P.462). Exploring decision - making within the wildland fire scenario Yukl (1989) showed how good decision - making achieved the best possible futures and therefore identified good decision - making as a key component for leadership.

The background briefing on emerging issues for fire managers from the AFAC and CRC in Fire note, (2009) refers to human factors which are broadly defined as factors which influence both how the human body operates (physiological factors such as dehydration, fatigue etc.) and how the mind operates (psychological factors such as SA, planning, trust in team members etc.). With their project focused on psychological factors (individual values) underpinning decision - making in safety critical complex and time pressured environments (compressed time event) based on fire service operations. Following extensive interviews they identified a wealth of valuable insight into influences on decision - making leading to a reluctance to change plans in response to a changing situation and a tendency by some leaders to ‘micro manage’ situations (narrow conservative bias / scope). They distilled their work into seven, what they describe as, ‘take home’ lessons which emerge from the data;

- Fire Commanders are not good at recognising when they are mentally overloaded at all levels of incident command (but at times some of this overload can be alleviated by basic decision aids).
- They tend to underestimate what the fire will do, with a bias to predict change as linear.
- They can be reluctant to change plans when the situation requires it, which appears to be linked to predicting change in the fire development (situational awareness).
- They learn from previous experiences, near misses and accidents (supporting Klein's Recognition-Primed Decision Model).
- The importance of personal knowledge, trust in people we know.
- They are good at doing stuff, but not at organising the fire ground, a lack of awareness regarding roles, or a move to an area they are comfortable with (bias; negative, liberal, lax, hit: positive; conservative, narrow, strict, miss).

If given the opportunity, it is proposed that operational fire commanders take on more responsibility than they should, micro managing (narrow, conservative bias / scope), or not being able to focus (broad, liberal bias / scope).

It may be that personality factors play a role in response to stress, but McLennan, Holgate, Omodei and Wearing, (2001) suggest that we have so far failed to find any evidence of a "personality type" associated with good incident command (with the same being found with SA (Carretta, Perry and Ree, 1996)). 'It seems that good incident command is less a matter of what kind of person a commander is than what he or she does while in command' (page 2, 39th IAMPS, Brussels 2003). Their model of incident command decision - making then covers four points;

- ✓ OIC quickly extracts the most relevant information available,
- ✓ rapidly develop a conceptualization or mental model of the situation,
- ✓ chose a response with a high probability of implementation effectiveness,
- ✓ monitors change in the situation to change their response tactics.

Showing the good incident commander operates in a manner that;

a. their effective working memory was not exceeded,
b. regulated their emotions and arousal level;

in summary they knew what to look for and what to do once they found it.

AFAC & CRC Fire note (2009), identified that poor commanders had fewer decision rules to apply and were more likely to use a problem solving approach, which meant they concentrated fully on the area of operations (narrow, conservative approach) or were swamped with information. When they were swamped salient information was likely to be given undue importance and relevant information to be overlooked (broad, liberal bias / scope). Often giving an impression and sometimes describing themselves as overwhelmed by the circumstances of the situation, reacting to developments in an ad-hoc manner and with difficulty forming a coherent plan. Poor commanders were prone to be surprised by changes in the situation, appearing that all their cognitive processes were fully occupied, with some acknowledging they felt anxious and unconfident. McLennan et. al. (2001) added a term of ‘disastrous incident command’ where serious injury or serious damage had occurred, or life had been lost and here they found an inappropriate choice of tactics as a result of key information being overlooked (narrow conservative bias / scope). Discussing what they describe as hard wire bias (the way they felt they would always react) as;

- optimism bias: a course of action where nothing can go wrong,
- sunk-cost bias: persisting with a tactic because resources have already been committed,
- need for action bias: where no restraint is exercised to a course of action and
- linear rate of change bias: ‘where human beings seem to be incapable of accurately predicting non-linear rates of change (De Soir 2003, page 5, 39th IAMPS, Brussels 2003)'.

(The use of the term bias in the above is a standard use where the individual will show his / her preference for the way they respond / react when under pressure at an incident to maintain a certain tactical plan for the way they manage the outcome. Not the way it is used within this thesis, where it is used in short for information bias / scope, the way an individual filters the information available to them as the incident commander, which they then use for deciding their tactics to produce a plan to bring the incident to a safe conclusion).

Davis (2010) discusses an inconsistent approach by incident commanders at high pressure incidents, an approach that would not be taken in training scenarios or at low pressure incidents by the individual, when making rapid tactical decisions under stress. Which he feels is due to experiencing stress induced pressure related to the environment and human factors, varying experience levels, training issues and a multitude of other reasons. With this inconsistent approach by incident commanders compromising the safety of both fire fighters and the public, the work by Davis (2010), looked to determine what factors contributed to successful decision - making and what methods were available to improve the decision - making process. As well as confirming how human and environmental factors impact on rapid decision - making, key recommendations were to include the Observe, Orient, Decide and Act (OODA) (Boyd 1987) loop into all training, teach the difference between naturalistic and traditional decision - making and implement the use of simulations. The Incident Command System (ICS) for the UK FRS within 'Fire and Rescue Manual Volume 2 'Fire Service Operations' (FRS, Incident Command, incident command 3RD Edition 2008'), establishes the basic doctrine of the FRS in the context of operational incident management and functional command and control processes that flow from it. It is considered that the system covers the 7 predictable areas within the need for command that Brunacini (1985) identifies as required for management of the incident ground; Action, Command and Control, Coordination, Planning, Organisation, Communications and Safety. While McLennan, Holgate, Omodei and Wearing (2001), discuss a naive ‘more is better’ assumption by some, promoting that more information available to incident commanders will inevitably result in better decision - making,

Work with the Fire Service and with incident commanders within the Fire Service at operational incidents has identified an issue in that the Fire Service training currently may not provide everything the incident commander needs to undertake his role at high pressured incidents. This work has identified that overall incident commanders are good at doing stuff, but not at filtering the right information to maintain SA for good decision – making to bring the incident to a safe conclusion. Snowden and Boone (2007) recognised that a changing situation (dynamic event) can become more complex and it may be necessary to apply different methods of decision - making to the circumstances, or different ways of filtering information. That stress at incidents brought on because of the complex nature of the incident appear to show the incident commander can move to a decision model they are more comfortable with in the way they manage the available information, producing an information bias (broad, liberal bias / scope or a narrow, conservative, bias / scope). Davis (2010) supports this in looking at an inconsistent approach by incident commanders when making tactical decisions when under stressful conditions and Putman (1995) identifies that people differ in the number of factors they use in making decisions.

2.5 Situation Awareness

There are many reasons why deaths of well trained personnel occur, but increasingly the focus is on decisions made and the ability of the human mind to process information in high-pressure situations. The analysis of FRS decision - making and errors increasingly involves consideration of the "Situation Awareness" of the personnel as being critical. The components of SA are seen as covering three elements; gathering information, interpreting information and anticipating future states, sometime described as What?, So What?, Now What? (Flin, O'Connor and Crichton, 2008, p23). This cognitive skill is primarily about gathering and processing information from the environment and using stored information to make sense of it. 'SA is essentially what psychologists call perception of attention, it is a continuous monitoring of the environment, noticing what is going on and detecting any changes in the environment' (Flin et. al. 2008: p. 17). Endsley (1995) reports that SA not only applies to a wide variety of environments, but that acquiring and maintaining SA becomes increasingly difficult as the dynamics and complexity of the environment increase. As dynamic situations require many decisions to be made in a time compressed environment and are dependent on an up to-date analysis of the ongoing situation. Kaempf, Wolf and Miller (1993) support the criticality of SA, as when analysing the decision - making of tactical commanders they identified that recognising the situation provided challenge to the commanders. While Okray and Lubnau (2004) identified that to maintain SA fire fighters during an ongoing incident need to maintain their up to date SA on the incident by reaffirming the situation. As SA incorporates an operator's holistic understanding of the situation, which forms a basis for decision - making and even the best trained decision makers can make the wrong decision with incomplete SA. While good SA can lead to the right decision being made, if it is part of the right package of training, the right procedures, good tactics, etc. Endsley, Sollenberger, Nakata and Stein (2000) identify that incident ground decision - making does not simply mean collecting information about the incident and environment to build an understanding / representation of the situation or to gain good SA, it means collecting it to help predict what is going to happen next..

SA is, or can be defined as the understanding of events within the realm of the individual's expertise as they unfold in time and for the individual being able to project the consequences of those events in the now (Wikipedia 'situational awareness' 09/10/14). Or as the Health and Safety Executive (HSE) see it, knowing what is going on around you; being aware of what is happening around you in terms of where you are, where you are supposed to be, and whether anyone or anything around you is a threat to your health and safety (information sheet, step 6, HSE 06/12). ‘Our knowledge, experience and education enable us to understand what is going on around us and helps us to determine if it is safe...our SA is only as accurate as our own perception or reading of the situation, so what we think is happening may not accurately reflect reality’ (information sheet, step 6, HSE 06/12, p.1). This would lead to the conclusion that everyone’s SA is individual and potentially different. Although there are numerous definitions of SA, Endsley (1995a) defines SA informally as ‘knowing what’s going on’, but her more formal definition, "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future," (1995a: p36) is firmly established and widely accepted. With some definitions being specific to their own environment, Endsley's definition is applicable across multiple task domains (Flin et. al. 2008) and in defining SA she emphasizes three things that SA is not. SA is not action or performance, it is not the same as long term memory knowledge and the product of SA is not the same as the process of updating SA. Although there are still some who question the validity and viability of the SA construct (Dekker and Hollnagel, 2004; Dekker and Woods, 2002) as providing an unnecessary construct, while there are already existing elements such as attention. The increased use of the construct in both theory and application are testimony to its viability.

As discussed fire causes more than 20,000 deaths annually in the EU (EU Centre for Fire Statistics, 2006), these statistics include fire fighters showing that even highly trained and well skilled fire service personnel make unsafe decisions under the dynamic and high pressure conditions of the fireground. There are many reasons why such deaths of well trained personnel occur, but increasingly the focus is on the ability of the human mind to process information in high-pressure situations. The key issue is the capacity of the fire fighter to maintain an accurate understanding, or mental-model, of a situation when there are many competing demands. This capacity is the person's SA. Under pressured fireground operations, even the best trained individual may create a flawed mental model; poor SA (Endsley and Strater, 2000). When this occurs, key information may be overlooked or dismissed, or faulty information may be used to make critical decisions (Catherwood et. al. 2010; 2011; 2012).

The importance of SA has long been recognised in other areas, such as aerospace (Edgar and Edgar, 2007), but has only recently been a focus for training in the Fire Services. Any means for training fire personnel to appraise and monitor their own SA under pressure offers an important adjunct to the training of fire fighters. As SA involves being aware of what is happening around you in order to understand how information, events, and one's own actions will impact upon staff deployed and goals and objectives of the incident, both immediately and as it develops into the future. A commander with a good sense of SA generally has a high degree of knowledge with respect to the inputs and outcomes of a given situation i.e. an innate "feel" for situations, people, and events that play out due to variables the commander can control (Kaempf et. al. 1993). While lacking or having inadequate ASA has been identified as one of the primary factors in accidents attributed to human error, and is especially important in work domains where the information flow can be high and poor decisions can lead to serious consequences (Storm King Mountain). Having a complete as possible and accurate SA is essential where a rapidly changing and a high situational complexity for the human decision maker is a concern, as it has been recognized as a critical foundation for successful decision - making across emergency response and in military command and control operations.

Even for an individual with good SA there are external influences that will impact on it, with stress having the ability to have a major influence (Ensdley, 1995), either physical stress, noise, temperature variations, etc. or social psychological stressors, fear, uncertainty, self-esteem, prestige etc. Mandler (1982) discusses that a certain amount of stress may actually improve performance, while a higher amount of stress can have an extremely negative consequences. Baddeley (1970) as already discussed identifies that under various forms of stress there is a tendency to narrow attention to a limited number of central aspects, with a decreased attention and working memory observed for peripheral information (conservative bias / scope).

Additionally, Flin et. al. (2008) discusses fatigue reducing the capacity for attention and stress having a similar detrimental effect, with the individual preoccupied with other problems and reducing attentional resources (liberal bias / scope). This is a critical problem for SA leading to neglect of some elements in favour of others, leading to disaster in a number of incidents Endsley (1993) identifies in the aviation industry. Along with other areas that can impact detrimentally on SA, such as workload, in a dynamic situations high mental workload is a stressor of particular importance and complexity of the situation is a major factor creating a challenge for operators to maintain good SA.

2.6 Bias

A critical factor however in any account of FRS decision - making must be the way the incident commander sees the incident and reacts to it when under pressure, what personal bias / scope he / she brings to the incident ground and do they understand that they bring it. Bias is an overall response tendency resulting from numerous brain functions known to influence selectivity in the processing of information. This selectivity has been shown as apparent in many facets of information processing, including perceptual, cognitive and even emotional operations, and reflecting the enhancement of some aspects of the available information and / or the inhibition of other aspects. A cognitive bias is the human tendency to make systematic decisions in certain circumstances based on cognitive factors rather than evidence, bias arises from various processes that are sometimes difficult to distinguish, but include information processing shortcuts, motivational factors, and social influence (Catherwood, Sallis, Edgar, and Medley 2011). Such bias can result from information processing shortcuts called *heuristics*, which include errors in judgment, social attribution and memory (Tversky & Kahneman 1973). Cognitive bias are a common outcome of human thought and often drastically skew the reliability of anecdotal and legal evidence, a phenomenon studied in both cognitive science and social psychology. This concept of bias derives from "signal detection theory" Green and Swets, (1966) in their model of the relationship between SA and bias figure 2.2: bias can shift towards a liberal criterion (with a risk of accepting more false information and making false alarm errors) or towards a more conservative criterion (with a risk of rejecting more true information and making miss errors). The decision to choose selected information from the range of information available can be described as the dynamic filter that is applied to the available knowledge. In signal detection models such as QASA (Edgar and Edgar, 2007), such filtering is described as "bias". It represents the response tendency of the decision - maker to accept or reject available information, when uncertain as to its accuracy.

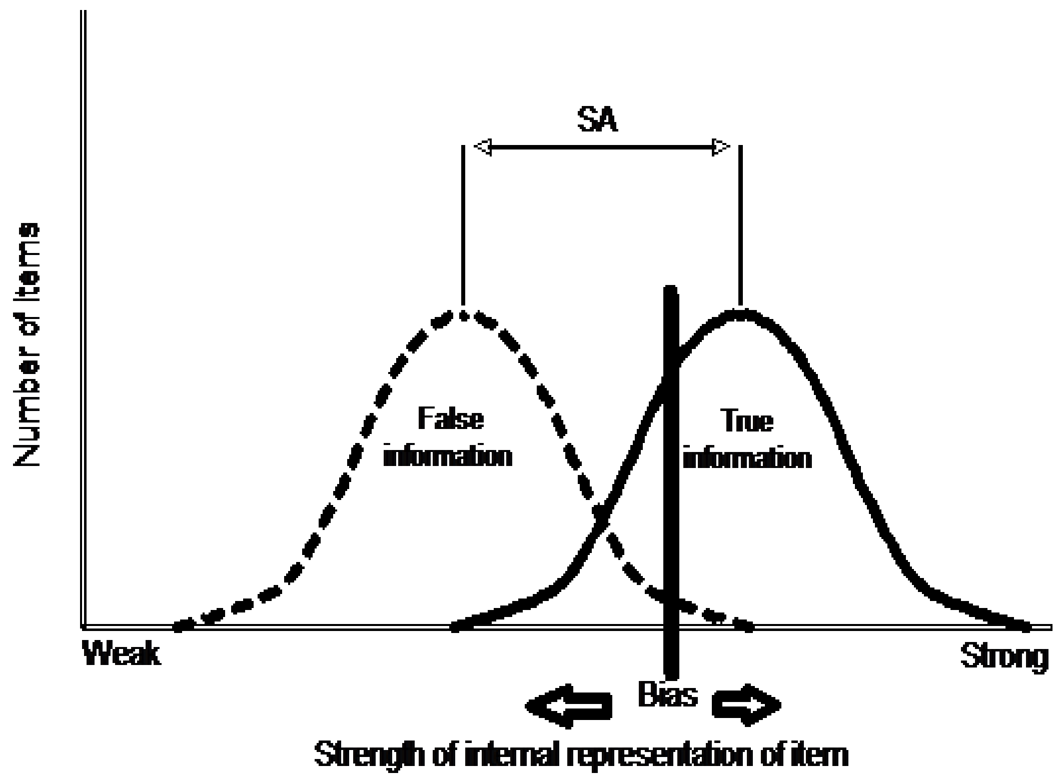


Figure 2.2. Model of the relationship between SA and bias

People with a conservative bias / scope have a tendency to trust a narrow range of available information, with the more conservative bias / scope the narrower the range of information they trust (tunnel vision), while those with more liberal or lax bias / scope, trust a wider / shallower scope of information, which could mean they look at the information only briefly (fleetingly) and to no great depth (butterfly effect). Bias / scope may apply to either externally available information (eg. tunnel vision may reflect a conservative bias / scope) or information in knowledge or memory. Bias / scope starts to explain errors in decision - making even when theoretically all the correct information is available and with hindsight in any review will be seen to be available.

As with all effective decision - making (Endsley, 1993) as previously discussed, incident ground decision - making does not simply mean collecting information about the incident and environment to build an understanding / representation of the situation (Catherwood et. al. 2010; Gasaway, 2008; Klein et. al. 2010; Omedei, McLennan and Elliott, 2005). This aspect of the decision - making might be described as the “filter” or “sift” that is applied to the knowledge available during perceptual and cognitive operations. In signal detection models such as QASA (Edgar and Edgar, 2007), such filtering is described as bias. The bias acts as a filter and represents the response tendency of the individual decision maker to accept or reject information and whether information passes that filter will be influenced by the credibility of that information to the individual.

Since any bias / scope of the decision maker can directly affect the selection or use of information for decision - making, it has to carry a potential for error with its associated risk and therefore a consequence to all on the incident ground. If the amount and quality of the information available to an individual remains the same, different bias / scope applied to that knowledge may lead to varying degrees of acceptance or rejection of the information available. Taking this into account a cautious or conservative bias / scope will permit use of only a narrow range of information, while a more liberal or lax bias / scope will allow use of a wider range of information that may be processed more superficially (Edgar and Edgar, 2007). While neither approach is necessarily high risk if the selected information is both of use and appropriate, an inappropriately strict or conservative bias / scope can lead to a narrow focus that neglects key aspects of a situation (misses), while an inappropriately lax or liberal accepting bias / scope might allow incorrect or irrelevant information (false alarms) to be accepted and used for decision - making. Inappropriate information bias / scope thus carries potential risk for making errors and it is important to determine if there are individual differences in bias / scope dispositions and to consider the factors that may affect such tendencies.

With known constraints on the brain systems, high perceptual load (the need to process a large quantity of perceptual features or information) may elicit a narrow bias / scope towards perceiving central features only, with peripheral information being overlooked (Forster and Lavie, 2009; Rees, Frith and Lavie, 1997). This could be of critical importance or especially critical in perceptually complex real world environments. Where constraints may occur in incident ground perception: for example, in a real life incident, the leader of a fire crew who was faced with processing many perceptual factors in a large wildland fire, may not have been able to process perceptual clues to changes in weather conditions, with fatal consequences to the crew members for decisions regarding the fire front and its movements (Useem, Cook and Sutton, 2005).

Other inherent constraints include those related to the cognitive workload on the attentional systems that determine the scope of information for selective or privileged processing by the brain (Posner, Rueda and Kanske, 2007) and *working memory* that dictate the selective focus for maintenance of that information in an active state (Baddeley, 2003; Cowan, 1998). While in some cases errors in incident ground command judgements and decisions have been linked to poor management of cognitive workloads (McLennan, Pavlou and Omedei, 2005). High cognitive load may involve a selective or narrow focus on some aspects of a situation, but at the cost of reducing cognitive resources for processing other information (Dretsch and Tipples, 2008; Franco-Watkins, Pashler and Rickard, 2010; Roberts, Hager and Heron, 1994; Zanto and Gazzaley, 2009). Which means this high cognitive work load could lead to poor filtering of information, with some key information not selected for attentional and working memory focus. For example, in a study of fireground command (McLennan, Pavlou and Omedei, 2005), one overwhelmed participant reported "I haven't taken in what the other officer has actually told me. He's told me we've got a fire on the container ship... things are being told to me and I'm not taking it in..." (p.217). So high cognitive workload may lead to missing, or not accepting useful information, or alternately to unfiltered acceptance of false or irrelevant information, thereby promoting false alarms (DeFockert, Rees, Frith, and Lavie. 2001;

Lavie, Hirst, de Fockert and Viding, 2004; Schwartz, Vuillemier, Hutton and Maravita. 2005).

Thus perceptual, attentional and working memory bias / scope may lead to misses and false alarm errors. Such bias / scope may in turn be driven by the priming of brain activity due to prior memory about a situation (Klein, 2008). Past experience can influence perception and cognition explicitly or implicitly (Kristjansson and Driver, 2008; Kŕol and El-Dredy, 2011; Schacter, Wig and Stevens, 2007; Shütz, Schendzielarz, Zwisterlood and Vorberg. 2007) and such influence is apparent in natural decision - making in the use of heuristic and "recognition-primed" decision - making processes (RPD) (Keller, Cokely, Katsikopoulos, and Wegwarth, 2010; Klein et. al. 2010). RPD is evident in fireground decision - making, with prior experience and expertise influencing choices and decisions (Gasaway, 2008; Klein, 1997, 2008; Klein et. al. 2010). As in the example of a fireground commander who moved a crowd away from a burning building with a rooftop billboard, based on prior experience of a similar incident in which the billboard created a risk in relation to it falling from the building into the street (Klein et. al. 2010). Nevertheless, fireground simulation studies have also shown that while experts make more competent decisions, they may also have a narrower focus on selected features of a situation (Perry, Wiggins, Childs and Fogarty, 2009) which could lead to misses and false alarms in decision - making.

As noted above in section 2.2, another key factor in decision - making bias / scope is motivational (Becker, Mortensen, Ackerman, Shapiro and Anderson, 2011) or emotional state (Mosier and Fischer, 2010). Negative emotional arousal may narrow attentional focus (Derryberry and Tucker, 1994) so that only details considered central to an event are retained (Christianson and Loftus, 1991). While positive arousal has been seen to promote less intensive filtering of information (Isen and Labroo, 2003) which could produce a more lax or superficial processing bias / scope. Even unconscious emotional cues (somatic markers) acquired during previous experiences (D'Amasio, 2000) can direct attention towards selected aspects of a situation and have an impact on the outcomes due to decisions made. This influence of emotional cues has been noted in many areas of natural decision - making including that of pilots or military commanders (Mosier and Fischer, 2010) and because of the decision - making process in these (stressful) types of situation may be relevant in fireground decision - making. For example, a fire fighter injured during a fire incident may experience either overt or unconscious anxiety when confronted by a similar situation in the future (Baumann, Gohm and Bonner, 2011), dictating a narrow bias / scope towards the features of the incident ground that caused harm, or were similar to events at the time on the previous occasion with the risk of overlooking other relevant features.

There may also be personality factors that can habitually dispose an incident commander towards either a narrowing of perception (tunnel vision) or a conservative approach in their selection of information or to a more lax or liberal approach, trusting or using a wider scope of information, but perhaps not processing it very deeply (butterfly syndrome) a liberal decision - making bias / scope. Personality traits have been linked to effective fireground command (Burke, 1997) and it may be that different patterns of bias / scope in fireground decision - making could be associated with particular traits. For example, risk taking or conversely risk adverse personality traits may respectively underlie relaxed or conservative bias / scope tendencies in some contexts (Li, Chao and Li, 2009).

In sum, there is potential for bias / scope in fireground decision - making to arise from numerous sources of brain activity that influence the selective processing of information. Given the range of factors that could induce bias / scope in this way, individual differences or variations in bias / scope tendencies may well arise for the same situation. An understanding of such individual bias / scope patterns would seem critical for improving and training self awareness in regard to the selection of information and potential risk tendencies in incident ground decision - making. Many factors can influence the way information is selected in high pressure operational situations. Natural limits on the capacity of the human brain to process information (e.g. in working memory) (McLennan Pavlou and Omedie, 2005), motivational factors and social influence may all be key factors. Experience may help, but does not necessarily eliminate the effects of such factors to remove bias / scope in decision - making. Experienced FRS commanders may rely on ‘Recognition – Primed Decision Making’ (RPD) (Klein et. al. 2010) and may not proceed by making choices, considering alternatives or assessing probabilities. But rather by acting and reacting on the basis of prior experience, with two of the key features of the RPD model being a focus on the situational assessment and checking the action plan will work using mental simulation. Nevertheless experienced personnel may still be affected by bias / scope in their selection of information because they are at risk of overlooking aspects of the situation that don’t fit with previous experience or expectation (Perry et. al. 2009).

These issues about how information is selected may be of prime importance in fireground decision - making and can explain some of the puzzling decisions / errors people make even when theoretically they have all the correct knowledge or information available to them. In tackling this the research will look to establish realistic exercises or training events and to replicate as closely as possible the pressures that are brought to bear on incident commanders. Then within the exercise / assessment testing the incident commander’s SA by using probes during or immediately after the event to assess the individual’s knowledge regarding the situation as they see it. Correct judgments in relation to the probes are hits and correct rejections, but errors are either misses or false alarms, with prior research (Edgar et. al. 2009) indicating that individuals tend towards either a) conservative decision bias / scope, or b) liberal bias/ scope.

2.7 Understanding decision - making bias / scope: to improve training and inform individuals during training opportunities

Recent research has examined how workers manage the unexpected events that are a feature of recognised high pressure occupations in general (Bechky and Okhuysen, 2011), with Branlat, Fern, Voshell, and Trent (2009) looking at firefighters specifically. So training for these occupations aim to mitigate the effects of anxiety or reduce the anxiety to manageable levels, with research suggesting anxiety is often associated with acute stress, Bauman et. al. (2011). Keinan and Friedland (1996) suggest that recommended training for personnel who work in highly stressful conditions is a phased approach, which can be compared to stress inoculation training (Meichenbaum, 1985). Johnson, Cannon-Bowers and Salas (1998) and Saunders, Driskell, Johnson and Salas, (1996) have shown that such training reduces stress in a number of domains including some recognised high pressure occupations. Burke, Salvador, Smith-Crowe, Chan-Serafin, Smith and Sonesh, (2011) also suggests that the highly engaging nature of stressful simulations may be particularly useful for domains in which on the job consequences of mistakes are severe.

To conclude, the current programme of research is ultimately concerned with improving safety in fireground operations through the development of assessing and training fireground SA (understanding of the immediate situation) and decision - making patterns. Past work (Catherwood et. al. 2010; 2011; 2012; Sallis et. al. 2013; Useem et. al. 2005; Salmon, Stanton, Neville Walker and Jenkins, 2009; Brunacini 1985 and Gasaway 2009) has shown that under pressure, professional training and competence per se do not fully protect Fire and Rescue Service (FRS) personnel from the risk of losing SA and thus making errors. These errors may occur due to decision - making tendencies or bias / scope corresponding to either of two patterns: either tunneling down on aspects of the situation and overlooking others (Eriksen and Murphy's 'zoom lens'), or alternatively attempting to deal with too much information at once (Catherwood, et. al. 2010; Sallis, et. al. 2013). The former a conservative bias / scope pattern will cause miss errors whereby key information may not be processed, and the latter a liberal bias / scope pattern will cause false alarms where irrelevant or even incorrect information may be used to make decisions. Even with the highest levels of training and skill, individuals can still make such errors which are due to the natural limitations of the human brain under pressure (Yukl 1989). The importance of SA has long been recognised (Endsley, 1988)(Endsley and Strater, 2000) in other areas, such as aerospace (e.g. Endsley, 1995; Endsley, Sollenberger, Nakata and Stein, 2000; Jeannot, Kelly and

Thompson, 2003; Taylor, 1990: Edgar and Edgar, 2007; Edgar, et. al. 2009) and medicine (e.g. Gaba, Howard, and Small, 1995), but has only recently been a focus for training in the FRS. Any means for training FRS personnel to appraise and monitor their own SA under pressure offers an important adjunct to the training of fire fighters and operational incident commanders. Such tendencies are addressed in training for many other situations (Croft, Banbury, Aymeric, Dudfield, Lamers, Roesssingh and, Lodge, 2000; Salas, Prince, Baker and Shrestha, 1995; Walker, Stanton, Kazi, Salmon and Jenkins, 2009) where human decision - making is under pressure (e.g. aircraft, military, medical contexts, oil platforms, etc.) but have yet to be noticeably incorporated into the FRS.

The main aim of the research reported in this thesis is to take the work identified within the 'Naturalistic Decision Making' model and to consider how 'Recognition-Primed Decision Making' (Klein, 2003; Klein et. al. 2010) has the ability to influence decision - making and influence outcomes on the incident ground. The output of the research can then be used to consider how bias / scope by the individual can influence / impact on the decisions made by the incident commander and the subsequent outcome of the situation. Variations in bias / scope across a number of individual incident commanders will also be examined as individual differences are likely to be important in any effort to train for improved SA. Understanding of changes in bias / scope and the factors that drive them will allow the progression of this work from a theoretical model into a training / assessment protocol that can help to identify how an individual's bias / scope can be identified and used to improve the outcome of the decisions made by that individual. There may be an opportunity then to use this research to help in the development of a tool that enables FRS personnel to engage in realistic simulations of fire service operations and receive feedback about their SA and type of decision bias / scope (whether they have a conservative bias / scope tunneling down or a liberal bias / scope broadening out) followed by guidance for improvement and self-monitoring of SA and bias / scope. This will provide the personnel with immediate insights into their own decision - making patterns and tendencies and provide the means by which to self-monitor these tendencies under pressure on the actual fireground. Hopefully this would allow greater understanding of how bias can affect their decision making and assist them to temper their conservative or liberal information bias and help in making ASA based decisions for a longer period. The broad objective would be to add value to their training by increasing their awareness of possible decision - making tendencies that could produce errors and increase risk to individuals, the environment or the wider society during their fireground operations.

Chapter 3

Scoping Study 1: Assessing SA and bias / scope in a breathing apparatus and guideline exercise

3.1 Introduction

As explained in the preceding chapters, as for all effective decision - making (Endsley, 1995; 2000), fireground decision - making does not simply involve accumulating information about the incident to build a good representation of the situation or to gain good situation awareness (SA) (Catherwood, Sallis, Edgar, Medley and Brooks, 2011; Gasaway, 2008; Klein, Calderwood and Clinton-Cirocco, 2010; Omedei, McLennan, Elliott, Wearing and Clancy, 2005). It also requires the *appropriate selection* in relation to the range of information available from both the external environment and the internal knowledge base of the incident commander, who is the decision maker. The decision to choose selected information from the range of information available can be described as the dynamic filter that is applied to the available knowledge during perceptual and cognitive operations. In signal detection models such as QASA (Edgar and Edgar, 2007), such filtering is described as “bias”. It represents the response tendency of the decision maker to accept or reject available information, when uncertain as to its accuracy. An understanding of the decision - making bias / scope of fire and rescue incident commanders and the factors affecting individual differences in bias / scope may prove invaluable in minimising risk in operational fireground decision - making.

The bias / scope of the decision maker directly impacts on the selection of information for decision - making, it carries potential consequences for error or risk. Even if the body of available knowledge does not vary, different bias / scope may be applied to the breadth of that knowledge, leading to varying degrees of acceptance or rejection of the information collected and available. A cautious or conservative bias / scope permits use of only a narrow range of information, while a more liberal or lax bias scope allows use of a wider range of information that may be processed more superficially (Edgar and Edgar, 2007) (see Figure 3.1). Neither approach is necessarily risky if the captured or selected information is useful and appropriate, but an inappropriately strict or conservative bias scope could lead to a conservative narrow focus that neglects key aspects of operational information available (misses), while an inappropriately liberal or accepting bias / scope might allow incorrect or irrelevant information (false alarms) to be accepted and used for decision - making. Bias / scope can therefore carry potential risk for making errors in dynamic incident management decisions and it is important to determine if individual knowledge of this bias / scope profile could impact beneficially for the successful outcome of an incident (improved decision - making), as well as to consider the factors that may affect such tendencies.

Following evidence and discussion about bias / scope and how it affected the military (Edgar and Edgar, 2007; Edgar, Catherwood, Nikolla and Alford, 2009), the question was raised regarding the fire and rescue service (FRS) and the similarity in their pressurised situation of incident command. The uncertainty being whether bias /scope impacts on fire fighters in the same way and could it therefore impact on the outcomes for the incident, or were the two situations totally different. Research in the USA on the 'Naturalistic Decision Making' (NDM) model (as discussed) identified that in an operational environment fireground commanders argued that they were not making choices, considering alternatives or assessing probabilities, but saw themselves as acting and reacting on the basis of prior experience gained from attending operational incidents and training exercises over time (Klein, Orasnu, Calderwood and Zsambok, 1993; Johnson, Cummings and Omodei, 2009). Two of the key features of the RPD model are being focused on the situational assessment and checking that the action plan will work using mental simulation. With just these two key features, what are the other influences that impact and to what extent do they make a difference to the outcome of key decisions and how these key decisions change incident outcomes? Past research, as mentioned previously, has shown that individuals differ in how much of the available information they use and trust in making decisions; referred to as the bias or scope of the individual. What is needed is to look at the way an individual applies bias / scope to the situation when under a great deal of stress (not using a rational basis) and how will this influence their ability to arrive at a satisfactory outcome to the situation. Even when individuals basically have the same knowledge of a situation, they may still vary in how, or how much of that information that they actually choose to use in making decisions. Some people may trust or use only a narrow range or scope of available information, which could be seen as narrowing of perception (conservative or tunnel vision), while others may be more lax, trusting or using a wider scope of information (liberal or butterfly syndrome) (Catherwood et. al. 2011). It may be the same person could vary in the bias / scope that they use in different situations, or at different types of incident (experience), a situational bias / scope. Although there may be other contributing factors to such bias / scope tendencies including perceptual, attentional, working memory load, emotional and personality considerations (Becker, Mortensen, Ackerman, Shapiro and Anderson, et. al. 2011; DeFockert, Rees, Frith and Lavie, 2001;Endsley and Rodgers, 1997; Foster and Lavie, 2009; Klein, et. al. 2010; Lavie, Hirst, de Fockert and Viding, 2004; McLennan, Pavlou and Omedei, 2005; Mosier and Fischer, 2010; Schwartz, Vuillemier, Hutton and Maravita, 2005).

The Incident Command System (ICS) within Fire and Rescue Manual Volume 2, Fire Service Operations, Incident Command 3RD Edition 2008, is the basic model for all United Kingdom based FRS. It establishes the basic doctrine of the FRS in the context of operational incident management and functional command and control processes that flow from it. The key elements of effective incident command are represented in 3 areas;

- Organisation of the incident ground; providing a recognised pattern for the incident ground for resource organisation.
- Incident Risk Management; hazard identification and applications of a safe system of work for undertaking the operation.
- Command Competence; skills, knowledge and understanding identified as required by the incident command and seen as the competencies to be maintained.

Based on this the aim of the first study was to try and identify if bias / scope came into the equation in relation to SA and fire fighter reaction to pressure at a realistic training incident. The broad aims of the study were to gain an understanding of fireground SA and decision - making in relation to how bias / scope influences these decisions and to identify further studies on how / if it could contribute to training guidelines for self awareness of how information is scoped personally in fireground situations. If the basis of good command training is based on continuation training and experience, then to assist this an understanding of any personal bias / scope and how personal bias / scope can / will impact on making and implementing operational decision would be of benefit to the incident commander.

The specific prediction / hypothesis is that: FRS personnel will display either conservative or liberal decision - making bias / scope (or related miss or false alarm errors, respectively) during FRS training exercises involving simulations of fireground incidents.

3.2 Methodology

This first study involved a realistic simulation of a commercial fire incident which involved 16 competent operational FRS fire fighters wearing full fire fighting personal protective equipment (PPE) and breathing apparatus (BA) in a cosmetic smoke filled darkened building in a search and rescue (casualty recovery) exercise. This scenario was used following a visit to the Avon South West Command centre run by Avon Fire and Rescue Service (AFRS), where operational FRS personnel were observed undertaking both Minerva and Hydra exercises (Minerva is a simulation system developed alongside its partner system Hydra, to operate critical incident simulation from a small incident to a major incident, with the opportunity to use a fire scenario or to build these into different scenario's such as plane and train crashes). The training centre provides the incident commander scenes of the incident from different perspectives, or view of the incident, each perspective is established within a different room to simulate the build up for the incident commander as the incident is approached and developing the incident in real time (based on the decisions that are made by the incident commander) during the training exercises. The staff participating were using real life scenarios and were being assessed during the exercise by the South West Command Centre staff and senior operational staff from the relevant

FRS. Following this observation, there was further discussion (with both the centre and university staff) from which the initial exercise to be used with the firefighters and managers from Gloucestershire Fire and Rescue Service (GFRS) and the theoretical and methodological basis for this study were developed.

3.2.1. Sample / participants

Sixteen operational fire fighters and managers from community fire stations in Gloucestershire were programmed to respond to a central point and undertake a BA search and rescue exercise and all 16 agreed to participate in the study. The 16 fire fighters and managers were broken down into 6 teams, 2 teams of 2 and 4 teams with 3 personnel in each of them. All the participants for the exercise were fully competent operational FRS personnel ranging in experience from 5 years to 27 years, 14 being male and 2 female and 4 being full time and 12 part time (retained) fire fighters from Gloucestershire FRS operational stations. The only selection criterion used was that they were operational FRS managers or fire fighters and informed consent was gained from each individual before they were to be involved, all participants were able to withdraw their consent should they need to.

3.2.2 Context and procedure

The exercise was undertaken in the evening during the allocated training period (start of the exercise approximately 19.30) and both the exercise set up and scenario was a new exercise to the fire fighters and managers who were taking part in it. It was undertaken within a whole time fire station training building which was built for training purposes, the training building had a flexible interior, which allowed for walls, stair cases and floor levels to be moved around or adjusted in other ways to change the premises to meet the needs of the exercise and to ensure participating staff did not get familiar with the building layout. The training building also allowed both heat and cosmetic smoke to create a realistic environment to the exercise by restricting vision and working in hot and humid conditions (replicating a fire environment). The exercise scenario was described as a fire with 'persons reported' (people reported as missing or not accounted for within the premise), with the building being set up to resemble an old garage / sales room, approximately 10 x 25 meters and sub divided. The fire fighters were informed they would need to use guidelines (a fixed 60m line for fire fighters to search off so they maintained a point of reference when searching a building with reduced visibility and would not get lost due to the lack of clear vision), to locate the casualties (which are mannequins used to replicate persons reported missing and trapped within the building from information received at the scene) reported within the premises. Following the initial briefing the crews then dressed in their fire fighting PPE and rigged in their BA sets. Once each fire fighter was established into their team (6 teams of 2 / 3 fire fighters), as a team they then prepared to enter the building by putting on the face mask of the BA set and turning on the compressed air cylinder (going gas tight) isolating themselves from the external environment and providing themselves a secure uncontaminated air supply. They undertook the necessary visual checks with a designated colleague to ensure they had not overlooked any of the safety dressing procedures in line with the operational policy.   Once each team leader (five male and one female) was satisfied that each of their team members was fully kitted and gas tight, they handed in their individual recognition tallies (a hard copy tally showing the fire fighters name and at what pressure their cylinder held at the time they had entered the building) to the BA entry control officer. The entry control officer placed the tallies in the BA entry control board, along with the time of entry (actual time shown on a digital clock on the BA entry control board), the pressure within the individuals cylinder (taken of the cylinder pressure gauge which would show how long the air supply within the cylinder would last under normal conditions) and undertook a calculation based on time and pressure to identify how much time their identified air supply for each individual would allow them to operate within the building and at what time they would need reliefs or to be out of the building. The entry control officer then briefed the crew on what the objectives of the exercise were and what they were to do once they had entered the building (area to search and where to start from) to help meet these objectives. Once the team leader had received the OK to proceed from the entry control officer each individual in the team attached themselves to the guideline (used within a building with poor visibility; smoke logged) using their personal lines (which is a short 6 meter line attached to the belt of the BA set and the BA guide line so the individual does not wander off and get lost, or fall down a hole in the building floor) and entered the building to begin the exercise, fight the fire and search to locate casualties and remove them to a safe environment.

The exercise lasted a total of 70 minutes, from being briefed on the requirements of the situation and their role in it at the entrance to the training building, undertaking the search of the premises in BA, working off the guide line and then servicing their BA equipment on exiting the building so they were ready to respond to a real emergency call should they need to. Immediately after the BA exercise, (exiting the building and removing their BA face masks) individuals were asked to respond to a set of true / false probe statements about both briefed and non briefed aspects of the exercise (Table 3.1 below). An example of the briefed item was: “You were briefed to search off branch line 2: true / false”, while an example of a non briefed items was: “There were two branch lines in the building: true / false”. All the operational fire fighters and managers taking part in the exercise were asked as individuals to participate within the study and all signed University consent forms in relation to the role they would be taking. Each individual fire fighter, from the 6 teams, was asked 19 questions (10 false and 9 true; 1 question was withdrawn as it could not be confirmed that all participants had entered that part of the building in relation to the proposed question) after completing the exercise, each sheet was collected in and was secured until they could be assessed, before the fire fighters were dismissed to clean and service their BA sets.

The premise was divided as would be expected for a property used to house this type of business, with no lighting internally (incoming electricity services isolated) and heavily smoke logged (using cosmetic smoke to simulate a fire and reduce vision as would be the case in a real incident). The BA entry control officer gave the individual teams a full briefing (on the incident related information available at that time and the aims and objectives for the team) before committing them to the premise. Training officers undertaking the role of both health and safety staff and procedural observer (using thermal imaging cameras so they could monitor participants within the building) had been assigned roles and areas of risk within the building to monitor and ensure safe passage could be made by the fire fighters in the training exercise. The 16 fire fighters as discussed were committed in teams of 2 or 3, forming a total of 6 teams; and each team was provided with the same brief prior to being committed to the exercise. In summary the brief was to work in BA off the guide line to undertake search and rescue, ensuring that they dealt with any situation (finding casualties, or the fire to extinguish) as they progressed. Following the end of the exercise and collection of the probe sheets all participants were called together to undertake a 20 minute debrief of the exercise, to review its aims and objectives and to share any comments (both positive and negative) they had regarding the exercise that could be of benefit to themselves or to the other fire fighters taking part in the exercise at a later date.

3.2.3 Test materials

Prior to the exercise, the exercise scenario was reviewed and probe questions were designed with guidance from subject matter experts and senior experienced FRS staff, they consisted of the following material. A full scenario planning document was provided and reviewed, there were originally 20 probe statements in total identified from the scenario and each required a true / false response (10 true and 10 false items in randomised order with respect to being true or false). For example, “There were 2 branch lines in the building: true / false” or “You were briefed that there was a child casualty: true / false”. As a pilot trial, the researchers attended the first exercise of this type and watched from a remote location, so they could review the probe sheets and ensure a direct correlation between what had occurred during the exercise and the questions that were posed within the probes, (Table 3.1). The probes, their use and the aims and objectives of the study were shared and discussed with the Fire and Rescue training staff who had set up the exercise and written the brief for it, and their comments and observations helped to make up the final probes. The probes for the individuals to respond to were tested at the first exercise of this type, as this was for a series of exercises to test BA procedures for a number of operational stations and competent fire fighters and managers. This series of exercises were designed to run over a number of weeks and included a number of operational stations and groups of fire fighters, the one at which our probes were initially tested or trialed, being held two weeks prior to the actual exercise used for this study. This ensured that the probes were a valid measure of the information provided to the participants of the exercise. It meant that the probes were also relevant to the exercise and the operational aims and objectives of the exercise for the FRS, which ensured they were relevant to the tasks for the fire fighters and managers exposed to them. Immediately following the exercise, after the fire fighters had left the training building, the true / false probe questions were presented to each individual in a written response sheet format. As explained above, the questions were aimed at finding out how much of the briefing and exercise information was retained (SA) and how narrowly or widely the personnel had scoped (taken in and accepted information from) the exercise situation (bias / scope). Because of the needs of the FRS exercise co-ordinators there was a slightly different brief for some of the teams. Teams two and five were briefed to search of branch line 2, where there was one cupboard on the route (which meant that question one ‘You were briefed to search off branch line 2’ was true and question 15 ‘There were two cupboards on your route’ was false. Teams one, three, four and six were briefed to search of branch line 1, where there were two cupboards on the route, making question 1 false and question 15 true.

QUESTION	T/F
You were briefed to search off branch line 2	T(2,5) F(1,3,4,6)
You were advised in the brief to conduct gauge checks	T
You were briefed that there were 2 casualties	F
There was a gas cylinder outside the building	T
You were briefed to conduct a R/H search pattern	F
There were two branch lines in the building	T
The first branch line was ~12m into the building	F
There were two staircases in the building	T
There was another team in the building at the same time as you	T
You were briefed that there was a child casualty	F
You were shown floor plans for the entire building	F
There are four appliances present	T
There was an emergency team on the BA board as you entered	F
There was a 45 gallon oil drum on your route	F
There were two cupboards on your route	T(1,3,4,6) F(2,5)
There was at least one bed on your route	T
You were using radio channel 2	F
You crossed the main guideline 3 times	F
All teams were teams of 3	F

Table 3.1. Probes identified following review of the exercise scenario and agreed with supervisory university staff, these were statements taken from the scenario to provide straight forward true / false responses to the participants.

The questions in blue related to the information provided by the BA entry control officer's briefing directly to the crews, this was in line with FRS procedure and undertaken prior to the crews being committed to the premises. The other probes were taken from what was happening within the premises as it was set up for the exercise, partly about the structure, partly about what they could be expected to find and partly about the process / procedure they were undertaking and expected to follow.

3.2.4 QASA

The responses were analysed by a "signal detection" type method using Quantitative Assessment of Situation Awareness (QASA) (Edgar et. al. 2009). The QASA technique requires true / false decisions about statements concerning a situation that are either true or false. The approach is based on signal detection theory (Edgar and Edgar, 2007; Stanislaw and Todorov, 1999) and provides a measure of a.) knowledge or SA (how well the individual discriminates true from false information) and b.) the bias applied by the decision maker to the available information (i.e. the tendency to accept or reject information as true). The technique gives two scores (scaled from -100 to +100 in each case):

i.) Knowledge (or situation awareness, SA) (100 being good, 0 being poor and -100 being misguided SA) and

ii.) Bias on a scale from very liberal (-100) to very conservative (+100), with 0 showing no bias either way. Liberal bias towards accepting and using a broader band of information (broader scope) is reflected in more "false alarm" errors, saying that an item was true when it was false and so showing weak or superficial processing of the situation / information. Conservative bias is cognitive and perceptual tunneling on a narrow band of information (narrow scope) and is reflected in more “miss” errors, saying that an item was false when it was in fact true, due to narrowed focus on a selective portion of the available information at the expense of the rest.

The way an individual applies bias / scope to the situation can influence the ability to arrive at a satisfactory outcome to the situation with “miss” errors associated with conservative bias / scope or tunneling and “false alarms” with liberal bias / scope or broadening that may produce a “butterfly syndrome” (hopping from one aspect of information to the next) in which irrelevant information attracts as much attention as important information.

See Table 3.2 for details and Appendix 1 for the computational details.

Score	**Knowledge/ Situation Awareness (SA) Index**	**Bias Index**
Positive (max +100)	Good SA. Distinguishes true information from false: higher score is better.	‘Strict’ conservative bias. Tends to reject information as false even if true: higher the score the greater this tendency. Risk of making “miss” errors due to high rejection of information even if actually true.
Zero	No SA – guessing?	No bias towards accepting or rejecting information. A ‘neutral’ attitude.
Negative (max -100)	Misguided. Judges false information as true and *vice versa.* More negative is worse.	‘Lax’ liberal bias. Tends to accept information as true even if false: the more negative the score the greater this tendency. Risk of making “false alarm” errors due to over-acceptance of information as true.

Table 3.2. Patterns of knowledge/SA and bias using the QASA measures.

The SA or knowledge score is conceptually similar to that provided by other established measures of SA, such as the Situation Awareness Global Assessment Technique (SAGAT)(Endsley, 1987). The bias measure in QASA however gives further insights into the critical question of how knowledge or information may be selected or filtered for decision making and whether this is being achieved in a strict and conservative way or alternately, a more lax or liberal manner. Moreover, QASA is uniquely suited for studying real world decision - making since it allows, and is able to measure, the state of an individual where true information may actually have a weaker representation than false. Thus QASA may be especially suited to studying the decision - making of individuals who are fundamentally misguided about a situation and hence at great risk of making errors. It has been used in a range of applications to date including simulated military contexts (Edgar, Catherwood, Nikolla, Alford, et. al. 2010; Edgar, Catherwood, Alford, Nikolla, Edgar and Brookes, 2011; Rousseau, Tremblay, Banbury, Breton and Guitouni, 2010). For these reasons, QASA is used in the present studies to assess knowledge and bias / scope patterns of FRS personnel during simulated fireground exercises. It is predicted that individual differences in bias / scope tendencies will be apparent for the same situation and that such tendencies will be independent of the level of knowledge or SA of the individual. In other words, even amongst those with the same SA there may be different bias / scope, so that when errors are made, some people may tend towards making miss errors and some towards false alarm errors.

3.2.5 Ethical issues

These studies were conducted in compliance with the ethical guidelines laid down by the British Psychological Society and ethical approval was obtained through the recognised procedures within the University of Gloucestershire. The studies took place at FRS establishments or within training situations at the time of routine training / assessment exercise sessions, although participation in these research studies was fully voluntary indicated by signed consent after a preliminary briefing. Participants were fully advised that there were no requirements to participate in the research project. No staff member elected not to be involved in this study and the results were anonymised for the purposes of general analysis and for reporting in any public manner. A general debrief and anonymised feedback on the data obtained was subsequently provided to the crews involved by visiting the operational stations that took part on their training nights (feedback brief appendix 2).

3.3 Results

As explained above (3.2.4), the responses were analysed by the method called QASA, this method takes into account not only the percentage of correct answers (the *knowledge* or *situation awareness* score) but also the individuals tendency to say true or false; that is their bias / scope to the information. As noted above, an individual saying true to everything is showing a very liberal, lax or accepting bias / scope to the information available to them, while a person saying false to everything is showing a very conservative, strict or rejecting bias / scope.

The QASA analysis requires the data from all the probes, whereas the briefed / non briefed probes can be considered using % correct.

QUESTION	T/F	% correct
You were briefed to search off branch line 2	T(2,5) F(1,3,4,6)	93.75
You were advised in the brief to conduct gauge checks	T	100
You were briefed that there were 2 casualties	F	100
There was a gas cylinder outside the building	T	25
You were briefed to conduct a R/H search pattern	F	93.75
There were two branch lines in the building	T	68.75
The first branch line was ~12m into the building	F	37.5
There were two staircases in the building	T	87.5
There was another team in the building at the same time as you	T	100
You were briefed that there was a child casualty	F	100
You were shown floor plans for the entire building	F	43.75
There are four appliances present	T	62.5
There was an emergency team on the BA board as you entered	F	75
There was a 45 gallon oil drum on your route	F	93.75
There were two cupboards on your route	T(1,3,4,6) F(2,5)	50
There was at least one bed on your route	T	56.25
You were using radio channel 2	F	93.75
You crossed the main guideline 3 times	F	75
All teams were teams of 3	F	68.75

Table 3.3. Identified probes with % scores shown for correct responses.

Overall the analysis shows that knowledge of the situation was good (SA), although predictably it was better for briefed items (mean: 88.6% correct) than non-briefed items (mean: 68.8% correct, with the 'chance' % correct if they just guessed being 50%) and the first probe of a non briefed item ("There was a gas cylinder outside the building") showed the lowest score of all (mean: 25% correct). This item produced a common theme from the fire fighters in their response to this question being asked, they said 'if I had seen there was a gas cylinder by the entrance door I would not have entered; so it could not have been there'.

Of most interest for the aims of this investigation however is that the results also show that two individuals can appear to have similar knowledge (SA), but in fact still have very different bias / scope in regard to that knowledge. The analysis shows different bias / scope patterns: with 7 people showing a liberal bias / scope pattern and scoping more broadly and accepting more information than others, while 9 people showed their bias / scope to be on the restricted side, with a slightly narrow focus, reflecting a conservative bias / scope. It is also of interest to note the individual differences in each of these patterns with some people having stronger bias / scope than others. It is very clear however that similar SA may yet be associated with different bias / scope tendencies.

As an example two individuals scored especially well on the SA / knowledge tests: Person A obtaining 88% correct and with Person B getting 91% correct, but their bias scores tell a very different story. Their results are shown in Figure 3.1: there are two scores shown for each person: a knowledge score in blue (from +100 or 100% correct ranging down to -100 or 100% wrong) and a bias score in red (also from +100 being very strict to -100 being very lax).

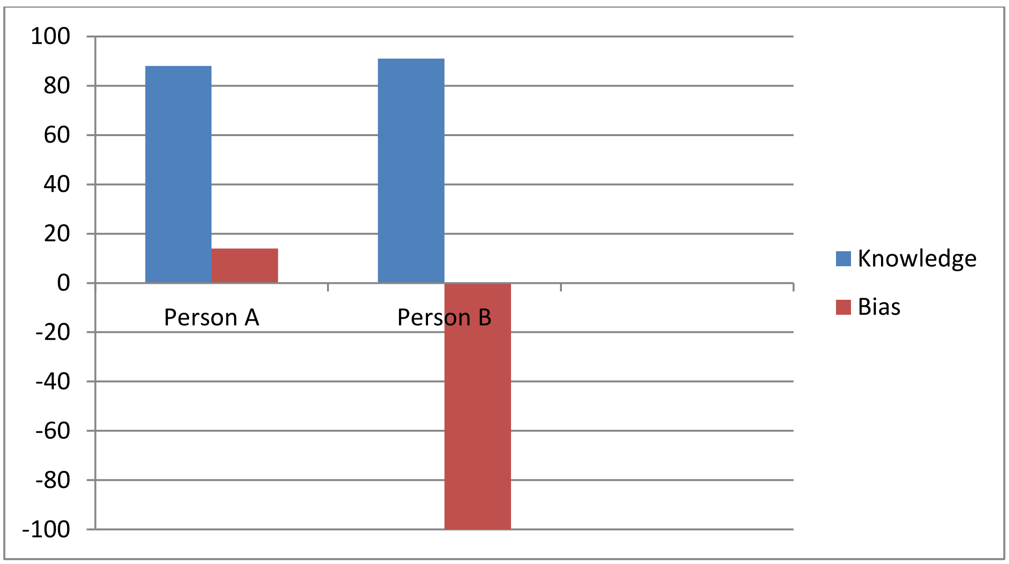


Figure 3.1. Examples of results from BA guideline exercise showing two people with apparently similar good knowledge scores, but very different bias: Person A having a conservative, narrower or stricter bias/ scope and Person B a liberal, lax or accepting bias / scope.

Person A tends to have a somewhat strict conservative bias / scope, while Person B shows a loose or liberal bias / scope, saying true not only to the correct items but indeed to many of the false or wrong items. This shows that these two individual fire fighters were applying very different filters, or bias /

scope, to the information: Person A was using a narrow scope, being more cautious or conservative in accepting something as true, while Person B was being much less cautious, using a much more liberal filter. Below (figure 3.2) is the full outcome of the varying knowledge scores and the bias shown across the range of the 16 individual fire fighters taking part in the exercise.

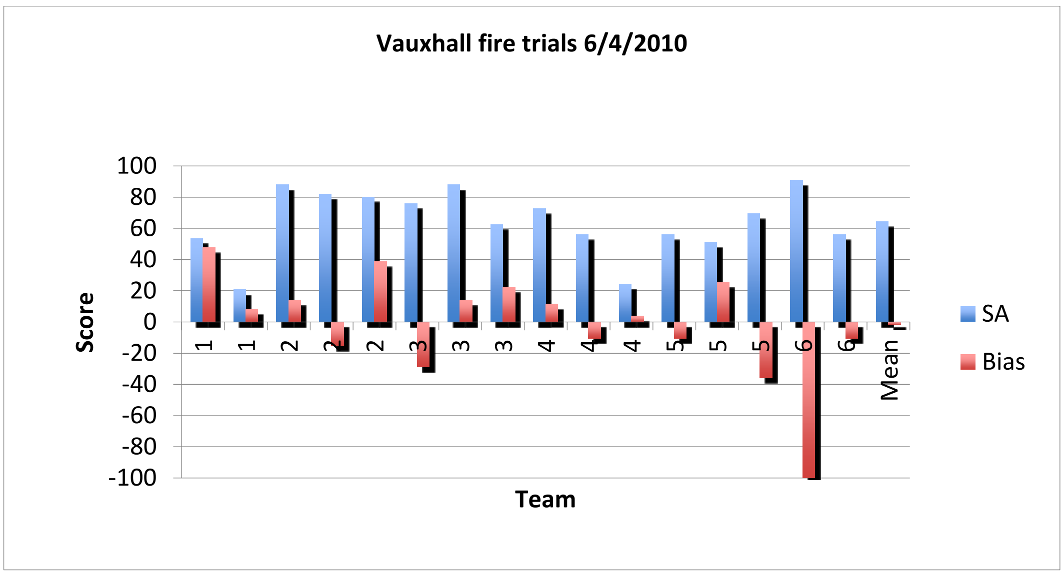


Figure 3.2. Examples of results from BA guideline exercise showing the different paten of knowledge scores and bias for the individuals in each of the 6 teams.

As an example of the potentially serious implications of such bias / scope patterns, a conservative, narrow bias / scope could explain why the gas cylinder was missed for example. The majority of fire fighters did not identify the gas cylinder even though they had to walk passed it whilst undertaking the exercise, which was a miss error. Given the gas cylinder was right next to the entrance door of the building which was supposed to be involved with fire right at the start of the exercise, could have meant the cylinder had been or would have been subjected to heat or damage. Following the crews getting gas tight in BA and being briefed by the BA entry control officer (most fire fighters would feel under stress at this period of an unknown exercise while under observation), it was possibly due to the individuals tunnelling down to the objectives of the exercise from a conservative bias / scope.

3.4 Discussion

Overall the analysis shows that SA was good, although predictably it was better for briefed items (average of 88.6% correct) than non-briefed items (average 68.8% correct). The retention of the briefing information given by the BA entry control officer to the crews before being committed to the premise appears good. The results also show however that two individuals can appear to have similar SA, but in fact still have very different bias / scope in regard to that knowledge. The analysis identified these different bias / scope patterns, with the majority having a slightly narrow focus, reflecting a conservative bias / scope, but the others showing a more liberal bias / scope tendency and also with clear individual differences in the extent of any such bias / scope. Overall then, the pattern of results support the hypothesis for the study that FRS personnel will display either conservative or liberal decision - making bias / scope (or related errors) during FRS training exercises involving simulations of fireground incidents.

The data analysed by the QASA tool thus clearly confirmed that most individuals displayed a high level of knowledge, but also showed either a conservative bias / scope (with miss errors) or a liberal bias / scope (with false alarm errors). In other words, although very few errors were made in SA or knowledge, *when they were made*, they tended to be either miss errors reflecting a conservative narrow bias / scope or alternately false alarm errors reflecting liberal accepting bias / scope. This has clear implications for fireground decision - making and training.

Each bias / scope type (lax or strict) can have implications for training with different pitfalls: too conservative, narrow or strict a bias / scope means you can reject information that is useful and true, making a *miss* call / error; while too liberal, lax bias / scope can mean you are using wrong or useless information; a *false alarm*. As an example, a sudden increase in risk level on the emergency incident ground situation could mean that Person B who was showing a liberal, lax or accepting bias / scope (Figure 3.2.) above may become much stricter in their bias / scope, with a narrowing bias / scope that will hone in on the items they feel are correct only and not look to utilize the wider information available. While it could also mean that the bias / scope of Person A who was showing a conservative, narrower or stricter bias/ scope could become much stricter too, with an extremely narrow bias / scope that misses or overlooks correct information outside the immediate area of their incident focus. There may be no simple answer about the best level of bias / scope used, as it will always depend on the demands of the emergency situation to a large extent. However it would appear that it could be beneficial to have some means to check on individual level of bias or scope and this will be explored within the further research, when it is proposed to look at the bias / scope of fire fighters over a wider number of operational stations and increased numbers of operational staff.

The particular interest of this research was how the incident ground information was scoped in terms of information bias that is whether individuals worked from either a liberal, broad or conservative, narrow span of available information (a liberal or conservative bias /scope, respectively). In other words, the aim was to determine whether they "trusted" a wide scope of information, but perhaps did not process it very deeply (the "butterfly syndrome") or whether they focused down on a small part of the available information, reflected in a narrowing of perception (tunnel vision) and cognition, in a conservative approach to their selection of information. This bias / scope can have an external or internal aspect; in an external sense it can affect the visual inspection of the incident ground (scanning widely to narrowly), or in an internal sense, it can affect the mental impression that is formed about the situation (thinking about the wider implications for the situation or only narrowing down on a few aspects). The two are closely linked: for example, a narrow internal bias / scope may mean that there is incomplete visual scanning of the situation and vice versa, a wider external bias / scope pattern may produce an incomplete detailed impression of the situation. This type of bias / scope may have (or have already impacted on) important consequences for decisions and errors made in actual incident ground situations (Catherwood, et. al. 2011; Catherwood, Sallis, Edgar and Medley, *2012*).

The ultimate aim of the project is to improve understanding of the processes underlying operational command and control decision - making on the incident ground and to see if it is possible to develop training self awareness of the bias / scope of information in actual incident ground situations. The main aim of this experiment was to determine whether the bias / scope patterns would be apparent in a realistic and challenging training exercise (putting fire fighters and managers into to an unknown building, in full fire fighting PPE and BA while being assessed). This was clearly the case and the participants showed either a conservative (positive) bias / scope pattern or a more liberal (negative) bias / scope pattern.

The question for further research is how does the individual scope and is it consistent in the way they undertake it. Is the bias / scope they show a resting bias / scope (one they repeat each time; one that they will invariably reveal or fall back on when under pressure) or is their bias / scope a situational one, that will vary each time being dependent on the situation they find themselves in when responding to an emergency call, or may even be influenced by their activities prior to responding to the incident / exercise (e.g. rebuilding a small clock motor, or involved in a blue sky exercise).

For the next study the questions of interest are whether there any such bias / scope error patterns and will they be consistent for individuals over situations / scenarios. Will experienced FRS personnel be less prone to displaying such bias / scope error patterns and will any such bias / scope patterns be reduced or moderated by providing detailed personal feedback on bias / scope and error tendencies to individuals following training exercises (i.e. individuals can use understanding about their own bias to reduce errors in decision - making).

3.5 Conclusions

The BA exercise in this experiment shows evidence of positive, conservative or negative, liberal bias / scope patterns in the FRS participants. There may be many contributing factors to such bias / scope patterns including perceptual, attentional, working memory load, emotional and personality considerations (Becker, et. al. 2011; De Fockert, et. al. 2001;Endsley and Rodgers, 1997; Foster and Lavie, 2009; Klein et. al. 2010; Lavie, et. al. 2004;

McLennan, et. al. 2005; Mosier and Fischer, 2010; Schwartz et. al. 2005). The role of such factors is not able to be determined from this experiment, but nonetheless the finding of bias / scope patterns in fire fighters is an important one that may have implications for understanding errors in incident ground decision - making. Future development of this research will explore bias / scope tendencies in further incident related decision - making and these should confirm or not, the tendencies that have been identified from the fire fighters who have taken part in this exercise session. The further work will also attempt to ascertain whether any bias / scope tendencies are consistent for individuals across different incident ground situations and contexts, a situational bias / scope. Or if the bias / scope tendencies shown are consistent for the individual, regardless of the situation, a resting bias / scope that will be the way they operate at times across all incidents.

These current findings confirm the methodological approach used as a valuable means for developing these future studies. The technique has clearly shown that there are response bias / scope tendencies in the decision - making of FRS professionals leading to either *miss* or *false alarm* errors. Further investigation of bias / scope patterns would thus seem critical to developing understanding of factors that could lead to increased risk in real incident ground decision - making for FRS operational fire fighters and managers. As we have discussed effective decision - making is dependent on good SA, which is an awareness of what is happening around the individual, in order to understand how information and individual actions impact outcomes, both short and medium term. A good feel for situations and events that happen due to variables the incident commander can control, with SA especially important where the information flow is high and varied and poor decision - making can and does lead to serious consequences.

Chapter 4

Table top exercises; house fire and factory fire: does bias / scope influence the operational outcome of pressurised fire incident decisions?

4.1 Introduction

Effective decision - making is dependent on accurate situation awareness (SA). SA involves being aware of what is happening around you, in order to understand how information and actions will impact objectives. With SA especially important in work domains where the information flow can be high and poor decisions may lead to serious consequences or understanding of what is happening in the situation (Endsley, 2000). Bias / scope can tend either to conservative, tunneling on a narrow band of information or alternately liberal, towards a broader scope. The way an individual applies bias / scope to the situation can influence the ability to arrive at a satisfactory outcome to the situation with *miss errors* associated with conservative tunneling and *false alarms* with liberal broadening.

The main aim of this study was to further assess SA and bias / scope in respect to fireground operations. In this study this was achieved by means of a tabletop exercise involving a presentation of a fire incident with information provided to the participant via text, photographic and video material (details below). Probe questions about key aspects of the incident information were interleaved at key points to assess the individual's SA and bias / scope using quantitative assessment of situation awareness (QASA) scores as for the first exercise. Again the aim was to firstly assess levels of SA, but against this to also determine if individuals vary in bias / scope, with some exhibiting conservative, narrow bias / scope (accepting only a narrow range of information as true and being in a position to make miss errors) and others a more liberal bias / scope (accepting a wider range of information as true and being more disposed to making false alarms). These aims were explored within these tabletop studies with it also being of interest to determine the effects of experience on these aspects of performance. It is also possible that personality factors habitually dispose someone towards either a conservative or liberal decision making bias / scope, but these were not tested in this series of exercises. Personality traits have been linked to effective fireground command (Burke, 1997) and it may be that different patterns of bias / scope in fireground decision - making could be associated with particular traits. For example, risk taking or conversely risk adverse personality traits may respectively underlie (liberal) relaxed or conservative bias / scope tendencies in some contexts (Li, Chao and Li, 2009). In sum, there is potential for bias / scope in fireground decision - making to arise from numerous sources of brain activity that influence the selective processing of information. Given the range of factors that could induce bias / scope in this way, individual differences or variations in bias / scope patterns may well arise for the same situation. An understanding of such individual bias scope patterns would seem critical for improving and training self awareness in regard to the selection of information and potential risk tendencies in fireground decision - making.

One of the initial aims of the project was to develop a technique that would in the first instance determine whether response bias / scope patterns are apparent for fire and rescue service (FRS) personnel in fireground simulation exercises and whether there are individual differences in bias / scope. The basic paradigm for this research has been developed in previous studies of SA and decision - making and involves the use of the QASA method (Edgar and Edgar, 2007; Edgar, Catherwood, Alford, Nikolla, Edgar and Brookes, 2011; Edgar, Catherwood, Nikolla, Alford, et. al. 2010).

The predictions or hypotheses are:

i) FRS personnel will display either conservative or liberal decision - making bias / scope (with related miss or false alarm errors respectively) during FRS training exercises involving simulations of fireground incidents.

ii) any such bias / scope error patterns will be consistent for individuals over situations / scenarios.

iii) experienced FRS personnel will be less prone to displaying such bias / scope errors.

iv) any such bias / scope will be reduced or moderated by providing detailed personal feedback on bias / scope and error tendencies to individuals following training exercises (i.e. individuals can use understanding about their own bias / scope to reduce errors in decision - making).

4.2 Domestic (house) fire table top exercises

4.2.1. Introduction.

As noted above, the main aim of this study was to determine if there were individual differences in bias / scope patterns for operational FRS personnel and if these patterns were consistent across two different table top fireground based exercises and if they differed with fire fighting experience.

4.2.2. Method

Design

The material for this exercise was based on a fire in a domestic property (house), with persons reported as missing (individuals believed to be still in the premises). The exercise was chosen to represent a familiar type of incident based on the station ground for the fire fighters taking part, a relatively straight forward house fire that the FRS would respond to, to test if bias / scope was evident.

All participants were operational fire fighters (or operational commanders who would respond to incidents on the fire engine) and all were provided with the same stimulus presentation, with both SA and bias scores being obtained in regard to the presented information, via the QASA method described above and below. Three groups of participants were tested on the domestic fire exercise: a) full time fire fighters and operational managers, b) part time (retained) fire fighters and operational managers and c) a student sample. The inclusion of the student sample into the experiment was to obtain validation of the professional relevance of the task for FRS decision - making: if FRS participants showed better SA than the students, this would confirm the validity of the task as a test of SA relevant to FRS professionals.

Sample

The FRS participants were all operational fire fighting personnel from a number of fire stations including larger urban and smaller county localities, with 30 full time fire fighters (mean age: 39 years and mean years of experience 13.8 years) and 20 retained (part time) fire fighters (mean age: 43.5 years and mean years of experience 14.4 years). There were seven people in operational managerial roles (crew and watch manager) amongst the full time group and four in operational managerial roles amongst the retained group. All FRS participants gave informed written consent for taking part in the experiment and their individual responses were collected anonymously. The student sample taking part in the first exercise was comprised of 30 local university students (mean age 25.9 years) randomly selected from psychology classes within the university, the students were also individually tested and each gave informed written consent for taking part in the experiment and their individual responses were collected anonymously.

Materials and procedure

The table top exercise was presented as a power point presentation, built up to reflect a fire in a domestic house where a person was reported missing (an individual was not accounted for and believed to still be in the house where the incident occurred) with the probe questions being designed with guidance from senior operationally experienced FRS staff. The material in the power point presentation consisted of slides and video showing the fire engine approach to the incident travelling from the local area to the incident ground. With the development of the house fire incident using standard fire service operations in relation to tackling the situation and bringing it to a safe conclusion. Each group of fire fighters were assembled within the training room of their operational station during their normal training period. After a preliminary briefing, the series of the power point slides and video segments representing the call of fire to a house in a local city area were shown to each of the small groups of participants (6 to 10 people) in the following sequence:

a) a slide with basic information about the incident; that at 14.57 there was a call to a fire, with a washing machine on fire in the kitchen of a house, requiring the assignment of two fire pumps (engines),

b) two slides respectively showing a map of the area and an aerial view of the neighbourhood and incident location, also showing a hazard (school) on the access route,

c) a 5 minute video segment showing the drive through an urban environment to the fire incident from the viewpoint of the driver / operational manager of a fire engine with accompanying siren and traffic sounds,

d) two slides providing a view of the street approach to the property and a street view of the property (with smoke escaping from the front window),

Figure 4.1. Example of images used in the domestic presentation (premises approach).

e) two short video segments with conflicting comments from two neighbors once they were at the address about whether an elderly occupant was in the house, or was away from the house and

f) a series of 22 rapidly presented images, providing a collage of views of the interior and rear garden of the house, including views of the hall and staircase, kitchen (with the cooker / stove rather than washing machine on fire), living room, landing and stairwell, bedroom and rear garden along with statements from the local press. (See Figure 4.1 and 4.2 for an example of the slide images).

Figure 4.2. Example of images used in the domestic presentation (bedroom view).

Interspersed at three pre set intervals were sets of probe statements presented as requests for clarification from the station officer (senior manager). There were 20 probe statements in total and each required a true / false response (10 true and 10 false items in randomised order with respect to being true or false). For example, “You passed three other emergency vehicles true / false” or “The bathroom could be occupied true / false”. The response probes also asked how confident participants were in their answer to each question on a Likert scale of 1 to 4 (one being a guess and four being sure), allowing for the measurement of three aspects of SA:

1) Actual situational awareness ASA: how good an individual’s ASA is compared to the ground truth.
2) Perceived situational awareness (confidence) PSA: how good an individual believes their PSA to be.
3) Bias: the tendency to use more, or less information in building SA.

These three measures provide a unique insight into the building of SA on the fireground. Participants were asked to record their individual responses on a prepared answer sheet along with details of their role, age and years of FRS experience for the FRS sample. The full list of probes are shown in Table 4.1 below;

1) Confirm possible parking issues in the area?
2) Confirm area high density housing?
3) Confirm shortest route from the station is it the optimal one?
4) Confirm single approach to house?
5) Confirm external signs of fire?
6) Confirm young children on street on approach to OR outside property?
7) You were greeted by the homeowner when you first arrived?
8) Front window was open on your arrival?
9) There are signs of child occupants in house?
10) Washing machine was on fire?
11) There is a single calor gas fire in the house?
12) There is a possible explosion hazard upstairs?
13) Stairway offers clear escape?
14) Bathroom could be occupied?
15) There are signs that the mother was still in the house?
16) There is double-gate access at rear of property?
17) Bedroom cupboards are shut?
18) There is a double oxygen cylinder in the bedroom?
19) There is a petrol mower in back yard?
20) Local press are critical of operations?

Table 4.1. Full list of questions (probes, for the house fire).

4.2.3 Ethical considerations

These studies were conducted in compliance with the ethical guidelines laid down by the British Psychological Society and ethical approval was obtained through the recognised procedures within the University of Gloucestershire.

The studies took place at FRS establishments or within training situations at the time of routine training / assessment exercise sessions, although participation in these research studies was fully voluntary indicated by signed consent after a preliminary briefing. Participants were fully advised that there were no requirements to participate in the research project. Some staff did elect not to be involved in the studies demonstrating that consent was fully voluntary. Results were anonymised for purposes of general analysis and for reporting in any public forum. Results were anonymised for purposes of general analysis but coded, so they could be compared should the same staff take part in other exercises and general anonymous feedback was provided to the group involved. Feedback (appendix 3) was also provided to all participants for the FRS, both mid way and at the end of the exercises.

4.2.4 Measures of SA and bias

As discussed previously at chapter 3; 3.2.4, the QASA approach (Edgar & Edgar, 2007) is based on signal detection theory (Stanislaw & Todorov, 1999) and assesses both knowledge or SA and the bias that is applied to the available information. QASA determines the proportion of correct responses (hits and correct rejections) and incorrect responses (misses and false alarms) and these scores are then re-scaled to respectively provide two measures, one of SA and the other of bias. Further justification and explanation regarding the measures is provided in Edgar and Edgar (2007) with the basic underlying signal detection theory described in Stanislaw &

Todorov (1999). QASA provides a score for SA (corrected for guessing) from +100 (perfect SA) to -100 (totally misguided and wrong SA). Bias is also scaled from +100 (very conservative bias / scope) to -100 (very liberal bias / scope), with zero meaning no bias either way.

4.3 Results: House fire exercise

Domestic fire exercise: overall patterns of SA and bias / scope. For this study, the overall level of SA for the FRS sample was high ($\bar{x}$ 70.9; SD 17.2), with FRS personnel showing significantly higher SA than the student sample ($\bar{x}$ 56.9; SD 21.5): t (78) = 3.184, p =.002), consistent with the professional relevance of the task for FRS personnel. The results for the bias scores however show a different pattern. The FRS and student samples do not differ in bias scores: t (78) <1, both samples having negative (liberal, accepting or lax) bias / scope patterns on average ($\bar{x}$ -18.7 and SD 30.4 for students and $\bar{x}$ -13.6 and SD 41.2 for FRS personnel), but further analysis for the main sample of interest (FRS personnel) confirms that there are individual differences in bias / scope tendencies.

Bias / scope patterns in FRS sample. There is clear evidence of three distinct bias groups or patterns amongst the FRS personnel: χ^2 (d.f. =2) = 16.12, p <.001 and furthermore, there is no significant correlation of bias / scope with SA for the FRS group: r = -0.09 (n.s.). In other words, as predicted, bias / scope tendency varies independently of level of SA.

The three bias / scope groups (Figure 4.3) amongst the FRS sample are respectively comprised of:

1) 29 Ps showing negative (accepting, liberal or lax) bias / scope tendencies (bias scores < 0) and thus tending to accept information as true (and so to make *false alarms* if they made errors),

2) 15 Ps showing positive (narrow, conservative, strict or cautious) bias / scope tendencies (bias scores > 0) and thus tending to reject information as true (and so to make *misses* when making errors) and

3) only six Ps showing no bias / scope patterns at all (bias scores = 0)

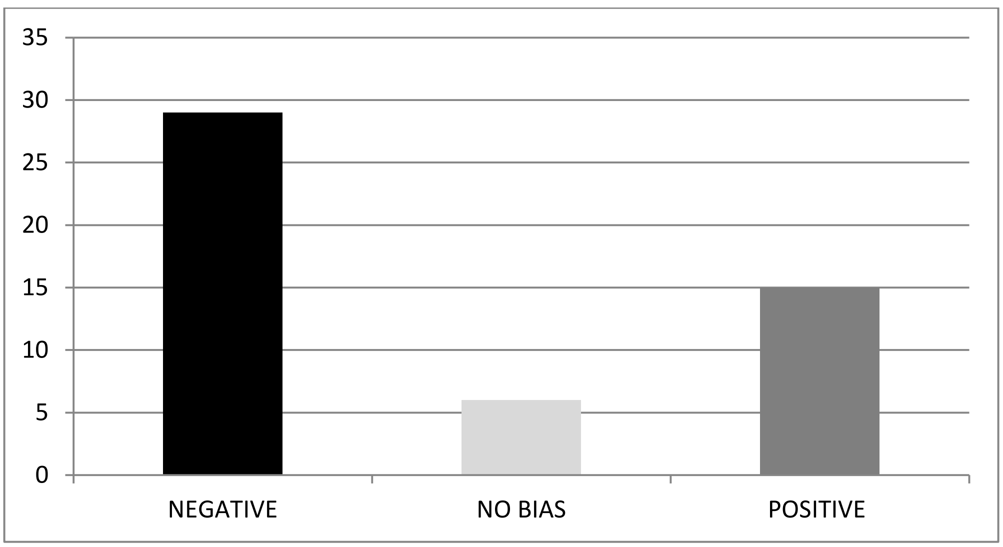


Figure 4.3. Domestic house fire table top exercise: Mean bias scores for the 3 bias groups in the FRS sample.

The group showing positive bias (x̄ 29.5; SD 30.4) differed significantly in bias scores from the group with negative bias (x̄ -38.8; SD 28.7): t (42) = 7.327, p <.001. Notably however there are no significant differences in the SA scores for these two bias groups: t (42) <1. In other words, even though the two groups had apparently comparable SA, they nevertheless had different tendencies for accepting or rejecting information, with the negative bias / scope group tending towards liberal acceptance and so to make false alarms and the positive bias / scope group having a more conservative criterion and so being more prone to making misses.

It should also be noted that within each bias grouping, there was a range of individual scores: from -100 to -2.4 for the negative / liberal bias group and from +100 to +5.3 for the positive / conservative bias group, indicating the sensitivity of the QASA analysis to reveal such individual variation (see Figures 4.4).

Any difference in patterns of ASA and bias / scope for full time and retained fire fighters and the relationship to years of experience was also examined. As noted above, the FRS personnel had significantly higher ASA than the non professional (student) sample but did not differ from that sample in bias / scope. Further analyses for the FRS sample do not reveal marked differences in either ASA or bias due to FRS status (full time vs. retained) or years of professional experience (See Figures 4.12 for individual results for Whole time fire fighters and 4.13 for individual results for Retained fire fighters for both exercises).

In regard to ASA, both full time and retained fire fighters achieved high levels: the full time group having a mean ASA score of 71.7 (SD 19.0) and the retained group having a mean of 69.5 (SD 14.4), with no significant differences in ASA for the two groups: t (48) <1 (n.s.). Moreover, there is no significant correlation of ASA with years of experience for either the full time group (r= -0.01, n.s.) or the retained group (r = -0.3, n.s.).

In regard to the bias / scope scores, both FRS groups on average showed somewhat negative bias / scope with this being more so for the full time (mean of -18.8, SD 42.9) than the retained groups (mean of -5.9, SD 38.4), but again there is no significant difference in bias / scope scores for the two groups (t (48) = 1.1, n.s.). Furthermore, there is no significant correlation of years of experience with bias for either the full time group (r= .002, n.s.) or the retained group (r= 0.17, n.s.).

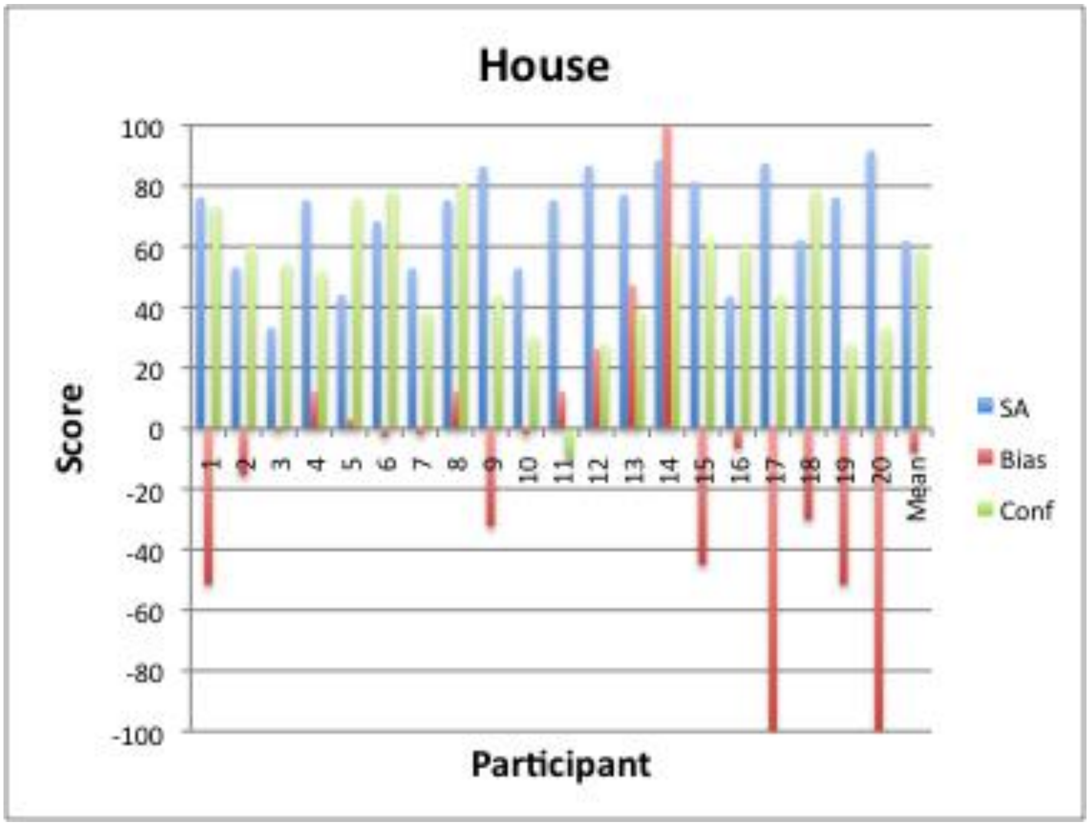


Figure 4.4. Domestic house fire table top exercise: knowledge and scoping patterns for the first 20 participants.

Question and correct answer	% of correct answer
1) Confirm possible parking issues in the area? Yes	75
2) Confirm: area high density housing? Yes	92
3) Confirm: shortest route from the station is it the optimal one. No	50
4) Confirm: single approach to house? No	75
5) Confirm: external signs of fire? Yes	83
6) Confirm: young children on street on approach to OR outside property? Yes	92
7) You were greeted by the homeowner when you first arrived: No	17
8) Front window was open on your arrival: Yes	83
9) There are signs of child occupants in house: Yes	92
10) Washing machine was on fire: No	83
11) There is a single calor gas fire in the house: No	50
12) There is a possible explosion hazard upstairs: Yes	92
13) Stairway offers clear escape: No	83
14) Bathroom could be occupied: Yes	83
15) There are signs that the mother was still in the house: Yes	92
16) There is double-gate access at rear of property: No	67
17) Bedroom cupboards are shut: No	42
18) There is a double oxygen cylinder in the bedroom: No	83
19) There is a petrol mower in back yard: No	50
20) Local press are critical of operations: Yes	92

Table 4.2 Percentage of the group giving correct response for each question.

4.4 Discussion

The ASA and bias / scope for the house fire exercises were calculated for each person; ASA was high with a mean (average) of 69.4 for the exercise. Of concern however is that there was no significant correlation between the ASA scores and the PSA (confidence) scores. In other words, people may have had poor ASA but perceived that their PSA was good or vice versa, had good ASA but judged it to be poor. The results indicated that the bias / scope and ASA measures obtained in the scenario showed no significant correlation.

The primary aim of this tabletop study was to determine if FRS personnel displayed bias / scope patterns in decision - making during table top fire incident exercises, which would confirm the outcome from our first exercise using six teams in breathing apparatus for the exercise. The evidence clearly shows that for most participants this was the case. The majority of FRS participants tended towards a liberal or negative bias / scope (and hence towards making *false alarm* errors), while the remainder showed a conservative or positive bias / scope (and hence towards making *miss* errors), with these differences not linked to level of ASA or knowledge, nor to years of experience or professional status (full time vs. retained). The level of ASA was high for both FRS groups and significantly higher than that for students, confirming the validity of the task content used for FRS personnel.

Nevertheless, the FRS sample did not show significant differences in bias / scope tendencies to those shown by the students. In other words, the bias / scope scores reflect tendencies that are statistically independent of FRS experience.

It cannot be determined why such bias / scope tendencies occurred in this exercise, but nonetheless the current evidence serves the important purpose of confirming that bias / scope tendencies are apparent for most participants. The level of ASA was high for most individuals, but when these people were *not* certain of the correct answer, they showed bias / scope tendencies associated with either miss errors or false alarms in decision - making. This is an important finding that may have valuable implications for fireground training, performance and risk. It could be argued however that the exercise is not sufficiently realistic to ascertain whether such bias / scope might occur in more realistic simulations or in actual fireground contexts. To further address this question, the next study uses a similar methodological approach but in a more complex training exercise.

4.5 Conclusions on the house fire exercise

The tabletop simulation exercise shows evidence of positive, conservative or negative, liberal bias / scope tendencies in the FRS participants and the students who took part. There may be many contributing factors to such bias

/ scope tendencies including perceptual, attentional, working memory load, emotional and personality considerations (Becker, Mortensen, Ackerman, Shapiro and Anderson, et. al. 2011; DeFockert, Rees, Frith and Lavie, 2001;Endsley and Rodgers, 1997; Foster and Lavie, 2009; Klein, Calderwood and Clinton-Cirocco, 2010; Lavie, Hirst, de Fockert and Viding, 2004; McLennan, Pavlou and Omedei, 2005; Mosier and Fischer, 2010; Schwartz, Vuillemier, Hutton and Maravita, 2005). The role of such factors is not determinable from these current experiments, but nonetheless the finding of bias / scope patterns is an important one that may have implications for understanding errors in fireground decision - making. Future development of this research will explore bias / scope tendencies in actual fireground decision - making and will ascertain whether any bias / scope tendencies are consistent for the individual across different fireground situations and contexts.

The current findings confirm the methodological approach as a valuable means for developing these future studies. The technique has clearly shown that regardless of level of knowledge or ASA, there are response bias / scope tendencies in the decision - making of FRS professionals leading to either *miss* or *false* alarm errors. The finding that bias / scope patterns are independent of ASA is an important one that coincides with previous evidence indicating that simply acquiring information or ASA does not necessarily lead to effective decision - making (Omedei, McLennan, Elliott, Wearing and Clancy, 2005). Further investigation of bias / scope tendencies would thus seem critical to developing understanding of factors that could lead to risk in real fireground decision / making.

4.6. Commercial (factory) fire table top exercise

4.6.1. Introduction.

As noted above, the main aim of this study was to determine if there were individual differences in bias / scope patterns for operational FRS personnel and if these patterns were consistent across two different table top fireground based exercises and if they differed with fire fighting experience. The second table top exercise was again based on a power point presentation, built up to reflect a fire in a commercial (factory) premises with a number of persons reported missing.

4.6.2. Method

Design

The material for the second table top exercise was based on a fire in a factory premises with a number of persons reported missing. The exercise was chosen to represent an event that was not an everyday type incident, but a realistic event for the fire fighters based on the operational station ground for the fire fighters taking part; this was designed as a more complex incident, a factory fire having higher operational risks; to test if bias / scope was evident.

The second exercise was conducted with a number of operational fire fighters from different stations, but the focus from this exercise was on the 20 individuals who had taken part in and who had completed the power point house fire exercise. It was undertaken at approximately 8 to 12 weeks interval to match in with their station based training programme. Over a period of time each group of fire fighters when on duty were assembled within the training room of their operation station during their normal training period and after a preliminary briefing, the series of power point slides and video segments representing the call of fire to a factory site in a local industrial estate were shown to each of the small groups of participants (6 to 10 people).

Sample

The FRS participants were all operational personnel from a number of Gloucestershire fire stations including larger urban and smaller county localities, with a number of full time fire fighters and a number of retained (part time) fire fighters. There were some fire fighters in operational managerial roles (crew and watch manager) amongst both the full time group and the retained group. All participants gave informed written consent to taking part in the experiment and their individual responses were collected anonymously. As mentioned previously only the information from the 20 fire fighters who had taken part in the house fire exercise were looked at within the data review following the exercise.

Materials and procedure

The table top exercise was presented as a power point presentation, built up to reflect a fire in a factory where a number of people were reported missing (individuals were not accounted for and believed to still be in the premises where the incident occurred) with the probe questions being designed with guidance from senior operationally experienced FRS staff. The material in the power point presentation consisted of the mobilising information (standard for all incidents),video footage showing the approach to the incident travelling from the local fire station in the fire engine and the development of the incident using standard fire service operations in relation to tackling the situation and bringing it to a safe conclusion. Each group of fire fighters were assembled within the training room of their operation station during their normal training period and after a preliminary briefing, the series of power point slides and video segments representing the call of fire to a factory were shown to each of the small groups of participants (6 to 10 people) in the following sequence:

a) a slide with basic information about the incident; a call to a factory unit fire, smoke issuing and persons reported, requiring the initial assignment of two fire pumps (engines)

b) two slides respectively showing a map of the area and an aerial view of the neighbourhood and incident location, also showing hazards (main train line to London and major road) next to factory unit,

Figure 4.5. Example of images used in the commercial factory presentation (site overview).

c) a 7 minute video segment showing the drive through an urban environment to the fire incident from the viewpoint of the driver / operational manager of a fire engine with accompanying siren and traffic sounds,

d) two slides providing a view of the factory approach to the main entrance with smoke issuing and a wider view of the factory yard showing it worked with heavy engineering,

e) a video segment with a clearly startled factory charge hand regarding what had caused the fire and how many members of staff were unaccounted for (leaving the Officer in charge of the first fire engine not knowing an exact number of how many staff were missing or their location),

f) a series of 22 rapidly presented images, providing a collage of views of the interior and office accommodation, including views of the factory floor, high level walkways, staircase, and welding bays. (See Figure 4.5 and 4.6 for an example of the slide images.)

Figure 4.6. Example of images used in the factory presentation (workshop view).

Interspersed at three preset intervals were probe statements presented as “requests for clarification from the station officer”, the most senior officer on their way to the incident. There were 30 probe statements in total and each required a true / false response (15 true and 15 false items in randomised order with respect to being true or false). Participants were asked to record their individual responses on a prepared answer sheet along with details of their role, age and years of FRS experience. The response probes also asked how confident participants were in their answer to each question on a Likert scale of 1 to 4 (one being a guess and four being sure), allowing the measure of three aspects of SA:

1) Actual situational awareness ASA: how good an individual's SA is compared to the ground truth.
2) Perceived situational awareness (confidence) PSA: how good an individual believes their SA to be.
3) Bias: the tendency to use more, or less, information in building SA.

These three measures provide a unique insight into the building of SA on the fireground. As discussed participants were asked to record their individual responses on a prepared answer sheet along with details of their role, age and years of FRS experience and a figure two if they had taken part in the first exercise showing a house fire. The full list of questions / probes presented at this exercise were:

1) *There were 3 appliances attending.*
2) *The map reference was on the turnout sheet.*
3) *The fire impacted more on the road than the railway line.*
4) The car park was more than half full
5) There is a risk of cylinders being involved.
6) There is no evidence of flammable liquids at the scene.
7) Sandwich panels are a risk in these premises.
8) You only travelled through one red traffic light.
9) A car reversed out in front of you.
10) You passed an ambulance.
11) You went through 2 pedestrian crossings.
12) You were travelling towards the town centre.
13) There were cylinders outside the factory.
14) The fire started in an office.
15) The person who met you was identifiable as the Fire Marshall.
16) Entry point was indicated on the plan
17) Hazards were indicated at the entry point.
18) There is a laboratory on the site.
19) The plans are less than a year old.
20) You entered through a roller-shutter door.
21) The roller-shutter access was clear.
22) There was high fire loading in the offices.
23) There was a portable gas heater in one of the offices.
24) There was evidence of smoke in the offices.
25) The shop floor was heavily smoke-logged.
26) Staff could be trapped at a high level.
27) There were three bodies in the factory.
28) There were numerous cylinders on the shop floor.
29) There was a cylinder near a body.
30) You were moving towards the seat of the fire.

Table 4.3 Full list of questions (probes for the factory fire).

4.6.3 Ethical considerations

The study was undertaken at FRS stations at the time of routine training / assessment exercise sessions; all participation in this research study was fully voluntary by signed consent after a preliminary briefing. Staff were fully advised that there are no requirements to participate in the research project. Results were anonymised for purposes of general analysis but coded with a figure 2 for FRS staff who had taken part in the first exercise, this way those staff who had taken part in both the first and second exercise could be identified and responses could be compared across the two exercises. The figure 2 allowed the age, role and years of experience to be matched to the returns of the first exercise and ensure we were measuring the information we required, but that the individual identity of the fire fighter remained confidential and unable to be identified. All studies adhered to both BPS guidelines and the university research ethics guidelines.

4.6.4 Measures of SA and bias

As discussed previously (3.2.4) the QASA approach (Edgar and Edgar, 2007) based on signal detection theory (Stanislaw and Todorov, 1999) and assesses both knowledge or SA and the bias / scope that is applied to the available information. QASA determines the proportion of correct responses (*hits* and correct rejections) and incorrect responses (*misses* and false alarms) and these scores are then re-scaled to respectively provide two measures, one of SA and the other of bias.

4.7 Results: factory fire exercise

Commercial fire exercise: overall patterns of SA and bias / scope. For this study, the overall level of SA for the sample was high with the mean average of 66.5. The results for the bias scores showed there was clear evidence of only two distinct bias groups or patterns amongst the personnel, with those having negative (liberal, accepting or lax) bias / scope patterns on average showed 13 personnel and 7 with a conservative, positive bias / scope pattern, but further analysis confirms that there were individual differences in bias / scope tendencies. There was no significant correlation of bias / scope with SA: In other words, as predicted, bias / scope tendency varies independently of level of SA.

The bias groups (Figure 4.7) for the FRS sample are respectively comprised of:

1) 13 participants showing negative (accepting, liberal or lax) bias / scope tendencies (bias scores < 0) and thus tending to accept information as true (and so to make false alarms if they made errors),

2) 7 participants showing positive (narrow, conservative, strict or cautious) bias / scope tendencies (bias scores > 0) and thus tending to reject information as true (and so to make misses when making errors) and

3) none of the participants showed no bias / scope at all (bias scores = 0)

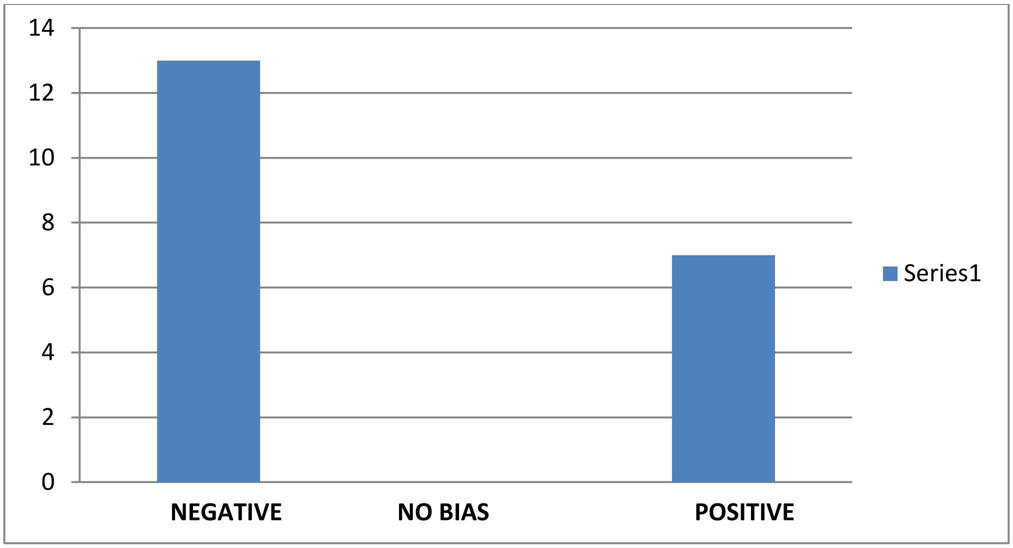


Figure 4.7. Factory fire table top exercise: mean bias scores for the three bias groups in the FRS sample.

The other important finding is that people showed bias / scope tendencies (no one had a bias score of zero or no bias).

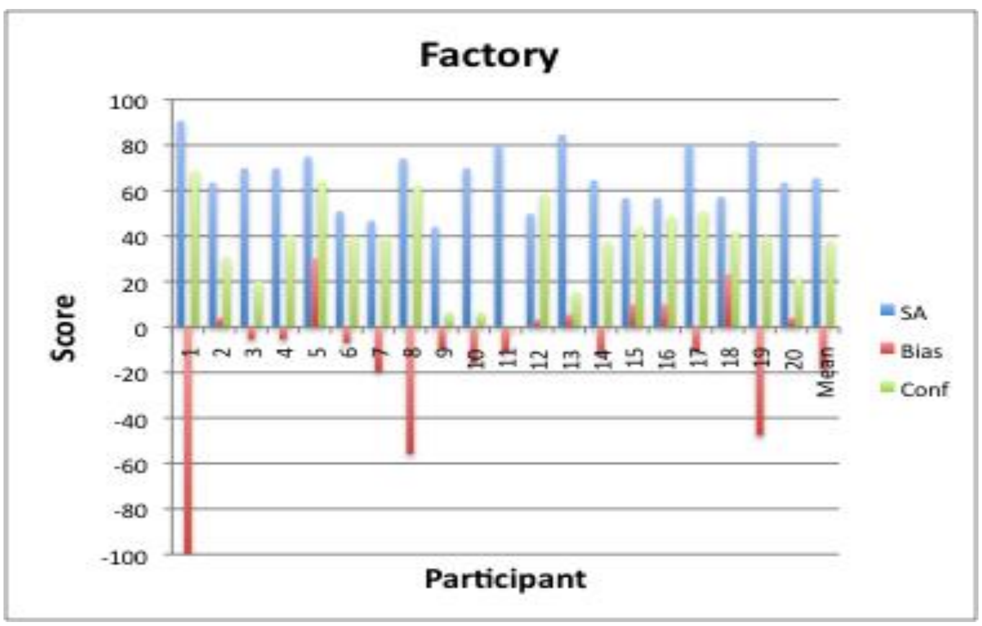
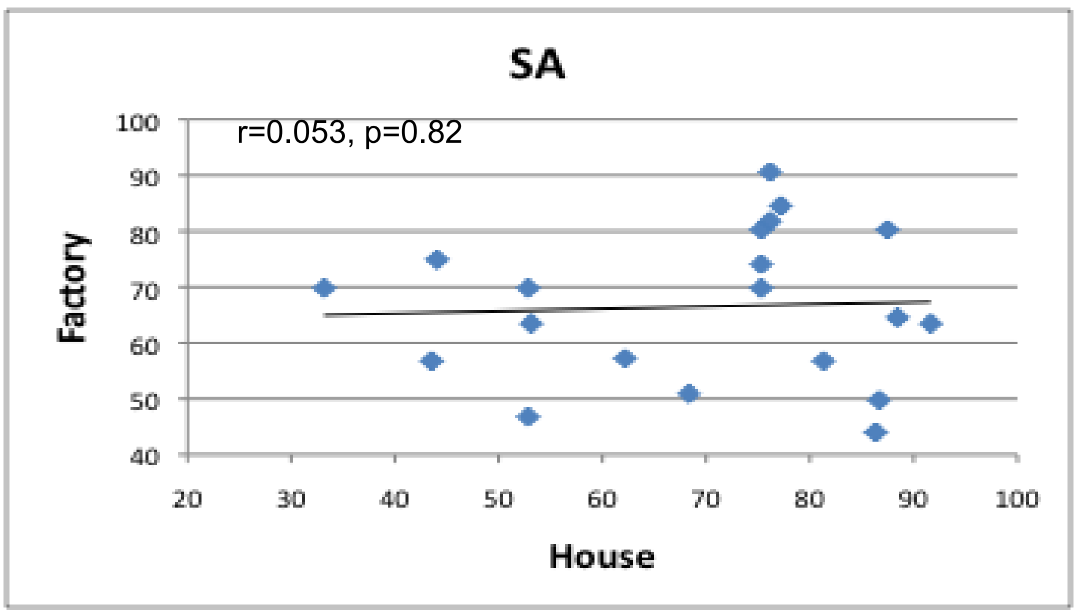


Figure 4.8. Factory fire table top exercise: knowledge and scoping patterns for each of the participants.

4.8 Factory power point exercise results and comparison with house fire exercise.

The SA and bias / scope for the house and factory exercises were calculated for each person. QASA provides a score for SA (corrected for guessing) from +100 (perfect SA) to -100 (totally misguided and wrong SA). Bias is also scaled from +100 (very conservative bias) to -100 (very liberal bias), with zero meaning no bias either way.

Comparison of the House and Factory Fire exercise results:



N=20

Figure 4.9. SA patterns for each of the participants.

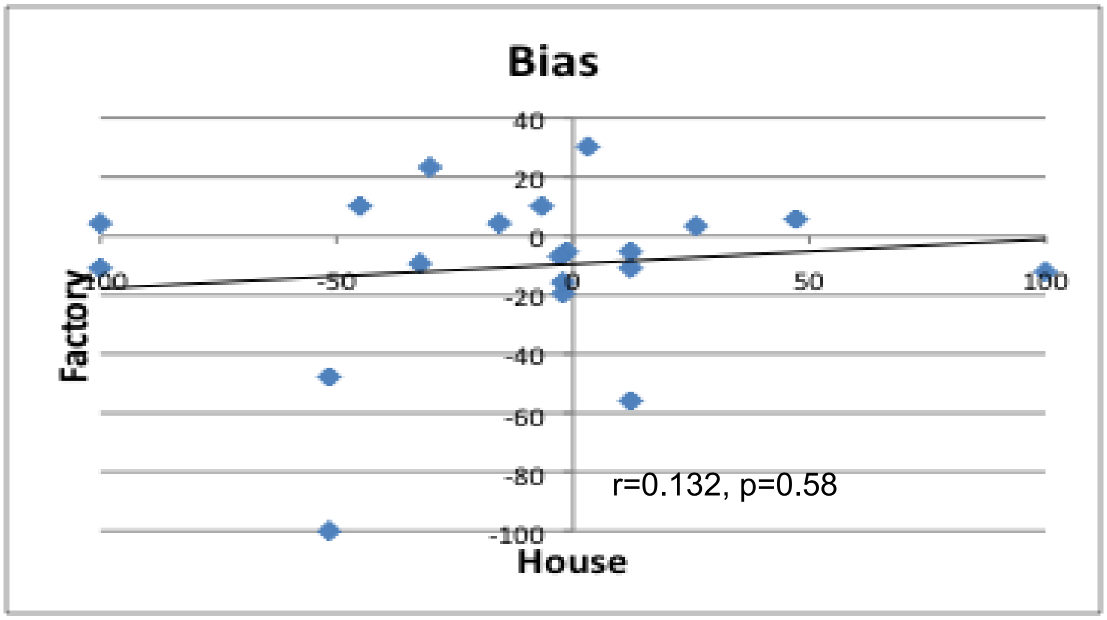


Figure 4.10. Bias patterns for each of the participants.

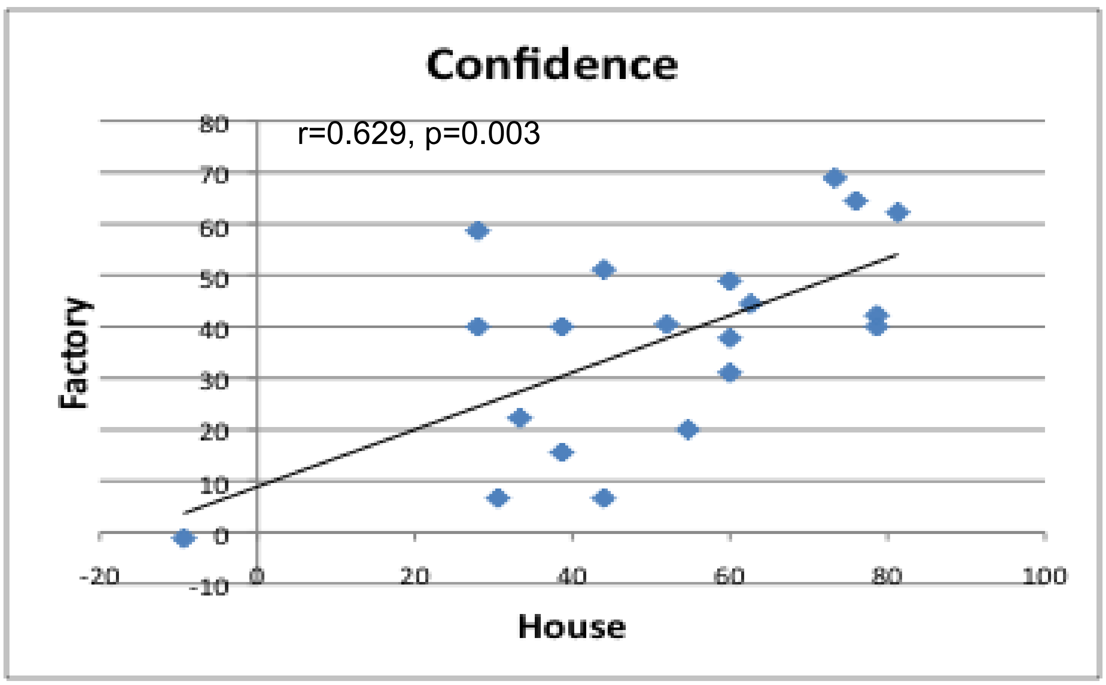


Figure 4.11. PSA (confidence) patterns for each of the participants.

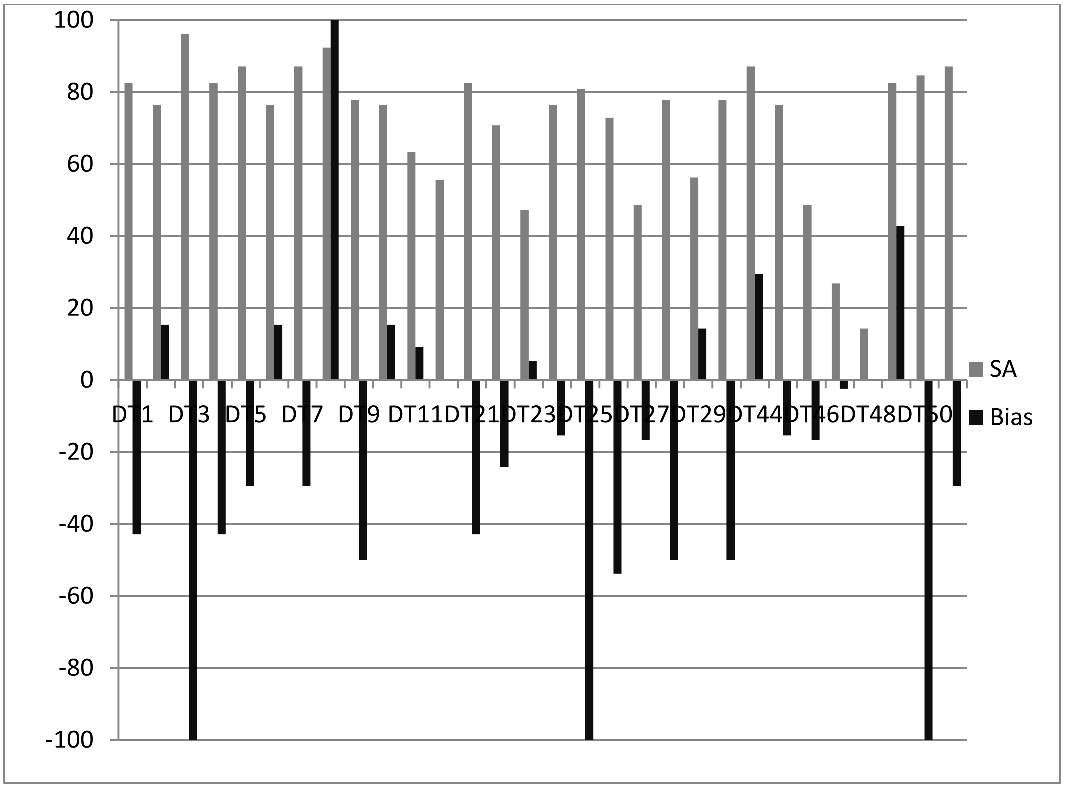


Figure 4.12. Table top exercise: Individual results: full time fire crew.

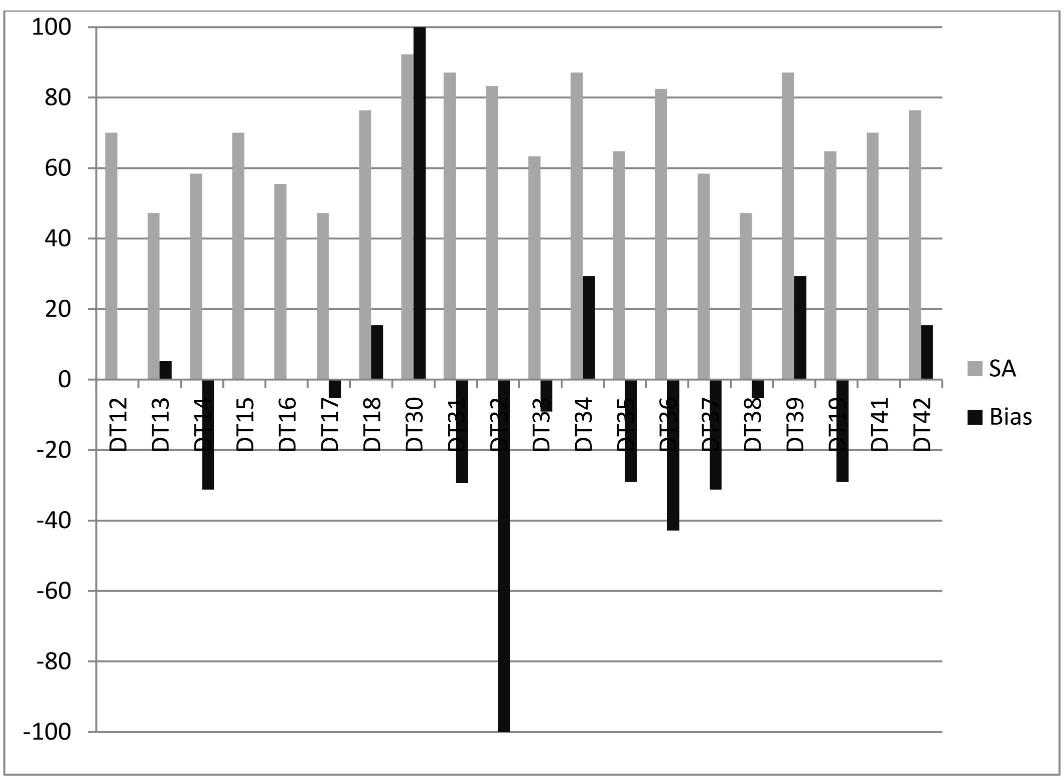


Figure 4.13. Table top exercise individual results: retained fire crew.

As noted ASA, confidence PSA and bias / scope for the house and factory exercises were calculated for each person using QASA. ASA was high in both exercises: with a mean (average) of 69.4 for the house exercise and 66.5 for the factory exercise. Also participants' PSA was at a similar level over the two exercises, meaning that if they had high confidence in their PSA in one exercise they also had high confidence in the other exercise, or low confidence in one and low confidence in the other (statistical correlation across the exercises is significant: $r = .629$, $p = .003$). Of concern however is that there is no statistically significant correlation between ASA scores and PSA scores. In other words, people may have had poor ASA but perceived their PSA as good or vice versa, had good ASA but judged it to be poor.

People with a conservative bias / scope accepted a narrower amount of information as being true but made more miss errors (eg. in the house fire exercise, they may have said false to the true statement: Confirm: area high density housing? making a miss error). On the other hand, people with a liberal bias / scope accepted a broader scope of information as true, but made more false alarm errors (eg. in the factory fire exercise they may have said true to the false statement: The roller shutter access was clear, making a false alarm error). Of interest is that there was no significant correlation between the bias scores across the two exercises, so people had a conservative bias / scope in the house exercise and liberal bias / scope in the factory exercise, or vice versa. Just six out of the total of 70 FRS responses showed no bias at all (figures 4.12 and 4.13).

4.9 Discussion

Actual SA was high in both exercises: with a mean (average) of 69.4 for the house exercise and 66.5 for the factory exercise and the fire fighters taking part over both power points perceiving their confidence (PSA) in a similar way for both exercises. This means that if they had high confidence in their PSA in one they also had high confidence in the other, or they had low confidence in one and low confidence in the other (correlation across exercises is significant: r =.629, p =.003). So the fire fighters tested appeared to be unaware of their own level of ASA.

The other important finding is that people showed bias / scope tendencies (only 6 in the first exercise had a bias score of zero or no bias). In the house exercise 15 people had a conservative bias / scope and the other 29 a liberal bias / scope; while in the factory exercise, 7 had a conservative bias / scope and the other 13 a liberal bias / scope. Of interest is that there was no significant correlation between the bias scores across the two exercises, therefore fire fighters may have had a conservative bias / scope in the house exercise and liberal bias / scope in the factory exercise, or vice versa.

The results indicated that the bias / scope and ASA measures obtained in each of the scenarios showed no significant correlation, so a fire fighter who showed high bias / scope or ASA on one scenario might show low bias / scope or ASA on the other. So individuals' levels of bias / scope and ASA varied according to the situation. The major difference between the house and factory exercises was the induced pressure that the participating fire fighters felt themselves to be under in the exercises. In the domestic exercise no one had experienced this type of exercise before and had, had to respond in an individual fashion, each had completed a university consent form for the first time and the attendance of a senior officer and two senior individuals from the university had brought to the exercise a tangible pressure. Fire fighters taking part were quiet and concentrating on the exercise power point, they were keen to get clarification on the process and clearly relieved at the end of the exercise when the process and the outcome of the process was explained to them in relation to how we intended to use the information. The answers to each of the probes were displayed to the group following the exercise and there was a discussion as to why some felt they had put down different answers and some justification as to why they had chosen one answer over another.

In undertaking the commercial (factory) exercise, a number of the fire fighters had taken part previously in the domestic exercise and were a lot more relaxed in both the briefing for the factory exercise and taking part in the exercise itself. It was observed before the start of the commercial exercise and during, by those present that the fire fighters were engaged in general conversation with other staff members both during the exercise and on the debrief, offering comments on the exercise set up and on each other's ability to manage a reasonable response. The one major difference on the factory fire table top exercise, to the previous house fire table top exercise and the breathing apparatus exercise, may thus have been a lack of pressure on the individuals taking part and how this played out on their individual responses to the questions posed with the probes. In considering if the bias / scope is a resting bias / scope or a situational bias / scope, this outcome with the difference between the two exercises being a reduction of pressure / stress in the factory fire exercise raises debate around the reaction of fire fighters and incident commanders dealing with the exercise in a different way to how they would deal with it normally. It is considered that in the normal management of the situation, whether training or at an incident, experience plays a major part in bringing it to a safe conclusion, but as pressure is applied as the incident grows, or gets more complicated, or high risk (major loss of life) then we start to see a non trained response and see the individual bias / scope involved with the decision - making. So if the bias / scope only influence decisions under pressure, then we cannot expect a correlation between the exercises if different pressures were applied.

Perhaps the most important result was that there was a highly significant correlation between PSA in the two scenarios ($r = 0.629$, $n = 20$, $p = 0.003$).

That is, individuals maintained their level of confidence (high or low) in their own PSA across the two situations, independently of their ASA. Which could lead to an individual believing that they were aware of everything that was going on at the incident and confident in their knowledge on which to base their decisions, when they have really poor ASA on the situation?

The primary aim of these tabletop studies was to determine if FRS personnel displayed bias / scope patterns in decision - making during table top fire incident exercises, which would confirm the outcome from our first exercise using a breathing apparatus crew. The evidence clearly shows that for most participants this was the case. Just six out of the total of 70 FRS exercise participants showed no bias / scope at all. The majority of FRS participants tended towards a negative or liberal bias / scope (and hence towards making *false alarm* errors), while the remainder showed a positive or conservative bias / scope (and hence towards making *miss* errors), with these differences not linked to level of ASA or knowledge, nor to years of experience or professional status (full time vs. retained). The level of ASA was high for both FRS groups and significantly higher than that for students, confirming the validity of the task content used for FRS personnel. Nevertheless, the FRS sample did not show significant differences in bias / scope tendencies to those shown by the students, the bias / scope scores reflected tendencies that are statistically independent of FRS experience.

It cannot be determined why such bias/ scope tendencies occurred in these exercises, but nonetheless the current evidence serves the important purpose of confirming that bias / scope tendencies are apparent for most participants in both incidents (the house fire being smaller or less complex than the factory, but nonetheless both showing similar outcomes).

The level of ASA was high for most individuals, but when they were not certain of the correct answer they showed bias / scope tendencies associated with either *miss* errors or *false* alarms in decision - making. This is an important finding that may have valuable implications for fireground training, performance and risk. It could be argued however that the exercises are not sufficiently realistic to ascertain whether such bias / scope might occur in more realistic simulations or in actual fireground contexts.

The other main aim of the studies here was to determine if bias / scope was consistent across situations or scenarios, these exercises did not show this conclusively one way or the other. People could be conservative in the house exercise and liberal in the factory, or vice versa, so bias / scope could vary over situation or even over time, which would suggest that bias / scope is unlikely to be a consistent personal disposition. It may be the case however that the exercises were different and were not of sufficient stressful intensity to reveal any personal resting or residual tendencies. The next study is an attempt to address this issue further by ensuring the pressure brought to the exercise, increases the stressful intensity of the exercise on the individuals to enable us to further understand the nature of information bias / scope in relation to ASA and decision - making on the incident ground.

4.10 Conclusions

Both the table top simulation exercises in these experiments show evidence of either positive (conservative) or negative (liberal) bias / scope tendencies in the FRS participants and the students who took part. There may be many contributing factors to such bias / scope tendencies including perceptual, attentional, working memory load, emotional and personality considerations, as discussed. The role of such factors is not determined from these current experiments, but nonetheless the confirmation of bias / scope patterns is an important one that may have implications for understanding errors in fireground decision - making. Future development of this research will explore bias / scope tendencies in actual fireground decision - making and will ascertain whether any bias / scope tendencies are consistent for the individual across different fireground situations and contexts.

The current findings confirm the methodological approach as a valuable means for developing these future studies. The technique has clearly shown that regardless of level of knowledge or ASA, there are response bias / scope tendencies in the decision - making of FRS professionals leading to either *miss* or *false* alarm errors. The finding that bias / scope patterns are independent of ASA is an important one that coincides with previous evidence indicating that simply acquiring information or ASA does not necessarily lead to effective decision - making (Omedei, et. al. 2005). Further investigation of bias / scope tendencies would thus seem critical to developing understanding of factors that could lead to risk in real fireground decision - making.

The results indicated that the bias / scope and ASA measures obtained in each of the scenarios respectively showed no significant correlation. That is, a fire fighter that showed high ASA on one scenario might show low ASA on the other and similarly bias / scope may be positive on one and negative on the other. Thus individuals' levels of bias / scope and ASA appeared to vary according to the situation.

The fire fighters in this study had good ASA overall and a level of confidence in their own PSA that was consistent across situations. This PSA was not however strongly related to ASA. Some of the fire fighters in these exercises considered their ASA to be good when in fact it was poor (and the converse). This lack of alignment between ASA and PSA could lead to decision errors if it occurred on the fireground, as it could lead to an individual believing they are aware of everything that is going on and confident in the knowledge on which to base their decisions, when they have really poor ASA on the situation. The results for bias / scope also indicate a basis for decision error.

Some people had a conservative, cautious approach to accepting information as true and others a more liberal, lax approach. The former represents a conservative bias / scope with a narrow focus on the incident that also produces *miss* errors, while the latter is a liberal bias / scope with a broader but shallower processing of the information, leading to *false* alarms. The outcome from these two exercises have shown that people could have a conservative bias / scope in one exercise and liberal bias / scope in the other, but either tendency could clearly provoke error in fireground decision - making.

The gap between ASA and PSA along with the bias / scope patterns allows for the *possibility* of error in decision - making that could have serious consequences in a real fireground situation. These tendencies are most likely due to processing constraints in the channels of the human brain. The participants presented with generally good ASA (as the exercises have demonstrated), but also displayed limits whereby they did not register the gaps between their ASA and PSA and also showed bias / scope error tendencies. If such patterns are apparent in the relatively calm environment in which this study was conducted, they may be even more apparent under highly stressful and dangerous conditions such as those that assailed the Storm King Commander in 1994. The human brain is a highly effective fire fighting tool, but its limitations are ignored at considerable peril. The further direction for this research is to develop guidelines that could support FRS personnel in monitoring their own ASA and bias / scope patterns under such conditions. The next study is an attempt to address this issue further by ensuring the pressure brought to the exercise increases the stress intensity of the exercise on the individuals, to enable us to further understand the nature of information bias / scope in relation to ASA and decision - making on the incident ground.

Chapter 5

Flexible duty manager's development and assessment exercises 2012 and 2013: how does bias / scope influence the operational outcome of pressurised fire incident command decisions?

5.1 Introduction

One of the initial aims of the project was to develop a technique that would in the first instance determine whether response bias / scope tendencies are apparent for FRS personnel in fireground simulation exercises and whether there are individual differences in bias / scope. From this to build on the outcome of this initial research to see if there was any pattern that could be identified with any bias / scope shown by individuals. The basic paradigm for this research has been developed in previous studies of situation awareness (SA) and decision - making and involves the use of the Quantitative Assessment of Situation Awareness (QASA) method (Edgar and Edgar, 2007; Edgar, Catherwood, Alford, Nikolla, Edgar and Brookes, 2011; Edgar, Catherwood, Nikolla and Alford, 2010). As discussed the QASA technique requires true / false decisions about statements concerning a situation. The approach is based on signal detection theory (Edgar and Edgar, 2007; Stanislaw and Todorov, 1999) and the QASA technique provides measures of:

a) Knowledge or actual situational awareness ASA.

b) Perceived situational awareness (confidence) PSA

c) The information bias / scope applied by the decision maker to the available information. As discussed, the bias measure in QASA gives further insights into the critical question of how knowledge or information may be selected or filtered for decision - making and whether this is being achieved in a strict and conservative way or alternately, a more lax or liberal manner.

When situational awareness (SA) is used alone (without the A or P prefix) it refers to SA generally without a specific type.

In the previous exercises real concerns about what happens to the individuals' bias / scope pattern when they are under pressure, or not under pressure were identified. In the BA exercise pressure was exerted as a result of the challenging environment and in the house fire tabletop with it being something new to the participants and by the presence of senior managers. Consideration of the bias ratings from the first two studies (the BA exercise and the house fire table top) suggested that the individuals taking part appeared to revert to type in relation to their bias / scope pattern; whether it was a resting bias / scope or a situational bias / scope. It was seen from these first two exercises that bias / scope could be a constant with the individuals undertaking them when they responded to the probes following the exercise, or at stages within the exercise. In the factory fire table top exercise a different response to the probes was seen and this was, or appeared to be driven by a greater understanding of the process and the impact of it personally from having participated in it before. A relaxed attitude of the individuals participating was carried through to the exercise. Therefore these tabletop exercises, or the environment in which they were undertaken may not have involved sufficiently realistic contexts or consistently high enough demand levels of stress (applied pressure) to the individuals to reveal any constancy in the bias / scope applied by the individual. The studies described in this chapter were designed to use the increased pressure on the individual, generated naturally within pre-programmed ongoing assessment / development exercises of operational flexible duty manager (FDM) at a station manager (SM) level.

It was found that in all of the previous exercises individual differences in bias / scope tendencies were apparent for the same situation and that such tendencies were independent of the level of knowledge or actual situational awareness (ASA) of the individual. In other words, even amongst those with the same ASA there may be different bias / scope, so that when errors were made some individuals tend towards making miss errors, conservative bias / scope and some towards false alarm errors, liberal bias / scope. The progression of this work is to explore if the bias / scope shown in the previous studies is down to the situation the FDMs partaking in the exercise find themselves in (different bias / scope shown by the same individual in different situations; a situational bias / scope), or if the bias / scope shown is within the FDMs (the same bias / scope shown by the same individual in different situations; a resting bias / scope). The previous tabletop exercises showed no evidence of the latter and suggested that the bias / scope could be down to the situation, although on reviewing the outcomes from the earlier studies we can see there is a bias / scope shown by the majority of individuals taking part. The house fire and factory fire table top exercises used some of the same participants, the outcome was to identify whether the bias / scope was situational or resting. The outcome was inconclusive in this respect and could have been down to differences in pressure exerted on the individuals taking part in different exercises. So the measurements of bias / scope within the house fire and factory fire scenarios do not provide a conclusive evaluation of whether trends are consistent within each individual, or they are driven by the situation in which they find themselves. With no clear relationship identified across these exercises for bias / scope suggesting either a situational bias / scope or a resting bias / scope, another set of exercises were planned to take the experiments forward to see whether the pressure of the situation influences the level of bias / scope. From the studies already presented there is some evidence that individual patterns of bias / scope change when the individual is under pressure, although, as will be discussed in Chapter 6, individuals do not appear to be aware of their own bias / scope. It would appear to be a subconscious reaction to the events around them, a personal response when stressed (outside their individual comfort zone) as a reaction to managing a more intense or complex incident. The study, described in this chapter, using

FDMs who were being assessed in an exercise that was tailored to test their operational competence and to ensure they are capable of managing a real incident of this type and nature, gave an opportunity to evaluate whether pressure influences bias / scope. Central to this was the opportunity over a two year period to test the same individuals, within the same study under the same (or similar) conditions and to see if their responses were based on the situation, or based on the individual.

This study examined the performance and reaction of a number of incident commanders in highly realistic simulation exercises testing their incident command skills. These exercises were assessable and were based on real incidents that the individuals would be expected to respond to and take over as incident commander. The exercises had been designed by the FRS training team and the assessment was undertaken by the FDMs peers who used an assessment sheet based on the individual FDM's role map (the job description that identifies what a FDM will need to undertake operationally to complete their role; appendix 4). The possible consequences of the individual not meeting the required standard for the assessment was based on two sets of criteria; the first level where they will be deemed to require assistance in specific areas would be a training programme designed for them to ensure that any areas identified as deficient were brought back up to an acceptable level. The second would impact on their actual operational status in the FRS where a failure to maintain a minimum level of competency (health and safety in relation to the incident ground and the operations they direct to bring the incident to a safe conclusion) means that they would lose their flexible duty response status and would have to re-qualify within three months, or stand to lose up to 20% of their salary and the car provided to undertake the role. Their reaction to simulated large scale fire ground incidents was examined using QASA to assess both SA and bias / scope. These simulations involved two similarly challenging and assessable fire ground exercises within a two year period. This study was looking to reveal how they filtered the information available to them, and will determine whether there was any consistency in this regard to see if under similar conditions and over a period of time, they produce related patterns of bias / scope. The ultimate goal was to review this information to consider how best to use it to the benefit of the individual in developing their incident command ability and to identify how they can utilise this knowledge to improve their individual decision - making and the outcomes for the incident. FRS fire fighting personnel will display conservative, liberal, or neutral decision - making bias / scope (or related errors) during FRS training exercises involving simulations of fireground incidents. The prediction for the current study is that given the highly demanding conditions, the incident commanders will display consistent levels of SA and bias / scoping tendencies across the two simulation assessment exercises.

The hypotheses for this study was:

i) any such bias / scope error patterns will be consistent for individuals over situations / scenarios across the two test exercises.

5.2 Background to simulated fireground incidents – assessment of flexible duty operational managers in 2012 and 2013.

The primary aim of the first study was to confirm that the bias / scope patterns for individual operational FRS personnel identified in the first table top study (chapter 4), reflected the individual's tendencies towards either accepting or rejecting the available information. In the study described here, in the first FDM command development / assessment fireground exercises, the aim was to see whether individual's bias / scope tendencies towards either accepting or rejecting the available information (Catherwood, Sallis, Edgar and Medley, 2012) could be identified. In particular the aim was to assess whether individual operational response officers in a controlled, but pressurised situation display one of three potential bias / scope patterns:

a) a narrow or conservative bias / scope (with a tendency to reject information and so make misses) or,

b) a lax or liberal bias / scope (with a tendency to accept information and so make false alarms), or,

c) a neutral bias / scope showing no such bias / scope in either direction.

Additionally, the aim of these studies was to assess the degree of consistency or correlation in SA and bias / scope between the first study from 2012 and the second study in 2013. Any correlation between the individual results for 2012 and 2013 might indicate either a situational bias / scope (a bias / scope that, for any individual, could vary across situations simulating a highly pressurised operational role), or a resting bias / scope (a bias / scope that would be consistent for an individual across simulations simulating a highly pressurised operational role). Given that these exercises were an integral part of actual incident command training and ongoing competency assessments, a broader goal was also to develop a way of using this knowledge to improve operational response officers' training. To this end, the results of the QASA were fed back to the staff involved in the debriefing (details below).

5.2.1 Method

Design

All participants were provided with the same stimulus situation, in a development / assessment simulated fireground incident. The simulated fireground incidents were based on a realistic and developing incident and each individual had to take over command from the first attendance commander, and move towards a successful conclusion from an operational, environmental and social perspective. Both SA and bias / scope scores were obtained in regard to the presented information, via the QASA method described above and below.

Participants

The participants for both studies were 22 operational FRS flexible duty incident commanders who provided operational response to incidents for the FRS within their county, on a shift pattern that covered 24 hours, 7 days a week, 365 days a year. All of the 22 for each study gave consent for their assessment information to be used and 19 of these undertook both the development / assessment in 2012 and 2013. Three who had undertaken the 2012 assessment were unavailable to attend in 2013, one due to retirement and two due to illness, three who undertook the 2013 assessment but not the 2012 assessment, were not included in the data analysis. These were FRS operational officers who responded to serious incidents requiring 3 fire engines (15 fire fighters) plus to deal with the incident (based on a pre determined attendance response to the specific premise, or type of incident following an operational risk assessment), where people were in danger of losing their lives (persons reported) or where hazardous materials were involved (environmental concerns). They responded on their own in their provided car (fitted with both blue lights and audible warning device as the fire engines would have already been mobilised from their station location) from their place of work, or home. In 2012 the participants were operational managers (21 male and 1 female) working (on call from their place of work, or their home for a set number of hours a week) across a UK FRS (mean age: 48.9 years and mean years of experience 23.1 years). The 2013 participants were 22 operational FRS incident commanders all male, of these, 19 had undertaken the development / assessment in 2012. All were flexible response duty operational managers working across a UK FRS (mean age: 49.9 years and mean years of experience 24.6 years). All participants were in managerial roles undertaking operational response both full time and retained.

5.2.2 Ethical Considerations

These studies were conducted in compliance with the ethical guidelines laid down by the British Psychological Society and ethical approval was obtained through the recognised procedures within the University of Gloucestershire. The studies took place at FRS establishments or within training situations at the time of routine training / assessment exercise sessions, although participation in these research studies was fully voluntary indicated by signed consent after a preliminary briefing. All data were collected once the formal assessment had finished and the running of the assessments was not altered in any way by the research project. Participants were fully advised that there were no requirements to participate in the research project. Some staff did elect not to be involved in the studies demonstrating that consent was fully voluntary. Results were anonymised for purposes of general analysis and for reporting in any public forum. General anonymous feedback was provided to the group involved, while personalised feedback on their own performance was provided to individuals. Individual assessment sessions were administered by trained FRS managers.

5.3 Development / assessment simulated fireground incident of flexible duty operational managers in 2012

5.3.1 Materials and Procedure

The exercises were designed by the FRS training team and the assessment was undertaken by FRS Group Managers who used an assessment criteria (Figure 5.1) based on the individual FDM's national role map agreed as part of their employment terms and conditions, with an example at appendix 4. The possible consequences of the individual not meeting the required standard for the assessment was based on two sets of criteria, the first level where they will be deemed to require assistance will be a training programme they would need to undertake within 3 months. Failure at the second level would impact on their actual operational status in the FRS, where failure to maintain a minimum level of competency would be the loss of their flexible duty response status. The assessment criteria were as shown in Figure 5.1.

Assessment criteria

The use of the traffic light system allows for an 'at a glance' look at where development needs are required with a fuller description given within the summary for each element.

Green-No significant development needs, candidate has provided clear and correct evidence to support this criteria

Amber-Minor development needs that have no risk critical aspects that would have led to an adverse occurrence

Red-Core development required where risk critical element has been ignored or not acted on.

Should there be "Red Lights" the candidate will be required to undergo further development in the highlighted areas and a re-assessment as directed by the training team manager. The question of whether the candidate remains engaged in operational duties during this retraining period will be at the discretion of the assessors and may be through consultation with senior operations manager.

Figure 5.1. Example of 2012 assessment criteria.

A full scenario planning document was provided (appendix 5) with the following initial information given to the exercise candidate;

The time is 1000hrs on a Monday morning. There is a light drizzle of rain at present with a brisk northerly wind and temperatures around 4˚C. The service has been called to a fire at Crypt school, just off Cole Avenue, in Podsmead, Gloucester. The Pre Determined Attendance (PDA) is 3 appliances from both Gloucester Stations and a Station Commander. Station Commander __________ was mobilised with the initial attendance.

On receipt of a make pumps 5 (increase fire engines to 5 for operational requirements at the scene, which would provide up to 25 FF's) message from WC Evans, the FRS Operations Control mobilise more resources to the Incident including 2 further Station Managers (1 to manage the incident command unit (ICU) to provide information and manage the scenes communications and another Station Manager who was to support the Incident Command System, for command and control.

Figure 5.2 Initial information given to the exercise candidate.

The candidate was mobilised by mobile phone or operational pager to respond to a briefing room where he / she received a brief from a senior operational officer for the incident, which included an update from the first incident informative message (a message from the incident updating the FRS control room and senior managers of developments at the incident, sent as soon as possible from the incident ground and updated every 20 minutes by the incident commander) from the current commander at the incident which had just been received. The informative was: 'From WC Evans at Crypt School, Gloucester, Fire in School, Building approx 10M x 80M well alight. 5 persons unaccounted for at this time. 4 breathing apparatus (BA), 1 hose reel jet (HR) & 2 (full fire fighting) Jets, in use'.

The FRS mobile incident command unit (ICU) (a unit that housed all mobile communications facilities for the incident ground, plus full access to all risk based information held on all premises within the county by the FRS and also providing secure internet links for interagency and national communications) was fully established and set up (as for a real operational incident) and staffed by operational staff as it would have been for a real incident. The whole exercise was scripted from start to finish, with various injects based on both the scenario (time based) and the decisions the incident commander made, as each decision would have consequences for the ongoing nature of the incident. Certain decisions would have an impact on the development of the incident and these would require the incident commander to respond to, or manage this development to bring the incident to a safe conclusion. A number of people were nominated as role players and were indentified to cover the following roles, Police, Ambulance, worried mother of a child that was missing and someone to play the part of a press reporter; each was given a script and would respond to the ICU at an agreed time during the incident. Other injects to the exercise covered the political dimension, with local politicians phoning up to find out what was going on and the need for the incident commander to brief senior officers who were not at the scene.

The task and probe questions were designed with guidance from senior experienced FRS staff and training managers. There were 24 probe statements in total identified from the scenario and each required a true / false response (12 true and 12 false items in randomised order with respect to being true or false) (List 5.1 below). All the probe questions were identified as key to the operational role of the FDM undertaking the exercise, each one was based on information the FDM would have needed or asked for to assist them in managing the incident, or they would have been provided based on the FRS operational procedures. In essence, all probes addressed important aspects of the situation, awareness of which would be beneficial to completion of the task. The researcher attended the first exercise and watching from a remote location reviewed the probe sheets, to ensure that the probes asked were correct. The researcher attended on the other 7 dates the exercise was run to ensure there were no changes within the exercise that could or would impact on the probes. Participants were asked to record their individual responses on a prepared answer sheet along with details of age and years of FRS experience.

	Please indicate if you believe the statements below are true or false
1	When you were called, there were five appliances mobilised.
2	There were six persons unaccounted for in the initial informative.
3	Police were requested before your arrival.
4	You were informed that plastics may be involved in the fire.
5	Plumes of smoke were evident in a number of locations
6	You were informed that a female teacher was missing.
7	Missing children were all initially reported as being in the chemistry lab.
8	The missing children were all in the age range 11-12 (first year in that school).
9	The fire alarm indicated the fire was on the ground floor.
10	The base pump over-ran the water supply.
11	Two sector commanders asked you for more BA resources.

12	A sector reported the fire had broken through the roof.
13	Sector commander notified location of 4 casualties.
14	All services to the site were isolated.
15	The police took responsibility for the safety of the children.
16	The suggested arsonist is a former pupil.
17	Information suggests that the arsonist purchased 50 liters of fuel.
18	GWAS were unable to attend site.
19	Police reported the arsonist had been arrested
20	HART requested a RVP location.
21	BBC radio asked about the madman loose in the grounds
22	BBC radio asked about the four children that were badly burned
23	A parent approached asking about their child.
24	BA teams reported recovering all the casualties.

Table 5.1. 2012, full list of probe statements in total identified from the scenario and each required a true / false response (12 true and 12 false items in randomised order with respect to being true or false).

The way these exercises were designed allowed the study to also look at the confidence the individual undertaking the assessment had in relation to the answers they gave, as the study wanted to look at the two key aspects of SA a person's A*ctual* Situational Awareness (ASA) (in using the probe statements) and their *Perceived* Situational Awareness (PSA) (in using a four point 'Likert' scale) (Figure 5.3).

	T	F		Guess	Fairly uncertain	Fairly certain	Certain
1	T						
2		F					
3	T						
4	T						
5		F					
6		F					
7		F					
8		F					
9		F					
10	T						
11	T						
12	T						
13		F					
14	T						
15		F					
16	T						
17	T						
18		F					
19		F					
20	T						
21	T						
22		F					
23	T						
24		F					

Figure 5.3 2012, list of 24 probe, 12 true and 12 false items in randomised order with respect to being true or false, the answer given to each question was to be supported by the degree of certainty the individual felt in giving that answer.

Ideally, these two aspects should match, indicating the participant has the same PSA as ASA and is making decisions based on fact. This has not necessarily been the case where previously some FDMs have shown a higher PSA than ASA, making decisions based on their own confidence, or a lower PSA than ASA. High ASA shows a good awareness of what is happening, while low scores show poor ASA, with negative scores showing a fundamentally wrong representation of the situation. Actual and perceived SA can vary independently across the situation. This raises the possibility that individuals may have a high resting level of PSA and that ASA could be low, giving a confident incident commander with little real understanding of what is happening (Catherwood et. al. 2012).

Given that these exercises were an integral part of actual IC training, the broad goal was also to propose a way of using this knowledge to improve operational response officers' training. To this end, the results of the QASA were fed back to the staff involved in the debriefing (appendix 6).

5.4 Development / assessment simulated fireground incident of flexible duty operational managers in 2013

The primary aim of this study was to confirm that bias / scope patterns for individual operational FRS personnel found in the first 2012 FDM command development / assessment fireground exercises, reflected the individual's tendencies towards either accepting or rejecting the available information (Catherwood et. al. 2012). The aim is thus to identify any correlation from the individuals who took part in both exercises between the individuals results for 2012 and 2013 that will point to either a situational (a bias / scope that could vary with the individual when attending a highly pressurised operational role), or resting bias / scope (a bias / scope that will reoccur with the individual when undertaking a highly pressurised operational role). Given that these exercises were an integral part of actual incident command training and ongoing competency assessments, the broad goal was also to propose a way of using this knowledge to improve operational response officers' training.

5.4.1 Materials and Procedure

The conditions and impact for the individuals taking part were the same as the exercise in 2012 above as the exercise was part of their continuous assessment process. A full scenario planning document was provided with the following initial information given to the exercise candidate;

> This premise is a palliative care centre for neurological patients. This includes RTC victims, Meningitis sufferers and Multiple Sclerosis sufferers. Most are private but some are NHS. All have mobility issues and other complications. The purpose of the Centre is to relieve suffering and to provide support services such as physiotherapy etc. Patient mobility ranges from out-patients who are fairly mobile to residential patients who are ostensibly bedbound.
>
> There are several treatment rooms, Physiotherapy facilities and a pharmacy in the premises along with 13 bedrooms. 5 bedrooms have en-suite facilities

whilst the rest use sluice rooms or WC’s.

The time is 16:00.

A serious fire has broken out in the kitchen area of the premises and this has rapidly spread to other rooms in the sub-ground floor level. It has also penetrated the lift shaft and moved up to the ground floor where it is burning in the central reception area. This is an open area for both ground and first floors, with a Grade 2 listed staircase linking the two. If the fire is not checked it will easily spread to the first floor.

Casualties:

- There are 4 people unaccounted for on candidate arrival. They are located in the following areas;
- Ground Floor: 1 staff member severely in the lift (they have opened the lift door onto the fire which has allowed fire spread up the shaft to 1st floor).
- First Floor: 1 patient in room 8
- Second Floor: 1 patient and 1 staff member in Physio room

Figure 5.4 Initial information given to the exercise candidate.

The assessment was undertaken at Avon FRS South West Command Centre, which allowed for a walk through scenario on arrival at the incident ground with different rooms showing a different perspective of the incident, moving through to the ICU within the same site.

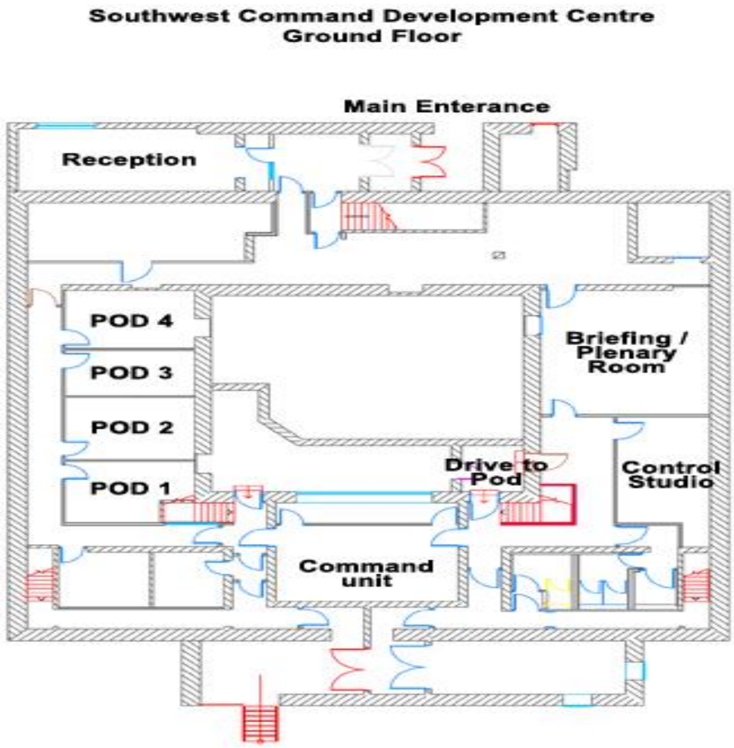


Figure 5.5 Avon South West Command Centre Lay Out (courtesy of AFRS)

Figure 5.6 Avon South West Command Centre Ops room (courtesy of AFRS)

The ICU was again fully set up as for a real operational incident and staffed by a specialist crew from Avon FRS that undertakes this provision for Avon FRS at their operational incidents. The whole exercise was scripted with various injects based on both the scenario and the decisions the incident commander made, as each decision would have consequences for the ongoing nature of the incident, certain decisions would have an impact and require the incident commander to respond. A number of people were nominated as role players and were identified to cover the following roles, Police, Ambulance, premises owner and both local and national press, each was given a script and would respond to the ICU at an agreed time during the incident. Other injects covered the political dimension, and the need for the incident commander to brief senior officers who were not available at the scene.

The task and probe questions were designed with guidance from senior experienced FRS staff and consisted of the following material. A full scenario planning document was provided and reviewed, there were 28 probe statements (List 5.2) in total identified from the scenario and each required a true / false response (14 true and 14 false items in randomised order with respect to being true or false) (Figure 5.5). Participants were asked to record their individual responses on a prepared answer sheet along with details of age and years of FRS experience. Their responses were collected anonymously and all gave informed written consent.

	Please indicate whether you believe the statements below are true or false and then indicate how sure you are that the answer you have given is correct (tick one box 'guess' to 'certain').
1	On mobilising, you were told there was a fire in a bedroom of a residential care centre.
2	There were some patients in a sit tight protocol.
3	There were 5 pumps when you were mobilised.
4	You were informed via radio that there were three BAs in use.
5	There were patients in wheelchairs outside the premises when you arrived.
6	Two BA teams were in the building when you arrived.
7	The fire started in a kitchen
8	There were five people unaccounted for.
9	In excess of 20 people had been evacuated by the time you arrived.
10	The building had three floors.
11	On your arrival there were four sectors operational.
12	On your arrival, there were concerns over water supplies.
13	On arrival at the command unit, you were informed of a house fire.
14	There were no persons reported missing in the house fire.
15	There was a report that some doors may have been wedged open.
16	The gas isolations were internal.
17	Fire compromised the lift shaft.
18	Control asked if the welfare unit was required.
19	Ambulance informed you that four ambulances were in attendance.
20	HART have been mobilised and are on their way.
21	There were three police staff available onsite.
22	The police believe the fire was arson.
23	There was one aerial in attendance.
24	There was a Sky news reporter on site.
25	An unconscious male patient was located in a bedroom.
26	A BA team located two casualties in the physio room.
27	You will / do hand over to a group manager.
28	There were two lifts in the building.

Table 5.2. 2013, full list of probe statements of 28 probe statements in total identified from the scenario and each required a true / false response (14 true and 14 false items in randomised order with respect to being true or false).

		True	False		Guess	Fairly uncertain	Fairly certain	Certain
1		F			kitc			
2		T						
3		T						
4		F			4			
5		T						
6		F			1			
7		T						
8		F			4			
9		T						
10		F			4			
11		F			3			
12		F						
13		T						
14		F			1			
15		T						
16		F			Ex			
17		T						
18		T						
19		F			2			
20		T						
21		T						
22		F						
23		T						
24		F			BBC			
25		F			Con			
26		T						
27		F			Area			
28		T						

Figure 5.7 2013, 28 probe statements, 14 true and 14 false items in randomised order with respect to being true or false, the answer given to each question was to be supported by the degree of certainty the individual felt in giving that answer.

Given that these exercises were an integral part of actual incident command training, the broad goal was also to propose a way of using this knowledge to improve operational response officers' training. To this end, the results of the QASA were fed back to the staff involved in the debriefing (appendix 6).

5.5 Measures of SA and bias

As referred to within previous chapters and above, the QASA approach (Edgar and Edgar, 2007) is based on signal detection theory (for the metrics used, see Stanislaw and Todorov, 1999) and assesses;

a) knowledge or actual SA (ASA; how well the individual discriminates true from false information) and,
b) the bias / scope that is applied to the available information (i.e. the tendency to accept or reject information as true).
c) A measure of perceived SA (PSA) derived from asking participants to rate how confident they are that their responses to the true/false probes are correct.

The true / false responses to the probe statements were analysed for both the true statements (signal trials) and false statements (noise trials). QASA determines the proportion of correct responses (hits and correct rejections) and incorrect responses (misses and false alarms) and then uses the rate of hits and false alarms to calculate:

a) A knowledge or ASA measure based on the non-parametric signal detection sensitivity measure, A' (scores being corrected for chance or guessing) and,

b) A bias measure calculated using B'' (performance in a yes / no or true / false decision task with both signal and noise trials, can be fully described in terms of just the hits and false alarm rate, since proportion of the other two types of response: correct rejections or misses follow from these rates) and,

c) A measure of PSA derived from confidence ratings (see above) on a scale of 1 to 4, with 1 indicating that the answer was a guess and 4 indicating that the participant is certain their response is right.

All of these scores were then re-scaled to provide two measures of SA (ASA and PSA) and another of bias / scope, each ranging from -100 to +100. Further justification and explanation regarding the measures is provided in Edgar and Edgar (2007) with the basic underlying signal detection theory metrics described in Stanislaw & Todorov (1999).

The two key aspects of SA are a person's ASA and their PSA (confidence). Theoretically, ASA can vary across the situation and PSA can remain relatively constant, and *vice versa*. This raises the possibility that individuals may have a resting level of PSA and that ASA could be low, giving a confident incident commander with little real understanding of what is happening. An example of an individual outcome from this exercise is shown below (Figure 5.8).

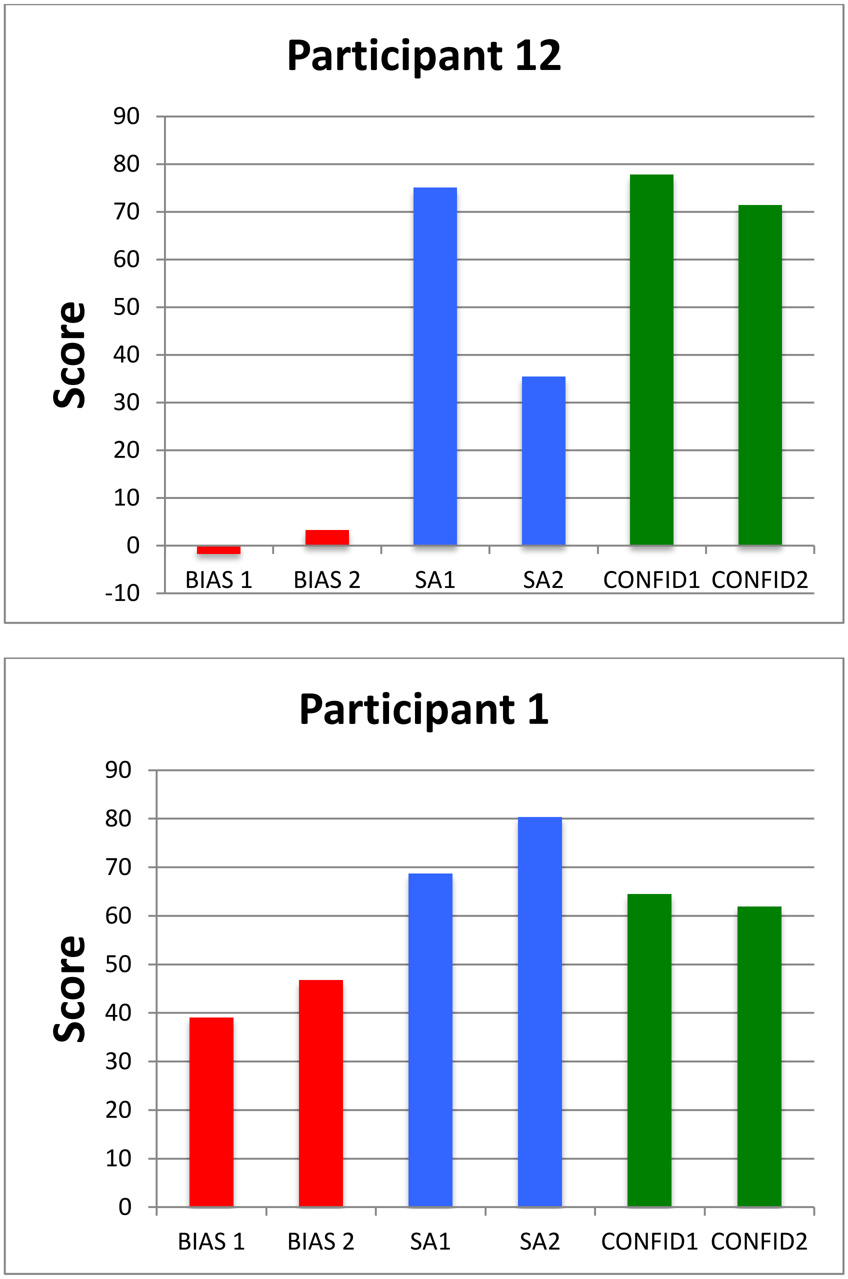


Figure 5.8 QASA results for 2 participants over the 2 exercises in the SWCC.

5.6 Results for both studies in the development / assessment simulated fireground incident of flexible duty operational managers in 2012 and 2013

The aim of these studies was to assess whether individual operational response officers in a controlled but pressurised situation display a particular potential bias / scope patterns, namely:

a) A narrow or conservative bias / scope (with a tendency to reject information and so make misses) or,

b) A lax or liberal bias / scope (with a tendency to accept information and so make false alarms) or,

c) No such bias / scope in either direction (neutral – or a score of zero on bias / scope).

These scores allow the identification any correlation (or lack of) between the individuals' results for 2012 and 2013 that might suggest either a situational, or resting, bias / scope.

In both exercises a small majority (56%) of the participants tended towards a positive or conservative bias / scope (and hence towards making miss errors) and 24% showed a very low or mixed bias / scope, with the rest showing a negative or liberal bias / scope (and hence towards making *false alarm* errors). With these differences not linked to level of ASA or knowledge, nor to years of experience or contractual status (full time vs. retained, exercise results from the table top exercises in chapter 4). The focus of most interest here is the correlation of ASA, PSA and bias scores for the 19 participants who did both exercises.

Data were analysed using a Pearson's correlation. The results for the bias scores (Figure 5.9) show there is a moderate positive correlation between the scores obtained by individuals on the two assessments ($r = 0.620$, $N = 19$, $p = 0.005$, two-tailed). This means that individuals showed similar bias scores over the two studies. Different individuals used different amounts of information, but each individual tended to be consistent across scenarios in what information they would accept or reject.

For ASA (Figure 5.10) there is no significant correlation ($r = -0.110$, $N = 19$, $p = 0.654$, two-tailed). ASA varied across scenarios, individuals that have good ASA in one scenario may have poor in a different one; and vice versa. An individual's handling of information may remain relatively constant across situations, but their level of ASA may vary. An individual's ASA appears to not be consistent across each incident / exercise they respond to, but their bias / scope appears to be.

For PSA (confidence) (Figure 5.11) there is a moderate positive correlation ($r = 0.477$, $N = 19$, $p = 0.046$, two-tailed). PSA appears to be consistent across scenarios – no matter how pressured, individual FRS managers had similar levels of confidence across the trials.

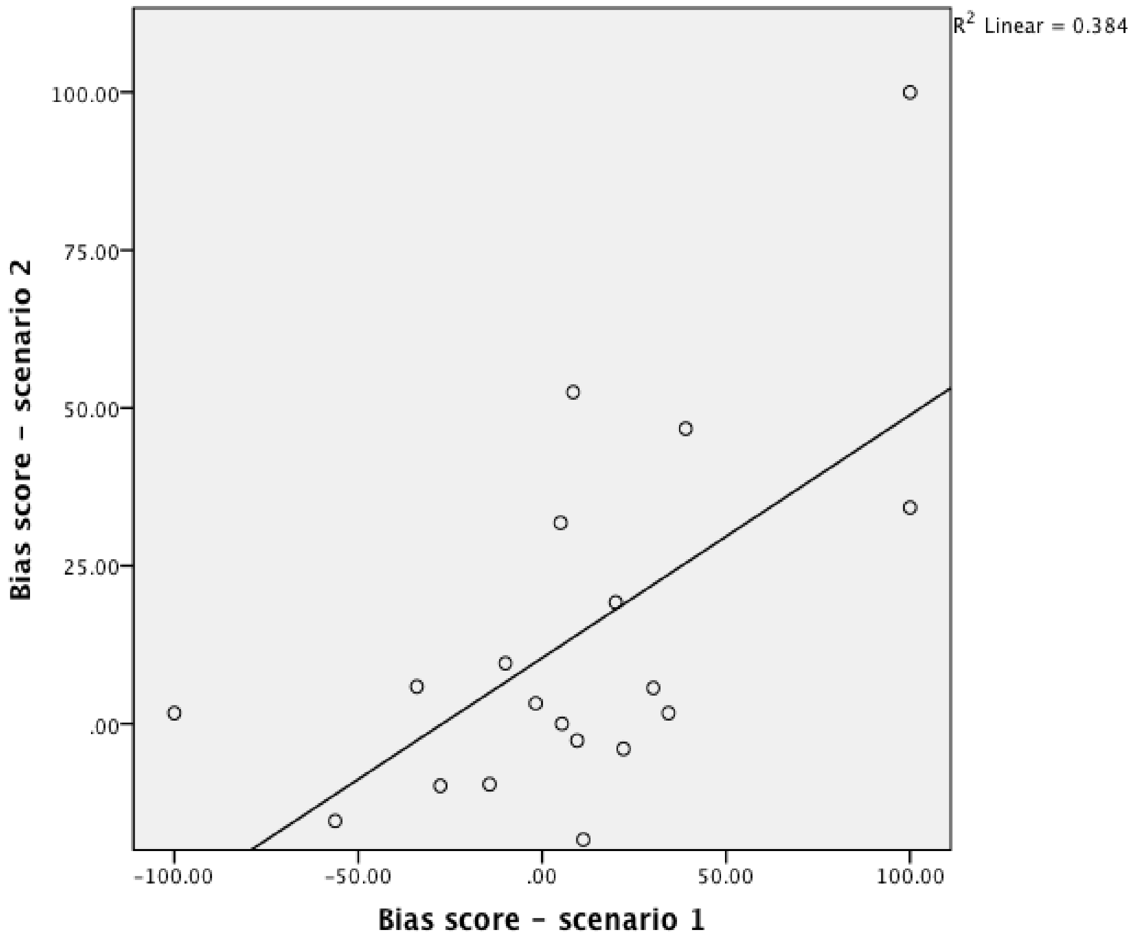


Figure 5.9 A scatter plot showing individual levels of bias in one study plotted against the other.

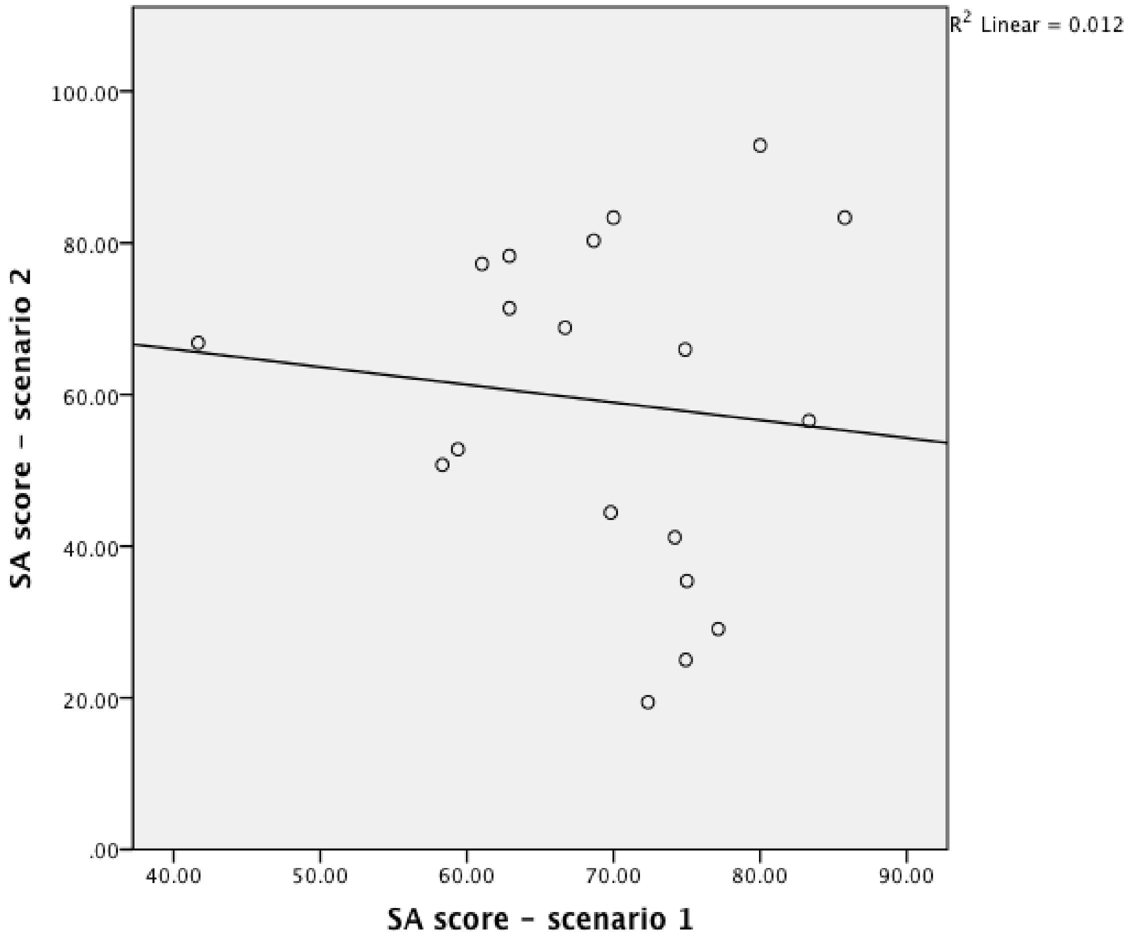


Figure 5.10 A scatter plot showing individual levels of actual situational awareness (ASA) in one study plotted against the other.

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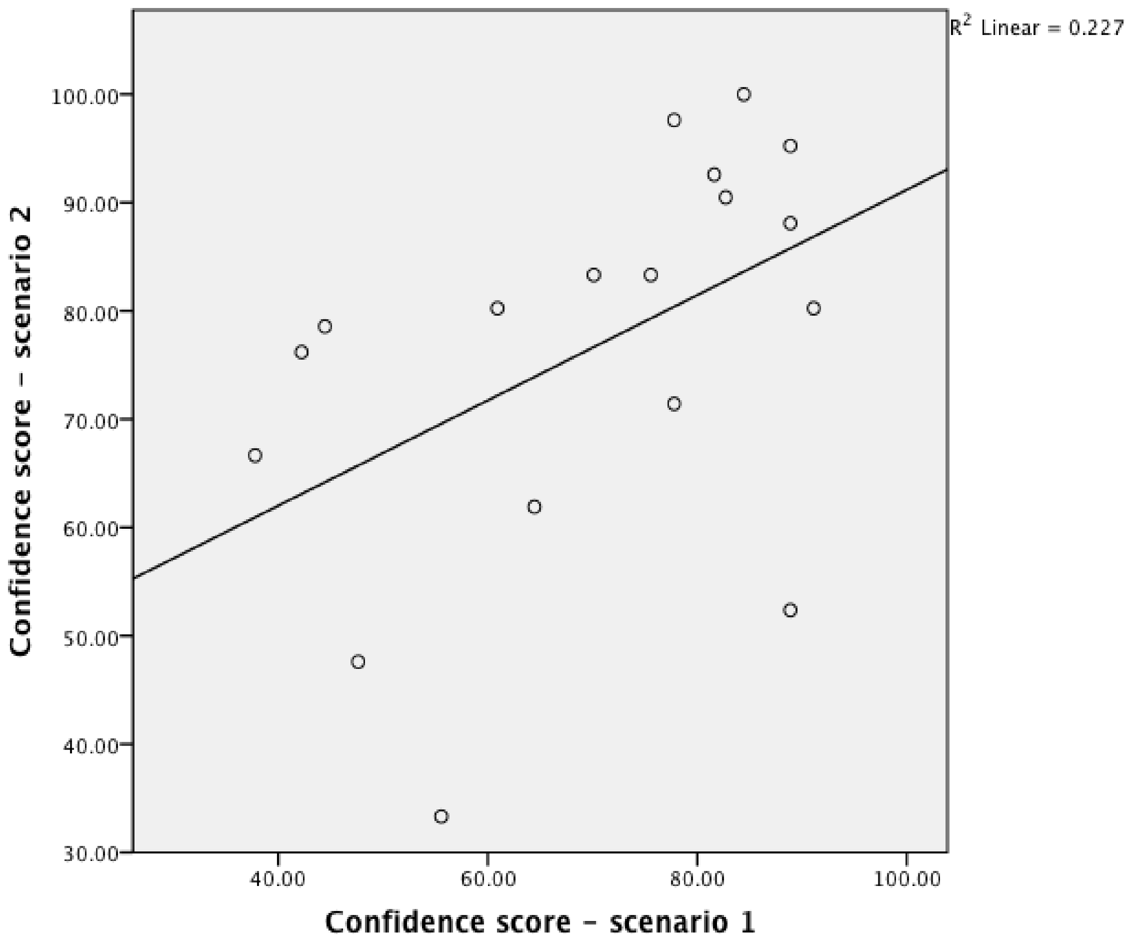

Figure 5.11 A scatter plot showing individual levels of perceived situational awareness (confidence) (PSA) in one study plotted against the other.

The finding that bias / scope tendencies may be regarded as having a resting point (Figure 5.9) would thus seem critical to developing understanding of factors that could lead to risk in real fireground decision - making.

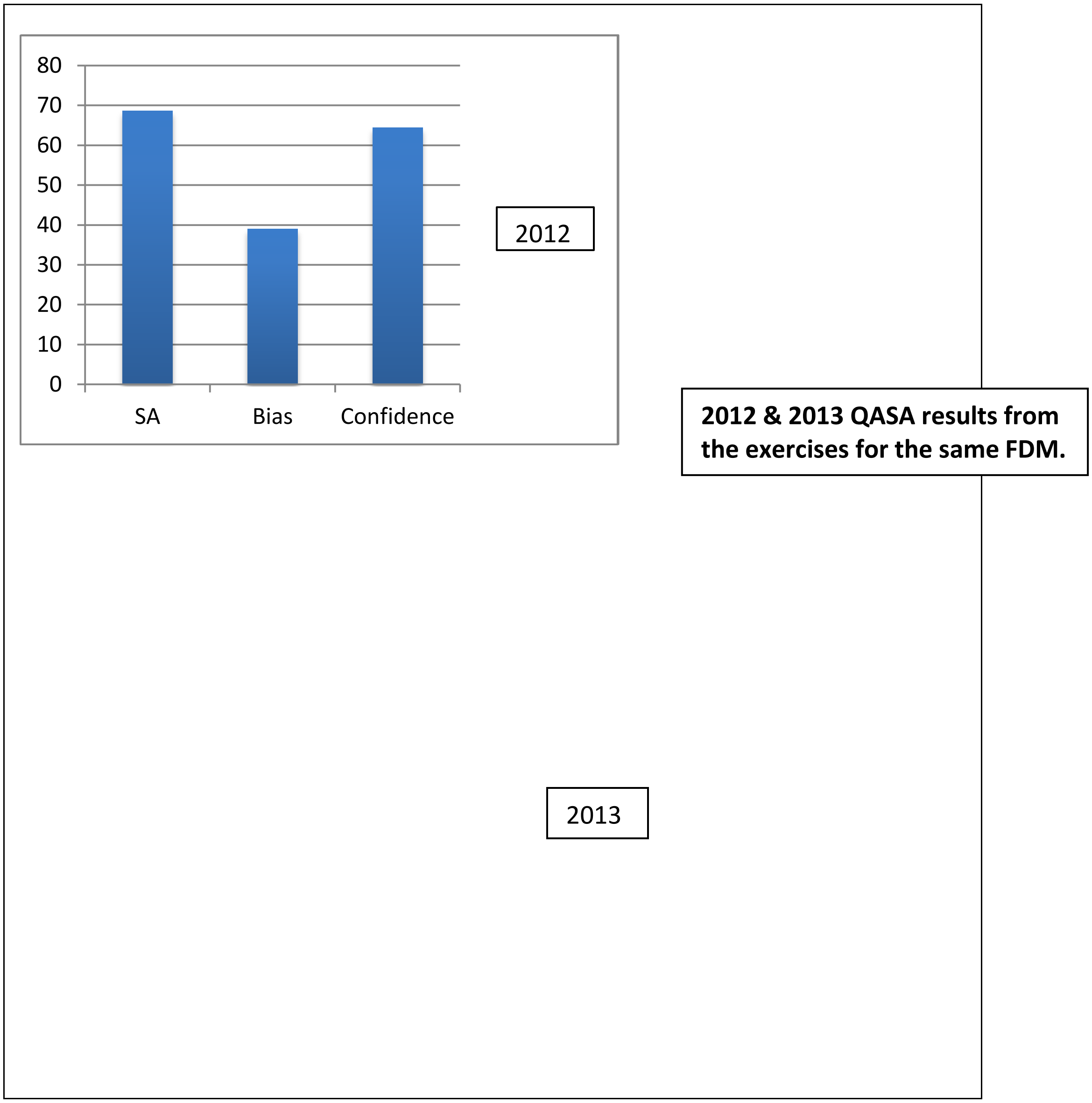

Figure 5.12 2012 & 2013, QASA results from the same FDM.

5.7 Discussion

The primary aim of this study was to measure three aspects of the SA (ASA, PSA and bias / scope) of individual operational FRS personnel found in the fireground exercises. It was of particular interest to establish whether individual scores on these three aspects of SA correlated across two different scenarios undertaken over a year apart (in 2012 and 2013). ASA was likely to be heavily influenced by the situation (some situations may be inherently more difficult to grasp) whereas there was the possibility that PSA and bias / scope could be consistent as they can conceivably be a property of the individual and so less influenced by the situation When the pressure is high, individuals seem to fall back on a resting bias / scope that remains consistent across scenarios, but pressure is an aspect of the situation and that is when consistent bias / scope seems to manifest. That is, their tendency to reject or accept information is similar across situations; but only when the pressure is high.

If there is evidence of a consistent resting bias / scope then this is an important finding as it suggests that the way an individual handles information when under pressure can be measured and will then be predictable. This knowledge could then be used to improve the training of operational response officers.

As discussed in both exercises the participants tended towards a positive or conservative bias / scope and hence towards making miss errors, with about a quarter showing a very low or mixed bias / scope. With the rest showing a negative or liberal bias / scope and hence a tendency towards making false alarm errors. These differences did not appear to be linked to level of ASA or knowledge, nor to years of experience or contractual status (full time vs. retained).

In looking at the current data it cannot be determined why any individual might have shown a particular bias / scope pattern (positive, neutral or negative) in these exercises, but nonetheless the data suggests that bias / scope tendencies are apparent, measurable, and consistent for most participants. The level of ASA was high for most individuals, but when they were not certain of the correct answer, they showed consistent bias / scope tendencies associated with either miss errors or false alarms in decision - making. The bias scores showed a positive and highly significant correlation indicating that individuals showed similar bias scores over both the development / assessment simulated fireground incident trial and assessable simulated fireground incident trial. These data provide support for the notion of a resting bias / scope (a bias / scope that will reoccur with the individual when undertaking a highly pressurised operation role), rather than a situational bias / scope (a bias / scope that could vary with the situation when attending a highly pressurised operational role). The resting bias / scope shown in these two exercises was a different outcome to the one identified in chapter 4, the table top exercises. While both exercises were realistic to the types of incident fire fighters could respond to the second table top exercise lacked any type of pressure / stress on the individuals taking part. Both of the exercises for FDMs were high pressure events for the individuals taking part as failure in either one would have implications for the individual in terms of both a credibility and financial loss. In the 2013 assessment exercise two FDM's failed their assessment and were taken off operational response, both were successful when retaking the assessment within the provided 3 month period. The pressure inherent in the exercises was a real difference to the table top exercises and appears the most likely explanation for the different pattern of results found.

One of the aims of this experiment was to determine whether the bias / scope patterns evident in the table top exercise would also be apparent in a more realistic and challenging situation. The participants showed a range of bias / scope, conservative (positive), liberal (negative) or neutral. Of interest, as in the previous studies was again the apparent independence of the level of ASA. As with bias / scope, for PSA (confidence) there was also a significant positive correlation across scenarios, with PSA being consistent across scenarios. No matter whether their PSA was high or low, individuals' PSA tended to remain consistent across scenarios and independent of their ASA. This suggests that there are likely to be times when there is a mismatch, for any individual, between perceived and actual SA. Fire fighters need to be aware that their ASA may not be what they think it is and also to be aware that given the correlation they are likely to feel confident, or not, at every incident / exercise they attend, regardless of the actual information they have and their understanding of the situation. In sum, although ASA varied for individuals across the tasks, bias / scope and PSA (confidence) were consistent.

5.8 Conclusions

The assessable simulation exercises in these experiments showed evidence of either positive (conservative) or negative (liberal) bias / scope tendencies in the FRS individual participants that were consistent across scenarios. There may be many contributing factors to the maintenance of such bias / scope tendencies including perceptual, attentional, working memory load, emotional and personality considerations as mentioned previously (Becker, Mortensen, Ackerman, Shapiro and Anderson, et. al. 2011; DeFockert, Rees, Frith and Lavie, 2001; Endsley and Rodgers, 1997; Foster and Lavie, 2009; Klein, Calderwood and Clinton-Cirocco, 2010; Lavie, Hirst, de Fockert and Viding, 2004; McLennan, Pavlou and Omedei, 2005; Mosier and Fischer, 2010; Schwartz, Vuillemier, Hutton and Maravita, 2005).

As discussed the role of such factors is not determinable from these experiments, but the finding of consistent bias / scope patterns, in the absence of consistent ASA, for individual FRS incident commanders is an important one that could have implications for understanding errors in incident based decision - making. In this research bias / scope tendencies in individual's decision - making have been clearly identified and with the key finding that these bias / scope tendencies are consistent for the individual across the two different fireground situations investigated here.

The finding that individuals showed similar bias scores over both the development / assessment simulated fireground incident study and assessable simulated fireground incident study, points to a resting bias / scope (a bias / scope that will reoccur with the individual when undertaking a high pressured operational role), rather than a situational bias / scope (a bias / scope that could vary with the situation when attending a highly pressured operational role).

The current findings confirm the methodological approach as a valuable means for developing future studies. The technique has clearly shown that regardless of level of knowledge or ASA, there are response bias tendencies in the decision - making of individual FRS professionals leading to either *miss* or *false alarm* errors. The finding that bias / scope patterns are independent of ASA is an important one that is congruent with previous evidence indicating that simply acquiring information or SA does not necessarily lead to effective decision - making (Omedei, McLennan, Elliott, Wearing and Clancy, 2005).

5.9 Next phase: feedback to the FDMs

Actual ASA varies across scenarios; individuals can have good ASA in one scenario but can have poor ASA in a different one and *vice versa.* PSA (confidence) appears consistent across scenarios; the confidence level (PSA) of the individual incident commander appears not to change even if their ASA does, no matter how pressured the exercise is. This is a key point as confidence (PSA) was also consistent in the tabletop exercises as well as in this study. So ASA varies with situation, bias / scope tends to a ‘resting point’ but only under pressure. While PSA (confidence) appears to stay the same no matter what the circumstances of the exercise, which is both fascinating and important.

How much information an individual uses from the information available at the incident varies across situations, so it could be positive (conservative / narrow) in one and negative (liberal / wide) in another when the situations are relatively low pressure. When the pressure at the exercise / incident is high, individuals appear to fall back on a resting bias / scope that remain consistent across scenarios. That is, their tendency to reject or accept information is similar across situations; but only when the pressure is high. So for incident commanders the implication is that the information processing of the individual may fundamentally change at an incident when the pressure increases. So incident commanders need to be aware that their ASA may not be what they think it is, it could be better, but it could be worse, and such an incongruence could lead to errors in decision - making.

Feedback is an important confirmation that may have valuable implications for fireground training, performance and risk. The next aspect of the research is to explore whether personal knowledge of such bias / scope tendencies can bring awareness of one's own bias / scope and an awareness of the risks attached to particular bias / scope tendencies. The possibility of increasing 'bias-awareness' in FDM's was explored by means of semi-structured interviews is discussed in the next chapter.

Chapter 6

Flexible duty operational manager's development and assessment exercises: Semi structured interviews 15 months after receiving feedback on the 2012 results.

6.1 Introduction

Following the results of the 2013 FDM exercises and identification of a possible resting bias / scope from the research data, there was an opportunity to review what the 19 FDMs who had taken part in both exercises saw as beneficial from their original debrief and their experiences. Each had been briefed on their individual profile from the 2012 study, as shown in chapter 5 (appendix 6) and had been given a breakdown of their bias / scope profile and both SA profiles (ASA and confidence - PSA). A discussion was also held with each individual on their profile and what it meant in relation to the way they reacted under the stressful assessment / development exercise they had undertaken in 2012. As identified previously it was felt to be an important part of the study to gain their views as to whether the information they had been provided with and what they had considered over the period of the assessments, had implications for fireground training, performance and risk.

Armitage 2007), argued that using just qualitative or qualitative methods were representative of the ‘mono method era’, whereby researchers used purely qualitative or quantitative research methods, depending on their research paradigm. The development of a “third way” has however been linked to the pragmatic paradigm. Within this, the employment of a mixed methodology, or approach, reflects the need for pragmatic decision making, consistent with working in ‘real world’ settings. A pragmatic paradigm allowed for differing data collection and research methods to be utilised, based on their appropriateness for the research undertaken and the research questions to be answered (Ritchie & Lewis, 2003). This presents an approach whereby methods are selected from a ‘tool kit’ rather than dictated by the paradigm employed. It is argued that this epistemological and methodological choice is reflected of the multiplicity of the ‘real world’.

In relation to the qualitative data analysis completed within this research, it was decided that thematic analysis would be the most suitable method. Braun and Clarke (2006) argue that thematic analysis is comparable with both essentialist and construction paradigms and offers a flexible research tool, often leading to rich and detailed understanding of the data. Due to research questions being identified, and interviews being structured to explore these, it was felt that thematic analysis of the data would be applied in a ‘theoretical’ way. This involved a ‘top down’ method of analysis, which provided a detailed analysis of aspects of the data. A number of methods were considered and it was decided that thematic analysis was most appropriate as it was argued to be the most appropriate tool to answer the research questions set. This being the case the next identified stage was to explore participants' personal views of how ASA, PSA and bias / scope tendencies could improve subject awareness of the risks attached to such tendencies. The participants' views were explored by means of semi-structured interviews with 14 of the 19 FDMs who had undertaken both exercises; 2 of the participants did not wish to take part in the interview part of the research and 3 were not available due to promotion out of the Service, one retirement and one who was on long term sick. Each FDM was given the opportunity not to take part and each gave consent prior to the interview taking place; being told that should they have no concerns regarding the interviews, all information from which would be confidential and they could withdraw their participation and any data collected at any time. Some FDMs chose not to take part in the semi structured interviews, specific reasons were not given or requested, and some were not available; but 14 of the 19 agreed to take part. The semi structured interviews were undertaken with each individual in a private office between 12 to 14 months after their first briefing on their individual performance in relation to the assessment outcome with respect to SA and bias / scope in 2012.

6.2 Direct Aims of the Research

The semi-structured interviews provided a collective response allowing a subjective evaluation of the importance that FDMs have placed on both bias / scope and SA since their introduction to it within this project. As discussed due to the research questions being identified, and interviews being structured to explore these, a thematic analysis of the data was applied in a 'theoretical' way. A 'top down' method of analysis, which provided a detailed analysis of aspects of the data based on the direct aims of the research. A number of methods were considered (Appendix 7), but it was decided that thematic analysis was the most appropriate tool to answer the research questions set, identifying a method of data analysis that could reflect reality for the participants, but also explore and unpick that reality (Braun and Clarke, 2006).

The aim of this analysis was to gain some understanding of how taking part in the exercises and being made aware of not only the concepts of ASA, PSA and bias / scope, but also their personal patterns, would influence FDMs subsequent approach to their operational role. The research question was thus:

How do FDMs feel that taking part in the exercises, and being briefed on their ASA, PSA and bias / scope, influenced how they regarded their operational role and the way they approached it?

6.3 Thematic analysis of the 14 semi structured interviews with FDMs who took part in both the 2012 and 2013 studies

The qualitative data was analysed using a thematic analysis approach, whereby interpretation of primary data was undertaken. Thematic analysis is a qualitative method of identifying and analysing patterns or themes from within data (Braun and Clarke, 2006). Gomm, Hammersley and Woods, (1994) identify that a researcher will always have some influence on the research they undertake, despite their use of skills to reduce this, each researcher will have their own values, belief and self that will influence the decisions they make throughout the research process. It is therefore important that this is acknowledged within the research.

6.4 Ethical Considerations

These studies were conducted in compliance with the ethical guidelines laid down by the British Psychological Society and ethical approval was obtained through the recognised procedures within the University of Gloucestershire. The studies took place at FRS establishments at a time suitable to the participants; participation in these research studies was fully voluntary indicated by signed consent after a preliminary briefing. Participants were fully advised that there were no requirements to participate in the research project; some staff did elect not to be involved in the studies demonstrating that consent was fully voluntary. Results were anonymised for purposes of general analysis and for reporting in any public forum, while personalised feedback on their own performance was provided to individuals. All data was stored on a single private computer, with password protection to log on and additional password protection to access the data folders. Hardcopies of any data were kept in a locked storage unit in a private location. Personal details for all participants have also been anonymised in the research write up.

6.5 Semi-structured Interview questions

The research question emerged from the previous studies and so the thematic analysis was theory-driven rather than inductive. This approach informed the interview questions that were as follows:

- Have you undertaken any personal learning in relation to the information I shared at the interview (your profile from the assessment)?
    - Prompt: what was this?

- Has it made you think about your bias in any way?
    - Prompt: can you explain this?

- Now you're aware of bias: have you recognize this in any of your decisions following the discussions we have had?

- Prompt: was this in a particular area of your work / environment?

- Has it made you think about your command of an incident in a different way?
    - Prompt: can you explain this (example)?

- Do you think this knowledge could, or has, changed the way you command an incident?
    - Prompt: Can you give any further examples?
    - Do you think this is a positive change?

- Do you think that you recognise the difference between actual and perceived SA? Can you explain this?

    - Have you thought about this since our last discussion?

    - Has it made any difference to the way you operate at an incident?

6.6 Thematic analysis of responses to questions asked during the semi-structure interviews.

Within the semi structured interview each of the 14 FDMs who took part was asked a series of questions based on their debrief from the first exercise approximately a year before (where they had sat down and discussed the outcome of their 2012 assessment), or related questions from the development of the research. The semi structured interviews were undertaken before the outcome of the 2013 assessment was shared with the participants, and without any update on SA or bias / scope from either the research or from the researcher.

The thematic analysis – method; The thematic analysis focused on one level and followed a semantic approach, identifying the themes within the meaning of the data and the analysis did not look beyond what participants had said or what had been written. The analytical process involved progressing from the descriptive where the data was simply organised to show patterns and then summarised; and taken through to interpretation, from the interpretation the significance of patterns and their broader meanings and implications were identified.

Gomm, Hammersley and Woods, (1994) identify that a researcher will always have some influence on the research they undertake, despite their use of skills to reduce this, each researcher will have their own values and beliefs that will influence the decisions they make throughout the research process. I have been involved with this research for over 6 years now and for over 25 years have been working with the FRS as an operational incident commander, as well as a training assessor and trainer with operation staff at both training exercises and operational incident assessments. As Deputy Chief Officer I was responsible for the overall day to day operational response of the Service and for the competence of its operational staff from recruit basic training and acquisition of skills, to fire fighter application of skills and maintenance levels, through to strategic incident command training and interagency working. As a senior manager within the Service I was also responsible for maintenance of discipline and grievance and direct line management of senior managers, but not for any direct line management (I was at least 3 levels of direct line management above) of station managers taking part in the research. I have been aware of this throughout this research project and the influence this could have on outcomes; there will always be the risk that I may not have questioned responses enough as I understand the language used and also that I may have used my own context to shape the / my understanding of some of their points. There is also the risk that in the discussion on bias / scope because I have been investing in the research my views of what firefighters should / are doing may be different from the reality they are telling me. But in this I have worked hard to complete each interview using the same procedure and following the semi-structured interview questions and prompts, to maintain the value of the research, but acknowledge that the influence that I bring to this research should not be ignored as it will have influenced the decisions at times within research process. The interview responses and thematic analysis have also been discussed with researchers outside the fire service in an attempt to ameliorate such influences.

A thematic analysis of the interviews was conducted using the six-stage process outlined by Braun and Clarke (2006). The stages were as follows:

Stage 1. Familiarisation with the data

Following each interview the interview data for all participants was transcribed in full by the interviewer, which started the process of familiarisation of the material content for the analysis, this allowed for reading and rereading of the data. Even at this early stage ideas for coding were captured and notes made. The tapes used to record the interview were kept in a locked cabinet should they be needed for reviewing transcripts or clarifying the context of the discussion at a later date.

Stage 2. Generating initial codes

Codes were then developed with the specific research question in mind; the process was a manual one using different coloured highlighters to identify groups of similar codes and making notes against them if there was a query in relation to the coding, or the possibility that the response could fit into multiple themes. Over all there were 27 codes identified within the specific questions across the interviews and these were approached with specific questions in mind that were identified to help with the development of the research. The codes were then brought together into groups, generally across the research and specifically under the questions that had been asked, once these were grouped the themes were developed and refined that are shown within the thematic map and reported within the following work, some codes worked across different themes. One code that did work across the themes was the code 'no change' where in a response to a number of question the answer was 'I have not taken it forward', 'it's the way I am', 'I did not consider it', or 'I don't see a need to change'. The work was undertaken systematically through the data set identifying interesting aspects (including the enthusiasm of some of the participants for the new knowledge, using notes) that formed the basis of repeated patterns (themes), giving full and equal attention to each data item.

Stage 3. Searching for themes

Taking account of the questions presented within the semi structured interviews and how these questions were developed to assist in taking the research forward collecting the different codes was undertaken by copying them into themes or potential themes, identified from these questions and the responses given. Then using copy and paste and arranging the codes under each potential theme, or identifying a number of different titles that could be used for the theme, both against the questions and as a holistic view of the process. This process allowed for a sense of significance for each individual theme to be identified and reinforced a single title that was identified and felt to be the correct one for the theme chosen.

Stage 4. Reviewing Themes

This stage refined the themes, reading and rereading each of the codes placed under the theme, drawing and redrawing the thematic map. Reviewing it to ensure what was being said by the participant was reflected by the choice of theme and the codes were coherent with the theme, looking for the themes to form a coherent pattern across all of the codes, with some codes reflected under more than one theme. A full review of the data set was then undertaken bearing in mind the research question, looking to see that the themes worked in relation to the data set and looking to see if there were other themes that could be identified, or needed to be identified.

Stage 5. Defining and naming themes

In reviewing the themes there was again a need to define and refine, to ensure the themes and data were coherent, ensuring that there was not too much overlap between the themes. In reviewing this and working through the names of the theme before finally naming the theme and then reviewing again the code under the named theme, no sub-themes were identified, so only the main themes already identified were named and used for the final analysis.

Stage 6. Producing the report

Themes were identified that related to different aspects of the research questions. These themes, and the part of the research question to which they pertain, are presented below in the thematic map, the 5 areas shown in blue are the areas identified from the interviews and the questions presented. For each of the areas identified from the interviews themes were identified and these themes are expanded on following the thematic map. The map at 6.1 below is the final outcome of the refining process that was undertaken over the reviews of the codes and then matching the codes to the themes.

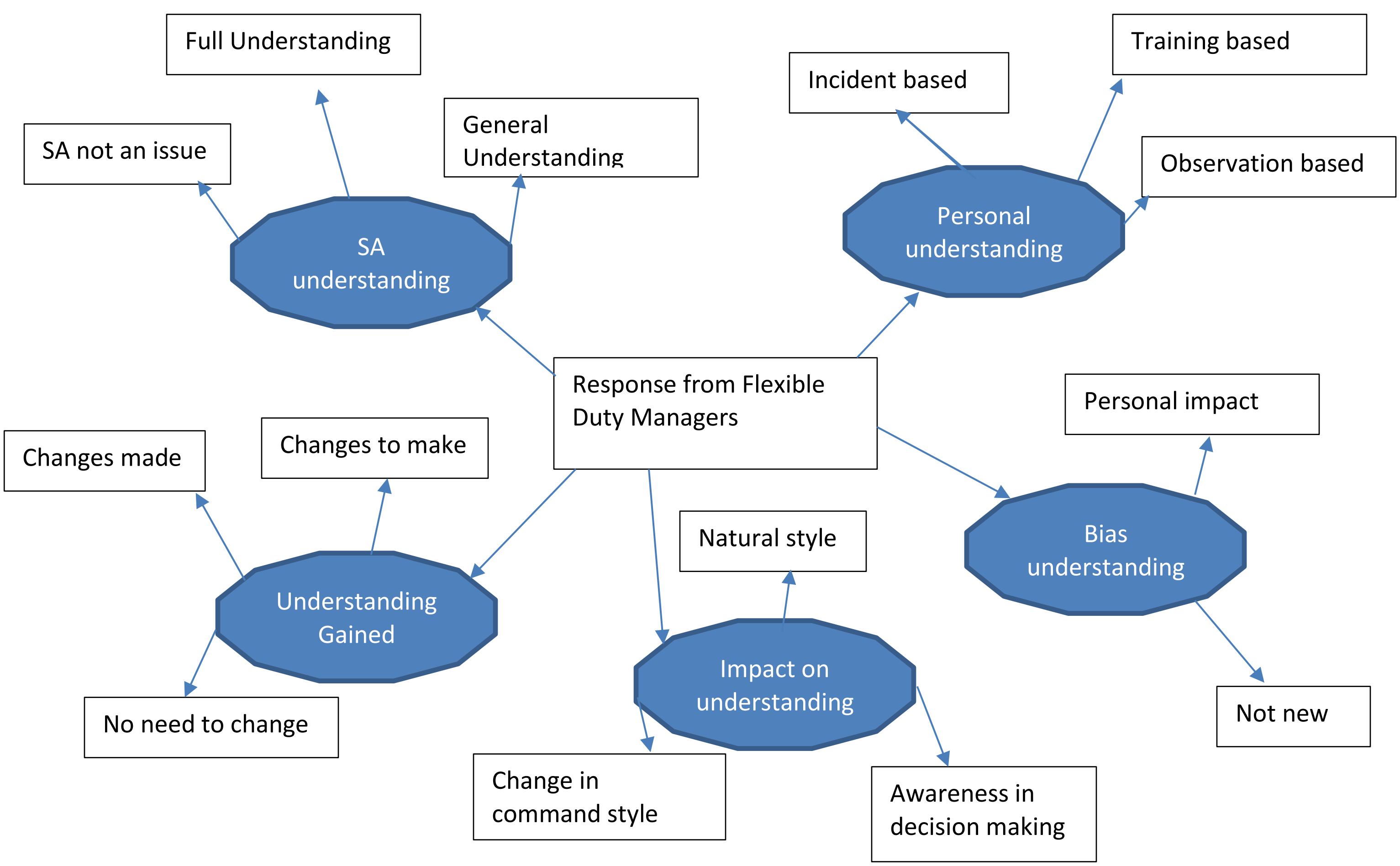

Figure 6.1; Thematic map developed from the information provided from the semi-structured interviews following coding.

Personal understanding on bias / scope and SA identified by FDMs in the 12 months period following the profile review of the 2012 assessment.

Within the questions the term bias was used (as FDMs were familiar with this from the research) so the term bias is reported, not the term bias / scope.

Theme	**Example Quote**
Incident based reflection	"I have tried to apply my understanding of what we discussed in those sorts of scenarios and a number of operational incidents I have been to, just trying to understand what my bias is, how I approach things, what my situational awareness is like so no specific learning but I have tried to apply it in my role." "I gave it a lot of thought to it and I tried to apply it a little bit. I reflected on how you explained bias and that you can have that sort of bias and that made a lot of sense to me in my performance at the incident".
Training / exercise	"Yes I did look at the information given me and I reviewed it quite a few times and from my perspective

based reflection	when you look at bias in terms of your perspective and your ability". "Yes I have been through the incident command process and the technical bulletins to try to enhance my knowledge and understanding of what I am doing. To make me feel more polished and professional, to make sure that I am going down the right route". "I gave it a lot of thought to it and I tried to apply it a little bit. I reflected on how you explained bias and that you can have that sort of bias and that made a lot of sense to me in my performance at the incident. So I tried to make some changes into the way I approached the recent assessment down at Lansdowne". “Since we had that conversation there has been a couple of courses that I have been involved in where I have reflected on elements of that conversation and that has been quite useful”.
Observation based reflection	"Every incident I have been on I have looked at other people and how they manage that incident, looking for their bias without asking questions looking to see if they are closing down or opening back up". "Yes I took on board what you said last year I have attended three or four fire seminars with some case

	studies which are always beneficial and force you to look into the incidents you have attended and what is coming out of these seminars".

In looking at the **theme of 'incident based reflection'**, an approach by three of the FDMs who had attended large / complex incidents was that each had taken the opportunity to look at their personal understanding of what had been discussed at the original debrief regarding the incident and its outcomes. Linking this into what had been discussed about their command of the large / complex incident they had attended / commanded and had taken the opportunity to reflect back on it. For each of the other FDMs who took part, the main observation was that they had not responded operationally to many large / complex incidents within the 15 month period between the profile discussion and the interview to reflect on. This lack of attendance for major incidents led to the **'training / exercise based reflection' theme** where 50% of the FDMs (seven) had reflected on the 2013 assessment and / or other training events to review the information presented at the discussion, linking it back into the information that was available to them for continuous professional development. Other than this direct approach that FDMs identified to review their personal information within the interviews, three had taken the completely opposite opportunity provided by this approach. They had taken the available opportunities to look at *other* incident commanders, **'observation based reflection', a**

theme that was based on reflection of others in relation to what they through their own actions would have been either, at an operational incident or at a training event and had considered the way that they managed ASA, PSA and bias. One of the participants from this group had taken the opportunity of reviewing the incident commander's position from attending national operational training seminars, where key incidents from around the UK FRS were debriefed to invited groups of operational response managers. These presentations focus on both good and bad practices that played out at the incident being debriefed, as well as improvements in incident command, operations, or procedures identified. From this the individual believed that using these as a discussion base and including the information on bias, ASA and PSA, could possibly bring real benefit to incident commanders.

Other than a very short "no, I don't think I have", the FDMs who have been exposed to their own performance in relation to bias and both ASA and PSA from the 2012 assessment, were quick to build on it and each felt that it had improved their own performance, but there was no way of testing this. The way they felt they had benefitted was either by using the themes identified of self analysis at incidents or exercises, or by reviewing and reflecting on other FDMs when they commanded an incident operationally, including reflection on incident commanders' actions when debriefed on major national incidents. The feedback from the interviews shows that a good understanding of both bias and ASA and PSA was maintained by the FDMs. All but one FDM discussed how they had used the information provided within their debrief session of the 2012 assessment to build on and to improve their own knowledge / understanding of both SA and bias to improve outcomes from an operational perspective.

FDM's considerations on bias understanding

Theme	**Example Quote**
Awareness of personal impact.	"It has, I don't know yet whether my bias is a set figure. I think what I suspect is it varies depending on the type of incident I am attending and how familiar I am with that type of incident. So if it is something I have done on a number of occasions it will allow me to step back and not concentrate on the detail so much; but if it is something I am less familiar with I will look at the detail more, my bias will be more positive I think because I will have to concentrate more and look more closely at what is happening around me". "Yes it is about having balance to understand what you need to do. That there is not too much information so that you don't know what to do, or too narrow decisions and missing massive parts".
The way I am!	"I remember what you told me that my bias is very minimal .... from what you have told me I don't need to develop that too much as it is about the right place ".

	"I felt it was clear that I used a wider perspective and by being more aware of that, that was sort of my natural style". "Yes, it has made me more aware of bias and of your own bias, but I suppose I wouldn't necessarily separate bias from some of the other elements of reflection of my performance".

The majority of participants said they had recognised bias in themselves in the way we had discussed it (an information bias that could impact when under pressure on the incident ground, or simulated incident ground) and had understood their own personal bias. They also identified that they had reflected on it in relation to its impact when undertaking operational decisions and the way they felt it could impact in the future. There were two themes that came from this area of discussion the **theme that showed an 'awareness of personal impact'** and a **theme that appeared to accept where the individual was**. In being more aware of their personal bias, they also appeared to be much more aware of the wider ASA and PSA discussion and appeared to be more aware of self reflection and the need to review and reflect on outcomes to improve their operational competence and decision - making. In looking at the theme of 'awareness of personal impact' in some responses they also appeared to raise the same questions that had been raised within the research, was the information bias a situational or resting bias. While some of the FDMs had recognised their bias and had picked up on it in reflection to make it a real consideration for operational use. Some (three) had appeared not to have taken it forward, which gave the theme of 'the way I am'. With a small number (two) not appearing to consider bias as a separate entity to all the other aspects of incident command training / management.

Impact on understanding of bias awareness on decision – making

Theme	**Example Quote**
Changes in command decision making style	"Yes I have and I make a conscious decision to stop and make a lot more planning phases and communication phases within the work place, I got time to sit down and watch myself". "Yes it wasn't that I was afraid to make a decision it was about evaluating everything, but not coming up with an answer. I was aware of that bias and trying to bring things in a bit so that's irrelevant, but those are relevant and bringing it in to my everyday management". "It is very difficult to recognise you are doing it but I think with the background I don't think that I will forget that anymore because I do understand when we discussed the bias it made sense to me. So it was fairly logical that I make sure I keep it in the back of my mind and monitor that that is the best thing you can do with a bias if you are aware of it that is the battle".

Not seeing a need for change	"I think you always want to get involved, the fireman in you is always going to be there, but I think you consciously try to step back maybe my negative bias is that I stand back too much and try to get a holistic view; maybe I need to try and improve my bias in that aspect". "No I haven't if I was really honest with you". "No I don't think I have, not consciously. I think you always self reflect. Sometimes you talk to the manager afterwards is there anything we might have done different but not during an incident".
Awareness on decision making	"I think it is innate at a level so I tend to revert to type, I am not saying I am comfortable but if it is less familiar I would definitely focus in more on the incident. It is not something I go to a job and think I am going to make my bias more positive here it is just the way I react to it". "Yes I have, not necessarily my decisions, but in my decision making process, because I wouldn't have said there were any dramatic surprises for me in our last conversation".

With the majority of FDMs already recognising and accepting that they had a bias and undertaking some reflective practice, it appeared to be for them an easy step to self analyse and look at the impact in relation to their ongoing decisions. In looking at the **theme with 'changes in command decision making style'**, again it was the majority who looked back at how their bias affected their decisions and the outcome for these decisions and there were some interesting insights to how this information was accessed, used, understood and then expanded on from an individual perspective. Some had taken direct action in relation to their identified bias "instead of taking a wide view I narrow it down", while others appeared to have considered it as a part of their internal makeup (they way they were) and looked to integrate it into a more internal aspect of their innate processes. "Regarding that bias, it is important that I don't look beyond my piece of the stained glass window as it were, because I can't affect any of that, but for me to ensure that bias covers the complete part of that stained glass window, if that makes sense, rather than being focused on just one part of it because that could be dangerous". There was again a **theme that showed up in 'not seeing a need for change'**, there were three FDMs who said they had not recognised bias within the decision – making at operational incidents or training exercises they had attended following the briefing, but only one of them was clear that they had not progressed any of the discussion we had at this last briefing. While the other two said no they had not progressed any of the new knowledge, they recognised they had taken it forward to a limited extent within the interview and one reflected that the outcome from the last assessment was important to fully understand their bias in relation to it being situational or resting. There was one direct reference to an operational incident, "Yes, last week the chap that was caught in machinery" an incident that due to its nature was time critical and likely to be highly pressurised, so it could be seen as a direct comparison to the assessed exercise where the original bias was identified. The **theme of ‘awareness on decision – making’** came out of the interview in progressing how bias could impact on the individual and its relevance’s within their decision – making, it was interesting to find that they had identified that while their bias had been identified within an operational context, they progressed it beyond that to other areas of high pressure work they had undertaken. Two had taken it out of the direct comparison with the operational / training environment and looked at it in the wider environment, reflecting that they felt that their bias was and did impact on other activities when they had to analyse information and make decisions.

The way the FDMs considered the understanding gained on SA and bias could change the way in which you command an incident

Theme	Example Quote
Possible change	"It will do, it is about having opportunities to use it". "It is hard to say because I have not been to any significant incidents, but it has definitely made me think about it". "I think it will".
Already changed	"Yes it has, from my perspective in terms of my command it is important to match my ability with my confidence, but it is

	important not to get influenced by too many pointers that can drag you into making the wrong decision". "Well it has given me some different ways of considering how I respond to a certain extent; it was things I had considered". "Yes it's made me think that I might be the overall commander, but you need that checks and balances to go back to those individuals that you are working with to say done this, done this what do you think, have I missed anything and having that check have you thought of that; it has paid dividends already". "I have no doubt that it has influenced the way I make decisions, the way I think about decision making".
Internal process; the way I am	"Not significantly, my thought processes may have changed slightly and occasionally if I think I am getting too focused in I can maybe take a step back so it has given me more of a structure but in terms of how I run an incident and the decisions I would make, probably not". "Not massively, it's made me think am I doing it, is this about right, am I happy with my focus am I taking in all the periphery, or am I not giving the task enough detail".

The **theme of ‘possible change’** due to the new knowledge gained was strong and most believed the potential was high; it appeared to be that they lacked the opportunity to use the new knowledge to make changes because of the declining incidents. With the **theme of ‘already changed’** the overall view was that it had provided something to think about in relation to their command and decision - making style at an operational incident or training exercise, but a concern in some quarters was that if you only thought about it at an operational incident then it may be too late. Most identified that there was a need to gather the information available at an incident or training exercise and identify from it what they through was valid and what they thought wasn't and also to check the information source. The majority had seen an identified need for reflection following an incident or exercise and a need to question why the information you had used was under consideration and why other information available wasn’t considered. A general consensus was that the new knowledge needed to be included into everything the individual was considering in relation to the incident to gain the best outcome required for the incident and how the decisions the individuals made could be clarified using this knowledge before implementation. All FDMs bar one thought it had changed the way in which they had commanded an incident, or would change the way they did it in the future, to a greater or lesser extent. Eight believed it would or did have a great impact on the way they now worked and how they would make decisions in the future. While others talked about a smaller impact, but at the same time explained how they would see it impacting on them in the future, or at the larger incident. In all but one response it was seen as a positive area to be looking at and one that held real value for command decisions in taking forward. While the **theme of ‘Internal process;** the way I am’ appeared to be just an acceptance of the new knowledge as something that always was and within the discussions a number of FDMs felt they could work on it, but as a small development for them along with all the other training they receive. Overall the views that were given reinforced the view with the research that a resting bias could be changed, or mitigated against, or a different way could be learned, in the same way automatic reading was a learned process as discussed earlier.

SA understanding, recognition of actual and perceived SA

Theme	**Example Quote**
SA understanding	"Actual (ASA) is what is occurring and perceived (PSA) is what I think is occurring so I would say yes". "Well actual is a true understanding of what is going on in my mind so understanding the resources, the tactics, the nature of the incident and how it is developing. A perception is purely about your interpretation of the situation and how you think it is your take on the situation, which may or may not be accurate and it could mean that it is inaccurate based on assumptions, or prejudice, or miss- information". "It made me think more about the confidence I have got and

	the ability I have got and how it needs to match up". "Yes I know what I do know and I know that I might think I know, but am happy to say that's not a fact that's an assumption, so I will look at that and get a fact so that that is no longer an assumption. Once I have the facts that it is genuine situation awareness not what I think". "I think I do know the difference, I think the issue with myself and I think when you are fairly experienced we have that library of incidents that we have attended in the past and we can very quickly try to fit what is in front of us in to something we have already experienced". "I think that different perception of something which is not what is exactly in front of you. You have to be very careful you don't try to make the two fit".
SA is not the issue	"I think I may recognise it, but a lot of my decisions are made on facts". "I think we need to recognise that however clever we think we are we need to make sure that all the things that are going on around us, we need to be able to review and put into the mix all the time". "I think it's perhaps demonstrated that we need to consistently review and be on top of the processes that are needed to carry out incident command".

General SA discussion	"I would hope it has made me better and enabled me to make more accurate decisions". "It has made a difference to how I operate; it's about giving yourself time to think". "I tend to listen to the information and don't try and fill in the gaps myself. It is easy to get part information because there is a lot going on and you fill in those gaps which don't always ring true". "I have never been a great one for self analysis".

The **theme of 'SA understanding'** there was a general understanding by most of the participants of both perceived SA confidence(PSA) and actual SA (ASA) in relation to the research project and discussion following the 2012 exercise, with the need to understand that ASA is paramount to making the best decision on the incident ground. The link to bias and how under pressure you could fall back onto a conservative / narrow or liberal / wide bias and the impact this would have on your ASA was understood by all the FDMs. Most FDMs had given consideration to ASA and PSA and the **theme 'SA is not the issue'** showed some challenge for individuals in recognising the difference between ASA and PSA and how this difference could impact on the outcome of any operational incident or training scenario. There was an understanding shown in the **theme 'general SA discussion'** of how important understanding ASA and PSA was for good decision - making. With part of that understanding linking into the ‘Primed Decision Making’ model (Klein 2003; Klein et al. 2010), with this also being linked to the size of the incident and the pressure the FDMs recognised from the situation. Nearly all the FDMs believed that a greater understanding of ASA, PSA and bias was positive and had made a difference to the way they operated; even the FDMs who had doubts did not identify a negative from the experience.

6.7 Overall conclusion on the responses from the thematic analysis from the FDM’s who were interviewed

As discussed, each of the 14 FDMs who took part in the interview sessions were asked a number of questions covering the areas that had been under discussion during the participants debrief following their 2012 assessment. The semi structured interviews were undertaken before the outcome of the 2013 assessment had been shared with any of the participants, and without any update to them on either SA or bias / scope.

The broad aims of the research were to 1) gain further understanding of fireground command and control decision - making in relation to how bias / scope influence decisions and 2) determine if once identified this can contribute to training guidelines for self awareness of how information is “scoped” personally in fireground situations.

In essence the basis of good SA must be a full understanding of any personal bias / scope and how personal bias / scope can / will impact on understanding and implementing operational decisions. The overall view following the thematic analysis was that each of the FDMs learned from the overall process and accepted the outcome in relation to their bias / scope and the impact this has on their PSA and ASA. In accepting this they agreed that the outcome to operational incidents was in the main dependant on a good understanding of both ASA for them to make the best decisions from the information available and to obtain the best outcomes in relation to bringing the incident to a safe conclusion. A number of FDMs also questioned whether the identification of bias / scope applied to just the operational environment or to their wider work. General comments in support of this were;

"So it feeds a bigger package of self awareness I suppose, so if I was to say to you now that I have just focussed on my bias and tried to analyse that, that then would be untrue but I suppose I have used it in a wider context like when I do self reflection; when I think about the way I approach certain issues or certain problems".

"Because I find my bias affects business decisions day to day, people management decisions day to day, the scenario in which it was tested was an operations scenario. But for me one of the key things is the fact that those bias impact in every decision you make day to day, let alone when you are dealing with potentially extreme circumstances".

Overall although not many of the FDMs had responded operationally to any / many large / complex incidents within the 15 month period between the profile discussion and the interview to reflect on, they had used other ways to review the information presented at the discussion and had linked it into the information that was available to them for continuous professional development. Some had taken the opportunity presented to them to look at other incident commanders and the way they manage ASA, PSA and bias / scope. There was also recognition and understanding of their own personal bias / scope, reflection on it and the impact it could have when making operational decisions, two of the participants raising the question 'was it a situational or resting bias'. Three had appeared not to have taken the knowledge forward in any specific way, but only one of them was clear that they had not progressed any of the discussion, while two others did not appear to think bias / scope was a separate entity to all the other aspects of incident command training.

The majority had looked at how personal bias / scope affected their decisions and the outcome for these decisions. With some taking direct action in relation to their identified bias / scope and others appearing to have considered it as part of their makeup (the way I am) and integrate it into a more internal aspect of their decision - making processes. The overall view was that it had provided something to think about in relation to their command and decision - making style at operational incidents. All FDMs bar one thought it had changed the way in which they had commanded an incident or managed an exercise, or would change the way they did it in the future. Eight thought it would have a great impact on the way they processed information in making decisions, while others talked about a smaller impact, but at the same time explained how they would see it impacting on them in the future, or at the larger more complex incident. In all but one response SA and bias / scope was seen as a positive area to be looking at and one that held real value for assisting in developing incident commanders and their command decisions - making into the future. The feedback and analysis from the interviews shows that a good understanding of both bias / scope and SA was maintained by the FDM's. With all but one FDM showing they had used the information gained at the discussion of the 2012 assessment to build on and improve their own knowledge / understanding to improve outcomes from an operational perspective.

6.8 Using the thematic analysis technique on the direct aims of the research to take forward and analyse the semi structure interview responses

The previous exercise outcomes and the discussion following the analysis of the data they produced have shown that bias / scope does impact on the individual FDM and the decisions they make at an operational incident under pressure. As discussed following the FDM's assessment exercises in October / November 2012 all the FDMs undertaking the exercise were debriefed in relation to their personal profiles. The personal profiles showed each individual their bias / scope position and the profile of the two areas of SA (PSA confidence and ASA). Following the second assessment exercise each FDM attended a meeting with the researcher and prior to discussing the results of the 2013 assessment they were offered an opportunity to undertake a semi structured interview. 19 FDM's had undertaken both the 2012 and 2013 assessment process and of these 14 took part in the semi structured interview process between March and June 2014, which was based on their previous debrief with no new knowledge on bias / scope or SA from their second exercise until after the interview. Following the thematic analysis of their responses a second review on the responses was undertaken using the three direct aims of the research in the same way as the themes had been used to help further analysis the information gained. As discussed above the overall response to the interviews showed a confidence by the majority of the FDMs that the process and the knowledge gained was considered to be of real value. This analysis allowed for the direct aims of the research to be evaluated by the FDMs who had gone through the process and were seen as the experts in evaluating the process in relation to their unique area of emergency response and incident command.

Considering how the thematic analysis answers the research question: How do FDMs feel that taking part in the exercises, and being briefed on their ASA, PSA and bias / scope, influenced how they regarded their operational role and the way they approached it?

Understand how information bias / scope by the individual influences or impacts decisions and outcomes in fireground exercises;

There was a wide acceptance of how bias / scope impacted and affected the outcome of the exercise, "you look at bias in terms of your perspective and your ability; I never really thought about that before", “I think what I suspect is it varies depending on the type of incident I am attending and how familiar I am with that type of incident". While for some individuals there was a much more positive acceptance of the way they understood it, "it is very difficult to recognise you are doing it, but I think with the background I don’t think that I will forget that anymore", and the way it had impacted on them, "well it has given me some different ways of considering how I respond". With some real enthusiasm for how they saw it impacting into the future, " that you can have that sort of bias and that made a lot of sense to me in my performance at the incident" and "I have no doubt that it has influenced the way I make decisions".

There also appeared to be a real understanding of how bias / scope can and did affect an individual, with a number of FDMs offering insight into how they had started to use it to improve the way they managed incidents, in relation to their own personal bias / scope identified at their last debrief, "it's made me think am I doing it, is this about right, am I happy with my focus am I taking in all the periphery, or am I not giving the task enough detail".

Identification of a narrow / conservative bias / scope at the debrief brought out comments such as, "I was happy to step up and allow him to remain in charge, before that yes I would have taken charge of the incident", and "I think you always want to get involved, the fireman in you is always going to be there, but I think you consciously try to step back". While those who had been identified with a wider / liberal bias / scope felt they needed to look deeper into the available information, "yes particularly in relation to flooding where we have got large geographical areas". Or even make a change in the way they managed an incident, "now part of my strategy is making sure all the information is put down, all the messages are collated in hard copy so that I can sit down and review what has happened in the last quarter of an hour" and "that awareness of it enables me to step back and do that in a more conscious way". With an acceptance by some that their bias / scope may not be just confined to the operational incident, "I have used it in a wider context like when I do self reflection; when I think about the way I approach certain issues or certain problems" and "I find my bias affect business decisions day to day".

The real test to both the understanding of bias / scope and SA from the interviews was shown in the way the information in relation to their personal bias / scope was accepted by the overwhelming majority of the FDMs and how they had reacted to it over the period since it had been discussed with them. While it had been explained to them at the first debrief that this was ongoing research and the position to confirm it as a situational or resting bias scope had yet to be established, they had recognised within their own actions occasions that supported the analysis they had been shown. Throughout the interview comments on the impact the debrief had, had on both operational incidents and exercises over the intervening time came out at the interview. "I have tried to apply my understanding of what we discussed in those sorts of scenarios and a number of operational incidents I have been to" and "so I was very conscious of building on the tactical situation and understanding my bias". With this being quite a consistent response right across all the interview questions, "absolutely the way I looked at the first assessment impacted on the second assessment" as well as "it made me think more about the confidence I have got and the ability I have got and how it needs to match up". With some responses appearing to be critical of the way they had undertaken incident management before the debrief, "make sure that I was carrying out the objectives that I needed to in a proper way", as well as "because it goes back to I make a positive effort to make sure I am not falling into a bias so that I miss something".

From the feed back there is a real acceptance of the information provided and how it will improve the way an individual can manage an operational incident, "it has paid dividends already", "I would hope it has made me better and enabled me to make more accurate decisions", "it has made a difference to how I operate; it's about giving yourself time to think" and "I tend to listen to the information and don't try and fill in the gaps myself".

Does bias / scope work in different ways across individual incident commanders;

There was a recognition across the group that bias / scope impacted differently on different individuals, "I have looked at other people and how they manage that incident looking for their bias without asking questions, looking to see if they are closing down (conservative bias / scope) or opening back up (liberal bias / scope)". With some real benefits identified because of this, which were considered to be a way to improve the individual position, "I took that on board looking at other people and what they do"; "other incident commanders coming at the role you learnt an awful lot from them". With again an acceptance that this had offered a new way to improve performance, by confirming what a number of FDMs felt they already knew, "complacency comes into it as well; you tend to ignore certain information because you assume it is going to be as it was in the past". Which again came across as a willingness to be critical of previous behavior in relation to incident management, "I think it is just going back to the detail again and making sure I confirm and utilise a number of methods to ensure that I keep the detail" and "I believe my particular bias may have led to me missing some information detail". As well as turning it into a more constructive criticism, “we have attended in the past and we can very quickly try to fit what is in front of us in to something we have already experienced".

A number of FDMs showed the wider understanding of how it worked differently for different individuals, while at the same time emphasising that they were already aware of any bias / scope they had, "I wouldn’t say it’s affected the way I actually carry out that process". Giving the impression they were already aware of their bias / scope, so the debrief was just confirmation of what they already knew, "I used a wider perspective and by being more aware of that, that was sort of my natural style", as well as "I think it is innate at a level so I tend to revert to type". With a few justifications coming into the interview as it progressed, "yes it wasn’t that I was afraid to make a decision it was about evaluating everything, but not coming up with an answer". As well as the acknowledgement that it can be different, for different FDMs with a number discussing self analysis in the way they applied their bias / scope, "I think that is really important for me, because then I get a true reflection", with some justification, "some of those outside influences might have affected me in a different way". Again there was an acceptance that the process was part of their internal makeup, but not a ready acceptance that it was a fixed part, "taking a wide view I narrow it down for the last assessment in a training environment", and "not necessarily my decisions, but in my decision making process". With the question again raised in relation to the wider application of resting bias / scope, "but for me one of the key things is the fact that those bias impact in every decision you make day to day, let alone when you are dealing with potentially extreme circumstances". Bringing it down to what many would refer to as their job, "how much of an influence that would have when you are talking about key decisions, really important decisions".

Progressing from the theoretical model into a training / assessment scenario to determine if an individual's bias / scope can be identified and whether this knowledge assists the outcome of the decisions in actual fireground conditions;

Overall the feeling was that the information from the assessment on both ASA, PSA and bias / scope was of real value in helping to make operational decisions on the fire ground and from the feedback and development identified, these benefits to the FDM are ones that can be built on. The obvious comparison with the first 2012 assessment was the 2013 one, "so I tried to make some changes into the way I approached the recent assessment" and "in the run up to that assessment I did a bit of self reflection on the results from last time and tried to consider how that would affect my contribution on the second assessment". With also a lot of references to review of the information and development from reflecting at incidents, "but you did not step back and say ok this is what I need to do". Which raises the question regarding a resting bias / scope or situational bias / scope, but given the debriefing to the participants on their first assessment didn't appear to make a difference to their bias / scope in their second assessment, there is a need to look to see if there is a correlation between ASA and PSA in the future, or how bias is impacted in the longer term. Looking to see if the pre knowledge on their bias / scope didn't impact on their bias / scope, did it impact on their PSA, did it make them look for more key facts about the situation, rather than assume they knew it following formal training, narrowing the difference between their ASA and PSA. As well as a direct influence on the individuals command decision process, "my bias will be more positive I think because I will have to concentrate more and look more closely at what is happening around me", as well as personal challenge and reflection, "with some the situational awareness thing is something that is useful because you can reflect during an incident, examine how well you understand what is going on and challenge yourself".

There was a positive response to the studies and the outcome to them in understanding the information provided and taking this on into the training environment for operational command, "you pointed out the danger of being really confident and not knowing what you are doing". With a consideration that just being told your outcome was of real benefit, "but just running through it increases your own awareness", and how it affects you in the longer term, "I think you tend to develop as a decision maker anyway so this is just one of those elements that fits into that development". With this development not just restricted to formal training events or to agenda items, “I have attended three or four fire seminars with some case studies which are always beneficial and force you to look into the incidents”. As well as some open conversation on how they had identified their own training needs from just the one session, “perhaps I need to pull out a little bit more and review where I am”, and how it had simulated thoughts on the wider incident command training needs, “How I do it. Is it positive or negative, what are the pros and cons”. With a lot of self reflection on the individual nature of the learning process, “it has made me more aware of bias and of my own bias”, “how I can develop that”, and in coming away from the incident “is there anything we might have done different”. So from the outcome of the semi structured interview it would appear that up to a point each FDM starts to set his own training agenda to improve the way he make operational decisions, “it is difficult to quantify what I actually do differently apart from you find that I look at that detailed picture whenever I can”, which enhances his professionalism, “I think it’s perhaps demonstrated that we need to consistently review and be on top of the processes that are needed to carry out incident command”. Even moving to provide their own assessment process, “it is very difficult for me to be able to grade how much of a difference that would make if you know what I mean”, and “this is an extremely valuable tool because it is giving the bench mark standard”.

6.9 Reflexive analysis

In reviewing the data provided and writing up the analysis it would appear, the most positive benefit coming from the interviews was the ownership shown by the individual FDMs in the way they had taken on the outcomes from the first assessment, “because I do understand when we discussed the bias it made sense to me”, acting like a “trigger to go away and do some more work because you should be concerned or worried about it”. Reviewing what they had been told and looking to improve in specific areas, right across the operational training requirement, “It is suggesting that I am looking a bit too narrow and maybe getting sucked in a little bit too closely so I think it is about trying to become more strategic take that step back”, and “it is very easy to rock up and take over and that’s probably what we do too often and shouldn’t do”.

In essence the basis of good SA on the incident ground must be a full understanding of any personal bias / scope (either negative / liberal or positive / conservative) and how this personal bias / scope can / will impact on the understanding of what is happening on the incident ground. With this understanding of how bias / scope can influence ASA, a fuller picture of the actual situation will be available to the incident commander and this will then ensure operational decisions are made with the best information available at the time, which will help to gain the best outcomes for all involved.

I have been aware of the influence I can bring to this area of the research throughout this research project and the influence this could have on outcomes, but have worked to remain objective to maintain the value of the research, but acknowledge that the influence that I bring to this research should not be ignored as they will have influenced the decisions at times within research process.

Chapter 7: Summary and conclusions

7.1 The main issue and aims of the thesis

The model used within the UK Fire and Rescue Service (FRS) for incident command is the ‘Managing Incident: Decision making model’ (Figure 1.4) (Fire and Rescue manual; Volume 2, Fire Service Operations, Incident Command 3rd Edition 2008). This model requires the incident commander to look at the incident information available, identify the type of incident resource required and bring it to a safe / satisfactory conclusion. In the USA they use Boyd’s OODA loop (Figure 1.5) for incident command incorporating four essential elements: Observe, Orient, Decide and Act (Boyd 1987), but this has similar stages to the UK's model. The training and development provided to the operational commander from the models discussed should take them through the conscious competence learning model (Gordon 1970) up to either the ‘conscious competent' or the ‘unconscious competent’. Under the four stages for learning any new skill the incident commander would travel sequentially through the unconscious incompetent, conscious incompetent, conscious competent to unconscious competent stages while undertaking incident response and dealing with incident management via operational incidents and exercising. Once promoted to a flexible duty manager and responding to operational incidents, this is the stage in the operational career of the individual their ability to manage an incident as an incident commander is exercised and assessed on a regular basis as a competent person undertaking a role within the incident command structure. The question raised within the thesis is, given that this competence is gained, assessed and exercised, how do we explain some of the puzzling decisions / errors people make even when theoretically they have all the correct knowledge and operational information available to them at the incident?

We know that information bias / scope can apply to either externally available information, what people are being informed of and seeing before them, as well as applying to the information people hold as their knowledge or memory. Even if / when a wide range of information is taken on board, people can still mentally or internally adjust their bias / scope so they select the points they want to use from the full range of information available held as knowledge within their memory. This process can explain some of the puzzling decisions / errors people make even when theoretically they have all the correct knowledge and information available to them. Following the outcome of the research it is felt that information bias could be looked on as developed subconsciously and can be seen as a reaction to events and exposure to situations one experiences. What the research has shown is that the action of a bias / scope (as defined in this thesis) can explain a variety of actions in pressured situations, driven by largely subconscious processes. In this way the bias / scope becomes a subconscious ‘attitude’ or reaction and focus that the individual undertakes to deal with the situation they are managing when under pressure; to assist them make decisions and, from their perspective, to bring the situation under control.

A cognitive bias is the human tendency to make systematic decisions in certain circumstances based on cognitive factors rather than evidence. These processes include information processing shortcuts, motivational factors, and social influence. Cognitive bias is a common outcome of human thought, and can often drastically skew the reliability of evidence and situational outcomes. In all, effective fireground decision - making does not just involve accumulating information to build a good picture of the situation or to gain good SA (Catherwood, Sallis, Edgar and Medley, 2010; Gasaway, 2008; Klein, Calderwood and Clinton-Cirocco, 2010; Omedei, et. al. 2005). It requires the right selection in relation to the information available from the external environment and the internal knowledge base of the decision - maker. This is the type of bias / scope that has been studied explicitly in this thesis and could be labeled as an, 'information bias.' As this information bias / scope of the decision maker directly affects the selection of information for decision - making, it carries implications for error or risk. Even if the body of available knowledge does not vary, different bias / scope may be applied to that knowledge, leading to varying degrees of acceptance or rejection of the available information. Inappropriate bias / scope thus carries potential risk for making errors and it is important to determine if there are individual differences in bias / scope dispositions and to consider the factors that may affect such tendencies.

There is a potential for bias / scope in fireground decision - making for conscious and unconscious processes to influence the information selection process. Given the range of factors that could induce bias in this way, individual differences or variations in bias / scope tendencies may well arise within the same situation. An understanding of such individual bias / scope patterns would seem critical for improving and training self-awareness in regard to the selection of information and potential risk tendencies in fireground decision - making. The initial aim of the current research was thus to develop a technique that would in the first instance determine whether response bias / scope tendencies are apparent for FRS personnel in fireground simulation exercises and whether there are individual differences in bias / scope. The QASA technique provides measures of:

a) Knowledge or actual situational awareness ASA.

b) Perceived situational awareness (confidence) PSA

c) The information bias / scope applied by the decision - maker to the available information. As discussed, the bias measure in QASA gives further insights into the critical question of how knowledge or information may be selected or filtered for decision - making and whether this is being achieved in a strict and conservative way or alternately, a more lax or liberal manner.

When situational awareness (SA) is used alone (without the A or P prefix) it refers to SA generally without a specific type.

It was predicted that individual differences in bias / scope tendencies would be apparent for the same situation and that such tendencies may be independent of the ASA and PSA of the individual. In other words, even amongst those with the same SA there may be different bias / scope, so that when errors are made, some people may tend towards making miss errors and some towards false alarm errors.

7.2 Summary of findings from the breathing apparatus study: Is there evidence of bias / scope in a realistic fireground exercise

This first study involved a realistic simulation of an operational fire incident within a commercial premise with 16 competent operational FRS fire fighting personnel wearing breathing apparatus (BA) in a cosmetic smoke filled darkened building in a search and rescue (casualty recovery) exercise. The broad aims of the study were to gain an understanding of the individual fire fighters fireground SA and decision - making in relation to how bias / scope influences these decisions and to indentify further studies on how it could contribute to training guidelines for self-awareness of how information is scoped personally in fireground situations. If the basis of good command training is based on continuation training and experience, then to assist this an understanding of any personal bias / scope and how personal bias / scope, can / will impact on making and implementing operational decisions would be a step forward in reducing some of the devastating incidents we have seen in the past.

The data analysed by the QASA tool identified that most individuals displayed a high level of knowledge (ASA) about the incident they were committed to, but also showed either a conservative bias / scope (with miss errors) or a liberal bias /scope (with false alarm errors). Overall the analysis shows that knowledge of the situation and what was going on was good (ASA), although predictably it was better for the briefed items undertaken by the BA entry control officer than non-briefed items. The results however also show that two individuals can appear to have similar knowledge (ASA) about the situation, but in fact still have very different bias / scope in regard to that knowledge. The real interest of this study however was how incident ground information is scoped, reflecting an information bias. That is, the aim was to determine whether individuals worked from a broad span of information available, with lax or liberal bias / scope, trusting the information they were presented with from all the different inputs using a wider scope of information available, but perhaps not processing it very deeply (butterfly syndrome). Or whether the individual focused down on a small part of the available information, reflected in a narrowing of perception (tunnel vision) and a conservative bias / scope in their selection of information. As noted before, this bias / scope can have an external or internal aspect; in an external sense, it can affect the visual inspection of the incident ground (scanning widely to narrowly), while in an internal sense, it can affect the mental impression that is formed about the situation (thinking about the wider implications for the situation or only narrowing down on a few aspects). The two are closely linked: for example, a narrow internal bias / scope may mean that there is incomplete visual scanning of the situation and vice versa, a wider external scanning pattern may produce an incomplete detailed impression of the situation lacking depth. This type of scoping may have important consequences for decisions and errors made in actual incident ground situations (Catherwood, et. al. 2010).

The ultimate aim of this part of the project was to improve understanding of the processes underlying operational command and control decision - making on the incident ground and to see if it is possible to train self-awareness of the bias / scope of information in actual incident ground situations. The main aim of the BA experiment was to determine whether bias / scope patterns would be apparent in a realistic and challenging situation, which was clearly the case. Nearly all participants showed either a conservative (positive) bias / scope tendency or a more liberal (negative) bias / scope tendency. The question for further research was whether such bias / scope is consistent for individuals, a resting bias / scope that is an inherent part of their cognitive apparatus for decision - making that may become especially apparent when under pressure. Or is bias / scope a situational tendency that will vary each time with the situation, or the emergency incident or exercise.

7.3 The table top exercises: assessing bias / scope consistency

The main aim of the second and third study was to determine and confirm that there were individual differences in bias / scope patterns for operational FRS fire fighting personnel using two different table top fireground based exercises and to assess if such bias / scope was consistent across the exercises. The table top exercises were based on a fire in a domestic property (house) and a fire in a commercial premises (factory), in both exercises there were persons reported as missing (individuals believed to be still in the premises). Both exercises were designed to reflect the individual fire fighter's tendencies towards either accepting or rejecting the available information and to confirm if they showed a defined bias / scope pattern within their response to the probes used. In particular the aims were to assess:

1) Whether individuals displayed one of three potential bias / scope patterns, namely:

> a) a narrow or conservative bias / scope (with a tendency to reject information and so make misses) or,
>
> b) a lax or liberal bias / scope (with a tendency to accept information and so make false alarms) or,
>
> c) no such bias / scope in either direction.

2) Whether such bias / scope were affected by firefighting experience.

3) If they did show bias / scope, whether it was consistent for the individual across the two scenarios.

In this exercise three groups of participants were tested:

a) Full time fire fighters and operational managers
b) Part time (retained) fire fighters and operational managers.
c) A student sample. The inclusion of the student sample into the experiment was to obtain validation of the professional relevance of the task for FRS decision - making.

The overall level of ASA for the FRS sample was high, with FRS fire fighting personnel showing significantly higher ASA than the student sample, consistent with the professional relevance of the task for FRS personnel. The results for the bias scores however show a different pattern. The FRS and student samples did not differ in bias scores, both samples having negative (liberal, accepting or lax) and also positive (conservative, narrow) bias / scope tendencies on average for students and for FRS personnel, but further analysis for the main sample of interest (FRS fire fighting personnel) confirms that there are individual differences in bias / scope tendencies.

The primary aim of this experiment was to determine if FRS fire fighting personnel displayed bias / scope patterns in decision - making during a table top fire incident exercise, which would confirm the outcome from the first BA training exercise. The evidence clearly shows that for most participants this was the case, just six out of the total of 50 FRS participants in the first study showed no bias / scope at all. The majority of FRS participants tended towards a negative or liberal bias / scope (and hence towards making *false alarm* errors), while the remainder showed a positive or conservative bias / scope (and hence towards making *miss* errors). With these differences not linked to level of ASA or knowledge, nor to years of experience or professional status (full time vs. retained). The level of ASA was high for both FRS groups and significantly higher than that for the students, confirming the validity of the task content used for FRS fire fighting personnel. Nevertheless, the FRS sample did not show significant differences in bias / scope tendencies to those shown by the students. In other words, the bias scores reflect tendencies that are statistically independent of FRS experience. For the fire fighters, ASA was high in both exercises, while fire fighters perceived their PSA (confidence) in a similar way over the two exercises, meaning that if they had high confidence in their ASA in one exercise they also had high confidence in the other exercise, or low confidence in one and low confidence in the other. Of concern however is that there is no significant correlation between the ASA scores and the PSA scores. In other words, people may have had poor ASA but perceived that their ASA was good or *vice versa*, had good ASA but judged it to be poor.

The other important finding is that the pattern of bias / scope tendencies differed across the two studies (no one had a bias score of zero or no bias / scope in the second study). There was no significant correlation between the bias scores across the two exercises, so people that had a conservative bias / scope in the house exercise and may have had a liberal bias /scope in the factory exercise, or the other way round. The results indicated that the bias / scope and ASA measures obtained in each of the scenarios showed no significant correlation. That is, a fire fighter that showed high bias / scope or ASA on one scenario might show low on the other. Thus individuals' levels of bias / scope and ASA varied according to the situation. Interestingly, there was *no* significant correlation between perceived and actual SA in either scenario, so the firefighters tested appeared to be unaware of their own level of ASA.

The major difference that appeared between the two table-top exercises was the induced pressure that the fire fighters who were undertaking them, felt themselves to be under. In the domestic (house) exercise no one had experience of this type of exercise before and the attendance of a senior officer and two senior individuals from the university had brought to the exercise a tangible pressure. In undertaking the commercial (factory) exercise nearly all the fire fighters had taken part previously in the domestic exercise and appeared to be a lot more relaxed in both the brief for the exercise and in the taking part in the exercise itself. The one major difference on the table top exercise and the previous breathing apparatus exercise appeared to be the pressure, or lack of pressure on the individuals taking part and how this played out on their individual responses to the questions posed with the probes. In considering if the bias / scope is a resting bias / scope or a situational bias / scope, this raises debate around the reaction of fire fighters and in particular incident commanders in dealing with the exercise / incident. In the normal management of the operational situation or training, experience is seen to play a major role in bringing it to a safe conclusion, but as pressure is applied as the incident develops, or gets more complicated, or higher risk (major loss of life); we start to see a non trained response - we perhaps start to see the individual bias / scope involved with the decision - making. So if the bias / scope only influence decisions under pressure, then we cannot expect a correlation between the exercises if different pressures were present.

It cannot be determined why such bias / scope tendencies occurred in this exercise, but nonetheless the current evidence serves the important purpose of confirming that bias / scope tendencies are apparent. The level of ASA was high for most individuals, but when these people were *not* certain of the correct answer, they showed bias / scope tendencies associated with either miss errors or false alarms in decision - making. This important finding could have valuable implications for fireground training in the future by improving performance and reducing risk. It could be argued however that the exercise in this study is not sufficiently realistic to ascertain whether such bias / scope might occur in more realistic simulations or in actual fireground contexts. There was also a lack of consistency of bias / scope across the two exercises, which was felt to be because of a lack of pressure exerted on the subjects taking part in the second exercise. To further address this question, the next study used a similar methodological approach but in a more realistic training exercise with a higher level of pressure or demand. This further research examined individual bias / scope and whether it is consistent (resting) for the individual, or is a situational one varying with the incident / exercise.

7.4 Scoping studies 4 and 5: Flexible duty station managers development and assessment exercises: how does bias / scope influence the operational outcome of pressurised fire incident command

The primary aim of this study was to confirm the evidence of bias / scope patterns for operational FRS fire fighting personnel found in the table top fireground exercises, reflecting the individual's tendencies towards either accepting or rejecting the available information (Catherwood, Sallis, Edgar and Medley, 2012). In particular however, the aim here was to assess whether individual operational response officers in a controlled but highly pressurised situation that had greater demand and personal consequences than the previous exercises showed a resting, or situational bias / scope. The primary aim of the second exercise in this study was to assess the consistency of any bias / scope patterns for individual operational FRS personnel found in the first command development / assessment fireground studies. The aim was thus to identify any correlation from the individuals who took part in both exercises between the individual results for 2012 and 2013 that will point to either a situational bias / scope (a bias / scope that could vary with the individual when attending a high pressure operational role), or resting bias / scope (a bias / scope that will reoccur with the individual when undertaking a high pressure operation role) and ultimately to propose a way of using this knowledge to improve operational response officers training and understanding of their bias / scope pattern.

All participants were immersed in the same situation as operational FRS incident commanders in an assessable simulated fireground incident. The simulated fireground incidents were based on a realistic and a developing incident that each individual had to take over the command of from the first attendance commander and move towards a successful conclusion from an operational, environmental and social perspective. The ASA, PSA and bias scores were obtained with respect to the scenario, using the QASA method described earlier. The participants were all flexible response operational officers working across a UK FRS and all participants were in managerial roles undertaking operational response (station manager) both full time and retained. Their responses were collected anonymously and all gave informed written consent.

Most of the participants tended towards a positive or conservative bias / scope (and hence towards making miss errors) and some 24% showed a very low or mixed bias / scope, with the rest showing towards a negative or liberal bias / scope (and hence towards making false alarm errors). With these differences not linked to level of ASA or knowledge, nor to years of experience or contractual status (full time vs. retained). The level of ASA was high 60> = 68% and 50< 20% confirming the validity of the task content for FRS personnel.

As discussed in Catherwood et. al. (2012) it cannot be determined why such bias / scope tendencies occurred in these exercises, but nonetheless the current evidence serves the purpose of confirming that bias / scope tendencies were apparent and consistent across both scenarios for most participants. The level of ASA was high for most individuals, but when these people were *not* certain of the correct answer, they showed bias / scope tendencies associated with either miss errors or false alarms in decision - making. In relation to bias / scope there was a statistically significant high positive correlation across the two sets of scores for each assessment, the p value was lower than the critical 0.05 significance level. This means that individuals showed similar bias scores over both the development / assessment simulated fireground incident study and the assessable simulated fireground incident study, which points to a resting bias / scope (a bias / scope that will reoccur with the individual when undertaking a high pressure level operation role), rather than a situational bias / scope (a bias / scope that could vary with the situation when attending a high pressure level operational role).

The key difference between this set of exercises and the table top exercises, appeared to be the pressure that was on the individual undertaking the exercises. The first table top exercise (house fire) was new to the individuals and they were unaware of the outcome or impact in relation to themselves (even though they were briefed that this was for the university). The attendance of a senior officer and two individuals from the university also increased the pressure for the individuals taking part. The second table top exercise (factory fire) was undertaken using some of the same fire fighters who had taken part in the first table top and had received a debrief on the outcome from this exercise. The environment for the second exercise was a great deal lighter than the first, with some laughter and joking taking place regarding the outcome, the participants were also familiar with the attendance of a senior officer and university staff. The inconclusive outcome for individual bias / scope patterns from the table top exercises led to the assessable flexible duty response officer exercises to assess the effect of pressure on individuals to help in identifying the individual bias / scope pattern.

One of the aims of this research was to determine whether the bias / scope patterns evident in the table top exercise would also be apparent in a more realistic and challenging situation. This was clearly the case. The participants showed either a conservative (positive) bias / scope tendency or a more liberal (negative) bias / scope pattern and of most interest, this was again independent of the level of ASA. More importantly, the positive correlation over both exercises suggests a resting bias / scope rather than a situational one. Which means, if there was a way to devise a process to identify an individual bias / scope by a manageable test, then training or information on an individual's bias / scope tendency could be worthwhile. A summary of all exercises can be found in appendix 8.

7.5 Overall conclusion of the responses from the thematic analysis from the interviews

As discussed, following the FDMs assessment exercises in 2012 all the FDMs undertaking the exercise were debriefed in relation to their personal profiles, and following the second assessment exercise each FDM had the opportunity to discuss the results of the 2013 assessment. 19 FDMs had undertaken both the 2012 and 2013 assessment process and of these 14 took part in a semi structure interview process between March and June 2014, which was based on their initial debrief of the 2012 assessment with no new knowledge on bias / scope or SA from their second exercise until after the interview. The 14 FDMs who took part in both of the operational assessments and the interview sessions were asked a number of questions covering the areas that had been under discussion during their debrief following their 2012 assessment. The semi structured interviews were undertaken before the outcome of the 2013 assessment was shared with them, and without any update on SA or bias / scope. The broad aims of the research were to;

1) gain further understanding of fireground command and control decision - making in relation to how bias / scope influence decisions and,

2) determine if once identified this can contribute to training guidelines for self-awareness of how information is scoped personally in fireground situations.

The overall view following the thematic analysis was that each of the FDMs learned from the overall process and accepted the outcome in relation to their bias / scope and the impact this has on their ASA and therefore on their decision - making. Within this two themes that emerged were ‘incident based reflection’ and ‘training / exercise based reflection’ suggesting an approach that looked at their personal understanding and linked this into what had been discussed with them about their command and they had then taken the opportunity to reflect back on it. Another theme was ‘observation based reflection’ not such a direct approach, but based on reflection of others actions in relation to what they thought their own actions might have been. The feedback from the interviews showed a good understanding of bias, ASA and PSA was maintained by the FDMs, a majority of participants said they recognised bias in themselves in the way it had been discussed (an information bias/ scope) and understood their own personal bias. There were two themes that came from this area of discussion, an ‘awareness of personal impact' and a theme that appeared to accept 'it's the way I am' in being aware of their personal bias / scope, they also appeared to be much more aware of the wider ASA and PSA. With the majority of FDMs appearing to recognise and accept that they had a bias and undertaking some reflective practice, it appeared to be for them an easy step to self analyse. In looking at the themes identifying 'changes in command decision making style' and 'awareness on decision making', it was interesting to find that while their bias had been identified within an operational context, they considered it in relation to other areas of high pressure. There was a theme of 'possible change' and a theme of 'already changed' showed the new knowledge had provided something to think about in relation to their command and decision - making style. All FDMs, bar one, thought it had changed the way in which they had commanded an incident, or would change the way they did it in the future, it was seen as a positive area to be looking at and one that held real value for improving command outcomes. The themes around 'SA understanding' and around 'general SA discussion' supported the important of understanding your personal ASA and PSA to improve decision - making. Nearly all the FDMs believed that a greater understanding of ASA, PSA and bias was positive and had made a difference to the way they operated; even the FDMs who had doubts did not identify a negative from the experience.

FDMs agreed that the outcome to operational incidents was dependant on a good understanding of SA for them to make the best decisions and to obtain the best outcomes. A number of FDMs also questioned whether the identification of bias / scope applied to just the operational environment or to their wider work. Although not many of the FDMs had responded operationally to many complex incidents within the 15 month period between the profile discussion and the interview to reflect on, they had used other ways to review the information presented at the discussion. The overall view was that it had provided something to think about in relation to their command and decision - making style at an operational incident or training exercise. The majority of FDM appeared to have used the information gained from the debrief of the 2012 assessment to build on and improve their own knowledge / understanding to improve outcomes from an operational perspective – suggesting a tangible benefit from the research.

7. 5. 1 Analysis using the direct aims of the research as the themes to take forward the research

The research question was; how do FDMs feel that taking part in the exercises, and being briefed on their ASA, PSA and bias / scope, influenced how they regarded their operational role and the way they approached it?

The previous exercise outcomes and the discussion following the analysis of the data the FDMs produced has shown that bias / scope does impact on the individual FDM and the decisions they make at an operational incident under pressure. Following the thematic analysis of their responses the overall response to the interviews showed a confidence by the FDMs that the process and the knowledge gained were considered to be of real value. The second analysis allowed for the direct aims of the research to be evaluated by the FDMs who had gone through the process and were seen as the experts in evaluating the process in relation to their unique area of emergency response incident command. As discussed, although not many of the FDMs had responded operationally to complex incidents within the 15 month period between the profile discussion and the interview that they could reflect on, they had used other ways to review the information presented at the discussion and had linked it into the information that was available to them for continuous professional development. There was also recognition and understanding of their personal bias / scope, reflection on it and the impact it could have when making operational decisions. In all but one response it was seen as a positive area to be looking at and one that held real value for command decisions. The feedback and analysis from the interviews showed that a good understanding of bias / scope and SA was maintained by the FDMs and used to improve their own knowledge / understanding with the aim of improving outcomes from an operational perspective.

In essence the basis of good ASA must be a full understanding of any personal bias / scope and how personal bias / scope can / will impact on understanding and implementing operational decisions. The take home message following the thematic analysis is that each of the FDMs learned from the overall process and accepted the outcome in relation to their bias / scope and the impact this has on their ASA. In accepting this they agreed that the outcome to operational incidents was in the main dependent on a good understanding of ASA for them to make the best decisions and to obtain the best outcomes. With a number of FDMs also questioning whether the identification of bias / scope could apply just to the operational environment or to their wider work.

7.6 Overall conclusion

The studies described here suggest that regardless of level of knowledge or ASA, there are response bias / scope tendencies that may affect the decision - making of individual FRS professionals leading to either miss or false alarm errors. The finding that bias / scope patterns are independent of ASA or PSA is an important one that coincides with previous evidence indicating that simply acquiring information or ASA does not necessarily lead to effective decision - making (Omedei et. al. 2005). While the findings that bias / scope tendencies may be regarded as resting within the individual would seem critical to developing understanding of factors that could lead to risk in real fireground decision - making. As discussed (Catherwood et. al., 2012) it cannot be determined why such bias / scope tendencies occurred in these exercises, but nonetheless the evidence presented in this thesis suggests that bias / scope tendencies are apparent and consistent for most participants (a resting bias / scope) when under pressure. Which was demonstrated by similar bias scores over both the development / assessment simulated fireground exercise and assessable simulated fireground exercise, suggesting a resting bias / scope within the individual, rather than a situational bias / scope.

The key difference between this set of exercises and the table top exercises, appeared to be the pressure that was on the individual undertaking the exercises. The inconclusive outcome for individual bias / scope patterns across the house and factory fire table top exercise led to the assessable flexible duty response officer investigations to try and increase the pressure on individuals to help in identifying the individual bias/ scope pattern. One of the aims of this experiment was to determine whether the bias / scope evident in the table top exercise would also be apparent in a more realistic and challenging situation, which was arguably the case. The participants showed either a conservative (positive) bias / scope tendency or a more liberal (negative) bias / scope tendency and of most interest, this was again independent of the level of SA. Most importantly from a development perspective, the positive correlation over both exercises suggests a resting bias / scope rather than a situational one.

In essence the basis of good ASA must be a full understanding of any personal bias / scope and how personal bias / scope can / will impact on understanding and implementing operational decisions. The take home message following the data and thematic analysis was that each of the FDM's learned from the overall process and accepted the outcome in relation to their bias / scope and the impact this has on their ASA. In accepting this they agreed that the outcome to operational incidents was in the main dependent on a good understanding of ASA for them to make the best decisions and to obtain the best outcomes. The project has shown a possible mechanism for improving safety in fireground operations by identifying an individual's bias / scope - and it may be possible to do this by developing accessible interactive software for the personalised vocational training of fireground SA. The work undertaken has shown that, under pressure, competence per se does not protect FRS personnel from the risk of losing SA. Critical errors may occur due not to a lack of competence, or even lack of information; but to a failure to make optimal use of readily available information. The key for the individual is to select enough of the right information to make the right decision, without selecting too much information overall and so becoming overloaded.

A possible model of how bias / scope may impact on the individual and how knowledge of the individual’s personal bias / scope may extend the individual’s ability to command an incident in the safest possible manner is presented in figure 7.1. The model attempts to put into visual format the influence current incident command training has on the trainee, in allowing them to extend their competence at an incident. The introduction of a way to identify bias / scope for the individual at an early stage of training should allow them to extend the period for making optimal decisions in relation to the incident beyond the competence that current incident command training alone allows.

7.7 A model of how the individual understanding of bias / scope could extend the competence for fire fighters

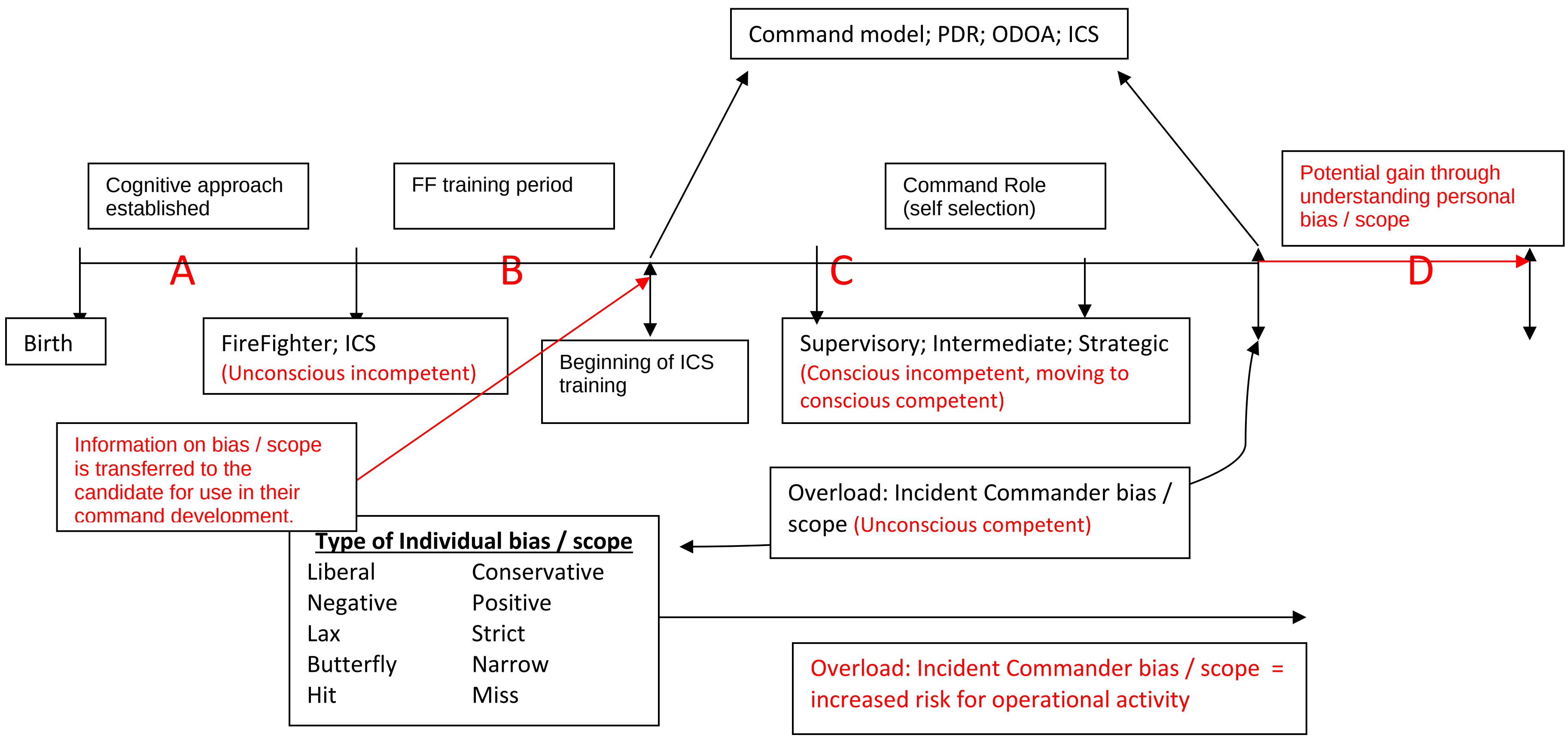

Figure 7.1 A Model for understanding how bias / scope could extend competence for fire fighters

The model identifies (Figure 7.1) how bias / scope may manifest as an integral part of an individual's incident command training process and as part of the mental processes and apparatus during development as a reaction to events and exposure to situations one experiences. Bias / scope in this case supports a variety of actions that have been possibly subconsciously understood by the individual to give the best results for dealing with situations when they are under pressure and in this way becomes a part of their strategy to manage or remedy the situation. Does information bias / scope start to explain some of the puzzling decisions / errors incident commanders make even when theoretically they have all the correct training and the information on the situation available to them in relation to the incident? Does bias / scope applied to either externally available information (eg. aspects that can be seen) or to information absorbed mentally; help us to understand some of the puzzling decisions / errors made by competent incident commanders at a number of different incidents and over a long period of time? Does bias / scope once applied make an incident commander react differently to what they are actually seeing before them and does it also influence them in relation to the information they use in their knowledge, or memory? Even if a wide range of information is taken on board, do people still mentally or internally adjust their bias / scope so they can select the points they want to use from the full range available in their knowledge or memory to fit their cognitive perspective and how do we improve the odds on incident commanders not doing this?

The four stages for learning any new skill

No matter what new skill we decide to learn, it has been suggested that there are four learning stages each of us goes through, encapsulated in the conscious competence learning model (Gordon 1970). Being aware of these stages helps us better accept that learning can be a slow and frequently uncomfortable process; the four stages are;

Stage 1 – Unconsciously incompetent (unskilled). We don't know what we do not know; we are inept in some areas and we are unaware of it. An example of this may be our first view and understanding of how a car works and how just getting the opportunity to get in will make us a driver.

Stage 2 – Consciously incompetent (unskilled). We know what we don't know. We start to learn at this level when sudden awareness of how poorly we do something shows us how much we need to learn. This can be the experience we have following the first driving lesson as a new driver, when we realise that just getting into the car is not what it takes to be a competent driver.

Stage 3 – Consciously competent (skilled). Trying the skill out, experimenting, practicing, we understand how to do the skill the right way, but need to think and work hard to do it. This has been likened to the driver who has just passed their driving test, they understand all they need to do to operate the car on the highway, but need to think about each of the operations as they experience the need to react.

Stage 4 – Unconsciously competent (skilled). If we continue to practice and apply the new skills, eventually we arrive at a stage where they become easier, and given time, even natural. Where most drivers find themselves after a period of time driving, the feeling you can have when turning up at work and you can't remember what happened to the journey. Or the day you stall the car at a junction and have to go back to the consciously competent in thinking about what you need to do to restart it and drive away.

An individual's progression (or not) through these stages is represented by the following regions in the model depicted in Figure 7.1.

Area A) Depicts the position of the man on the Clapham omnibus;

This is the position that the average person in the street with no specific education or training in how to manage an emergency event outside of what would normally be expected for Joe Public. Each individual will react differently as each would have had different experiences and may be able to use some of these experiences to mitigate some elements of the emergency incident. In looking at the average person, they have undertaken no specific education or training on the needs of incident management or the structure required to manage an operational incident. They have no experience of prioritisation in relation to bringing an emergency incident to a safe conclusion and in this sense they can be viewed as an ‘unconscious incompetent’, not aware of what they don’t know in relation to managing an emergency event.

B) Depicts the position of the average new fire fighter following basic training and undertaking development;

This is seen as the period following an individual joining the FRS and developing within the FRS in relation to their understanding of incident command as an objective tool to bring about a safe conclusion to an emergency incident. As well as an overview of the incident command system and how it impacts in relation to their position within the organisation at this period and within its operational parameters and their current understanding of the operational needs. They can be assessed as a ‘conscious incompetent’ for development, starting to be aware of what they don’t know in relation to the whole incident command system and how their role as an operational fire fighter fits in to it. Over the first sixteen weeks of joining they will be in development and will quickly move from ‘unconscious incompetent’ to ‘consciously incompetent’, in relation to both incident command and the incident command system. While their knowledge of the incident command system will develop at an early stage, their knowledge of incident command will not develop at the same rate and during their period as a fire fighter at most incidents they will be task orientated. This task focus on directed outcomes within the incident envelope will be a direct outcome of the management of the incident and their contribution will be responding to the incident command structure. During this period staff within this stage of development will start to develop an understanding of the incident command process / system, but will not be in a position (unless circumstances dictate) to implement it. Their knowledge of the incident command system will be paramount to their personal development at this level within the organisation and their ability to work safely within the organisational structure when on the incident ground.

C) Depicts the position of the developing incident commander, undertaking their command role that will progress as their career develops;

The individual will make a conscious choice to develop as an incident commander by applying for promotion, or to stay as an operational fire fighter. Once the decision is made to apply for promotion, the individual will apply to become an incident commander (this approach is via them becoming a Service manager as they will have to manage both staff and processes during the period they are not undertaking incident command duties) and this will be the beginning of their development in relation to this role. This is due to the amount of both training they have received within their firefighter role and the operational experience they have gained at emergency incidents, and exercises they have attended.

In relation to incident command at this stage of their career most individuals will be seen within their development as a 'conscious incompetent'. With all their training, development and exercising undertaken focused on bringing them up to the 'conscious competent' stage. Their training will be managed over a period of time and progress will be based on both the amount of training and their operational experience (with both being subject to opportunity in relation to promotion chances and incidents attended). There is also the managerial element of the role that will be developed in tandem with their incident command role and development in this area will influence any other opportunities they have for development. The incident command training undertaken will be developed through the 3 stages of;

- Supervisory, the officer in charge of the first attendance fire engine and crew to the incident, mainly dealing with small fires, road traffic collisions and other call outs.
- Intermediate, the officer responding to incidents in support of the fire engine using a car provided with blue lights and horns, and responding to larger incidents such as house fires with persons reported, or commercial fires, large road traffic collisions and more major incident types (and managing other incident commanders in a subordinate role).
- With the third stage being strategic management, taking charge of the major incident, which will cover all types' of emergency incidents, from political to multiple fatalities at either a road traffic incident or fire? This will also included managing incidents on behalf of the organisation off site and working with other emergency services and category one responders. This will take place at the Strategic Co-ordinating group level, working at the impact to the wider community, environment and financial costs.

D) Potential gain through knowing bias / scope;

The research described in this thesis has identified that individual fire fighters show bias / scope and the bias / scope the individual shows can be either a conservative or liberal one, but appears to be a resting bias / scope. So if a way can be found to identify an individual fire fighter's bias / scope, by way of undertaking a test in relation to managing an emergency incident, then from the studies described here it would appear that informing them of this bias / scope could improve the way they develop through their incident command training and be able to extend their competence in managing an incident beyond that resulting from the current incident command training.

This data gathered from the studies described in this thesis suggest that the effects identified could be used to inform further studies. The general approach used has demonstrated that there are response bias / scope tendencies in the decision - making of FRS professionals leading to either miss errors or false alarm errors. Further investigation of bias / scope tendencies would thus seem critical to developing an understanding of factors that could lead to risk in real incident ground decision - making. While it is accepted that these assessments were undertaken during training exercises and whether these training exercises could really replicate operations is always questionable, the exercises used brought their own pressures. The BA exercise was in hot and realistic conditions, with observers placed inside the building, and this was a relatively new experience for most staff, so being under observation in this way was considered stressful. Both of the exercises for FDMs were high pressure events for the individuals taking part as failure in either one held both a credibility and financial loss for the individuals (appendix 8; break down of exercises undertaken). The nature of the FDM exercises, particularly, focused on getting the best out of each of the individuals from an operational perspective and looked to ensure competence of the individual on behalf of the organisation. The pressure applied through these exercises appeared to be the real difference when compared to the table top exercises.

7.8 Overall conclusion set against the aims of the research

7.8.1 Assessment of the outcomes of the research as compared to the broad aims at the outset.

There were 2 broad aims for the research;

1) To gain further understanding of fireground command and control decision - making in relation to how bias / scope may influence data gathering and subsequent decisions.

For fire fighters taking part in the exercises, there was a clear bias / scope pattern shown. A few showed a nil bias / scope, but the majority showed either a positive, conservative or negative, liberal bias / scope and when the fire fighters were put under pressure in their role the research results demonstrated that a particular bias / scope tended to reoccur in the same way for the same individual, suggesting the bias / scope pattern was a resting bias / scope within the individual. With the possibility that the bias / scope pattern reflects a resting bias / scope, the value of knowing what type of bias / scope an individual has will allow the individual to either stand back to review decisions, ensuring their bias / scope is not impacting on the selected decision, or to use it within their training to help reduce any subconscious impact.

2) To determine if once identified this can contribute to training guidelines for personal self-awareness of how information is scoped in fireground situations.

From the follow up interviews the participants felt there was real value undertaking the work and being shown their individual bias / scope and SA patterns and each had undertaken work to improve their own ASA. With the research suggesting a resting bias / scope for those undertaking the two assessment exercises in 2012 and 2013, training on improving awareness of their individual bias / scope is seen as providing real benefit within their incident command training to help reduce or mitigate any negative impact this bias / scope may have on decision - making.

Therefore it could be argued that the basis of good ASA must be a full understanding not only of aspects of the situation, but also an understanding of any personal bias / scope and how personal bias / scope can / will impact on understanding and implementing operational decisions.

7.8.2 Specific Aims of the Research

The broad aims discussed above resulted in 3 specific aims for the research across all the studies undertaken and discussed previously;

1) To understand how information bias / scope by the individual influences or impacts on decisions and outcome in fireground exercises.

For nearly all the participants within the exercise bias / scope impacted on their decision - making, with them either using a narrow conservative bias / scope or a wide liberal bias / scope when scoping the information available on the incident. Depending on which type of bias / scope was made led them to making either miss errors, or false alarm errors, which may have impacted on their decision - making in relation to trying to obtain the best outcome for the incident.

2) To determine whether bias / scope works in different ways across individual incident commanders.

With bias / scope being identified and while either broad liberal or narrow conservative, it was different for each individual and the outcome of the study from the pressurised assessments suggesting a resting bias / scope. In each case the bias / scope pattern found was individual to the participant taking part and in debriefs following the first study for FDMs in 2012, each of the individuals found no surprise in relation to being informed of their own bias / scope pattern.

3) Finally to then progress this work from the theoretical model into a training / assessment scenario to determine if an individual's bias / scope can be identified and whether this knowledge assists the outcome of the decisions in actual fireground conditions.

This is the next step for this research and is being undertaken through the European Union with the assistance of their Erasmus plus program; this work will take place with other European fire services in Poland, Demark, Belgium and Holland and is identified in the next chapter.

7.8.3 Support for original hypotheses

The hypotheses were:

i) FRS personnel will display either conservative or liberal decision - making bias / scope (with related miss or false alarm errors respectively) during FRS training exercises involving simulations of fireground incidents.

The majority of the fire fighters taking part in the studies undertaken displayed either a conservative or liberal decision - making information bias / scope during FRS training exercises involving simulations of fireground incidents. Only in a small number of cases did fire fighters show no bias / scope pattern over all of the studies undertaken.

ii) any such bias / error patterns will be consistent for individuals over situations / scenarios.

The FDMs taking part in the pressurised studies did generally display the same bias / scope in relation to the information available for the exercise, showing either a conservative or liberal decision - making bias / scope during FRS assessment exercises involving simulations of fireground incidents. The bias / scope pattern suggests that, for the FDMs taking part in these studies, were showing a resting bias / scope, a pattern of information bias / scope that would reoccur for the individual when undertaking incident command within a stressful environment.

iii) experienced FRS personnel will be less prone to displaying such bias / errors.

There was no evidence found to substantiate this hypothesis as within all the studies experience with the situations simulated did not show an effect on the outcomes to the exercises. The only evident difference of experience was that trained firefighters showed better ASA on the tabletop exercises than university students.

iv) Any such bias / scope will be reduced or moderated by providing detailed personal feedback on bias / scope and error tendencies to individuals following training exercises (i.e. individuals can use understanding about their own bias / scope to reduce errors in decision - making).

From the follow up interviews the participants felt there was real value taking part in the studies and being shown their individual bias / scope and ASA, PSA patterns, with the majority having undertaken work to improve their own ASA. With the research suggesting a resting bias / scope for those undertaking the two assessment exercises in 2012 and 2013, training on their individual bias / scope is seen as a possible way of providing real benefit within their incident command training.

Chapter 8; Future Considerations

8.1 The identified need for the research

Gasaway (2008) looked at barriers to situational awareness (SA) and impacts to decision - making, describing high stress environments as ones that contained multiple sources of information, physical / mental stress, communication issues, distractions, and interruptions among others. He also identified that understanding what was needed for good SA and having the correct SA about the situation was a necessary skill for understanding what is happening during any fire and rescue emergency incident. In looking at the impact of these factors in relation to a single incident Putman (1995) wrote on the collapse of decision - making and organisation structure on Storm King Mountain. The analysis of this incident identifies that commanders differ in both the number of factors they use in decision - making and the value they place on each of these individual factors. The analysis also identified that in a situation where fear and panic is created, individuals can regress towards a simpler, more habitual thinking that does not reflect appropriate training guidelines. Individuals rarely have a full understanding of the few facts they have in relation to the incident and how they are processing them in making their decisions (Tavris and Aronson, 2011). Studies (AFAC & CRC fire note 2009; p.4) also show that our thinking tends to underestimate hazards, particularly if the hazard is increasing at a logarithmic or at an exponential rate. 'The human consequences of suboptimal decisions by fire leaders are compellingly clear and conversely, optimal leadership decisions are no less vital for successfully suppressing a fire', (Useem et. al. 2005, P.462). Exploring decision - making within a wildland fire scenario, Yukl (1989) showed how good decision - making achieved the best possible outcomes and therefore identified good decision - making as a key component for leadership, with poor decision - making compounding the situation and increasing pressure. These demands and risks are clearly shown by incidents such as the Storm King Mountain fire in July 1994, a fire fighting disaster where 14 fire fighters lost their lives. Putnam (1995) felt that a high pressure environment and high stress, predictably lead to the collapse of clear thinking and organisational structure', while Useem et. al. (2005) suggests that under-preparation, acute stress and ambiguous authority, can and do result in suboptimal decisions by team leaders on a fire line. Both identified how one could decide the crucial factors that allowed this disaster to happen and both looked at the inputs and outputs gained from the leadership of the fire fighting crews committed to resolving this incident.

It is important to consider what decision - making models incident commanders' use in making these key decisions and if there is a single model that helps, or will incident commanders use the one that they are first taught, or the one they are most comfortable with. In the end it may not matter which model is ostensibly being followed, since Useem et. al. (2005) and Putnam (1995) recognise that in situations that create fear and panic, increased stress and pressure on leaders *will* follow. Within their paper Useem et. al. (2005) identify research that confirms when individuals are under time pressure or perform multiple tasks at the same time, they are more likely to make suboptimal decisions. Much of the stress experienced by fire fighters is a direct product of the urgent and diverse demands imposed on crew leaders and incident commanders when confronted by a fast evolving fire (Janis and Mann, 1977; Finucane, Alhakami, Slovic, and Johnson, 2000; Gilbert, 2005).

The studies in this thesis aimed to explore why some of these decisions are made, why an incident commander, as happened in the Storm king mountain incident, can move from effective decision - making in the morning, to making what Useem et. al. (2005) classify as suboptimal decisions leading to multiple loss of life in the afternoon. The training for incident commanders is well established in most FRSs and has been developed over time. Most of this training is culturally based, taking into account how the FRS has been established (full time, part time or volunteer), how it has been funded (centrally, locally, or by donation), its support structure as part of a national group, local authority, or voluntary unit and the legislative health and safety environment it operates within. With this being the case the incident command training program is not easily transferred as a whole (from one country to another and in some areas from one location to another), although elements of good practise within the training program have been accepted by most FRS and included within their training packages and will continue to be.

The research described in this thesis has looked at other factors that could influence the decision - making process for operational incident commanders, focusing on the key issue of information bias / scope in FRS decision - making. The research investigated whether FRS fire fighting personnel displayed bias / scope during realistic simulations and exercises and if so, whether the bias / scope was conservative, narrow or liberal, broad in nature. There has been some preliminary application of this theoretical framework to fireground decision - making (Saveland, 2005), but the current research has extended this by quantifying information bias / scope to enable appraisal of such individual tendencies across different studies and over time. The effect of the provision of personalised feedback to individuals concerning their bias / scope has also been investigated.

The current research has also explored the effects of FRS fire fighters experience on information bias / scope. Experienced FRS fire fighting personnel may act on the basis of prior experience using “Recognition primed decision making (RPD)” (Klein, 2003; Klein et. al. 2010), rather than fresh appraisal of fire situations (Klein et. al, 1993). RPD is beneficial if it aids focus on correct aspects of the situation and the situation does not change greatly from the previous incidents that it is modeled on.

This thesis addressed a number of important questions concerning information bias / scope in FRS fire fighting personnel. Does the same person show different bias / scope in different situations or at different types of incident (experience), suggesting a situational bias / scope? Or do individuals have a natural and consistent bias / scope, a resting bias / scope that is consistent across different situations? One important issue was whether the manifestation of information bias / scope might be linked to the way individuals react under pressure and therefore to the way they manage an incident. Will the FRS incident command system and command models already established and in use within the training and operational environment provide enough support to meet the requirements of the critical incident commander? Can there really be effective training of incident command without knowing whether individuals have a conservative decision - making bias / scope, classifying less information as true, making more correct rejections but also more misses or alternately a more liberal bias / scope, deciding more is true, thus making more hits but also more false alarms (figure 1.6)? Would that same incident commander knowing and understanding more about their personal bias / scope and how it impacts on their ASA and decision - making under pressure at an operational incident make better decisions?

The broad aims of the research was to gain further understanding of fireground command and control decision - making in relation to how bias / scope might influence decisions and to determine if once identified this can contribute to training guidelines for personal self-awareness of how information is scoped in fireground situations. In essence the basis of good ASA must include a full understanding of any personal bias / scope and how personal bias / scope can / will impact on understanding and implementing operational decisions.

The direct aims of the research were to understand how information bias / scope by the individual may influence or impact on decisions and outcome in fireground exercises and then to determine whether bias / scope works in different ways across individual incident commanders and finally to then progress this work from the theoretical model into a training / assessment scenario to determine if an individual's bias / scope can be identified and whether this knowledge assists the outcome of the decisions in actual fireground conditions.

8.2 How the research described in this thesis extends previous research and theory.

The current research significantly extends prior research and theory on naturalistic decision making, on SA and on incident ground decision - making in general, and in the FRS in particular. Past research has examined barriers to SA (Gasaway, 2009) and the knock-on effect on good decision - making; describing problematic environments as ones that contain multiple sources of information, physical / mental stress, communications issues, distractions, and interruptions. Putman (1995) identified that commanders differ in both the number of factors they use and the value they place on each of these factors, with individuals rarely having a full understanding of the few facts they have in relation to the incident, and how they are processing them in making their decisions. To understand this in relation to fire fighting operations, it is necessary to understand how decision - making on the incident ground relies on maintaining SA and making decisions under time pressure (Saveland, 2005). It requires the individual to identify the decision criteria, make the appropriate selection and allocate any weighting they feel is justified to the range of information on offer, either from the incident ground, its contextual environment or their internal knowledge base in relation to the incident. Identifying that a necessary skill for understanding what is happening during any fire and rescue emergency incident is SA (Gasaway, 2010). The components of SA are seen as covering three elements; gathering information, interpreting information and anticipating future states, sometime described as What?, So What?, Now What? (Flin, O'Connor, and Crichton, 2008, p23). This cognitive skill is primarily about gathering and processing information from the environment and using stored information to make sense of it. Kaempf, Wolf, and Miller (1993) support the criticality of SA, as when analysing the decision - making of tactical commanders they identified that recognising the situation provided challenge to the commanders. Endsley, Sollenberger, Nakata and Stein (2000) identify that incident ground decision - making does not simply mean collecting information about the incident and environment to build an understanding / representation of the situation or to gain good SA.

A key issue is the capacity of the fire fighter to maintain an accurate understanding, or mental model, of a situation when there are many competing demands. In pressurised fireground operations, even the best trained individual may create a flawed mental model; poor SA (Endsley and Strater, 2000). When this occurs, key information may be overlooked or dismissed, or faulty information may be used to make critical decisions (Catherwood et. al. 2010; 2011; 2012). The term bias / scope is used differently within this study to the way it is used in SA, the term used for the bias as discussed within this work is 'information bias', to refer specifically to the use of information (conservative / narrow or liberal / broad). Since any bias / scope of the decision maker can directly affect the selection or use of information for decision - making, it has to carry a potential for error with its associated risk and therefore a potential consequence to all personnel on the incident ground. If the amount and quality of the information available to an individual remains the same, different bias / scope applied to that knowledge may lead to varying degrees of acceptance or rejection of the available information, impacting directly on ASA. In essence, individuals with access to exactly the same information could have quite different ASA. A cautious or conservative bias / scope will permit use of only a narrow range of information, while a more liberal or lax bias / scope will allow use of a wider range of information that may be processed more superficially (Edgar and Edgar, 2007). There is potential for bias / scope in fireground decision - making to arise from numerous sources of brain activity (Catherwood, Edgar, Nikolla, Alford, Brooks, Baker and White 2014) that influence the selective processing of information. An understanding of such individual bias / scope patterns would seem critical for improving and training self-awareness in regard to the selection of information and the potential risks in incident ground decision - making.

The studies described in this thesis investigate a missing factor in building ASA - information bias / scope. The research suggests that FDMs under stress may fall back to a resting bias / scope and the FDMs have acknowledged that they feel they can moderate the impact of this bias / scope by training or using the incident command system support more. Neither a liberal / broad or conservative / narrow bias / scope is necessarily wrong or right, but each has its own dangers. If people apply too narrow a bias / scope they run the risk of ignoring important aspects of a situation, while having a broad bias / scope may mean that irrelevant or even wrong information is given equal weight to useful or relevant information. There may be many contributing factors to such bias / scope tendencies including perceptual, attentional, working memory load, emotional and personality considerations, as previously discussed. The role of all such factors cannot be determined from this research, but nonetheless the finding of consistent bias / scope patterns in fire fighters is an important one that may have implications for understanding errors in incident ground decision - making. The finding of a possible resting bias / scope in incident commanders is an even more important one, which will have implications for understanding errors in incident ground decision - making and how we can help to reduce them. The ultimate goal of the current research is to further the understanding of this bias / scope tendency, in order to support the training of effective fireground decision - making.

8.3 Development and next steps

From the research outcomes identified within the project in relation to a resting bias / scope for FDMs, the next aim for this line of investigation will be to work and develop a vocational training protocol. That will facilitate an individual's use of information to drive optimised decision - making in high pressure situations. In looking to develop a future training protocol or future training activities it is felt at this time it could be based around an incident based training exercise tool to identify an individual's information bias / scope and then to inform them about this information bias / scope to then work to improve individual decision - making. In doing this it is hoped it would go some way to helping to improve ASA and the decision - making process of incident commanders and improving safety of incident ground operations for all personnel involved.

The importance of SA has long been recognised in other areas, such as aerospace and the military, but has only recently been a focus for training in the FRS and no prior study has examined the role of information bias / scope. Any means for training FRS fire fighting personnel to appraise and monitor their own SA and bias / scope under pressure offers an important step in increasing safety on the incident ground in the training of incident commanders. The data from these studies reported in this thesis is uniquely placed to address this gap. Critical errors may occur due not to a lack of competence, or even lack of information; but to a failure to make optimal use of readily available information in decision - making. The key for the individual is to select enough of the right information to make the right decision, without selecting too much and so becoming overloaded or selecting too little and making key decisions based on very little information. This approach will not be aimed at eliminating such natural tendencies (which the research presented here suggests might be difficult or impossible), but is looking to provide individuals with an *awareness* of any bias / scope in their own information processing. Explaining to them the implications of any such information bias/ scope, as it can or will impact on their ASA, their decision - making based on that ASA, and the quality of those decisions in relation to the objectives of the incident. As shown by the current studies understanding these mental aspects of ASA and decision - making are essential to improving safety. By extending the ability of the fire incident commander to work under pressure to manage the information availability and in doing so improve their decision - making at operational incidents is as necessary as are basic fire fighting competencies. Simply providing vocational expertise per se may not protect individuals from losing SA under pressure and failing to gain the objectives to bring the incident to a safe conclusion.

Given that decision - making under pressure is not confined to the FRS (the initial development of the QASA approach was taken from work with the military), the studies undertaken within a project of this type could also have an impact beyond the FRS. The approach has been developed within the FRS as it provides a challenging environment where the impact of improvements to training is likely to be high. The underlying model underpinning the approach is, however, both quite unique and quite generalisable giving it the ability to transfer across and into other organisations. The model on which it is based could be applied to a wide range of situations, including, for example, other emergency services, strategic decision - making in crisis situations and possibly teaching methods in exam techniques. The reality of poor ASA and poor decision - making based on poor information use is already widely acknowledged, but the tools to measure this have not previously existed. The development of these studies could provide the tools to assess the individual and how they maintain good ASA and so improve decision - making. Identifying any information bias / scope when under pressure and then designing training to assist individuals in minimising any impact the indentified bias / scope could have. This approach would give the methods developed within this thesis a potential impact across all processes and organisations where humans are required to make pressurised decisions. For the individual FRS personnel who employ such a tool, this could ultimately enable them to perform at a higher level under pressure on the actual incident ground, to extend their competence in a more dynamic or complex developing incident. This would allow them to improve their ASA, reduce decision - making errors and thereby improve safety for FRS personnel and for the wider community that they serve.

As mentioned earlier a next step for this research is being undertaken through the European Union with the assistance of their Erasmus plus program; this work will take place with other European fire services in Poland, Demark, Belgium and Holland.

9. References

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Appendix 1; Further details on the QASA method (See Method in chapter 3 for other details)

'As noted in the Method for Experiment 1, the QASA method is based on signal detection theory (for further explanation of relevant aspects of signal detection theory see: Green & Swets, 1966 and Stanislaw and Tadorov, 1999). In traditional signal detection theory, the decision required is usually whether a signal is present, against a background of noise, in any given stimulus. A modified version of this approach is used by the QASA tool, with *signal* and *noise* replaced respectively by *true* and *false* information. The QASA approach erasures SA by presenting a series of True/False probe statements (some of which are true and some of which are false) drawn from the situation of interest, and the individual's task is to state whether they believe the statement to be true or false.

The QASA tool then uses signal detection theory to give a measure of how well the individual can tell true from false information (the SA or Knowledge score) and also an indication of the individual's bias, i.e., how biased they are towards accepting information as true or rejecting information as false (the Bias score). The SA score is based on a nonparametric signal detection measure, A' that corrects for guessing and represents the person's ability to tell true from false information. A' is a robust measure as it can be applied even for sample distributions where the variances may be unequal. Bias is calculated using B'' which represents the person's overall tendency to accept or reject information.

A more comprehensive justification for using A’ and B” (as opposed to d’ and s, the usual signal detection measures of Knowledge and Bias) is given in Edgar and Edgar (2007) and further discussion of the underlying computational aspects can be found in Stanislaw and Todorov (1999). Essentially however the QASA tool calculates these scores by using the “hit rate” (i.e., the proportion of responses on the “signal” trials that are correct “hits”) and the “false alarm rate” (i.e., the proportion of responses on the “noise” trials that are false alarms).

The essential computations can be represented as (after Stanislaw and Todorov, 1999):

$$A' = 0.5 + \left(\operatorname{sign}(H-F)\,\frac{(H-F)^2 + |H-F|}{4\max(H,F) - 4HF}\right)$$

$$B'' = \operatorname{sign}(H-F)\,\frac{H(1-H) - F(1-F)}{H(1-H) + F(1-F)}$$

(where *H*= hit rate and *F* = false alarm rate and *max (H, F*) = either *H* or *F*, whichever is the greater).

The A’ and B’’ scores are then re-scaled to give two measures, each running from -100 to +100. An advantage of the QASA tool over other signal detection approaches is that it makes relatively few assumptions about the shapes of the underlying distributions of the trace strengths of true and false information, or even that true information should have a generally stronger representation than false'.

Appendix 2; “Scoping” study: BA Guideline Exercise 6 April;

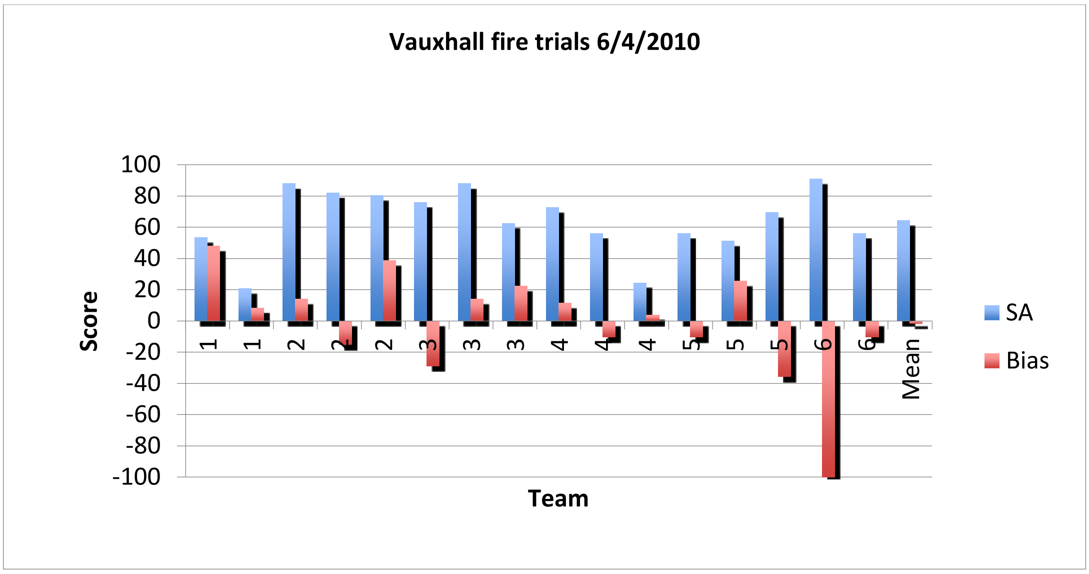
Gloucestershire FRS and CRACKLE (Centre for Research in Applied Cognition, Knowledge, Learning and Emotion) University of Gloucestershire

Sixteen people from 6 teams were asked 19 questions after finishing the exercise. The questions were aimed at finding out how much of the briefing was retained and how narrowly or widely the personnel had “scoped” (taken in and accepted information from) the exercise situation. The response to the questions (over all the teams) is shown below

QUESTION	T/F	% correct
You were briefed to search off branch line 2	T(2,5) F(1,3,4,6)	93.75
You were advised in the brief to conduct gauge checks	T	100
You were briefed that there were 2 casualties	F	100
There was a gas cylinder outside the building	T	25
You were briefed to conduct a R/H search pattern	F	93.75
There were two branch lines in the building	T	68.75
The first branch line was ~12m into the building	F	37.5
There were two staircases in the building	T	87.5
There was another team in the building at the same time as you	T	100
You were briefed that there was a child casualty	F	100
You were shown floor plans for the entire building	F	43.75
There are four appliances present	T	62.5
There was an emergency team on the BA board as you entered	F	75
There was a 45 gallon oil drum on your route	F	93.75
There were two cupboards on your route	T(1,3,4,6) F(2,5)	50
There was at least one bed on your route	T	56.25
You were using radio channel 2	F	93.75
You crossed the main guideline 3 times	F	75
All teams were teams of 3	F	68.75

The questions in blue relate to the briefing and the rest to the exercise situation. In general the retention of briefing information appears good. The results for the situation questions are mixed: eg. 25% noticing the gas cylinder (at the entrance to the building where the guidelines were initially connected) but 87.5% noticing the two staircases.

The research team has used an analysis called QASA (Quantitative assessment of situation awareness) to get an impression of how individuals were “scoping” the situation. The analysis shows different patterns: with some people scoping more broadly and accepting more information than others, but overall the scope tended to be on the restricted side, with a *slightly narrow focus* (which could explain why the gas canister was missed for example). This is also a common finding in other contexts where decisions have to be made under time and stress pressures (eg. military situations). It is not necessarily good or bad to scope widely or narrowly: different situations may need one or the other approach. But it may help FRS personnel to be aware of their own”scoping” pattern at any point in time. The research team plans to continue exploring these issues to help develop useful ideas for training FRS personnel in the future. This study was just one step in that direction and we are very grateful for the help of all personnel at the exercise.


Vauxhall fire trials 6/4/2010
Score
100
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3
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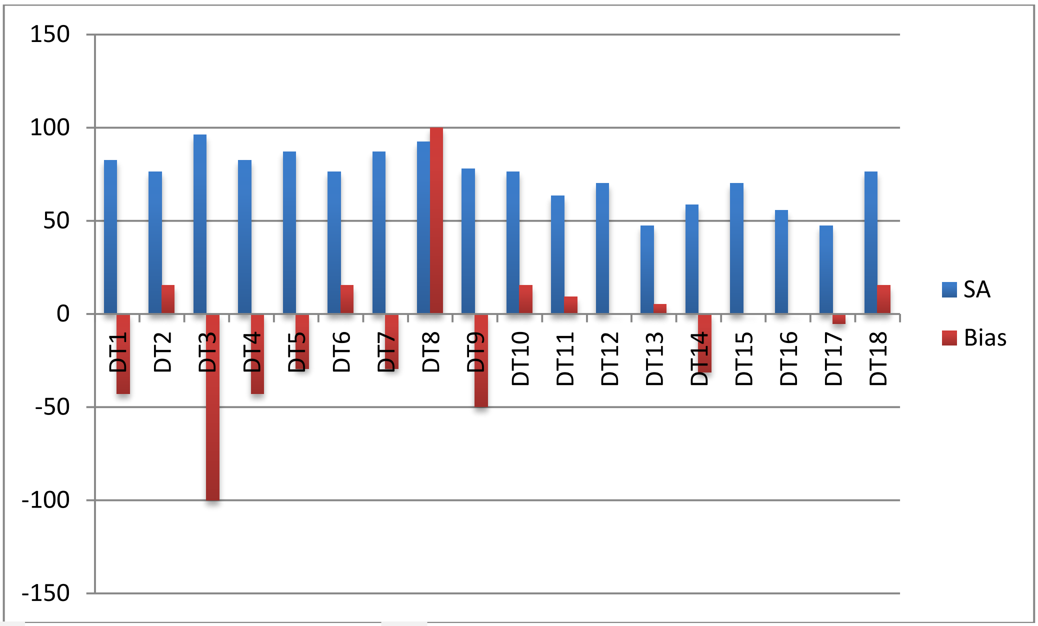
Mean
Team
SA
Bias

Appendix 3. Feedback was also provided to all participants for the FRS, both mid way and at the end of the exercises, example of mid way feedback.

There were individual differences in how the information had been scoped. Some people tended to show a slightly narrow scope. They were using a fairly cautious bias or filter in regards to what they would accept as being true or useful. Other personnel showed a different pattern: they had a somewhat broader scope or less cautious filter and were more inclined to say something was true (even when they weren't sure if it was). This means that they were saying Yes to correct items, but they were also saying yes to false ones. These people were making more false alarms than their colleagues. Some other people didn't show a particular tendency either way. There is no right or wrong scope to apply: it depends on the demands of the situation. Sometimes a broad scope may be the best way to proceed but other times a narrower filter may be the better option. The important finding here is that people will show different patterns and each approach does carry its own risks. It might be helpful then to have feedback on how the situation was scoped.

Figure 4. 3 shows the pattern for each of the 18 people and it is clear that there are differences amongst the personnel from person 1 (D1) to person 18 (D18). The blue bars show how good each person's knowledge (situation awareness) scores are (from -100 to +100%) and the red bars show which way they were scoping: from very cautious or narrow (+100)

to very lax or broad (-100). It is clear that people can seem to have the same level of knowledge (situation awareness) but they may be using very different scopes or filters. For example, DT 1 and DT2 show similar levels of knowledge about the situation, but when they *don't* know the answers, DT2 is more inclined to be cautious and less likely to accept something as true than is the case for DT1.



Knowledge: %correct SCOPE: below zero = broader filter, accepting scope

above zero= stricter filter, narrower scope

Figure A. 1 *Knowledge and Scoping patterns for each of the participants*

Conclusions:

The results are not intended to be a judgment on particular personnel. The most important aspect is that they show that there can be individual differences in how the same information is scoped or taken in. Some people used a cautious scope or filter while others used a broader or less strict scope when judging information. Both approaches have their own risks. It is possible that the same person may use different scopes depending on the situation. The project aims to explore if this is the case in future work. Overall, the project is working towards some means for FRS personnel to self-check their own scoping at key decision-making points, with the aim being to support good decisions and lower risk. Your participation has been of immense value towards this goal. Thank you for your help.

Appendix 4. Example of a National Occupational Standard EFSM2 for Fire Service Station Managers;

Unit title:	EFSM2 - Lead, Monitor and Support people to resolve operational incidents
Scope of this unit	
This unit relates to the leadership role taken at operational incidents. This includes initial review and planning of incident management, operating within the Incident Command System. It includes implementation, review and monitoring of plans and management of resources to resolve the incident. It also includes planning and conduct of relevant briefings.	
This unit contains three elements: **2.1 Review and determine incident status** This includes your initial review of the incident type, status and progress, the collection of relevant information and analysis of implications for the community and for resource allocation. **2.2 Assume responsibility and implement action to support those involved in the incident** This includes your formulation of a plan for resolution of the incident, taking account of anticipated risks, monitoring the progress of activities against your plan and making relevant adjustments. It includes obtaining advice from relevant specialists and the conduct of operational briefings with relevant personnel. **2.3 Debrief following resolution of incident** This includes the arrangements and conduct of relevant briefings both immediately following and at later stages of incident review.	

Unit title:	**National Occupational Standard EFSM2 -** Lead, Monitor and Support people to resolve operational incidents	
Element titles:	2.1	Review and determine incident status
	2.2	Assume responsibility and implement action to support those involved in the incident
	2.3	Debrief following resolution of incident

Knowledge for this unit	**2.1**	**2.2**	**2.3**
The range and sources of information required to evaluate and manage incidents and how to access this	●		
Relevant legislation and its correct interpretation and implementation	●		
Your role, responsibilities and level of authority at operational incidents	●	●	
The roles, responsibilities, limitations and capabilities of personnel and other agencies	●	●	
Lines of communication at incidents and the incident command system	●	●	
The range and type of resources available at incidents, their capabilities and limitations	●		
How to prioritise and allocate tasks and set clear objectives at incidents to achieve operational objectives	●		
Your local community, its characteristics and associated risks	●		●

Dynamic risk assessment and associated health, safety and welfare issues	●		●
How to communicate effectively and efficiently with personnel to achieve changing objectives and manage sensitive issues		●	
How to anticipate needs and requirements of the incident and of the personnel involved in its resolution		●	
Issues of confidentiality, security including data protection, intellectual property rights, Human Rights and the implications of potential litigation		●	
Organisational objectives, values and how to operate within them	●	●	●
Methods, styles and principles of leadership and their application in operational contexts	●	●	
The range, type and extent of information needed for effective debriefs		●	
How to analyse trends, identify needs for change to procedures and instigate action to make relevant improvements			●
Methods of providing feedback and how to select those appropriate to the context and sensitivities of the situation			●
Requirements and methods of reporting on incidents and how to report to key internal, external, political and community contacts			●
How to formulate and implement an incident plan and the factors affecting this	●	●	
How to distinguish between relevant and irrelevant information and formulate plans and decisions which influence successful resolution of incidents	●	●	
The range of specialists available and how to make best use of their technical expertise and support		●	

Appendix 5. Station Commander Assessment Exercise

The time is 1000hrs on a Monday morning. There is a light drizzle of rain at present with a brisk northerly wind and temperatures around 4˚C. The service has been called to a fire at Crypt school, just off Cole Avenue, in Podsmead, Gloucester. The PDA is 2 appliances from both Gloucester Stations and a Station Commander. Station Commander __________ was mobilised with the initial attendance.

On receipt of a make pumps 5 message from WC Evans Operations Control mobilise more resources to the Incident including 2 further Station Commanders (1 to manage the ICU and the candidate to support the Incident Command System).

The candidate will be mobilised by mobile phone/pager to a briefing room where he/she will receive a brief for the incident including an informative just received: From WC Evans at Crypt School, Gloucester, Fire in School. Building approx 10M x 80M well alight. 5 persons unaccounted for at this time. 4 BA, 1 HR & 2 Jets.
(Observations at this time – WC in charge and is looking to candidate to take over: SC on PDA has not attended – Where are they?
Actions; Large building with potentially large numbers of BA: consideration for stage 2 and Main Control; water supplies available (MDT)? Large occupancy in the building: Roll call and potential for parents descending; Plans?)
Resources sent on MP5 = 5 pumps + ICU + support pump + BAT + support pump + ISU + DCU + IT support + workshops + 3 SC's (General + Command Support + FI level2)

The candidates brief from WC is as follows:
"we have 5 persons confirmed unaccounted for; search & rescue and firefighting operations is underway; we have 1 pump at the front, 1 pump around the back, and 1 securing a water supply at the entrance; ICU is setting up and SC _______ is here to run command support but has not received a briefed as yet; there is a great deal of smoke about with a thick black plume from the roof and by the smell I would say there are plastics involved; the teachers and pupils are self deploying and are difficult to manage; there is an increase in fire

development over the last 10 mins and it is my intention to flood the building with BA teams; we have 4 pumps in attendance and all personnel employed at present; my last informative was: Fire in School. Building approx 10M x 80M well alight. 5 persons unaccounted for at this time. 4 BA, 1 HR & 2 Jets. I have BA crews using channel 3 and all other traffic on channel 1. Are you taking over?"
(Considerations – Last known location of the missing? Teachers or pupils? ages? Tactical mode? Contact with the Head teacher? Message to take over? Access points for building and site? Fire alarm system and location? Sectorisation? Sector commanders? Communications network?)
SC takes over (or not)?
If not confirm their role at the incident.
If so what role does WC undertake?
(Consideration: Confirm tactical plan – Sectors, resources, IC structure).

Inject (1) – Head Teacher:
Approach the ICU and seek out IC. Provide a set of school plans and an overview of the fire risk assessment for the site. Provide a roll call for the IC.
"I can confirm that 1 teacher and 4 children are unaccounted for at this time. The teacher is a white male aged 26 and called Dave Allen. The four children are Charlie Sharp aged 14, Arvad Prahad aged 13, Billy Finn aged 14, and Martha Bell aged 13. Dave Allen was last known to be taking a class in the English room on the first floor of the building. Both Arvad and Martha were in his class at the time of the incident. Charlie should have been in a chemistry class on the ground floor and Billy should have been in a geography class on the first floor (show them on the plans).
We have an emergency policy for this situation and need to identify a safe location for all the school children at this time as we have to consider welfare (as it is raining cold windy etc). Are you happy with us using the sports hall?"

If asked where and how the fire started – "Not sure at present. I did hear someone say that a pupil was in the building with a can of petrol but I did not see this myself. I know that the Fire Alarm panel indicated that the fire is on the first floor."

(Considerations: Holding area for kids and teachers, missing persons, evacuation, safety officers, FI level 2, + Police involvement from an arson perspective, potential crime scene, cordons, traffic control,).

Inject (2) – from Base pump to IC/OC:
"we are running low on water as the base pump is over running the supply. We need to find an alternative water supply as soon as possible".

(Considerations: Make up, resources required, alternative mains supply, open water, specialist appliances, water officer role).

Inject (3) – [Police] Sergeant Bob Blue:
"We are dealing with the traffic management as requested. We are also looking into the possibility of the fire being a malicious arson attack and the suspect may be still on the premises. Calls are being received by the Police Control from parents regarding the location and safety of children. Have you considered this aspect and what are you proposing to do?
Is there anything further that we can do for you?"

(Considerations – obtaining details and description of possible offender as they maybe still on premises? Is there an investigating officer for these threats to provide a link into investigation strategy?)

Inject (4) – [GWAS] ADO Gary Green:
"I have 2 ambulances on scene at present. How many casualties are we looking at? HART have been mobilised from a local event and should be here very shortly.
Do you need anything else from me?"

Inject (5) – from Ops Control:
"HART wish to know if there is an RVP for this incident."

Inject (6) – from sector 1 commander to IC/OC:
"BA crews are struggling to make progress due to thick smoke and high temperatures. Can we have 4 more BA wearers for relief purposes and an emergency team?"

Inject (7) – from sector 3 commander to IC/OC:
“I require 4 BA wearers for relief purposes and an emergency team”.

Inject (8) – from sector 1 commander to IC/OC:
“the fire is piercing the roof now. This should make firefighting inside easier with reduced smoke levels but will develop the fire significantly”.

Inject (9) – Ops Commander (or SC1 if OC not in operation) to IC:
We have confirmed the isolation of all the services to facilitate operations. It has meant that the power to the whole site is down.

Inject (10) – from HART Team Leader:
(dependant on direction) “I have 6 vehicles including an incident response unit and extended duration BA equipment for use if you need it. Where do you want me to set up?”

Phone inject (11) – (ring ICU mobile 07799347496) from Fire Gold (CFO):
“The service are receiving many calls from worried parents asking about their children. Will Windsor-Clive is with me and three local Cllrs have already contacted me regarding the incident. Can we have an update regarding the current situation there please? Can you call us in 20mins with a further update.”

Inject (12) – Police Chief Inspector:
“We can inform you that the suspect is a former pupil [male, white, aged 15, Paul Orange]. Our intelligence suggests that he purchased a quantity of petrol from the local garage on his way here, 50 litres or so. Articles on social media networks suggest that he has planned this for some time and may be considered dangerous. We have cordons in place and are managing them. Cole Avenue has been closed to traffic and diversions are in place. We are waiting to identify appropriate areas for a rest centre. Do you require any more information from me at this time?”

Inject (13) – (Liaise with Jess/Chris in CP) Civil Protection Officer/Schools Team:
Concern for the children’s welfare. Crime scene so Police will need to interview kids (organise a strategy). Move pupils to place of safety. Refreshments for those that we are unable to clear the site.

(Consideration; Reunite strategy – parents in one area, kids in another. Pupils unaccounted for not necessarily in school. Names of missing, Parents contact details. Contact Highways also. Keep Councillors updated.)

Inject (14) – BBC Radio Gloucestershire:
"Are you the Officer in charge and if so can you give me an interview please? I understand that a couple of children have been badly burnt can you comment?"
FOLLOWED DIRECTLY BY:
Inject (15) – Parent:
approaching the bus "I've heard about this fire and can't get hold of my little Billy, can you tell me if he is ok?"

Inject (16) – sector 1 commander to IC/OC:
"a BA team have located 2 casualties and are withdrawing from the building".

(Considerations: ICU Officer proposal of a crew refreshments/relief plan.)

Group/Area Commander is now in attendance and requires a handover brief (OTHERS). – END EX

Station Commander Assessment Timetable: Venue: HQ

ICU to arrive at 0900hrs to allow an hour to set up.

Start – briefing (15 mins) in meeting room 1 (or suitable briefing room)

- To include drive to
- Proceed to ICU in car park
- Receive a handover briefing from the existing Incident Commander

- Delegation of roles including suitable briefing
- Incident Management (approx 30 mins)
- Handover to GC/AC (OTHERS)

- Candidate self reflection in meeting room 1 (15 mins)
- Assessors to conduct general debrief of role players

- Assessors to debrief candidate (15 mins)

Total time: 1 hour 15 to 30 mins

Candidate 1 – 1000-1130hrs

Candidate 2 – 1130-1300hrs

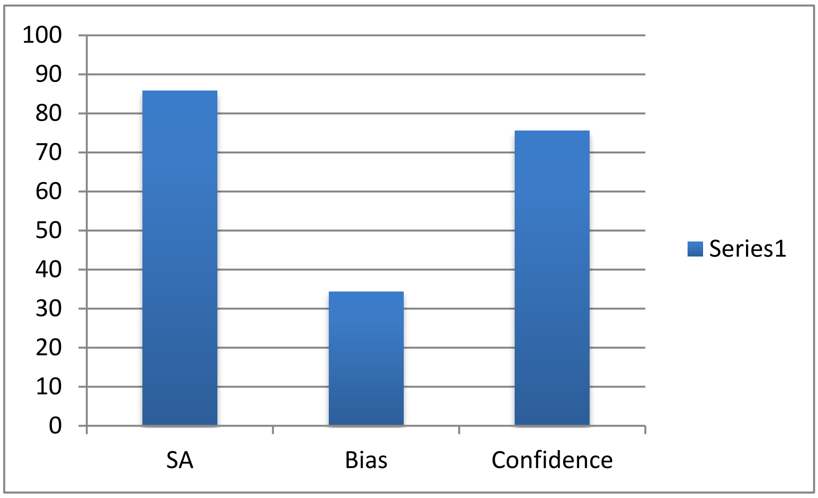
Candidate 3 – 1400-1530hrs

Candidate 4 – 1530-1700hrs

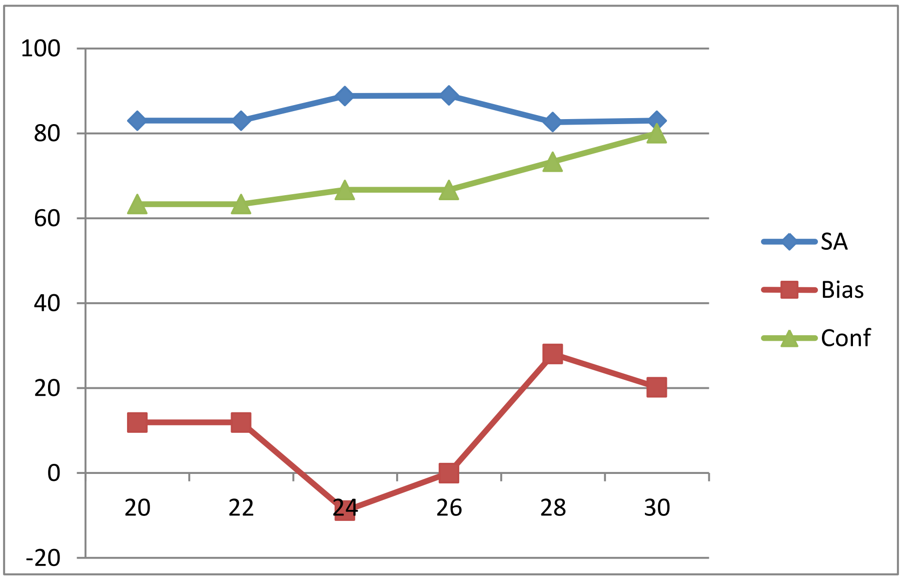
Appendix 6. 2012, results of the QASA as they were fed back to the staff involved in the debriefing.

Got 1/6 (Nos.) metacog wrong - One F when T. Zero T when F.

SA	Bias	Confidence
85.7708468	34.3554798	75.5555556



	SA	Bias	Conf
20	82.9761905	11.8881119	63.3333333
22	82.9761905	11.8881119	63.3333333
24	88.7752525	-8.8863892	66.6666667
26	88.8888889	-1.542E-14	66.6666667
28	82.6388889	28	73.3333333
30	82.9826038	20.1978566	80



Below is the model of the relationship between Situation Awareness (SA) and bias in regard to the example of incident management under pressure:

Bias can shift towards a liberal criterion (with a risk of accepting more false information and making false alarm errors) or towards a more conservative criterion (with a risk of rejecting more true information and making miss errors). SA comprises an individual's awareness of what is going on around them that will, in turn, guide decision making and action.

Range of Scores	Knowledge (SA)	Bias
Positive (max + 100)	Good knowledge: distinguishes true from false; higher the score the better.	Strict or conservative: tends to reject information as false even if true; higher the score the greater the tendency (lack of confidence in source / self?); increased risk of miss errors.
Zero	No knowledge – guessing?	Neither accepts or rejects information (neutral attitude)
Negative (max – 100)	Misguided: judges false information is true & vice versa; more negative is worse	Lax or liberal: tends to accept information as true, even if false (over confidence in source / self), the greater this score the greater this tendency. Increased risk of false alarm errors

<u>Situational Awareness 85.8</u>

Two key aspects of SA are a person's *actual* SA and their *perceived* SA. Ideally, these two aspects should match but this is not necessarily the case. High SA shows a good awareness of what is happening, while low scores show a misguided SA, or a fundamentally wrong representation of the situation.

A score of 85.8 shows a very good knowledge of what is going on at the incident, identifying the ability to tell true from false; the higher the score the better understanding of the environment and a good personal picture of the incident.

Bias 34.4

Positive bias scores above 0 are taken to reflect a conservative or cautious bias; a tendency to reject information (but at risk of making miss errors). While negative scores below 0 reflect a more liberal bias, a tendency to accept information as true (so making false alarm errors). While a 0 score reflects no bias either way; equally likely to accept or reject information.

A score of 34.4 shows a conservative bias. A conservative bias could possibly lead to “miss” errors under some circumstances when attention is highly focused or tunneled in difficult conditions. This bias tendency reflects a likelihood of rejecting information (reject information as false even if true) based on the incident and the environment.

Confidence 75.6

SA can vary across the situation and perceived SA (confidence) can remain relatively constant, while actual SA can be in the negative. This raises the possibility that individuals may have a ‘resting level’ of perceived SA and that actual SA could be low, giving a confident incident commander with little real understanding of what is happening!

Confidence is very high at 75.6%, matched with an actual SA of 85.8 reflecting a very good grasp of the ongoing situation and an ability to reconcile the individual ability in handling the incident.

Appendix 7: Epistemological and Methodological Discussion

It has been argued that historically two main research paradigms have employed, that of positivist (related to quantitative approaches and an epistemology of truths and facts), and constructionist (typically related to qualitative approaches and an epistemology that sees the world as interpreted by individuals) approaches (Armitage, 2007). Within these quantitative methods were identified to result in numerical data, whereas qualitative approaches result in open ended, textual data. Armitage went on to argue that both methods were representative of the ‘mono method era’, whereby researchers used purely qualitative or quantitative research methods, depending on their research paradigm. The development of a “third way” has however been linked to the pragmatic paradigm. Within this, the employment of a mixed methodology, or approach, reflects the need for pragmatic decision making, consistent with working in ‘real world’ settings.

A pragmatic paradigm allows for differing data collection and research methods to be utilised, based on their appropriateness for the research undertaken and the research questions to be answered (Ritchie & Lewis, 2003). This presents an approach whereby methods are selected from a ‘tool kit’ rather than dictated by the paradigm employed. It is argued that this epistemological and methodological choice is reflected of the multiplicity of the ‘real world’.

In relation to the qualitative data analysis completed within this research, it was decided that thematic analysis would be the most suitable method. Braun and Clarke (2006) identify two main styles of qualitative models of analysis and within these are a number of types. These being, those that are linked to a particular theory and applied in a fairly rigid way, for example interpretative phenomenological analysis (IPA); and those that are applied with different manifestations, for example discourse analysis and thematic analysis. They go on to argue that thematic analysis is comparable with both essentialist and construction paradigms and offers a flexible research tool, often leading to rich and detailed understanding of the data.

Due to research questions being identified, and interviews being structured to explore these, it was felt that thematic analysis of the data would be applied in a 'theoretical' way. This involved a 'top down' method of analysis, which provided a detailed analysis of aspects of the data. A number of methods were considered and it was decided that thematic analysis was most appropriate as it was argued to be the most appropriate tool to answer the research questions set. Within this paper this required identifying a method of data analysis that could reflect reality for the participants, but also explore and unpick that reality (Braun & Clarke, 2006).

Other methods considered included grounded theory and interpretative phenomenological analysis (IPA). Grounded theory was felt to require a process of data collection and analysis, which is repeated with the aim of identifying and testing new theories (Greckhamer & Koro-Ljungberg, 2005). It was felt that a 'bottom' up method would also not be suitable, as the researcher had already explored the area in completing the initial literature review and was aware of common themes and areas to explore, prior to designing the research questions.

The aim of IPA is to explore in detail how participants are making sense of their personal and social world, with an attempt to explore personal worlds rather than producing objective statement (Smith & Osborn, 2007). The aim within this research was to explore personal experiences and how this related to outcomes from the exercises and briefings undertaken. It was therefore felt that IPA was not appropriate for this study.

Appendix 8; Break down of exercises undertaken.

Event	Input	Outcome	Other Information
Visit to Avon Incident Command Centre (September 2009)	To look at the facilities and to understand the exercise scenario and how competence is assessed for operational purposes.	Facilitated discussion on how this could be used and developed within the work program we had identified.	
Attendance at a major Breathing Apparatus exercise (February 2010)	To look at the scenario and to understand how an exercise of this nature can be used to provide information in relation to individual differences in Bias patterns for operational personnel.	Facilitated discussion on how this could be used and developed within the work program we had identified.	
Attendance at a major Breathing Apparatus exercise (April 2010)	The primary aim of this study was to determine if there are individual differences in Bias patterns for operational FRS personnel in a fireground exercise, reflecting the individual's tendencies towards either accepting or rejecting the available information.	The main aim of this experiment was to determine whether the bias patterns expected in the exercise would be apparent in a more realistic and challenging situation (this was clearly the case).	There were 16 operational fire and rescue service personnel working in teams of two to four in the exercise.
Attendance and assessment at a domestic house fire designed table top exercise (June - September 2011)	The primary aim of this study was to determine if there are individual differences in Bias patterns for operational FRS personnel in a "table-top" fireground exercise, reflecting the individual's tendencies towards either accepting or rejecting the available	The primary aim of this experiment was to determine if FRS personnel displayed bias patterns in decision-making during a table-top fire incident exercise (the evidence clearly shows that for most participants this was the case).	All participants were provided with the same stimulus presentation (house fire) and both SA and Bias scores were obtained in regard to the presented information, via the QASA method.

	information. To also undertake a comparison in relation to a table top exercise and an operational exercise.		Comparison of SA for FF's and students were undertaken later and showed FF's had a greater SA.
Attendance and assessment at a commercial factory fire designed table top exercise (November - January 2012)	The primary aim of this study was to determine if there are individual differences in Bias patterns for operational FRS personnel in a "table-top" fireground exercise, reflecting the individual's tendencies towards either accepting or rejecting the available information. To also undertake a comparison be getting the agreement of staff to allow us to reflect back on their initial responses to the 'house fire' scenario and identify any change.	The primary aim of this experiment was to determine if FRS personnel displayed bias patterns in decision-making that vary during table-top fire incident exercises.	All participants were provided with the same stimulus presentation 9factory fire) and both SA and Bias scores were obtained in regard to the presented information, via the QASA method.
Attendance at a major Incident command exercise / assessment for 4 Group Commanders. (March 2012)	The primary aim of this study is to determine if there are individual differences in Bias patterns for these Group Commanders under a stressful assessment process.		4 Group Manager assessments looking at incident command competence.
Attendance at a major Incident command exercise /	The primary aim of this study is to determine if there are individual	The primary aim of this experiment is to determine if FRS personnel	22 station Manager assessments looking at

assessment for 22 Station Commanders, Gloucestershire. (October - November 2012)	differences in Bias patterns for these Station Commanders under a stressful assessment process.	displayed bias patterns in decision during a simulated fire incident exercises. The data will be analysed by QASA as before. However in this case if the participant consents, they will be given feedback on their individual bias	incident command competence.
Attendance at a major Incident command exercise / assessment for 22 Station Commanders, Avon. (November - December 2013)	The primary aim of this study is to determine if the individual differences in Bias patterns for the Station Commanders taking part are replicated from the first study. Progressing it to see if there is a way of producing a simple model to use in identifying what an individual's bias is. Which will allows us to understand if knowing what your bias is can allow you to counter it, or review your decision against it, when making key operational decisions under pressure!	The primary aim of this experiment is to determine if FRS personnel displayed the same bias patterns in decision during a simulated fire incident exercises. The data will be analysed by QASA as before. However in this case if the participant consents, they will be given feedback on their individual bias	22 station Manager assessments looking at incident command competence. 17 whole time 5 retained duty system
This will be the follow-up study in which consenting participants will be interviewed (with a semi-structured approach) to determine whether providing feedback on bias following first exercise	This will involve the preparation of guidelines for assessing, providing feedback on and monitoring bias patterns in FRS training exercises based on the findings from the series of studies above.	The guidelines will be shown to FRS personnel for their feedback which will be incorporated into the dissertation.	

has made any difference to their awareness and performance. (March - June 2014)			