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

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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.

Insert Table 1 about here

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

Insert Figure 1 about here

314

315

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

Insert Figure 2 about here

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.

364

Insert Figure 3 about here

365

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

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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

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

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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.

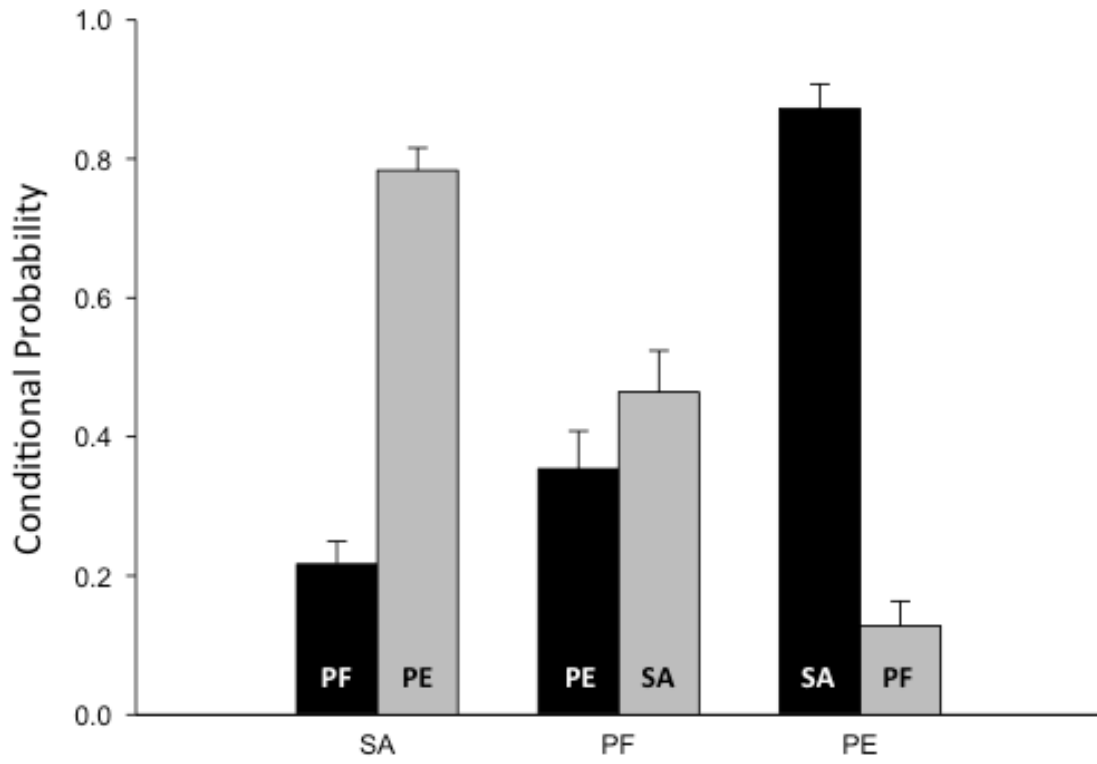
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587 *Figure 3.* Levels of situation awareness during situation assessment: Mean frequencies (+SEM) of
588 level 1 (perception), level 2 (understanding) and level 3 (anticipation) immediately preceding plan
589 formulation (left panel) and plan execution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

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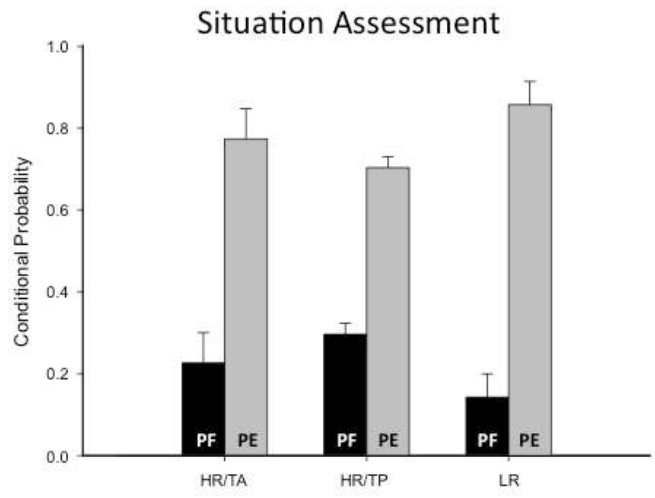
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Figure 1

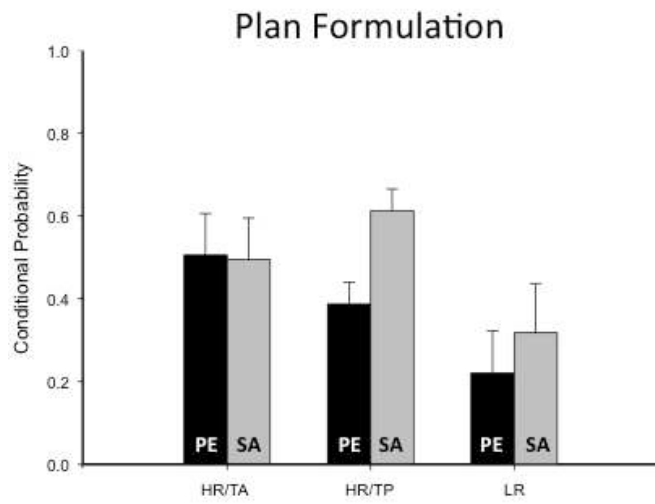


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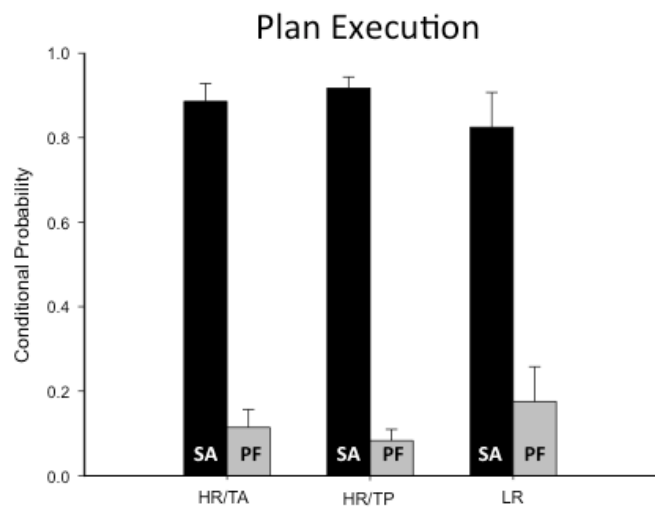
Figure 2



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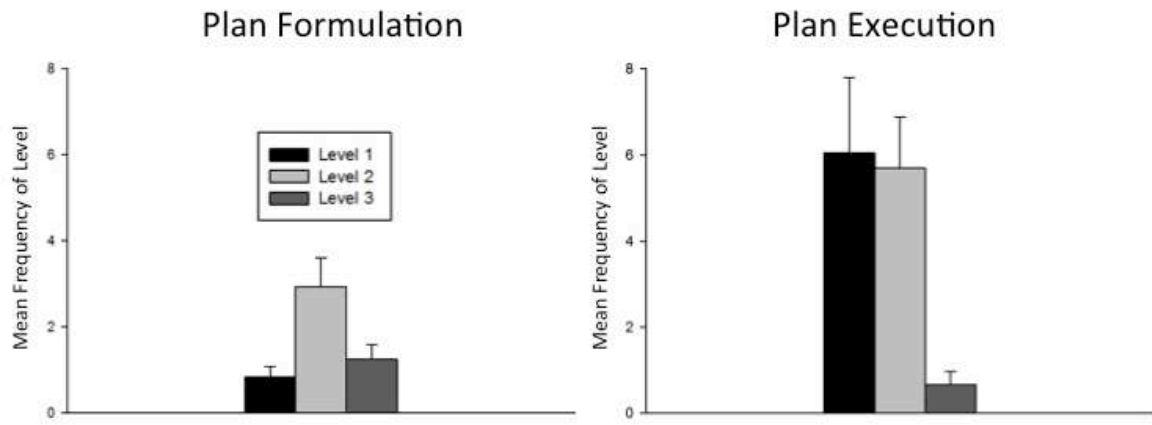
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Figure 3



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