An investigation of operational decision making *in situ*: Incident command in the UK Fire and Rescue Service

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Précis

Decision making at operational incidents involving the UK Fire and Rescue Service was investigated using first-person video footage. This footage was independently coded and used to guide recollection by participants. The resulting analysis revealed marked departures in the decision making process from the normative models that have informed operational guidance.

Running head: Incident Command

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Abstract

Objective. To better understand the nature of decision making at operational incidents in order to inform operational guidance and training.

Background. Normative models of decision making have been adopted in the guidance and training for emergency services. These models assume that decision makers assess the current situation, formulate plans, and then execute the plans. However, our understanding of how decision making unfolds at operational incidents remains limited.

Methods. Incident commanders, attending 33 incidents across six UK Fire and Rescue Services, were fitted with head-mounted cameras; and the resulting video footage was later independently coded, and used to prompt participants to provide a running commentary concerning their decisions.

Results. The analysis revealed that assessment of the operational situation was most often followed by plan execution rather than plan formulation; and there was little evidence of prospection about the potential consequences of actions. This pattern of results was consistent across different types of incident, characterized by level of risk and time pressure, but was affected by the operational experience of the participants.

Conclusion. Decision making did not follow the sequence of phases assumed by normative models and conveyed in current operational guidance, but instead was influenced by both reflective and reflexive processes.

Application. These results have clear implications for understanding operational decision making as it occurs *in situ* and suggest a need for future guidance and training to acknowledge the role of reflexive processes.

Keywords: dynamic decision making, emergency services, operational models

Understanding decision making by emergency responders has the potential to inform training and practice, and thereby to improve safety. It could also shape models of naturalistic decision making. For example, fire officers responsible for incident command need to make decisions in highly challenging environments, which can be characterized as time pressured, with high stakes and often involving ill-structured problems (Orasanu & Connolly, 1993). The consequences of ineffective decision making in such environments can be costly, with human error being cited as the cause of most fire-fighter injuries (DCLG, 2013). Error could perhaps be mitigated by understanding the basis of decisions and ensuring that through training personnel have the appropriate cognitive, social and personal resources (Flin, O'Connor & Crichton, 2008). However, our understanding of operational decision making *in situ* is limited by a paucity of directly relevant data. Evidence from studies using simulated incidents or those requiring retrospection (on the part of incident commanders) can provide only relatively remote clues about the process of interest: decision making at emergency incidents. In the present study this issue was addressed through a detailed analysis of dynamic decision making at actual incidents that were attended by officers across the UK Fire and Rescue Service and video recorded. Without such direct evidence, many emergency services have adopted normative, reflective models, as a basis for operational training and understanding, when a variety of theoretical perspectives are relevant to this and other examples of naturalistic decision making.

Reflective Models of Operational Decision-making

Dewey (1933) argued that when people solve problems, they do so in an analytical and rational way, that proceeds according to an orderly sequence of phases. These ideas are echoed in normative models of decision-making that typically identify three key phases: Situation assessment (SA), plan formulation (PF) and plan execution (PE; e.g., Lipshitz & Bar-Ilan, 1996; van den Heuvel, Alison & Power, 2011). This type of model represents one perspective that has been taken in studies involving the emergency services, including the Police (van den Heuvel *et* *al.*, 2011) and at major incidents requiring a multi-agency response (House, Power & Alison, 2013). The normative three-phase model can also be identified within the current decision model adopted in the Fire and Rescue Services Incident Command System in the UK (CFRAU, 2008). In situation assessment, the decision maker forms an understanding of the situation by considering the information, cues and clues available to them. The result of this phase provides the foundation of the planning process, and consists of both understanding and a projection of the situation into the future (Endsley, 1995). For example, fire incident commanders are expected to gather information that is relevant to the incident, resources, and hazards, in order to inform the selection of the appropriate course of action. The plan formulation phase includes identifying the problem or problems and generating possible solutions, and the selection of an appropriate course of action. Here, fire incident commanders are expected to identify objectives and develop a tactical plan where suitable actions are selected and planned. The final phase of plan execution involves the implementation of the plan. For fire incident commanders, selected actions are communicated to those who will implement them, and subsequent activity is controlled by the incident commander to ensure that it is carried out appropriately and effectively. However, the fact that the normative model is embedded within training and operational guidance need not mean that it represents how decisions are made in practice.

Reflexive Components of Decision Making

It has been argued that normative models of decision making, like those outlined above, do not capture how decisions are often made (Klein, 1993). In addition, decisions can involve the use of heuristics including those based upon previous experience (e.g., Gigerenzer, 2007; Shafir, 1994; Tversky and Kahneman, 1979). Also, cues in the environment can activate or prime knowledge structures (schemas) that include actions, goals and expectancies previously related to that or similar environments (e.g., recognition-primed decision making; Klein, 1993). In such cases, options are not evaluated against one another, but rather the decision to act might be one that is deemed, by the decision maker, to be satisfactory rather than optimal (e.g., Abernathy & Hamm, 1993; Klein, 1993, 2003). Alternatively, the basis for an action might be more reflexive and automatic, affected by previously established associations that have developed between situational cues, actions and outcomes (e.g., Doya, 2008). The generality of such acquired (associative) influences and the variety of ways in which they can affect behavior suggests that they could exert a powerful influence over incident command at operational environments (e.g., Balleine & Ostlund, 2007; Cohen-Hatton, George, Haddon & Honey, 2013; Dickinson, 1980). These more reflexive, procedural influences might or might not be appropriate to the given operational environment.

The principal aim of the present study was to investigate the basis of decisions made at a range of incidents responded to by the UK Fire and Rescue Service. To do so, the unfolding activities of incident commanders were observed, video-recorded and then independently coded as reflecting situation assessment (SA), plan formulation (PF), and plan execution (PE). The transitions between categories were used to investigate whether decision making was based upon reflective, normative processes in which case SA should be followed by PF and then PE, or more reflexive processes, where SA is followed immediately by PE (cf. Sacket, 1979). The results of a previous study of fire incident commanders, using retrospective interviews, suggested that officers do not evaluate alternative courses of action, but appeared to be reacting on the basis of prior experience, and choosing a satisfactory course of action (Klein, Calderwood & MacGregor, 1989; see also, Klein, 1998). Although the completeness of such recollections can be limited (Omodei & McLennan, 1994), it can be improved (in simulated exercises) by using first-person footage from helmet-mounted video cameras with fire officers (McLennan, Omodei, Rich & Wearing, 1997; see also, Omodei, McLennan & Wearing, 2005; Omodei, McLennan & Whitford, 1998). Here, the independent codings of video footage were coupled with information from a subsequent interview, in which the recall of the incident by the commander was assisted by the presentation of the original footage. To provide an assessment of any nascent plan formulation during situation assessment, a supplementary analysis examined the level of situational awareness displayed immediately prior to either plan formulation or plan execution phases (Endsley, 1995). In this analysis, SA was coded as: Level 1, which corresponds to perception of elements of the situation; Level 2, which relates to an understanding of the situation; and Level 3, which involves anticipation of the likely development of the situation, and might serve as further evidence of planning.

An additional aim of this study was to assess the role of operational command experience in the behavior of officers at incidents. In most professional domains, experience gradually shapes the development of high-level, complex skills (e.g., Ericsson & Lehmann, 1996). However, decision making experience in many operational contexts is necessarily limited (because of the tenure of the officer or the infrequent nature of the incidents themselves) while the consequences of errors can be life threatening. The way in which experience interacts with the nature of decision making at operational contexts in general, and the Fire and Rescue Service in particular, is an important issue that has not yet been addressed. Moreover, this issue is particularly timely given the downward trend in the number of operational incidents over recent years (DCLG, 2012), with the consequence that the levels of operational exposure are expected to continue to decline. If prior command experience shapes the nature of operational decisions (cf. Klein, 1998; Klein *et al*., 1989), then the transitions identified in the primary analysis (i.e., involving SA, PF, and PE) should be related to the participants' experience.

Method

Participants. Twenty-three incident commanders (22 male and 1 female) volunteered for this study and provided informed consent for their participation. They were drawn from six UK Fire and Rescue Services: East Sussex Fire and Rescue Service, Hampshire Fire and Rescue

Service, South Wales Fire and Rescue Service, Tyne and Wear Fire and Rescue Service, West Midlands Fire Service, and West Yorkshire Fire and Rescue Service. The sample included level 1 incident commanders (*n* = 17), who would be the first Fire and Rescue staff on scene at an incident, and level 2 commanders (*n* = 6), who provide a greater level of command at a higher risk or more complex incident.

Participants completed a questionnaire relating to their previous operational exposure. This questionnaire was designed to identify how long each participant had spent in operational command positions. The mean overall command experience was 13.77 years (*SEM* = 1.11; range: 1.25-22.4 years). There were 2 officers with less than 5 years of experience, 6 with 5-10 years inclusive, 7 with 11-15 years inclusive, 4 with 16-20 inclusive, and 4 with > 20 years. The mean command experience in the current position was 7.10 years (*SEM* = 0.87; range: 0.08-18 years). There were 8 officers with less than 5 years of experience, 9 with 5-10 years inclusive, 5 with 11-15 years inclusive, 1 with 16-20 inclusive, and no officers with more than 20 years of experience.

Equipment. Each participant wore a head-mounted 1080p high-definition video camera measuring 42 mm × 60 mm × 30 mm (GoPro Hero 3, Half Moon Bay, USA) which captured video footage and sound. The cameras were worn for the duration of each incident, from the time of initial alert. These cameras captured all activity from the point of view of the wearer. Footage was replayed to the participants on a laptop computer (HP Pavilion, Hewlett Packard), on a 15.2" screen during a cued-recall debrief interview.

Procedure. The six Fire and Rescue Services nominated stations that were likely to respond to a range of incidents. All incident commanders at these stations were invited to participate in this research, and all volunteered to take part. The researchers (SRC-H and PCB) spent six consecutive 24-hour periods at each Fire and Rescue Service, and were located with the duty watch of participating incident commanders. Each participant was fitted with the camera at the start of his or her shift, and it was checked for ease of use and comfort. Watch members, although not direct participants, were briefed on the process and it was established whether or not they were comfortable with being filmed. Only one watch member indicated s/he was not, and alternative arrangements were made for the duration of his/her shift. Each participant was briefed fully on the procedure and gave their informed consent for their participation in accordance with local ethical approval through the School of Psychology, Cardiff University. The two researchers observed the incidents, wearing observer jackets to clearly distinguish themselves from the incident command team. Both were themselves sector competent operational fire officers (group commanders), and experienced incident commanders. At incidents, one researcher observed the incident commander (positioned to minimize disruption to on going activity), and the other observed the scene in general.

An information sheet that outlined the purpose of the study and the intended data usage was provided to anyone (including members of the public) at the incident who might have been captured in the footage. The observation and filming could be stopped at any time at the request of an individual under observation, or operational monitoring officer in attendance, to limit any additional pressure that being observed may present. As both researchers had a dual role as operational fire officers, professional judgement was used and the option was given to cease observation if it was deemed to be affecting the performance of the incident commander. There were no occurrences where it was judged necessary to intervene.

Within 24 hours of each incident, participants took part in a cued recall debrief. This involved having them review the video footage taken from their video cameras. They were asked to recall their thoughts and rationale for various decisions that were made at the time the footage was taken. All footage was stored securely on a drive encrypted with TrueCrypt software (TrueCrypt version 5.1, TrueCrypt Foundation). Footage was transcribed and analysed, and then erased within 30 days.

Results

Coding of Activity

The video footage of the activity of incident commanders was separately coded by the two researchers as indicative of situation assessment (SA), plan formulation (PF) or plan execution (PE). Table 1 summarizes this coding and provides examples of each category. These independently coded categories of activity represent the primary data, and inter-rater reliability checks revealed that the sequences of state transitions were highly reliable across the two coders. Thus, three randomly chosen excerpts of video footage (one from each type of incident; see below) were scored by both researchers and there was > 95% agreement between the sequences of state transitions that were generated. The independent codings were also compared to information provided by participants during the cued-recall interview. In particular, the information provided by participants was used to confirm the correctness of the independent codings. For example, the video footage might show the incident commander verbalizing a rationale for an activity that was coded as plan formulation; and during the interview, they might expand upon their rationale and intended plans, confirming that the independent coding was correct.

To examine the level of situation awareness displayed immediately prior to either plan formulation or plan execution phases, it was coded as: Level 1, which corresponds to the perception of elements of the situation; Level 2, which relates to an understanding of the situation; and Level 3, which involves anticipation of the likely development of the situation (Endsley, 1995). Instances of each level can be seen in Table 1.

Insert Table 1 about here

Data Analysis

To assess whether or not the decision-making activities (i.e., SA, PF, PE) followed the sequence and phases predicted by normative decision models, a lag sequential analysis was conducted, in which the conditional probabilities that SA would be followed by PF (or PE), and PF by PE (or SA) were calculated (Sackett, 1979; see also, O'Connor, 1999). To do so, a criterion position was first designated for all participants. Here, this position was the first phase (SA, PF or PE) that was recorded within the 'In attendance' stage of the incident. This stage is presaged by the incident commander's arrival at the incident. Following this point, coded activity in the form of the three categorised decision phases (i.e., SA, PF, PE) was used to generate a lag sequence of the transitions between the different categories. For example, the lag sequence for the categorised decision phase list: SA, SA, SA, PE, PE, PF, PF, PF SA, PE would be: SA, PE, PF, SA, PE. That is, the lag sequential analysis removes immediate repetition of the same decision phase and provides a trace of the category transitions. The lag sequential analysis ended when the incident commander sent a 'stop message' to fire control, which signals the conclusion of the emergency phase of the incident is imminent.

From these traces, the mean overall conditional probability of one phase being following by another was calculated (i.e. SA to PE or PF; PF to PE or SA; PE to SA or PF). For example, a mean conditional probability of 0.5 for transitions from SA indicates that for a given incident transitions from SA were as likely to be to PF as to PE. The analysis of the overall conditional probabilities of the phase transitions during the incidents was complemented by an analysis of the initial part of the incident: the criterion position and the very first transition from situation assessment. These additional measures are important because it might be predicted that early in an incident there would be more evidence plan formulation than later in the incident; and that pooling the state transitions across the whole incident would underestimate the extent to which situation assessment is followed by plan formulation.

Nature of Incidents

There were 33 incidents captured for analysis that covered a broad range of activity and were separated into three groups:

(1) Those that posed a high degree of risk to either emergency responders or the public, but that were not time critical (High Risk/Time Available). For example, one incident involved a road traffic collision where a car had collided with a lamppost on a dual carriageway, after rolling over several times. The driver of the car was trapped inside the car, but had escaped serious injury. The focus of the operation was to extricate the driver using a 'gold standard' approach, where the maximum amount of space was created so the casualty could be removed on a long board as a precautionary measure, to avoid further damage to their neck or back that might have resulted from the accident. The paramedics in attendance were satisfied that there was no time-critical nature to the casualty's injuries, so there was little time pressure at this incident.

(2) Those that posed great risk and for which urgent action was required to prevent harm or a dangerous escalation of the incident (High Risk/Time pressure). One instance from this group involved a fire in a domestic property, where the incident commander had information to suggest that someone had deliberately been locked inside the burning property. The incident commander had to consider the risk posed to both firefighters that would enter the property and the risk to the person they believed to be trapped. The conditions were rapidly worsening, so the incident commander had little time available to decide which actions would effectively resolve the incident. A second example from this group of incidents was a coach crash on a major motorway during rush hour. There were more than 60 casualties in total at this incident, with some trapped and in a critical condition, who needed to be released for urgent hospital attention.

(3) Those incidents where there was little risk posed, and no time constraints (Low Risk; cf. Alison, Doran, Long, Power, & Humphrey, 2013). For example, during the course of data

collection, the UK experienced severe weather conditions that resulted in serious storm damage. At one incident, there was damage to the roof structure of a building with the result that there were large pieces of metal that might fall. As the area had been closed, there was little risk posed to the public, and the incident commander had plenty of time available to decide how best to remove the damaged pieces and resolve the incident.

Eight of the incident commanders took part in more than one incident. However, as they were different types of incident (such as a house fire and a road traffic collision, rather than two house fires) they were (for the most part) treated as unique episodes for the purpose of the statistical analysis. The total amount of command experience, within their current roles, in the three groups of incidents was similar: High Risk/Time Available (M = 5.45, SEM = 1.61), High Risk/Time Pressure (M = 7.53, SEM = 1.66), and Low Risk (M = 7.89, SEM =1.39). ANOVA showed that there was no significant effect of group ($F < 1$).

Table 2 about here

Lag Sequential Analysis

Overall Results. Figure 1 depicts the mean conditional probabilities for transitions predicted by the normative three-step model (i.e., SA to PF, PF to PE, and PE to SA; black histogram) and the alternative transitions (i.e., SA to PE, PF to SA, and PE to PF; grey histogram). Inspection of this figure reveals that the incidents were most likely to involve transitions from situation assessment to plan execution rather than the predicted sequence of situation assessment to plan formulation. Also, plan formulation was as likely to be followed by plan execution as situation assessment. One-sample t-tests confirmed that: SA to PE transitions were more likely than (and SA to PF less likely than) would be expected by chance (i.e., 0.50), $t(32) = 8.64$, $p <$

0.001, $d = 1.51$. As will become evident in the final section of the results, the nature of these transitions did not correlate with the experience of the incident commanders. PF to PE (and PF to SA) transitions were no more likely than would be expected by chance, $t(26) = 1.21$, $p > 0.23$, $d = -0.47$; but, as we shall see, the nature of these transitions was correlated with the experience of the incident commanders. However, as predicted by the model, PE was more likely to be followed by SA (and less likely to be followed by PF) than would be expected by chance, $t(32) = 10.52$, $p < 0.001$, $d = 1.83$.

The transitions between the three categories occurred in the context of the following mean frequencies of category per incident: SA = 41.45 (SEM = 6.10), PF = 5.51 (SEM = .93), and PE = 17.06 (SEM = 2.25); confirming that many cases plan execution occurred without a preceding phase of plan formulation. ANOVA confirmed that there was a main effect of category, $F(2, 64) = 39.33$, $p < .0001$, $\eta p^2 = .55$, and subsequent tests confirmed that there were more instances of SA than PE and more instances of PE than PF (smallest $t(32) = 5.93$, $p < 0.0001$, $d = .92$). The mean frequencies of the different levels of situation awareness (1, 2 or 3) that preceded transitions from SA to either PF or PE are presented in a separate section below.

The pattern of conditional probabilities was evident when analysis was restricted to the first incidents that were attended by the 23 participants: SA to PE transitions ($M = 0.78$; $SEM = 0.04$) were more likely than would be expected by chance, $t(22) = 6.99$, $p < .005$, $d = 1.46$; PF to PE transitions ($M = 0.41$; $SEM = 0.06$) were no more likely than would be expected by chance, $t(19) = 1.45$, $p > .16$, $d = -.49$; and PE was more likely to be followed by SA ($M = 0.90$; $SEM = 0.02$) than would be expected by chance, $t(22) = 17.10$, $p < .005$, $d = 3.56$.

Insert Figure 1 about here

First Transitions and Criterion Position. The key finding from the preceding analysis of the entire course of the 33 incidents was that SA was more likely to be followed by PE than PF. It is also informative to examine the first transition from SA because this transition might reveal that SA was more likely to be followed by PF at the start of an incident. However, for 27 of the 33 incidents, the first transition from SA was to PE (sign test, $p < 0.001$). Similarly, it is of interest to examine the nature of the criterion position – the first category for the lag-sequential analysis. Across the set of incidents, only one began with PF, and, of the remainder, 19 began with SA and 13 with PE.

Group Level Results. The pattern of results evident in the overall analysis was consistent across the three types of incident. The overall number of phase transitions (of any kind) was somewhat higher in Group High Risk/Time Pressure (n = 11; M = 43.64, SEM = 5.39) than in either group High Risk/Time Available (n = 9; M = 28.00, SEM = 8.30) or group Low Risk (n = 13; M = 27.92, SEM = 11.93). However, an ANOVA revealed that there was no statistically significant difference between the groups ($F < 1$). The results of principal interest, the transitional probabilities for each group, are shown in the upper (from SA), middle (from PF), and lower (from PE) panels of Figure 2. Inspection of these panels reveals that the pattern of results that was evident in the overall results was apparent for each of the three groups. Separate ANOVAs for each of the three state transitions did not reveal any effects of group, largest $F(2, 32) = 2.16$, $p >$ 0.13, $\eta p^2 = .13$. That is, at each type of incident: situation assessment was more likely to be followed by plan execution rather than plan formulation (upper panel). There was little indication that plan formulation was any more often followed by plan execution than further situation assessment (middle panel); with the caveat that the nature of this transition was modulated by the experience of the incident commanders (see final section of the results). Plan execution was more likely to be followed by situation assessment than plan formulation (lower panel). The consistency between the three types of incident is clear. However, it is possible that with a broader range of incidents or with groups of incidents that were more coherent, differences based on type of incident might have been observed.

Insert Figure 2 about here

Levels of Situation Awareness

The results of the lag-sequential analysis show that situation assessment was more likely to be followed by plan execution rather than plan formulation. We also coded the level of situation awareness at each transition from situation assessment: Level 1 (perception), Level 2 (understanding) or Level 3 (anticipation). The left panel of Figure 3 depicts the levels of situation awareness prior to plan formulation and the right panel the corresponding scores for prior to plan execution. The lower frequency of plan formulation than plan execution means that the scores are correspondingly lower in the left panel than in the right panel. However, it is clear in both panels that the mean frequency of Level 3 situation awareness was low. An ANOVA conducted on levels of situation awareness immediately preceding a transition to PF revealed a main effect of level, F (2, 64) = 8.48, $p < 0.005$, $\eta p^2 = .21$. Paired-sample t-tests revealed that SA level 2 was more frequent than both SA level 1 ($t(32) = 3.32$, $p < .005$, $d = 0.69$) and SA level 3 ($t(32) = 3.07$, $p < .005$, $d = 0.58$). A parallel ANOVA conducted on levels of situational awareness immediately preceding a transition to PE revealed a main effect of SA level, F (2, 64) = 9.39, $p < 0.005$, $\eta p^2 = .23$. Paired-sample t tests revealed that SA levels 1 and 2 were more frequent than SA level 3 (smallest $t(32) = 3.66$, $p < .005$, $d = 0.90$). Thus, analysis of the level of situation awareness provided little evidence of nascent planning during situation assessment.

Insert Figure 3 about here

Individual Differences in Experience

There was evidence that the participants' experience in the current role was differently related to the key transitional probabilities (from SA to PF/PE and from PF to PE/SA). While the transition between situation assessment and plan formulation/execution was not related to experience (r = -0.04, p > 0.80), there was a significant correlation between experience (in years) and the transition from plan formulation to plan execution/situation assessment (r = 0.38, p < 0.05); with increases in experience being related to an increased likelihood of plan formulation being followed by plan execution. It is perhaps worth noting that a supplementary analysis revealed that the latter relationship was particularly marked for the High Risk/Time Pressure incidents (r = 0.90, p < 0.005). Thus, the fact that the overall analysis indicated that plan formulation was no more likely to be followed by plan execution than by situation assessment needs to be qualified by the observation that the forms of transition from plan formulation are related to experience.

Discussion

Current operational models in the UK emergency services follow normative models of decision making in making the assumption that decision-making involves three stages: from situation assessment, to plan formulation, and then plan execution. Indeed this approach is embodied in the model currently adopted in National Fire Policy in the UK (CFRAU, 2008), under whose auspices our sample of incident commanders operates. However, the process of decision making at incidents has not been directly investigated or formally characterized in any detail. The pattern of transitions (between situation assessment, plan formulation, and plan execution) that we observed across 33 incidents was inconsistent with the normative three-stage model outlined above. More specifically, situation assessment was most frequently followed by plan execution rather than plan formulation, and plan formulation was no more likely to be followed by plan execution than further situation assessment; with the latter transition being modulated by experience (see below). This pattern of results was surprisingly consistent across incidents that posed quite different challenges (cf. Klein, 1993), with some being relatively straightforward and others involving multiple challenges that could have been addressed through the concurrent use of different strategies. Moreover, a more fine-grained analysis of the levels of situation awareness that proceeded plan execution (or plan formulation) rarely indicated any form of prospection (i.e., anticipating the consequences of an action).

It is important to note that while these findings do not represent an assessment of the effectiveness of the participants at any of the incidents, they do provide clear information about how decision-making unfolds over time at such incidents that complements findings from retrospective interviews (Klein *et al*., 1989). The observation that situation assessment is most often immediately followed by plan execution suggests that particular situational cues might directly prime specific decisions that do not involve (explicit) plan formulation and evaluation, but remain directed towards the objective at hand (i.e., recognition primed decisions; e.g., Klein, 1993). This possibility is clearly related to the idea that situational cues could come to associatively provoke actions previously performed under similar circumstances (see Dickinson, 1980; see also Balleine & Ostlund, 2007; Cohen-Hatton *et al*., 2013). The fact that our participants' experience in their current role did not correlate with the transition from situational assessment to plan execution appears to be inconsistent with these analyses, as is the fact that this transition did not differ across different types of incident. However, because there was little variability in this transitional probability, the lack of a correlation is difficult to interpret. In contrast, there was a relationship between experience and the transition from plan formulation and execution, and it is to this transition that we now turn.

On the relatively few occasions when participants engaged in explicit plan formulation, they were no more likely to implement the plan than to look for additional information. One interpretation of this pattern of results is that it reflects a process of deliberation under conditions of uncertainty (see van den Heuval *et al*., 2012). The observation that experience in the current role was related to plan formulation being immediately followed by plan execution is consistent with this interpretation (cf. Ericsson & Lehmann, 1996). However, it should be noted that this finding does not mean that a greater degree of operational experience equates to better incident command or command decisions. The quality of decision making was not assessed here. The fact remains that in our group of participants plan execution proceeded without plans being deliberately formulated (or options being evaluated), and with little evidence of prospection during situation assessment.

The conclusion of the previous paragraph might appear counterintuitive, if not paradoxical: A role that might appear to be the embodiment of reflective decision making, in practice appears to involve little by way of explicit planning. However, our results do not stand alone in supporting this conclusion. Rake and Njå (2009; see also Klein *et al*., 1989) report the results from extensive, qualitative observations and interviews involving 22 incident commanders about incidents in Norway and Sweden. The overwhelming impression gained from these observations, like those of Klein *et al*. (1989), was that the incident commanders in were not reflective or planful, but rather reflexive and procedural (cf. Klein, 1993). Rake and Njå (2009) also reported the results from interviewing 28 incident commanders about hypothetical scenarios. Under these conditions, these authors concluded that there was more evidence of deliberation. However, such evidence is difficult to interpret and might not be representative of behavior at operational incidents.

In summary, our results indicate that normative models of decision making, upon which the current operational decision models are based (e.g., CFRAU, 2008), do not capture the way in which decisions are made in the incident command operational environment, where reflexive processes operate alongside more reflective ones. Our new results join those of Rake and Njå

(2009) and Klein *et al*. (1989) in suggesting that operational training and guidance needs to recognize and consider the influences of these different processes.

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Biographical Details

Sabrina R. Cohen-Hatton received her PhD from Cardiff University, where she is now an Honorary Research Associate, and she has now moved from the South Wales Fire and Rescue Service to the London Fire Brigade. Phillip C. Butler is employed by London Fire Brigade. Robert C. Honey received his D.Phil. from the University of York, and is a Professor in the School of Psychology at Cardiff University.

Key points:

1. Decision making is central to operational command and yet there is little evidence about how this process unfolds at emergency incidents.
2. This study investigated decision making at a corpus of such incidents and revealed that the structure of decision making was not consistent with normative models that have shaped operational guidance.
3. These findings provide a critical impetus for operational guidance and training to acknowledge the role of both reflective and reflexive processes.

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Table 1: Coding Dictionary

Decision Phase	Incident Command Model Definition	Description	Example
Situation Assessment (SA)	Gathering incident, resource or hazard information.	Acknowledgement of information relating to the environment, surveying scene.	"*No sign of any fire or smoke in the back. The guys across the road says he's not in... the doors are locked. It looks like it's [the houses] back to back.*"
Plan Formulation (PF)	Identification and prioritising objectives, developing tactical plan.	Problem identification, ordering of tasks, planning activities, consideration of rationale.	"*We'll have to keep the smoke there or start evacuating above…if we can't contain it we'll have to get a couple more BA [Breathing Apparatus] in…*"
Plan Execution (PE)	Communicating actions and controlling activity.	Communication of tasks, controlling progress of tasks, setting tempo, changing activities.	"*Turn the PPV [positive pressure ventilation] on and open the windows…*"

Level of Situation Awareness	Model Definition	Description	Example
Level 1	Perception	Description or acknowledgement of elements of the situation.	"*There was smoke issuing*"
Level 2	Understanding	Evidence of understanding what the elements of the situation mean in terms of the overall picture, or making sense of the elements.	"*It's still smoky enough to warrant a BA team down in the basement, plus also the floors are [broken], so I don't really want to. We need to go down there, clear it out.*"
Level 3	Anticipation	Evidence of predicting the likely outcomes of actions, or the likely development of the situation.	"*Even if we break those windows, it's not going to do much [in relation to ventilation]…*"

Table 2: Categories of Incidents Attended

Incident Category	High Risk/Time available	High Risk/Time Pressure	Low Risk
Fire in domestic property	3	2	5
Fire on other domestic property	0	1	0
Fire in commercial property	0	4	1
Other fire	1	0	2
Road traffic collision	3	3	1
Other rescue	1	1	2
Animal rescue	0	0	1
Dangerous structure	1	0	1
TOTAL	**9**	**11**	**13**

Figure legends

Figure 1. Lag sequential analysis: Overall results. Mean (+SEM) conditional probabilities of transition from situation assessment (SA to PF or PE; left pair of bars); from plan formulation (PF to PE or SA; central pair of bars); and from plan execution (PE to SA or PF; right pair of bars). Note: The sum of the mean conditional probabilities for each pair of transitions is 1 for transitions from SA and from PE. However, because there were several incidents where no transitions from PF occurred, the sum of the mean conditional probabilities is less than one in the case of PF.

Figure 2. Lag sequential analysis: Group level results. Mean (+SEM) conditional probabilities: of transitions from situation assessment (SA) to PF or PE (upper panel); from plan formulation (PF) to PE or SA (middle panel); and from plan execution (PE) to SA or PF (lower panel). With the results separated by group: High Risk/Time Available (HR/TA; left pairs of bars), High Risk/Time Pressure (HR/TP; central pairs of bars), and Low Risk (LR; right pairs of bars). Note: As in Figure 1, the sum of the mean conditional probabilities for each pair of transitions is 1 for transitions from SA and from PE. However, because there were several incidents where no transitions from PF occurred, the sum of the mean conditional probabilities is less than one in the case of PF.

Figure 3. Levels of situation awareness during situation assessment: Mean frequencies (+SEM) of level 1 (perception), level 2 (understanding) and level 3 (anticipation) immediately preceding plan formulation (left panel) and plan execution (right panel).

Figure 1

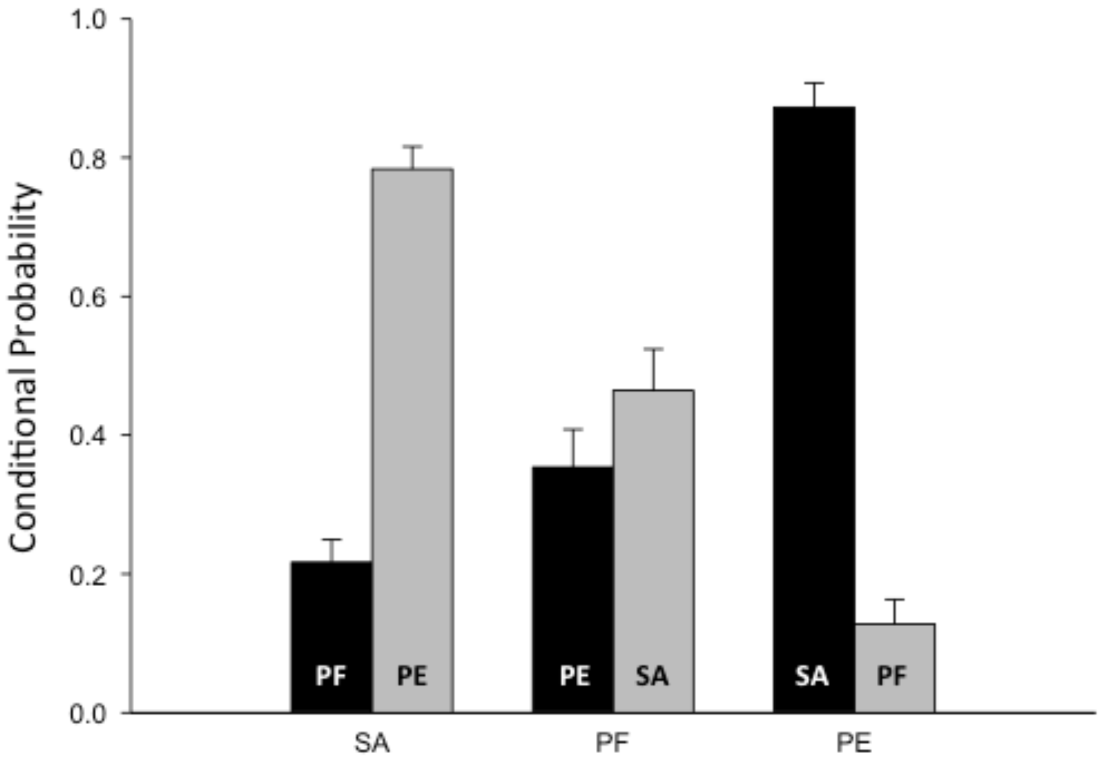
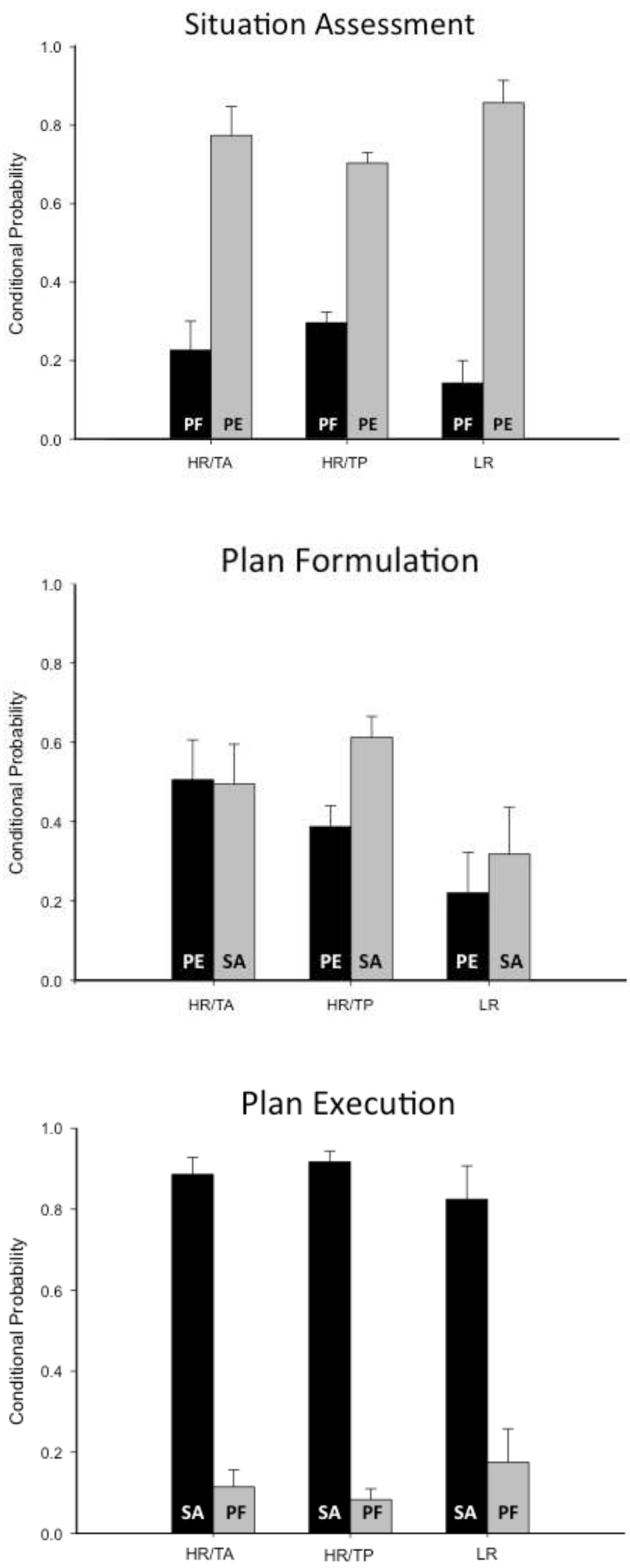
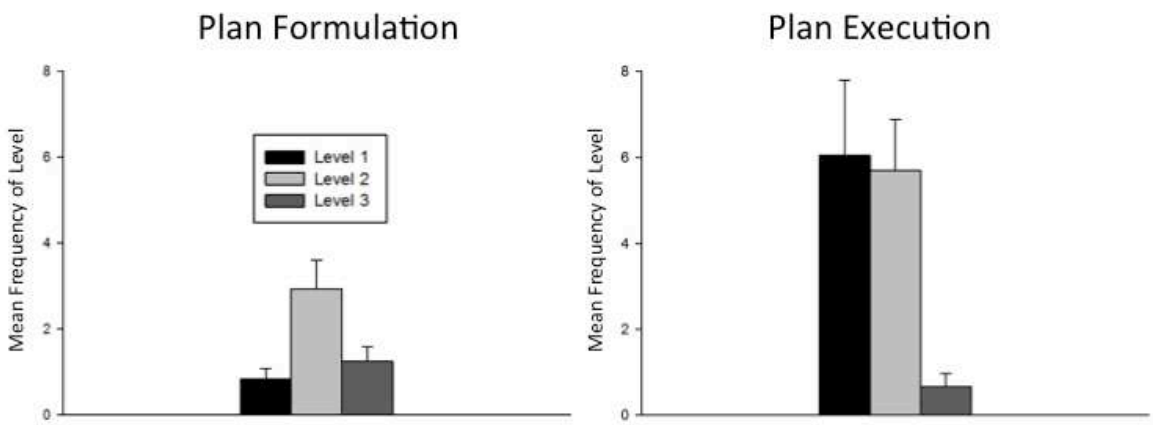

Conditional Probability
1.0
0.8
0.6
0.4
0.2
0.0
PF
PE
PE
SA
SA
PF
SA
PF
PE

Figure 2



Situation Assessment
Conditional Probability
1.0
0.8
0.6
0.4
0.2
0.0
PF
PE
HR/TA
HR/TP
LR
Plan Formulation
Conditional Probability
PE
SA
HR/TA
HR/TP
LR
Plan Execution
Conditional Probability
SA
PF
HR/TA
HR/TP
LR

Figure 3


Plan Formulation
Plan Execution
Mean Frequency of Level
Mean Frequency of Level
Level 1
Level 2
Level 3
0
2
4
6
8