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

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5 Sabrina R. Cohen-Hatton<sup>1, 2, 3</sup>, P.C. Butler<sup>4</sup> and R.C. Honey<sup>1</sup>

6 <sup>1</sup>Cardiff University, <sup>2</sup>Chief Fire and Rescue Officer Association,

7 <sup>3</sup>South Wales Fire and Rescue Service, <sup>4</sup>London Fire Brigade

8  
9  
10 Précis

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

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16 Running head: Incident Command

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18  
19 *Word count:* Introduction (1283), Method (729), Results (2528), and Discussion (821) = 5361

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21  
22 Revision submitted in December 2014 to: *Human Factors*

23

## Abstract

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

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

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

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

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

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

45 *Keywords:* dynamic decision making, emergency services, operational models

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

#### 64 Reflective Models of Operational Decision-making

65 Dewey (1933) argued that when people solve problems, they do so in an analytical and  
66 rational way, that proceeds according to an orderly sequence of phases. These ideas are echoed in  
67 normative models of decision-making that typically identify three key phases: Situation  
68 assessment (SA), plan formulation (PF) and plan execution (PE; e.g., Lipshitz & Bar-Ilan, 1996;  
69 van den Heuvel, Alison & Power, 2011). This type of model represents one perspective that has  
70 been taken in studies involving the emergency services, including the Police (van den Heuvel *et*

71 *al.*, 2011) and at major incidents requiring a multi-agency response (House, Power & Alison,  
72 2013). The normative three-phase model can also be identified within the current decision model  
73 adopted in the Fire and Rescue Services Incident Command System in the UK (CFRAU, 2008).  
74 In situation assessment, the decision maker forms an understanding of the situation by considering  
75 the information, cues and clues available to them. The result of this phase provides the foundation  
76 of the planning process, and consists of both understanding and a projection of the situation into  
77 the future (Endsley, 1995). For example, fire incident commanders are expected to gather  
78 information that is relevant to the incident, resources, and hazards, in order to inform the selection  
79 of the appropriate course of action. The plan formulation phase includes identifying the problem  
80 or problems and generating possible solutions, and the selection of an appropriate course of action.  
81 Here, fire incident commanders are expected to identify objectives and develop a tactical plan  
82 where suitable actions are selected and planned. The final phase of plan execution involves the  
83 implementation of the plan. For fire incident commanders, selected actions are communicated to  
84 those who will implement them, and subsequent activity is controlled by the incident commander  
85 to ensure that it is carried out appropriately and effectively. However, the fact that the normative  
86 model is embedded within training and operational guidance need not mean that it represents how  
87 decisions are made in practice.

#### 88 Reflexive Components of Decision Making

89 It has been argued that normative models of decision making, like those outlined above, do  
90 not capture how decisions are often made (Klein, 1993). In addition, decisions can involve the use  
91 of heuristics including those based upon previous experience (e.g., Gigerenzer, 2007; Shafir, 1994;  
92 Tversky and Kahneman, 1979). Also, cues in the environment can activate or prime knowledge  
93 structures (schemas) that include actions, goals and expectancies previously related to that or  
94 similar environments (e.g., recognition-primed decision making; Klein, 1993). In such cases,  
95 options are not evaluated against one another, but rather the decision to act might be one that is

96 deemed, by the decision maker, to be satisfactory rather than optimal (e.g., Abernathy & Hamm,  
97 1993; Klein, 1993, 2003). Alternatively, the basis for an action might be more reflexive and  
98 automatic, affected by previously established associations that have developed between situational  
99 cues, actions and outcomes (e.g., Doya, 2008). The generality of such acquired (associative)  
100 influences and the variety of ways in which they can affect behavior suggests that they could exert  
101 a powerful influence over incident command at operational environments (e.g., Balleine &  
102 Ostlund, 2007; Cohen-Hatton, George, Haddon & Honey, 2013; Dickinson, 1980). These more  
103 reflexive, procedural influences might or might not be appropriate to the given operational  
104 environment.

105         The principal aim of the present study was to investigate the basis of decisions made at a  
106 range of incidents responded to by the UK Fire and Rescue Service. To do so, the unfolding  
107 activities of incident commanders were observed, video-recorded and then independently coded as  
108 reflecting situation assessment (SA), plan formulation (PF), and plan execution (PE). The  
109 transitions between categories were used to investigate whether decision making was based upon  
110 reflective, normative processes in which case SA should be followed by PF and then PE, or more  
111 reflexive processes, where SA is followed immediately by PE (cf. Sacket, 1979). The results of a  
112 previous study of fire incident commanders, using retrospective interviews, suggested that officers  
113 do not evaluate alternative courses of action, but appeared to be reacting on the basis of prior  
114 experience, and choosing a satisfactory course of action (Klein, Calderwood & MacGregor, 1989;  
115 see also, Klein, 1998). Although the completeness of such recollections can be limited (Omodei  
116 & McLennan, 1994), it can be improved (in simulated exercises) by using first-person footage  
117 from helmet-mounted video cameras with fire officers (McLennan, Omodei, Rich & Wearing,  
118 1997; see also, Omodei, McLennan & Wearing, 2005; Omodei, McLennan & Whitford, 1998).  
119 Here, the independent codings of video footage were coupled with information from a subsequent  
120 interview, in which the recall of the incident by the commander was assisted by the presentation of

121 the original footage. To provide an assessment of any nascent plan formulation during situation  
122 assessment, a supplementary analysis examined the level of situational awareness displayed  
123 immediately prior to either plan formulation or plan execution phases (Endsley, 1995). In this  
124 analysis, SA was coded as: Level 1, which corresponds to perception of elements of the situation;  
125 Level 2, which relates to an understanding of the situation; and Level 3, which involves  
126 anticipation of the likely development of the situation, and might serve as further evidence of  
127 planning.

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

## 141 Method

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

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

150 Participants completed a questionnaire relating to their previous operational exposure.  
151 This questionnaire was designed to identify how long each participant had spent in operational  
152 command positions. The mean overall command experience was 13.77 years ( $SEM = 1.11$ ; range:  
153 1.25-22.4 years). There were 2 officers with less than 5 years of experience, 6 with 5-10 years  
154 inclusive, 7 with 11-15 years inclusive, 4 with 16-20 inclusive, and 4 with  $> 20$  years. The mean  
155 command experience in the current position was 7.10 years ( $SEM = 0.87$ ; range: 0.08-18 years).  
156 There were 8 officers with less than 5 years of experience, 9 with 5-10 years inclusive, 5 with 11-  
157 15 years inclusive, 1 with 16-20 inclusive, and no officers with more than 20 years of experience.

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

164 *Procedure.* The six Fire and Rescue Services nominated stations that were likely to  
165 respond to a range of incidents. All incident commanders at these stations were invited to  
166 participate in this research, and all volunteered to take part. The researchers (SRC-H and PCB)  
167 spent six consecutive 24-hour periods at each Fire and Rescue Service, and were located with the  
168 duty watch of participating incident commanders. Each participant was fitted with the camera at



169 the start of his or her shift, and it was checked for ease of use and comfort. Watch members,  
170 although not direct participants, were briefed on the process and it was established whether or not  
171 they were comfortable with being filmed. Only one watch member indicated s/he was not, and  
172 alternative arrangements were made for the duration of his/her shift. Each participant was briefed  
173 fully on the procedure and gave their informed consent for their participation in accordance with  
174 local ethical approval through the School of Psychology, Cardiff University. The two researchers  
175 observed the incidents, wearing observer jackets to clearly distinguish themselves from the  
176 incident command team. Both were themselves sector competent operational fire officers (group  
177 commanders), and experienced incident commanders. At incidents, one researcher observed the  
178 incident commander (positioned to minimize disruption to on going activity), and the other  
179 observed the scene in general.

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

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

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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.

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Insert Table 1 about here

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219 Data Analysis

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

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

244 Nature of Incidents

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

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

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

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

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

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

280 \_\_\_\_\_  
281 Table 2 about here  
282 \_\_\_\_\_

### 283 Lag Sequential Analysis

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

292 0.001,  $d = 1.51$ . As will become evident in the final section of the results, the nature of these  
293 transitions did not correlate with the experience of the incident commanders. PF to PE (and PF to  
294 SA) transitions were no more likely than would be expected by chance,  $t(26) = 1.21, p > 0.23, d =$   
295  $-0.47$ ; but, as we shall see, the nature of these transitions was correlated with the experience of the  
296 incident commanders. However, as predicted by the model, PE was more likely to be followed by  
297 SA (and less likely to be followed by PF) than would be expected by chance,  $t(32) = 10.52, p <$   
298  $0.001, d = 1.83$ .

299         The transitions between the three categories occurred in the context of the following mean  
300 frequencies of category per incident: SA = 41.45 (SEM = 6.10), PF = 5.51 (SEM = .93), and PE =  
301 17.06 (SEM = 2.25); confirming that many cases plan execution occurred without a preceding  
302 phase of plan formulation. ANOVA confirmed that there was a main effect of category,  $F(2, 64)$   
303  $= 39.33, p < .0001, \eta^2 = .55$ , and subsequent tests confirmed that there were more instances of  
304 SA than PE and more instances of PE than PF (smallest  $t(32) = 5.93, p < 0.0001, d = .92$ ). The  
305 mean frequencies of the different levels of situation awareness (1, 2 or 3) that preceded transitions  
306 from SA to either PF or PE are presented in a separate section below.

307         The pattern of conditional probabilities was evident when analysis was restricted to the  
308 first incidents that were attended by the 23 participants: SA to PE transitions ( $M = 0.78; SEM =$   
309  $0.04$ ) were more likely than would be expected by chance,  $t(22) = 6.99, p < .005, d = 1.46$ ; PF to  
310 PE transitions ( $M = 0.41; SEM = 0.06$ ) were no more likely than would be expected by chance,  
311  $t(19) = 1.45, p > .16, d = -.49$ ; and PE was more likely to be followed by SA ( $M = 0.90; SEM =$   
312  $0.02$ ) than would be expected by chance,  $t(22) = 17.10, p < .005, d = 3.56$ .

313

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Insert Figure 1 about here

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316

317            *First Transitions and Criterion Position.* The key finding from the preceding analysis of  
318 the entire course of the 33 incidents was that SA was more likely to be followed by PE than PF. It  
319 is also informative to examine the first transition from SA because this transition might reveal that  
320 SA was more likely to be followed by PF at the start of an incident. However, for 27 of the 33  
321 incidents, the first transition from SA was to PE (sign test,  $p < 0.001$ ). Similarly, it is of interest to  
322 examine the nature of the criterion position – the first category for the lag-sequential analysis.  
323 Across the set of incidents, only one began with PF, and, of the remainder, 19 began with SA and  
324 13 with PE.

325            *Group Level Results.* The pattern of results evident in the overall analysis was consistent  
326 across the three types of incident. The overall number of phase transitions (of any kind) was  
327 somewhat higher in Group High Risk/Time Pressure ( $n = 11$ ;  $M = 43.64$ ,  $SEM = 5.39$ ) than in  
328 either group High Risk/Time Available ( $n = 9$ ;  $M = 28.00$ ,  $SEM = 8.30$ ) or group Low Risk ( $n =$   
329  $13$ ;  $M = 27.92$ ,  $SEM = 11.93$ ). However, an ANOVA revealed that there was no statistically  
330 significant difference between the groups ( $F < 1$ ). The results of principal interest, the transitional  
331 probabilities for each group, are shown in the upper (from SA), middle (from PF), and lower  
332 (from PE) panels of Figure 2. Inspection of these panels reveals that the pattern of results that was  
333 evident in the overall results was apparent for each of the three groups. Separate ANOVAs for  
334 each of the three state transitions did not reveal any effects of group, largest  $F(2, 32) = 2.16$ ,  $p >$   
335  $0.13$ ,  $\eta p^2 = .13$ . That is, at each type of incident: situation assessment was more likely to be  
336 followed by plan execution rather than plan formulation (upper panel). There was little indication  
337 that plan formulation was any more often followed by plan execution than further situation  
338 assessment (middle panel); with the caveat that the nature of this transition was modulated by the  
339 experience of the incident commanders (see final section of the results). Plan execution was more  
340 likely to be followed by situation assessment than plan formulation (lower panel). The  
341 consistency between the three types of incident is clear. However, it is possible that with a

342 broader range of incidents or with groups of incidents that were more coherent, differences based  
343 on type of incident might have been observed.

344

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Insert Figure 2 about here

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346

347 Levels of Situation Awareness

348 The results of the lag-sequential analysis show that situation assessment was more likely to  
349 be followed by plan execution rather than plan formulation. We also coded the level of situation  
350 awareness at each transition from situation assessment: Level 1 (perception), Level 2  
351 (understanding) or Level 3 (anticipation). The left panel of Figure 3 depicts the levels of situation  
352 awareness prior to plan formulation and the right panel the corresponding scores for prior to plan  
353 execution. The lower frequency of plan formulation than plan execution means that the scores are  
354 correspondingly lower in the left panel than in the right panel. However, it is clear in both panels  
355 that the mean frequency of Level 3 situation awareness was low. An ANOVA conducted on  
356 levels of situation awareness immediately preceding a transition to PF revealed a main effect of  
357 level,  $F(2, 64) = 8.48, p < 0.005, \eta^2 = .21$ . Paired-sample  $t$ -tests revealed that SA level 2 was  
358 more frequent than both SA level 1 ( $t(32) = 3.32, p < .005, d = 0.69$ ) and SA level 3 ( $t(32) = 3.07,$   
359  $p < .005, d = 0.58$ ). A parallel ANOVA conducted on levels of situational awareness immediately  
360 preceding a transition to PE revealed a main effect of SA level,  $F(2, 64) = 9.39, p < 0.005, \eta^2 =$   
361  $.23$ . Paired-sample  $t$  tests revealed that SA levels 1 and 2 were more frequent than SA level 3  
362 (smallest  $t(32) = 3.66, p < .005, d = 0.90$ ). Thus, analysis of the level of situation awareness  
363 provided little evidence of nascent planning during situation assessment.

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Insert Figure 3 about here

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366



## 367 Individual Differences in Experience

368           There was evidence that the participants' experience in the current role was differently  
369 related to the key transitional probabilities (from SA to PF/PE and from PF to PE/SA). While the  
370 transition between situation assessment and plan formulation/execution was not related to  
371 experience ( $r = -0.04, p > 0.80$ ), there was a significant correlation between experience (in years)  
372 and the transition from plan formulation to plan execution/situation assessment ( $r = 0.38, p <$   
373  $0.05$ ); with increases in experience being related to an increased likelihood of plan formulation  
374 being followed by plan execution. It is perhaps worth noting that a supplementary analysis  
375 revealed that the latter relationship was particularly marked for the High Risk/Time Pressure  
376 incidents ( $r = 0.90, p < 0.005$ ). Thus, the fact that the overall analysis indicated that plan  
377 formulation was no more likely to be followed by plan execution than by situation assessment  
378 needs to be qualified by the observation that the forms of transition from plan formulation are  
379 related to experience.

## 380 Discussion

381           Current operational models in the UK emergency services follow normative models of  
382 decision making in making the assumption that decision-making involves three stages: from  
383 situation assessment, to plan formulation, and then plan execution. Indeed this approach is  
384 embodied in the model currently adopted in National Fire Policy in the UK (CFRAU, 2008),  
385 under whose auspices our sample of incident commanders operates. However, the process of  
386 decision making at incidents has not been directly investigated or formally characterized in any  
387 detail. The pattern of transitions (between situation assessment, plan formulation, and plan  
388 execution) that we observed across 33 incidents was inconsistent with the normative three-stage  
389 model outlined above. More specifically, situation assessment was most frequently followed by  
390 plan execution rather than plan formulation, and plan formulation was no more likely to be

391 followed by plan execution than further situation assessment; with the latter transition being  
392 modulated by experience (see below). This pattern of results was surprisingly consistent across  
393 incidents that posed quite different challenges (cf. Klein, 1993), with some being relatively  
394 straightforward and others involving multiple challenges that could have been addressed through  
395 the concurrent use of different strategies. Moreover, a more fine-grained analysis of the levels of  
396 situation awareness that preceded plan execution (or plan formulation) rarely indicated any form  
397 of prospection (i.e., anticipating the consequences of an action).

398         It is important to note that while these findings do not represent an assessment of the  
399 effectiveness of the participants at any of the incidents, they do provide clear information about  
400 how decision-making unfolds over time at such incidents that complements findings from  
401 retrospective interviews (Klein *et al.*, 1989). The observation that situation assessment is most  
402 often immediately followed by plan execution suggests that particular situational cues might  
403 directly prime specific decisions that do not involve (explicit) plan formulation and evaluation, but  
404 remain directed towards the objective at hand (i.e., recognition primed decisions; e.g., Klein,  
405 1993). This possibility is clearly related to the idea that situational cues could come to  
406 associatively provoke actions previously performed under similar circumstances (see Dickinson,  
407 1980; see also Balleine & Ostlund, 2007; Cohen-Hatton *et al.*, 2013). The fact that our  
408 participants' experience in their current role did not correlate with the transition from situational  
409 assessment to plan execution appears to be inconsistent with these analyses, as is the fact that this  
410 transition did not differ across different types of incident. However, because there was little  
411 variability in this transitional probability, the lack of a correlation is difficult to interpret. In  
412 contrast, there was a relationship between experience and the transition from plan formulation and  
413 execution, and it is to this transition that we now turn.

414         On the relatively few occasions when participants engaged in explicit plan formulation,  
415 they were no more likely to implement the plan than to look for additional information. One

416 interpretation of this pattern of results is that it reflects a process of deliberation under conditions  
417 of uncertainty (see van den Heuval *et al.*, 2012). The observation that experience in the current  
418 role was related to plan formulation being immediately followed by plan execution is consistent  
419 with this interpretation (cf. Ericsson & Lehmann, 1996). However, it should be noted that this  
420 finding does not mean that a greater degree of operational experience equates to better incident  
421 command or command decisions. The quality of decision making was not assessed here. The fact  
422 remains that in our group of participants plan execution proceeded without plans being  
423 deliberately formulated (or options being evaluated), and with little evidence of prospection during  
424 situation assessment.

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

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

441 (2009) and Klein *et al.* (1989) in suggesting that operational training and guidance needs to  
442 recognize and consider the influences of these different processes.

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#### Author note

Correspondence should be addressed to either S.R. Cohen-Hatton or R.C. Honey, School of Psychology, Cardiff University, Tower Building, Park Place, Cardiff CF10 3AT, UK; Phone: +29 20875868, Fax: +29 20874858, Email: [cohensr@cardiff.ac.uk](mailto:cohensr@cardiff.ac.uk) or [Honey@cardiff.ac.uk](mailto:Honey@cardiff.ac.uk).

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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.

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Key points:

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1. Decision making is central to operational command and yet there is little evidence about how this process unfolds at emergency incidents.

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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.

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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.	<i>“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.”</i>
Plan Formulation (PF)	Identification and prioritising objectives, developing tactical plan.	Problem identification, ordering of tasks, planning activities, consideration of rationale.	<i>“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...”</i>
Plan Execution (PE)	Communicating actions and controlling activity..	Communication of tasks, controlling progress of tasks, setting tempo, changing activities.	<i>“Turn the PPV [positive pressure ventilation] on and open the windows...”</i>
Level of Situation Awareness	Model Definition	Description	Example
Level 1	Perception	Description or acknowledgement of elements of the situation.	<i>“There was smoke issuing”</i>
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.	<i>“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.”</i>
Level 3	Anticipation	Evidence of predicting the likely outcomes of actions, or the likely development of the situation.	<i>“Even if we break those windows, it's not going to do much [in relation to ventilation]...”</i>

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Table 2: Categories of Incidents Attended

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550	Incident Category	High Risk/Time available	High Risk/Time Pressure	Low Risk
551				
552	Fire in domestic property	3	2	5
553	Fire on other domestic property	0	1	0
554	Fire in commercial property	0	4	1
555	Other fire	1	0	2
556	Road traffic collision	3	3	1
557	Other rescue	1	1	2
558	Animal rescue	0	0	1
559	Dangerous structure	1	0	1
560				
561	<b>TOTAL</b>	<b>9</b>	<b>11</b>	<b>13</b>

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## Figure legends

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

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

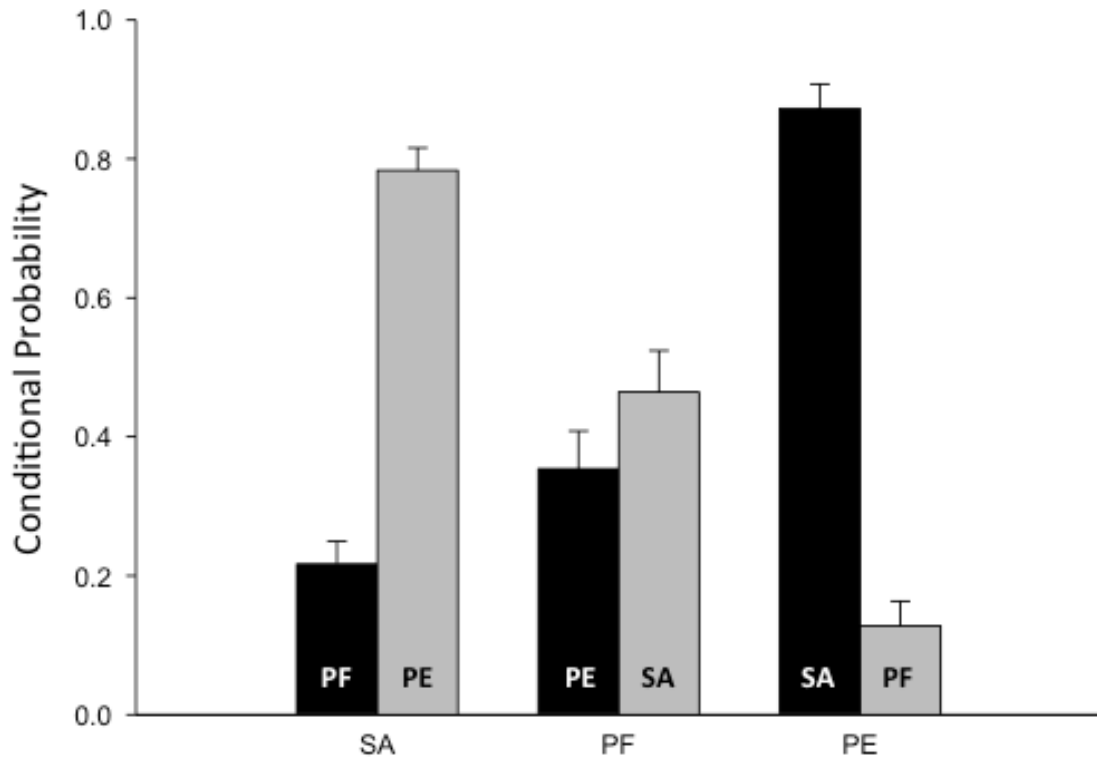
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587 *Figure 3.* Levels of situation awareness during situation assessment: Mean frequencies (+SEM) of  
588 level 1 (perception), level 2 (understanding) and level 3 (anticipation) immediately preceding plan  
589 formulation (left panel) and plan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

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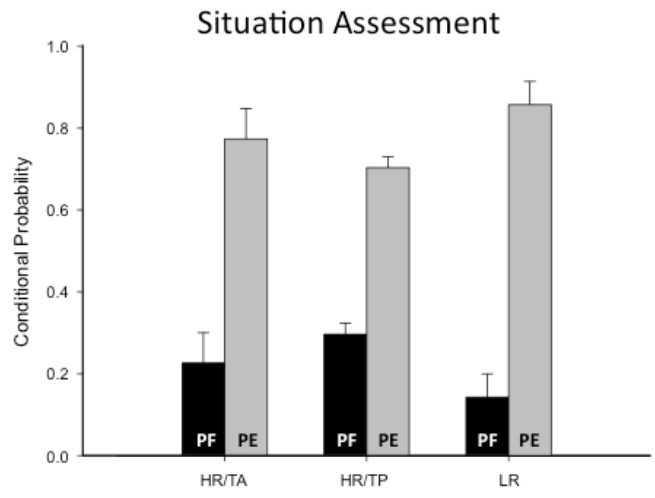
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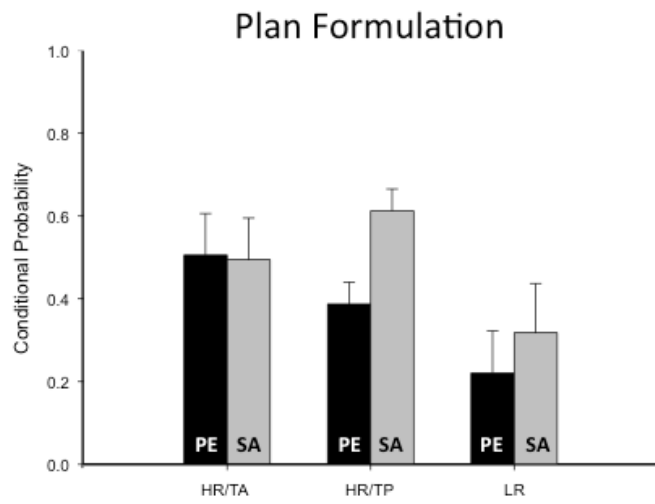


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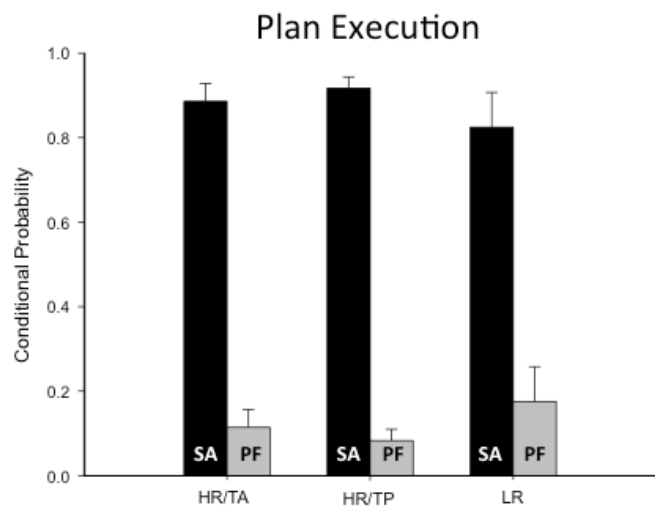
Figure 2



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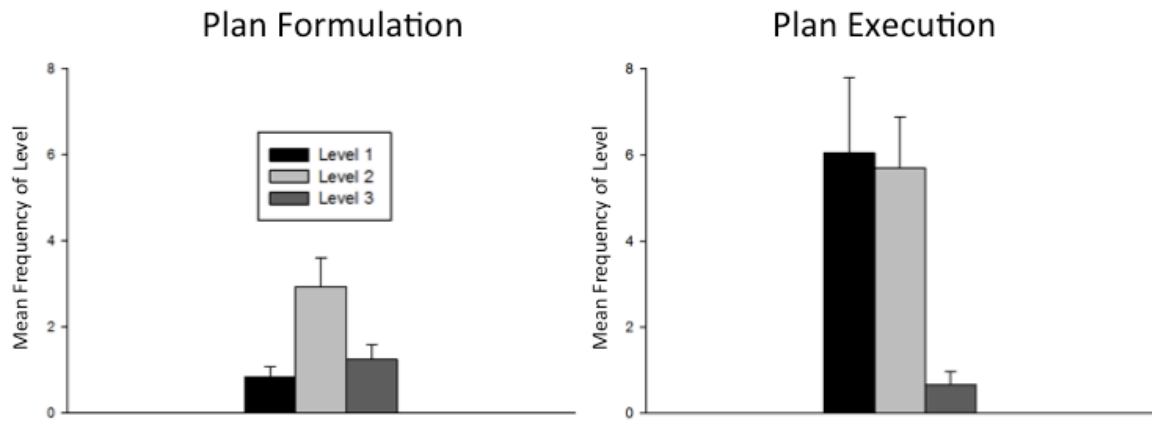
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Figure 3



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