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Effect of stress on safety-critical behaviour: An examination of combined resilience engineering and naturalistic decision-making approaches

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Abstract

Combining the conceptual tools and methods of resilience engineering (RE) with naturalistic decision-making (NDM), in the context of police critical incident command, this study explores the capacity of individual commanders to manage occupational stress during a critical incident or crisis. A case scenario and interviews, together with cognitive task analysis (CTA), are used to investigate how stress affects decision making and performance. The analysis shows: (1) As a social process, sensemaking goes beyond an individual's cognitive capacity. It depends on teams and involves collaboration, sharing and assessing risks and uncertainties. (2) In terms of improvisation, decision-making requires organisational support in training and authorisation. (3) The mechanisms that ensure the synchronisation of activities link to an operational communication strategy grounded on transparency and trust between the parties involved. (4) Individual adaptive capacity also has organisational characteristics. It improves by facilitating and stimulating proactive learning across the organisation. Bringing RE and NDM together, clarifies interdependencies. Thus, the gap between the organisational system and the individual's performance might be closed, which improves performances at the sharp end by a feedback loop that reconciles bottom-up and top-down views.

KEYWORDS
coping capacity, decision-making, occupational stress, resilience engineering, sense making, uncertainty

1 | INTRODUCTION

Combining the conceptual tools and methods of resilience engineering (RE), the domain of organisations, with naturalistic decision-making (NDM), the province of the individual, in the context of police critical incident command, this study explores the capacity of individual commanders to manage occupational stress during a critical incident or crisis. Stress has been labelled as a difficult and often confusing subject (J.

Driskell & Salas, 2013). Many researchers have focused on identifying multiple sources of stress, particularly occupational stress in the working environment, and its impacts. Some emphasise that the work environment acts as a stressor (Cooper & Marshall, 2013), others propose that stress results from an individual's response to a stressor (Lazarus & Folkman, 1984; Nisar & Rasheed, 2020; Selye, 2013). These stressors are caused by some sort of threat, such as work overload or disagreement and conflict in the environment. Dealing with threats in highly dynamic

scenarios in emergency response operations (ERO) can impose a high degree of stress. Coping with such contexts requires alternative approaches that are suitable for addressing the dynamics of EROs. In this setting, resilience and its engineering (design) in systems (commonly known as resilience engineering [RE]) have been acknowledged as proactively capable of managing risk and performance in highly complex and dynamic environments (Chuang et al., 2020; Dekker, 2006; Patriarca et al., 2018).

Research in the RE field focuses mainly on the organisational and functional level (the blunt end), although resilient performance results manifest at sharp ends and on an individual level. From an operational perspective, affirming resilience in any safety-critical operations is done with scenarios (Mendonça, 2008). Several empirical studies have explored how RE tools and concepts enhance the ability of emergency managers (Son et al., 2020; Steen, Patriarca, et al., 2021), police officers (Taylor, 2020), prison's performance management systems (Steen, Ingvaldsen, et al., 2021) or physicians (Fairbanks et al., 2014) to deal with complex situations, make decisions and prioritise actions. These studies use a systemic perspective and RE's analytical methods to enhance adaptive practices in EROs and thus the ability to deal with risks and vulnerabilities.

Bergström et al. (2015), however, are cautious about having high expectations regarding front-line operators' ability to estimate inherent risk and vulnerability, especially when trying to achieve conflicting goals. The individual's cognitive ability is vital when balancing multiple goals—the so-called trade-off adaption (Hollnagel, 2009, p.141; Woods, 2018). This ability is about extracting cues from the environment and adopting specific strategies to deal with the immediate threat level. To this end, the NDM research paradigm (Klein, 2018; Klein & Jarosz, 2011; Lipshitz & Strauss, 1997; Zsambok, 1997) offers a series of concepts, tools and models that can enhance sharp-end operators' adaptive capacity. The recognition-primed decision-making (RPD) model (Klein et al., 1986) is one of the main approaches in the NDM field and is applied to study how professionals make decisions in the operational setting. RPD focuses on the individual level—on the experts who make decisions in challenging environments (the sharp end). However, an ERO hinges on *teamwork*. In this regard, Salas et al. (1993) point to 'dual tasking' in studying team performance, that is, considering both individual tasks and team tasks (e.g., communicating and coordinating). Nonetheless, the RPD model does not cover the team aspect and its influence on individual decision-making.

These scientific perspectives (RE and NDM) offer valuable tools and concepts for enhancing EROs. However, both also have limitations. This study aims to investigate how integrating the NDM and RE fields enhances individuals' (e.g., critical incident commanders') cognitive skills, helping them make better choices and operate more safely in challenging circumstances. The research question is: *How does the application of RE and NDM together affect the capacity to deal with stress, thus promoting safe performance at the sharp end?*

This study is an interdisciplinary research endeavour. The methodology is an exploratory qualitative research approach based on the cognitive task analysis, which relies on multiple data sources, including semi-structured interviews and ethnographic research. This study's contribution to the existing literature is twofold: (1) The application of the principles of RE to an individual level, contributes to the RE concept's increased practical relevance in a safety-critical context. (2) The development of a structure to understand and analyse safety-critical behaviour and resilience's related features and the role of intuitive 'pattern-matching' in a unified approach, which connects the fields of NDM and safety management.

2 | THEORETICAL BACKGROUND

This section focuses on studies related to stress, RE and NDM to provide a conceptual framework to study the effect of stress on safety-critical behaviour.

2.1 | Occupational stress as a concept

Occupational stress (hereafter stress) is a multivariate process involving sources of pressure, psycho-physiological distress, lack of control, work dissatisfaction, depression, anxiety, mental health disorders, hopelessness and suicide ideation (Iliceto et al., 2013). According to Beehr (2014, p.11), the core of stress experienced is the presumed causal relationship between characteristics of the work or workplace (stressor) and poor employee health (strain). Furthermore, several researchers emphasise the effect of uncertainty on stressful experiences (for a review, see Archy et al., 2016). For this study, we adopt the following definition of stress proposed by Steen (2019): 'Stress is a two-dimensional combination of threat appraisal and coping capacity, associated with uncertainty. Stress, in its functional form, is formulated:

$$\text{Stress} = f\,(Th, Cc, U).$$

where T_h represents the threat, C_C represents coping capacity, and U represents the uncertainty about the magnitude of the threat and the existing ability to cope with it. Stress, in other words, depends on the individual's appraisal of a situation, given current coping capacities, which has a mediating effect on stress (Figure 1).

The threat element is related to organisational factors (e.g., organisational structure and role clarification, imprecision and ambiguity in policies and procedures and management-autonomy) and work activities (e.g., environmental interruptions or disturbances, interpersonal conflict at work, heavy workload, role ambiguity, and
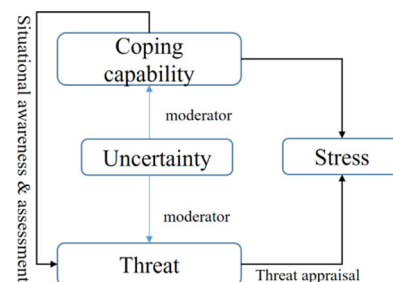

FIGURE 1 Stress as a combination of threat appraisal and coping capacity, associated with uncertainty
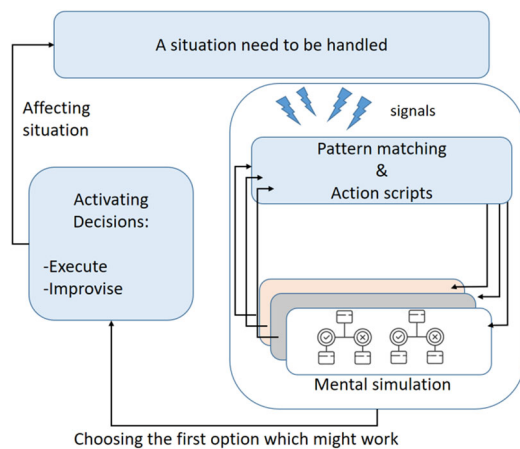
FIGURE 2 Main components of the RPD model, based on Klein (2008)

the complexity of incident situations). It is also related to the socially related factors at work (e.g., conflict, unfriendly attitudes among officers and leaders and lack of support from leaders or colleagues). Coping capacity is related to the available resources, skills, and opportunities to face challenges that could lead to adverse outcomes (Parsons et al., 2016). The uncertainty element in the stress definition has a moderator effect. The higher the level of uncertainty, the higher the level of stress (Steen, 2017). Regarding the context of this study, critical incidents in police settings involve extreme uncertainty, limited and incomplete information, significant time pressure and complex decision problems. Dealing with uncertainty is a crucial component in decision-making and can cause a deviation from strategic decision processes. The more uncertain a situation is to a decision-maker, the higher risk is perceived (van den Heuvel et al., 2014).

2.2 | Resilience and resilience engineering

Various fields commonly adopt the concept of resilience, including ecology, political science and organisational theory, psychology, safety management and performance management. This study incorporates the concept from a safety management perspective. That is, a system's ability to adapt to changes and sustain its operations after a major mishap or in the presence of continuous change (Hollnagel, 2011, p. 12). Groenendaal and Helsloot (2020) point to four common characteristics of resilient systems, including adaptability (capacity to adjust or transform in response to changing conditions), cohesion (the existence of processes that preserve continuity), efficiency and diversity.

The safety management perspective encompasses resilience in resilience engineering (RE). That is, the science devoted to designing and developing measures and activities to manage and increase resilience (Steen & Aven, 2011). Adaptive capacity is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions and generalised responses to broad classes of

challenges (Walker et al., 2002, p. 6). According to Bruneau et al. (2003), it depends on resourcefulness and redundancies. Furthermore, the availability of substitutable elements can be activated when disruptions occur.

Rather than anticipating and providing responses to specific unwanted events, RE's impetus improves the resilience capacity embedded in a system by managing its adaptive capacity in an uncertain and dynamic world. In this way, systems can achieve a higher level of resilience through an anticipatory style, enabling them to plan and adapt to changes in their environment before they occur (Provan et al., 2020). In this respect, the system must have the capacity to anticipate and monitor future threats and opportunities, respond to regular and irregular disruptions and learn from experience (Hollnagel, 2011). Besides these elements, Provan et al. (2020) point to synchronisation as vital for improving operational resilience. Such synchronisation requires coordinated information flows and actions across the networked system. It also provides a means for making sense of the working environment and its dynamicity, enhancing the operational system's ability to remain within its safe boundaries.

From the RE perspective, learning from failures and successes is at the heart of understanding the context and acknowledging what is needed to support a safe adaptation and success at the scene of action. The learning process requires a search for brittleness, addressing gaps in understanding the underlying elements of operational variability, trade-offs and re-prioritisations. It provides insights to develop the skills needed to meet future challenges and anomalies (Woods, 2018) and thus enhances the ability to anticipate changes.

2.3 | Naturalistic decision-making

NDM, as a scientific field, was developed in the 1980s upon heuristics theories (e.g., Tversky & Kahneman, 1982) and behavioural decision theory (Slovic et al., 1977; Wright, 1984). It emerged to explore how people make decisions in real-world settings. In such an environment, particularly in a complex and uncertain situation, it is never possible to get complete information about the situation at hand, which is why, according to Klein (2013, p.26), we use a lot of 'common sense' in decision making.

NDM focuses on cognitive functions such as decision-making, sensemaking and situational awareness, and planning in natural working environments. The NDM perspective applies in clinical decision-making (Epstein, 2012), organisational factors in higher education (Hora, 2012) and criminal investigations (Ask & Alison, 2010). Moreover, through the lens of the NDM perspective, Hine et al. (2018) explore how perceptual, cognitive, and physiological impairments affect police enforcement's ability to assess the situation at hand and make decisions. They conclude that classical decision-making theories might be ineffective in dealing with force scenarios. Instead, using heuristics will enable officers to speed up their decision-making processes.

Through a descriptive method, the recognition-primed decision making (RPD) model developed by Klein et al. (1986) illustrates how

experts make decisions in demanding and complex situations, when decisions need to be made under time pressure including critical incidents and crises. As illustrated in Figure 2, they have identified three critical aspects of making decisions (pattern matching and action scripts, mental simulation and activating decisions).

The elements of the RPD model, namely sensemaking, detecting problems, (re)planning, decision-making and adapting, are macro-cognitive functions that deal with complex situations (Klein, 2018, p. 48), such as police critical incidents and crises. Klein (2021) addresses two main mechanisms embedded in the RPD model, namely the intuitive pattern-matching part and the conscious mental simulation to do the analysis. Once decision-makers are assigned to deal with an emerging critical incident or crisis, they try to understand the situation by searching for pitfalls and signals and assessing the problem at hand while also deciding how to deal with it. According to the RPD framework, the process starts with situational recognition based on existing information and knowledge, past experiences and intuitions. Then, by pattern matching, the decision-maker chooses a course of action and evaluates it through the mental simulation of action in the contextual condition.

3 | METHODOLOGY

This explorative study applied a qualitative research approach through the cognitive task analysis method (CTA) lens to capture the underlying factors that affect sharp-end operators' performance in dealing with a critical incident or crisis. Three main aspects of CTA are knowledge elicitation, data analysis and data representation (Crandall & Hoffman, 2013), explained in the following section.

3.1 | Knowledge elicitation

Knowledge elicitation in this study developed into two phases. The first phase was theory-driven. The review of relevant literature on RE and NDM to find areas of convergence between these two disciplines and explore how they might complement and enhance operators' adaptive capacity from a theoretical point of view. In line with CTA (ibid), the data collection centred on peoples' real-world experience in the second phase. Therefore, triangulation of

qualitative methods of ethnographic research and semi-structured interviews achieved reliable insights to answer the research question.

3.2 | Ethnographic research

One of the challenges of ethnographic research is getting access to a working environment to undertake fieldwork. When a researcher enters the field, developing a trusting relationship with participants might be challenging if the researcher is an 'outsider' (Lindberg & Eule, 2020; Lopez-Dicastillo & Belintxon, 2014). One coauthor has completed more than 30 years' service in a UK police force. His insights and connections were invaluable for designing the study and getting access to participants. Besides, his observations, which systematically described his experiences of the events and behaviours he encountered (Marshall & Rossman, 1999, p. 79) in the police force, provided a unique opportunity to understand the working environment and to translate the empirical findings through the lens of the study's context.

3.3 | Semi-structured interviews

Each interviewee had a previous professional relationship with one of the authors in this study. This relationship made it easier for the participants to open-up and share their thoughts. The purposive selection depended on knowledge about or experience with the phenomenon of interest (Etikan, 2016). All participants were members of the UK police, as incident commanders, with service experience ranging from 17 to 31 years (Appendix C). The interviews were conducted using Microsoft Teams and lasted between 45 and 60 min. Each interview was recorded and transcribed into about 3000–3500 words and assigned a code Inf1 to Inf12. Informed consent from the subjects assures that information would be confidential and data would be anonymized, avoiding identifying individuals, incidents, or organisations.

The research followed Rasmussen's approach (1976), founded on the recollection of complex cases and challenging events experienced (Crandall & Hoffman, 2013). A case scenario (Appendix A), an incident that a UK police force uses to train incident commanders and negotiators, was used as a framework for the interviews. This enabled the interviewees to describe their own experiences when dealing with critical incidents and crises. Figure 3 illustrates the main steps in the scenario.
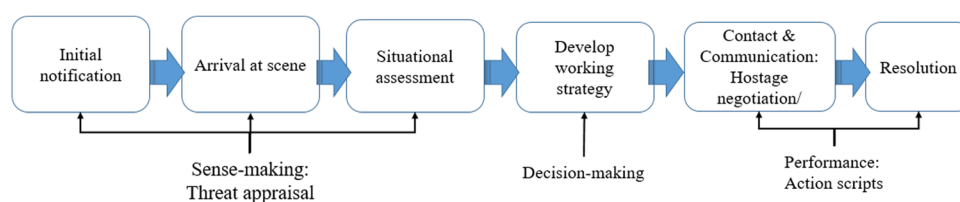

FIGURE 3 Different stages in the incident response process

3.4 | Data analysis

The first step in the data analysis was reading through the interview transcription, line by line, and writing reflection memos, identifying patterns (themes) how participants conduct tasks. According to the study's conceptual framework, phrases and repeated topics were highlighted and assigned initial codes to articulate their content. Codes included cognitive ability, uncertainty, communication, trust, tacit knowledge, complexity and response plan. The qualitative data analysis package NVivo 11 was used for this initial coding. After establishing the codes, with the research questions in mind, the terminology from the study's theoretical background was used as a template to generate themes. See Appendix B, establishing 21 codes and eight different themes from the interview transcripts.

4 | FINDINGS

The findings suggest that the interviewees path of action, when acting in the role of critical incident commanders, is consistent with the RPD model (Section 2.3). However, there is a gap in learning between the individual and organisational levels.

The interviewees response process started with cognitive framing, that is, acquiring information and making sense of it. They continued by finding an appropriate strategy, deciding to deal with the situation at hand. Finally implementing a course of action that is reflective of the RPD. However, due to organisational demands formal debriefs are rarely completed. Moreover, there is no systematic mechanism within the organisation to capture and disseminate learning from critical incidents. In this section, these elements are linked together into a conceptual model on how stress might affect safety-critical behaviour (Figure 4). The model is used in the next section to frame the discussion of how RE ideas, combined with NDM, might enhance an individual's capacity to deal with stress, thus improving safety-critical behaviour. And having clearly identified the learning gap between the individual and organisation how this could be closed using the combined approaches of RE and NDM.

Table 1 illustrates the specific components referred to be the interviewees.

5 | DISCUSSION

5.1 | The effect of stress on safety-critical behaviour

5.1.1 | Stress and sensemaking

The interviewees highlighted that sensemaking is a crucial element in any emergency response operation. In their view, understanding the situation enhances their capacity to deal with the situation, assess conditions, and allocate resources to attain higher-priority goals (Hegde et al., 2015). The interviewees were aware that stress had the potential to undermine their response. However, each had learned to adapt and manage the impact of stress when dealing with critical incidents and crises. Reference was made to coping with the physiological and cognitive aspects of stress. However, by constantly re-assessing the situation and adapting their response to new information the interviewees did not go on with the first available explanation of what is happening (Boin & Renaud, 2013, p. 42). Klein (2011, p.130) uses a metaphor, 'puzzles and mysteries', to explain how different sources of uncertainty require a different approach to coping. These were reflected by the interviewees. For example, puzzle-type issues, such as how many people are in the house were solved by gathering more intelligence (e.g., checking criminal records in the police systems or community health and social works). A well-developed set of procedures provides critical incident commanders guidelines on dealing with the puzzles. Conversely, resolving mysterious issues, such as the husband's mental health and intention requires analytical skills, synthesising cues from contextual features, making sense, and being aware of the situation.

The findings point to two core themes that underlie sensemaking in dealing with such contexts as the scenario: information sharing and communication (cf. Appendix B, Codes d, e and r). The most common way the interviewees make sense of a situation is by speaking to those already at the scene. The results from interviews reveal that stress affects the sensemaking process in three dimensions: perceptual (i.e., how officers perceive the situation), cognitive, and physiological. These may also affect situational awareness. For instance, the disclosure that selective memory during critical incident command, may exclude seeing and hearing crucial information.

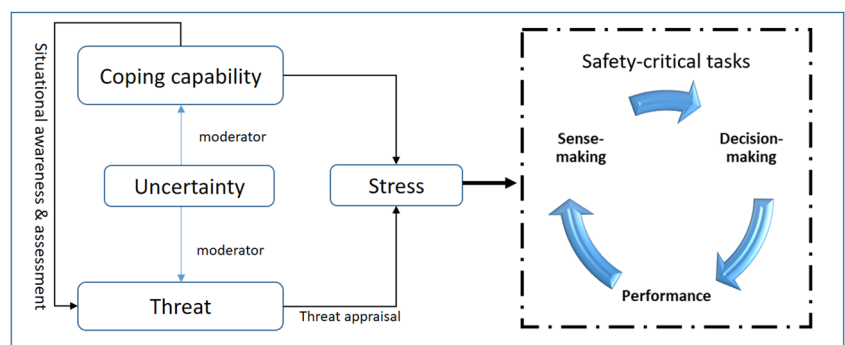**FIGURE 4** the effect of stress on safety-critical tasks

TABLE 1 Interviewee summary response framework

Component	Evidence/Examples
Stress and sense-making	We all like control, and you can't be in control of some threat exposure—(Inf.3)
	If I get an incident in front of me that I've never dealt with before, I know that internally you're a bit nervous and stressed in respect of how you're going to deal with it—(Inf.10)
	You need a set of tools, knowledge and competence to apply to the situation that allows you to process information and make the right decision—(Inf.3)
	I'm just looking for as much information as possible to make sense of the situation—(Inf.8)
Decision-making	Decision making is a craft that could be improved by training, and experience—(Inf.4)
	Information and intelligence are at the heart of decision making. That's a constant flow. So, you can make a decision fast, I mean on one minute or two, based on what you have as updated information—(Inf.10)
	You don't see all that information at the same time and in the right order—(Inf.7)
	You very quickly reappraise what's already been done and change what you need to change—(Inf.5)
Performance	What affects my performance in a stressful situation are: my experience, my current operational credibility, training, confidence in dealing with these types of incidents—(Inf.1)
	Everybody might suffer from selective memory in information processing—(Inf.5)
	Performance is about ensuring that we get a safe conclusion, promptly—(Inf.12)
	There is no doubt that a whole lot of learning comes out of incidents but never gets passed on—(Inf.3)
	As a police officer, I always look back at incidents and think maybe I should have done something differently—(Inf.5)

The initial briefing for the research scenario provides immediate but limited information about the people, premises, and police response. This reflects the incomplete information that occurs in the operational environment. The interviewees enhanced their sense-making and situational awareness through other sources, for instance, police databases regarding previous conviction, and firearms access. Moreover, other agencies, such as the social work department or community mental health teams, will also be contacted, if necessary. These actions are undertaken to reduce uncertainty at the scene and informs the interviewees' decision-making.

At an organisational level, interviewees were provided with training which included inputs from more experienced critical incident commanders, discussing previous incidents, especially those the organisation considered unsuccessful. The police organisation provided a clearly defined structure with many specialist resources commanders could use in critical incidents. According to the interviewees, effective communication between the system components is necessary to ensure accurate sensemaking. Distortions or omissions will inhibit understanding the situation. Therefore, the commander's role is to ask questions to elicit accurate information. After training, the interviewees were confident that the organisational system was tested and resourced, and they could put the training into practice at the sharp end of operational duties.

However, all the interviewees highlighted that their own subsequent experience of operational command of critical incidents and crises (Appendix B, Codes l and u) provided the confidence and capability to make sense of situations and successfully manage them. There are two key aspects here. First, the organisation can only provide a framework to help the commander deal with uncertainty.

Second, ultimately, successful critical incident commanders will enhance their coping capacity by analysing their sensemaking ability and the team, thereby increasing their action scripts and experience.

From an RE perspective, the sensemaking ability relies on anticipation and preparedness activities in a complex and uncertain situation. Resilience influences factors that increase coping capacity (Cc, Section 2.1). Such factors include administrative support to improve the collaborative nature of the coordinated activity, teamwork, and networking. Here, sensemaking is a process by which the actors involved in the operation grasp changes, reflect on what is going on in their circumstances, and promptly share their intelligence. These reflections, in turn, serve as the prime impetus for acting (Weick et al., 2005). In a resilience-based approach, the emphasis is on making sense of ongoing changes and updating the risk picture collaboratively to address uncertainties. The resilience-based approach also acknowledges risks of future emergencies resulting from performance variability (e.g., when facing a situation with a shifting set of assumptions or incomplete, ambiguous and conflicting data). As the operation's scale grows, interdependencies increase and uncertainty intensifies. Alongside complexity, the issue of uncertainty causes a challenging atmosphere for coordination.

In such a situation, sensemaking goes beyond an individual's cognitive capacity. As a social process, it depends on teams and involves collaboration, sharing and interpreting and assessing risks and uncertainties. The way each interviewee assesses risks is closely related to how they perceive their operational environment and its demands through vertical and horizontal relationships (Hollnagel, 2009). By bringing RE and NDM together, the interdependencies are clearer. Thus, the gap between the organisational

system and the individual's performance might be closed, which will lead to better performances.

5.2 | Decision-making

Decision-making in a complex, uncertain real world is more than simply resolving conflicts. It requires ongoing control of the situation in unpredictable environments, thorough knowledge of the context and the ability to take decisive action if required (Rasmussen, 1993). The uncertainty component of stress (Section 2.1) might result in so-called decision inertia, leading individuals to act based on previous choices without considering the possible outcomes (Alós-Ferrer et al., 2016). Decision inertia appears where multi-attribute choices in a highly uncertain and complex working environment (Power & Alison, 2018). The interviewees were aware their decisions will be scrutinised. They acknowledge the adverse effects on career progression should the management of the incident be unsuccessful. However, the outcome was uncertain because of the many variables inherent in the case study and other critical incidents. To help with such uncertainty, the interviewees would seek specialist advice relating, for instance, to the deployment of firearms, public order, and negotiators (see Appendix B, Codes l, m and s).

The findings also indicate that, in terms of improvisation, decision-making requires organisational support in the form of systematic tools, information sharing and training and authorisation. A potential conflict is an imperative of using standard procedures and instructions while confronting the need to improvise. Nevertheless, the interviewees were comfortable making decisions that may have been at variance with formal procedures, faced with the need to improvise. They felt justified in using such variations in the context of a threat to life and other risk assessments.

Moreover, the findings highlight the role of group dynamics (Jones & Roelofsma, 2000) and collaborating activities (Appendix B, Themes) as crucial elements in the decision-making process. The mechanisms that ensure the synchronisation of activities, thus strengthening the ability to interact, are linked to an operational communication strategy grounded on trust, respect and openness between the parties involved (Pollock & Steen, 2020). Resilience in this context is about having effective and proactive communication. While effective communication is concerned with sharing all relevant information in an open, honest, accurate and precise way (Spetalen et al., 2004), proactivity embraces being at the forefront of changes in situations. When standard operating procedures are not appropriate for the situation at hand, flexible and creative thinking is required and imposes an additional source of stress (Flin, 1996). Prior exposure to emergency conditions through experience or simulation develops a commander's decision-making and team-management skills, which will make the real-world challenges easier to tackle. The fundamental component of resilience training is its ability to keep up with changes across the operational environment. In this respect, the focus on cognitive skills and training activities in NDM and RE, emphasising proactive learning, strongly links these two scientific fields.

The application of combined RE and NDM tools could enable a feedback loop from the organisation to the sharp end, and conversely, from the sharp end responding to organisational changes.

5.3 | Performance

The key performance goals for the interviewees are a safe conclusion, clarity in communicating the intent and parameters to those present, instilling confidence and projecting calmness, ensuring everyone knows their roles and responsibilities, and how all these factors fit together to achieve a common purpose. However, the findings indicate that stress may harm performance (Appendix B, Codes, n, m and k). For instance, stress may cause a commander to be nonresponsive and ignore the possible risks inaction brings. Alternatively, they may overreact and compromise the peaceful resolution of the event for fear of appearing hesitant and indecisive.

Performing satisfactorily under threatening conditions requires the ability to maintain one's composure and emotional control while staying focused on the tasks at hand under stress (T. Driskell et al., 2014, p. 254). However, should the situation escalate, the interviewees extended their boundaries of tolerance to withstand unpredictable changes. Klein (2011, p.247) reflects on RE dynamic and complex situations and suggests deploying an anticipate-and-adapt strategy. The successful implementation of this strategy depends on the adaptive capacity, flexibility, and authorisation to improvise (Appendix B).

The UK adopts a multiagency emergency-management model with a collaborative approach. The interviewees highlighted that communication is essential in ensuring that all participants understand their role and responsibilities during a response. While a collaborative approach is desirable, ultimately, the final responsibility rests with the incident commander. Each interviewee used self-reflection and analysis to improve their performance. The interviewees considered learning at an individual rather than an organisational level. Reasons for this included the lack of adequate learning infrastructure and a lack of prioritisation from the organisation's top. Any information gathered is not communicated widely across an organisation.

The gap between the organisation and individual learning obstructs an effective feedback loop. It is rare for comprehensive debriefing to occur. Therefore opportunities to improve future performance are missed (see Appendix B, Code t). There seems to be a tacit understanding at an organisational level that no further action about learning or improved performance is necessary when an incident ends without loss of life. In contrast, individual incident commanders diligently review and assess their decisions to identify learning and improve performance. RE and adaptation—which have organisational characteristics—enhance the resilience of sharp-end performers by facilitating and stimulating proactive learning across an organisation. Proactive learning in the organisation will, in turn, promote solution-orientation decision-making and creativity in dealing with dynamic and uncertain situations.

6 | CONCLUSION

This study explored how NDM and RE complement each other through a practical example of police critical incident command. While RE emphasises organisational elements in strategic planning, decision-making and prioritising, NDM accentuates the role of experience and knowledge (explicit and implicit) in macrocognitive functions at an individual level. At an organisational level, a resilient emergency management system acknowledges the quest for dealing with operational dynamicity. It highlights the importance of synchronisation and interoperability in multiagency ERO. This study's findings highlight a link between the NDM focus (sharp end) and RE at the blunt end (organisation) and accentuate the feedback gap. One explanation of this gap is related to the organisation only being concerned about the safe resolution of the critical incidents and not building its corporate memory to share with other sharp end operators. Closing the feedback loop could improve individual performance because the commanders could benefit from other commanders' experiences through the increased knowledge and access to successful strategies and action scripts. Uncertainty could be reduced by improving the corporate memory through a systematic learning mechanism, which would improve organisational performance. The scope of training activities would more accurately reflect the situational needs faced by commanders, and the organisation would prioritise learning (e.g., through debriefs). As a result, capability building extends beyond the individual to organisational learning. Adopting the 'no blame' culture from RE may also reduce stress due to scrutiny and potential career harm experienced by the incident commanders. From a 'constructivism' view, both fields acknowledge the role of intelligence, experiences, and interplay with the world as means to knowledge acquisition and learning. Bringing together these fields, at the design phase of emergency response operation, the organisations enhance their capacity to foster the incentive needed for sharing knowledge from the individual's various skills, tacit knowledge, and experiences (NDM) to the organisational level. From the organisational level, on the other hand, the application of RE methods cultivate flexibility related to human aspects in the coordination process, design of systems with flexible response options, as well as networks building, joint training and capability-building programs. It also improves emergency management and system adaptation conditions by engaging the sharp end crew in strategic decision-making. There is potential to extend this paper's scope by looking more closely at the sharp-end operator's cognitive abilities and ability to interact. Using scenario-based training to address this, as is suggested in the NDM context (e.g., Shadowbox training, Klein & Borders, 2016), its combination with a systemic approach, such as FRAM from the RE field, provides an in-depth understanding of the operational context. A joint approach will improve the quality of the training scenarios. The current study may serve as a foundation for further research incorporating an ethnographic and naturalistic perspective.

DATA AVAILABILITY STATEMENT
Research data are not shared.

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APPENDIX A: INTERVIEW GUIDE

Biographical: tell me about yourself (age, sex, experience, training, etc.)

Consider our scenario (we explain our case scenario).
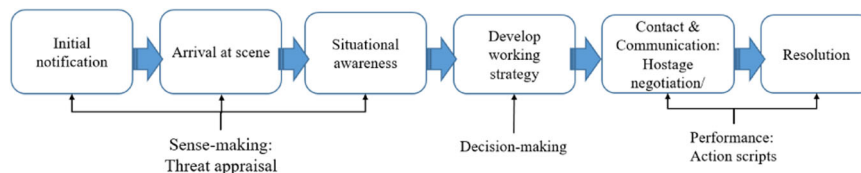
Stage 1: Initial notification

What factors affect your stress levels in general? And, specifically, when you first receive the initial notification?

How would you describe the feeling (body-reaction) of stress that you experience in this case-scenario?

– What are your immediate thoughts (mental stimulation & anticipation) about the situation (scenario?)

Stages 2 and 3: Arrival at scene/situational awareness (sense-making)

– What are you looking for (cues) in such a situation? How do you gather information?
– Which factors affect your ability to make sense of the situation (what is actually happening here?)
– How do you deal with uncertainties involved with the situation?

Stage 4: Developing a working strategy/decision-making

– How do you make your decisions? What do you consider? (ref. national decision model)
– Which factors affect your ability to make your decisions?
– How do you deal with group-dynamic issues in your communication with different stakeholders (in terms of interaction, common ground, joint situational awareness and interoperability)?

Stage 5: Making move (Actions)/hostage negotiation

– How confident would you feel in handling the situation (being up to the task)?
– What variations might be associated with your tasks? How do you cope with the uncertainty and variations?
– In your view, do the training and standard guidance/procedures cover all aspects of the response operation? What would you change to improve your response capability?

Stage 6: Resolution

- Explain what contributes to the successful resolution in such scenarios. How do you, as a commander, ensure that these are performed?
- Outline how such situations (e.g., case-scenario) have an impact on your work as a police officer and/or your private life.
- Tell us about the post-incident activities that you would conduct.
- To your knowledge, will a situation like our scenario be analysed afterwards to adapt training(s)? How could it be improved?
- How do you and your organisation learn from this incident?

APPENDIX B: INTERVIEWS, CODES AND THEMES

Raw data: Excerpt from interviews	Codes: Specific segments of data	Themes: Emerging patterns
1. To me, SA* is about the processing of information and intelligence and risk assessments against the desired objective—(Inf.7) 2. The physiological impact of notification of a critical incident is like 'an adrenaline rush'— (Inf.6) 3. An essential element in DM** for me is to continually re-evaluate the circumstances and amend plans to reflect the changes—(Inf.12) 4. There will be different people in attendance have an opinion that is different from you. You ought to consider those differences—(Inf.9) 5. We seek information and specialist advice to developing options—(Inf.6) 6. Collaboration is like necessary means to move the situation forward. It helped bring focus to the immediate task—(Inf.6) 7. We use police force standard procedures (the National Decision Model) as the basis for planning & making decisions—(Inf.1) 8. I have experiences increased temperature, stomach-churning, mind racing in anticipation of what is going to happen—(Inf.4) 9. DM is a craft that could be improved by training, and experience—(Inf.4) 10. Standard procedures give me a basis. It doesn't mean you have got to follow it around the loop. It's about being able to have the mental furniture and the awareness to capture all the information you've got—(Inf.10) 11. You're looking at what you've got & modelling your thinking. It's just a circle you're re-assessing all the time—(Inf.11) 12. You're directing your officers, and you're making your decisions according to how the scenario changes—(Inf.11) 13. I assess the resources I will need (e.g., negotiators, firearms, public order, etc.) based on both situational complexity and standard procedures—(Inf.11) 14. The police force faces demanding situations and risk every day. So the first thing you are thinking about is the different risks, risks to the victims, the public, and yourself and your colleagues—(Inf.2) 15. The bottom line is that the operation is my responsibility. So, I will take the lead on it. Still, I would consider what other involved actors were saying and what they wanted to be done—(Inf. 9) 16. I could not make all the judgements and decisions; you rely on resources applying their expertise to execute the plan—(Inf.3) 17. You need a set of tools, knowledge and competence to apply to the situation that allows you to process information and make the right decision—(Inf.3) 18. [..] training and exercise is the best way to promote effective decision making—(Inf.4) 19. Information and intelligence are at the heart of DM. That's a constant flow. So you can make a decision fast, I mean on one minute or two, based on what you have as updated information—(Inf.10) 20. The critical point in response is the ability to reassess the situation with risks, decisions, priorities and actions—(Inf.12) 21. There's the real feeling of what you've got to do as well as what you can, timely. Because people's lives may be at risk and so there is a lot of pressure—(Inf.4) 22. There is no doubt that a whole lot of learning comes out of incidents but never gets passed on—(Inf.3) 23. Turning up at a domestic and dealing with that dynamic situation is what I do in a daily basis. It's up to me to make sure that threat, risk and harm are addressed—(Inf.10) 24. You know the fight or flight; it rises to the occasion. You try to be as calm and as professional as possible and try to project that. But I think inside your heart is racing fast—(Inf.4)	**(a) Complexity** [3, 23, 36, 56, 60] **(b) Competence** [17, 31] **(c) Planning** [3, 7, 13, 16, 32] **(d) Communication** [4, 5, 12, 28, 33, 54] **(e) Dynamicity** [3, 10, 12, 13, 19, 20, 23, 32, 42, 50, 59] **(f) Training & Exercise** [9, 18, 35, 36, 38, 40, 45, 62] **(g) Standard procedures** [7, 10, 13, 45] **(h) Information processing** [1, 10, 12, 17, 19, 42, 46, 48, 49, 51, 56, 59, 63] **(i) Intelligence** [1, 5, 19, 46, 47, 51] **(j) Roles/responsibilities** [5, 6, 13, 15, 16, 21, 23, 28, 34, 44, 57] **(k) Risk & uncertainty** [8, 12, 13, 14, 20, 21, 23, 27, 37, 50, 60, 61] **(l) Tacit knowledge& experience** [10, 17, 21, 22, 26, 29, 30, 31, 35, 36, 38, 41, 47, 48, 54, 56, 62] **(m) Time pressure** [6, 13, 19, 21, 25, 43, 57, 59] **(n) Stress** [2, 8, 24, 37, 39, 52, 54, 58] **(o) Judgement** [1, 10, 11, 16, 17, 20, 21, 30, 41, 46, 47, 56, 59] **(p) Collaborative climate** [4, 5, 6, 12, 15, 16, 27, 28, 40, 44, 49, 55, 57]	**Sense-making** [a, h, i, f, r, k, l, n, o, r, u] **Anticipating & updating plans** [a, c, g, j, k, q] **Resourcefulness & diversity** [b, c, f, l, q] **Emergency response** [a, d, e, f, g, m, n, o, p, s] **Group dynamic** [a, d, f, t, u] **Joint decision-making & interaction** [d, e, j, m, n, p, r] **Learning** [f, l, t] **Situational assessment** [a, b, d, e, h, l, k, n, o, r]

Raw data: Excerpt from interviews	Codes: Specific segments of data	Themes: Emerging patterns
25. Performance is about ensuring that we get a safe conclusion, promptly—(Inf.12)	**(q) Resourcefulness** [10, 11, 13, 16, 17, 29, 33]	
26. Often, you'll deal with the situation, and then you'll find out that it was one very similar to an experienced one—(Inf.8)	**(r) Info. gathering & Sharing** [1, 2, 5, 6, 11, 19, 28, 43, 46, 54, 58, 59, 63]	
27. A successful resolution is working together with the resources you've got to bring an incident to an unharmed conclusion—(Inf.11)	**(s) Improvised solutions** [47, 48, 53]	
28. It depends on the information, clear briefing about clarity and clear direction, and seeking that clarity before someone is deployed. And that officers under your command understand the parameters they are working within –(Inf.10)	**(t) Debriefing and reporting** [28, 29, 32, 33, 57, 64]	
29. It's about using your experience. Make sure people are briefed properly. Make sure you get sufficient resources for what you're trying to achieve—(Inf.10)	**(u) Self-confidence** [29, 31, 36, 53]	
30. Reflection on experiences and using them for dealing with the situation at hand is crucial [. .]—(Inf.1)		
31. It's about trusting yourself & confident that you know what you're doing—(Inf.6)		
32. Frequent briefings, so everyone knows what they are doing. Keep re-iterating— (Inf.5)		
33. Results depend on the availability of the resources and that they are properly instructed—(Inf.5)		
34. I think a lot of senior officers are concerned of the stress exposure and coming up short when managing a critical incident—(Inf.3)		
35. You become the person responsible. So everybody starts to look at you. I think there's a pressure that comes on of it—(Inf.12)		
36. How you perform depends on the training and experiences that develop the mind with muscle memory—(Inf.2)		
37. What affects my performance in a stressful situation are: my experience, my current operational credibility, training, confidence in dealing with these types of incidents—(Inf.1)		
38. If I get an incident in front of me that I've never dealt with before, I know that internally you're a bit nervous and stressed in respect of how you're going to deal with it— (Inf.10)		
39. If it's a scenario where you get pre-planning and thinking time, that's great. Otherwise, it is instinctual—(Inf.2)		
40. The worse decision, sometimes, is making a no-decision. That unfolds and unravels very quickly—(Inf.2)		
41. While advisors advise and commanders command; they (advisors) are the ones who are trained and been through far more training, far more experience, far more calls than I have—(Inf.8)		
42. As a police officer; I always look back at incidents and think maybe I should have done something differently— (Inf.5)		
43. You've also got to keep focused on actually what's happening and playing out in front of you—(Inf.8)		
44. You try not to jump ahead to horrendous outcomes. This takes you away from what you should be focused on. Get facts—(Inf.8)		
45. DM will not just be internal; we'll also have partner agencies involved. It's about having a proper joint understanding of actions— (Inf.10)		
46. It's about using the training & the national (standard) decision-making model subconsciously—(Inf.1)		
47. You're looking at the info. & intelligence, making the big picture of that up—(Inf.1)		
48. You can only deal with what you've got. You rationalise & justify your decisions; based on what you have in your mind—(Inf.7)		
49. [. .] hindsight is a wonderful thing to understand a situation and find a solution— (Inf.7)		
50. Results depend on having a clear understanding of the situation within the group— (Inf.9)		
51. You don't see all that information at the same time and in the right order—(Inf.7)		
52. I'm just looking for as much information as possible to make sense of the situation— (Inf.8)		
53. Stress has its impact on us. One hundred percent. You see things that other people would never be exposed to		
54. I will always stand up for my decisions. So, don't shy away from it—(Inf.10)		
55. [. .] not everybody can 'brief' a senior officer. Some just panic. [. .] due to the transfer of information, misconceived updates or lack of knowledge about something key to the incident—(Inf.10)		
56. Collaboration relied on the trust between individuals involved—(Inf.9)		
57. Understanding the context had a profound role in how to deal with the situation— (Inf.8)		
58. A lot of the time, you won't get a chance to deliver the briefing. That comes down to leadership. The people there, who know their roles and responsibilities and what you expect—(Inf.3)		

Raw data: Excerpt from interviews	Codes: Specific segments of data	Themes: Emerging patterns
59. Your body and mind are starting to adapt to what you know. It is a journey of information overload—(Inf.4)		
60. You very quickly reappraise what's already been done and change what you need to change—(Inf.5)		
61. Many senior officers are concerned about the exposure and coming up short when managing a critical and complex incident—(Inf.3)		
62. We all like control, and you can't be in control of some threat exposure—(Inf.3)		
63. Real-time observation and participation versus getting in a training environment, based on post-incident analysis, are quite different when it comes to learning—(Inf.5)		
64. Everybody might suffer from selective memory in information processing— (Inf.5)		
65. As I experienced, the last thing you are going to do at any debrief is identifying weaknesses—(Inf.5)		

APPENDIX C: ANONYMISED INTERVIEW DETAILS

Interviewee reference	Interview time and date	Police command experience
Inf.1	1100 h 01/02/21	28 years
Inf.2	1400 h 02/02/21	29 years
Inf.3	1000 h 03/02/21	30 years
Inf.4	1000 h 04/02/21	31 years
Inf.5	1000 h 05/02/21	30 years
Inf.6	1100 h 08/02/21	24 years
Inf.7	1100 h 09/02/21	17 years
Inf.8	1100 h 11/02/21	30 years
Inf.9	1030 h 15/02/21	30 years
Inf.10	1400 h 15/02/21	26 years
Inf.11	1030 h 18/02/21	30 years
Inf.12	1000 h 17/02/21	30 years