Communication and coordination across event phases: A Multi-Team System Emergency Response

Teamwork across event phases in multi-team systems

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Abstract:
This paper explores how multi-agency response teams communicate and coordinate in different phases of a simulated terrorist incident. Procedural guidelines state that responders should coordinate their response to a major emergency across two phases: "response" (when the incident is ongoing) and "recovery" (when the threat has subsided, but the legacy of the incident is ongoing). However, no research has examined whether these phases map to the behaviours of responders in situ. To address this, we used measures of communication and coordination to examine how behaviours evolved during a simulated terrorist incident in the U.K. We grounded our approach within the theoretical literature on multi-team systems. It was found that the current response/recovery classification does not fit the nuanced context of an emergency. Instead, a three-phase structure of "response/resolve/recovery" is more reflective of behaviour. It was also found that coordination between agencies improved when communication networks became less centralised. This suggests that collaborative working in multi-team systems may be improved by adopting decentralised communication networks.

Keywords:
Multi-team Systems, Communication, Coordination, Extreme Teams

Data availability statement:
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Large scale emergencies, such as terrorist attacks, environmental disasters (e.g., the Australian bushfires), and the global COVID-19 pandemic, require emergency response teams to engage in fast and coordinated action to reduce harm and save life. To achieve this, emergency organisations must form a multi-team system (MTS): a network of component teams working to achieve separate, but related objectives within a framework of over-arching shared goals (Mathieu, Marks & Zaccaro, 2001; Shuffler, Jimenez-Rodriguez & Kramer, 2015). The creation of MTSs brings together diverse skills and abilities that enables them to perform in dynamic, challenging and complex task environments (Marks, DeChurch, Mathieu, Panzer & Alonso, 2005; Zaccaro, Marks & DeChurch, 2012). However, it can also foster a range of inter-team challenges related to competing priorities, poor communication and ineffective coordination (Fodor & Flestea, 2016; Kerslake, 2018; Pollock, 2017; Waring, Alison, Shortland, & Humann, 2019). Despite the fact that emergency response teams are, by their very nature, a MTS, there have been few examples of research explicitly studying these teams through a MTS lens (*see* Waring et al., 2019 & Fodor & Flestea, 2016 for exceptions). This is possibly because much of the research on MTSs remains theoretical (Luciano, DeChurch & Mathieu, 2018; Shuffler & Carter 2018; Zaccaro et al., 2012) and the emergency response literature has tended to focus on traditional teamwork while studying ‘interoperability’ between response teams (Alison et al., 2015; Chen, Sharman, Chakvarati, Rao & Upadhyaya, 2008; Salmon, Stanton, Jenkins & Walker, 201). This paper will address this issue by qualitatively analysing observational data collected from a simulated counter-terrorism emergency response exercise, using a MTS lens. This will enable us to: (i) identify whether MTS theories can be applied in practice; and (ii) expand our understanding of emergency response teams beyond the traditional team literature.

A practical aim of the paper is to explore the argument within MTS theory that networks of teams show shifts in their response in accordance with the changing demands of the task context (Aiken & Hanges, 2012; Luciano et al., 2018; Zaccaro et al., 2012). To our knowledge, there is little empirical research that has examined how these dynamic shifts occur in practice, resulting in a lack of understanding of how MTSs adjust their behaviours in response to evolving task demands and changing system objectives (Aiken & Hanges, 2012; Luciano et al., 2018; Shuffler et al., 2015). In the current study we address this absence by exploring how MTSs adjust their behaviours in different phases of a simulated emergency incident.

When an emergency occurs, response teams structure their operations into two distinct ‘phases’: the response phase (i.e., when the incident is ongoing) and the recovery phase (i.e., when the imminent threat has subsided, but the legacy of the incident is ongoing and requires further action) (Australian Institute for Disaster Resilience, 1998; Cabinet Office, 2012; FEMA, 2017). For example, during a terrorist attack the response phase would involve emergency responders neutralising the threat, saving life, and protecting the community; while the recovery phase would involve rebuilding trust in the community, supporting victims in the longer-term and helping to ‘restore normality’. It is assumed that these two phases have distinctly different MTS structures due to the differing task demands involved. Indeed, organisational guidelines on how to manage these two phases differs considerably (e.g., different over-arching aims; different chair; different organisations involved). However, no research has sought to test the assumptions that: (i) the behaviours of a MTS change in line with the transition from response to recovery, suggesting that (ii) emergency response can be split into two distinct phases. It may be argued, for example, that the distinction between ‘response’ and ‘recovery’ phases is too sharp as there is a period between the two phases when the immediate threat to life reduces, but the incident has not yet moved into recovery.

We test these assumptions by comparing the behaviours of a MTS across distinct timepoints of an emergency simulation: (i) incident ongoing; (ii) 48 (simulated) hours after the incident; and (iii) 3 (simulated) weeks after the incident[1]. We are especially interested in the team processes involved in the middle timepoint (48 hours after) as this is usually classed as a 'response' phase by emergency commanders, but it is less time urgent and uncertain than the first timepoint as the imminent threat to life has subsided. By analysing these data, we will be able to explore how the MTS changes across the different timepoints of the emergency and whether the behaviours of the MTS match the "response; recovery" structure imposed by emergency organisations. By referring to the wider theoretical literature on MTS in the interpretation of our findings, we hope to offer insight into how established frameworks operate in practice and in changing task environments.

Relevance of the MTS literature for Emergency Response Contexts

The MTSs literature has grown in recent years in response to observations that the traditional teamwork literature did not adequately explain task environments that required multiple teams to work together (Lanaj et al., 2013; Luciano et al., 2018; Zaccaro et al., 2012). Unlike traditional teams, MTSs require effective collaboration within *and* across teams, with component teams required to simultaneously attend to their own objectives in addition to the wider superordinate goals of the system (Luciano et al., 2018; Rico, Hinsz, Davison & Salas, 2018; Zaccaro et al., 2012). This is referred to as a hierarchy of proximal (intra-team) and distal (inter-team) goals - a complex network of interrelated component team and shared superordinate system goals (Mathieu et al., 2001). The existence of multiple

[1] These are 'simulated time-points' and as such did not take place at intervals of 48hours and 3 weeks. All phases of the simulated incident took place on the same day. This is standard practice in emergency incident training and is designed to maintain immersion and ensure the training remains feasible for staff members to attend (Alison et al., 2013).

component teams within the overarching inter-team network, together with the hierarchy of goals, defines MTSs as complex structures that have unique challenges across performance episodes (e.g., which team has the most expertise across different tasks? Who becomes the main MTS team leader and does this change depending on the task? Which components team's goal takes priority when planning teamwork?).

Drawing on the MTS literature is important when studying emergency response teams as their very nature requires inter-team collaboration and for agencies to balance their priorities alongside the over-arching priorities of the multi-team network (e.g., to save life and minimise harm). Although previous research on emergency response teams has sought to understand 'interoperability' between agencies (e.g., between Police, Fire and Ambulance services), this research failed to link with the growing body of theory on MTSs (Chen, Sharman, Chakvarati, Rao & Upadhyaya, 2008; Mishra, Allen & Pearman, 2011; Salmon et al., 2011). Instead, much of this research continues to draw on the traditional team literature to interpret findings and focuses largely on practical applications.

A dominant theory within the MTS literature is Luciano et al.'s Meso-Theory of System Functioning (2018). This theory proposes that the structure and interactions of MTSs fall along two dimensions: differentiation (the degree of difference and separation between component teams) and dynamism (the fluidity of the system over time). These two dimensions are vital to the success of MTSs – there must be a degree of differentiation as complex emergency incidents require a diversity of skillsets from distinct component teams (e.g., the Police, Fire and Ambulance service). In addition, the network must be dynamic, with the number of component teams and the relationship between teams changing according to the demands of the task (e.g., it may be necessary for the Police to take charge during the response phase of the incident and for a different agency to take charge during recovery).

While the differentiation and dynamism of the MTS is what makes these teams suited to responding in uncertain, high-stakes settings, they also create unique challenges to team processing (Luciano et al., 2018; Zaccaro et al., 2012). Two such processes that have relevance to emergency response and are highlighted as important within the MTS literature are: (i) communication (defined as a reciprocal process of sending and receiving information; LePine, Piccolo, Jackson, Mathieu & Saul, 2008); and (ii) coordination (defined as the enactment of behavioural and cognitive mechanisms that enable teams to synchronise their efforts to achieve goal related outcomes; De Dreu & Weingart, 2003).

Communication in MTS. Effective communication enables MTSs to build a shared understanding of the incident through the transfer of information across component teams, which facilitates synchronised action (Davison, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012; Keyton, Ford & Smith, 2012; Waller & Uitdewilligen, 2008). Communication is challenging in MTSs due to the organisation-specific expertise of each component team (i.e., differentiation), their use of inconsistent language and the lack of familiarity amongst inter-team colleagues (Fodor & Flestea, 2016; Mishra, Allen & Pearman, 2011; Waugh, 2004). This can lead to lack of clarity about what information needs sharing with who and when, and high levels of *information opacity* - ambiguity across component teams about one another's activities (Luciano et al., 2018). As the emergency incident unfolds and the demands within the environment increase, component teams have been shown to abandon inter-team communication and instead focus on intra-team objectives. Alison et al. (2015) found that when emergency tasks lacked direction, were non-time bounded and involved two or more agencies, teams reduced inter-team communications and prioritised (redundant) intra-team information seeking.

Effective communication is also challenged by the fluidity (dynamism) in the MTS structure. This fluidity relates to component teams joining and leaving the response at different times, making it difficult for teams to consistently maintain effective communication channels (Fodor & Flestea, 2016). The fluidity also relates to different teams occupying the central role in the network depending on the demands of the task (Davison et al., 2012). This is necessary to allow the appropriate teams to address salient tasks but can mean that information is not relayed to the remaining component teams. This is due to central teams focusing on intra-team communications to complete the task at hand, in absence of maintaining communication channels with the wider network. For instance, during the response to the 2017 Manchester Arena terrorist incident, the high task demands placed on the Police commander to deal with the immediate aftermath of the explosion was found to directly contribute to a lack of communication with inter-team colleagues in the Fire Service, who were located at a different site. This poor communication across agencies led to a two-hour delay in the deployment of the Fire Service to the incident ground, who were waiting for further instruction, meaning their skills and expertise could be not be utilised until later on in the response (Kerslake, 2018).

Coordination in MTSs. Coordination enables component teams to attend to intra-team goals, while ensuring that their actions are cohesive to the over-arching, superordinate goals of the system (Mathieu et al., 2001, Mathieu et al., 2018). Goal discordancy (the dissimilarity and incompatibility of goals across component teams, Luciano et al., 2018), impedes coordination and reduces MTS performance (DeChurch & Marks, 2006). Power and Alison (2017a) found that emergency responders in a simulated counter-terrorist attack rated their goals to be highly consistent, but their self-report goals were role-specific and contradictory (i.e., Police sought to suspend all emergency activities in the 'hot zone' to 'neutralise the threat', whilst Paramedics sought to 'save patient life' in the same zone, while Firefighters sought to 'protect responders' before operating in this zone). This was attributed to the existence of 'abstract' superordinate goals in MTSs (i.e., save life) that component teams translate into contradictory role-specific 'concrete' objectives (i.e., neutralise threat, save patients, protect responders). To coordinate effectively, the MTS must ensure that their intra-team goals remain cohesive, while continually reappraising how these goals are directed towards evolving demands in the environment (DeShon Kozlowski, Schmidt, Milner & Wiechmann, 2004; Lucianio et al., 2018).

Coordination is made more challenging by the fluidity in MTS structures and the often-brief time in which component teams work with one another (e.g., forming quickly to respond to an emergency and disbanding shortly afterwards). This brevity makes it difficult for the MTS to develop transactive memory systems and team mental models (the knowledge possessed by team members of other team members expertise which develop as teams become more familiar), both of which are thought to underpin coordination in traditional teams (Austin, 2003; Smith-Jentsch, Kraiger, Cannon-Bowers, & Salas, 2009). Without periods of familiarisation in which to develop implicit coordination, MTSs must instead actively engage in behaviours to establish coordinated action across component teams.

Research Aims

In the current study, we sought to explore the behaviour of an emergency response MTS by focusing our analysis on their communication and coordination across a simulated counter-terrorism incident. Communication was measured through social network analyses (i.e., to identify how component teams communicated with one another across the three timepoints of the simulation) and coordination was measured by analysing the interactions of team members (i.e., coding verbal indicators of coordination between component teams). We used our analyses to identify how the MTS structure changed across the three phases of the incident. This was to identify whether the procedurally distinct 'response' and 'recovery' phase have delineated structures in practice. This analysis of how the MTS changed across these different timepoints, aligns with a call for more research within the MTS literature to explore how MTSs manage team processes across different task demands (Wjnaldum et al., 2019; Waring et al., 2019). Accordingly, the core research question of this paper is: How do MTS communication and coordination processes evolve across different phases of a simulated emergency incident?

Method

Data for this study were collected from participants taking part in a mandatory training exercise that simulated a Strategic Coordinating Group (SCG) responding to a terrorist attack. When a major emergency takes place in the UK, the SCG is responsible for providing strategic direction to a Tactical Coordinating Group (TCG), who translate these objectives into actions that can be implemented by operational commanders "on the ground". The SCG can be likened to Multi-Agency Coordination Groups in the U.S and Emergency Operation Centres in Australia (Australian Institute for Disaster Resilience, 1998; FEMA, 2017). SCGs comprise senior representatives from across the blue light services, local council, central government and the military, who engage in round-table discussions at a location away from the incident site to establish the strategic direction to the response (Wilkinson et al., 2019). Representatives from SCGs are guided by the principles of the Joint Decision Model – the U.K's decision-making framework designed to increase interoperability across agencies (JESIP, 2013). As such, SCGs offer a suitable context to explore inter-team behaviours in MTSs because effective communication and coordination across component teams are defined as key components to their success (Salmon et al., 2011).

Data were collected from an immersive table-top simulation of the strategic multi-agency (n = 11 agencies) response to a terrorist incident. Immersive simulations differ from laboratory studies by focusing on data collection with expert practitioners, in an environment that adequately represents the complexities of the organisational context (Brown, Power &

Conchie, 2020). As such, immersive simulated environments are expected to elicit similar behavioural patterns and cognitive processes as would be found *in situ* (Manser et al., 2017). For MTSs operating in extreme environments, immersive simulations provide a realistic level of stress and uncertainty, while offering a safe and ethically appropriate context in which to conduct research (Alison et al., 2013; Brown, et al., 2020; Power & Alison, 2017a). Prior research has evidenced the use of single and repeated simulations in studies of major incident response (*see* Alison et al., 2015a; Wilkinson, Cohen-Hatton & Honey, 2019).

Each phase of the simulation took place sequentially, with a short break in between, and were designed to emulate the SCGs that would normally take place in a real-world terrorist incident: SCG1 (incident ongoing), SCG2 (48 hours after), and SCG3 (3 weeks after). SCG1 and SCG2 were classed as response phases and SCG3 was classed as a recovery phase. Each phase of the simulation was designed by subject matter experts from the Local Resilience Forum to test principles of the Joint Decision Model (JESIP, 2013) and ensure the simulation provided benefits to participants as a training exercise. The simulation took place in a large boardroom with audio and written information provided to participants at relevant moments in the simulation timeline. As some agencies were only represented by a single team member, and to ensure that the simulation adequately emulated the inter and intra-team behaviours of a MTS, agency specific updates were provided in written form throughout and spread evenly across the three SCGs. This included information such as up-to-date casualty numbers (to the Ambulance service), information on timeline of body identification (to the Coroners) and information on the investigation into the attackers (to Police officers). In a genuine incident it is likely that these updates would be provided electronically by intra-team partners situated away from the location where members of the SCG were meeting.

Participants

Participants were 30 strategic decision-makers and support staff (e.g., loggists – individuals who log information and decision making) from emergency response authorities in the U.K. who would be likely to respond in the event of a real incident. This included representatives from the blue light services (Police, Fire and Ambulance), local council, coroner's office, military, central Government (see Table 1 for a breakdown of representatives in each SCG). Experience ranged from four months – 38 years (*M* = 16 years, *S.D* = 9.75). To preserve anonymity, and in agreement with training coordinators from the Emergency Services, no other demographic data were collected. The majority of participants took part in all three SCGs (*n* = 23), although some participants only attended specific SCGs, reflective of how agencies would be represented in the event of a genuine incident. Ethical approval for this Study was obtained from a University in the U.K.

Procedure

Before the start of the simulation, participants were informed that psychologists were present and that research on teamwork during major incident response was taking place. Participants were asked if they were willing to be audio- and video- recorded during the simulation and were invited to ask questions. All participants agreed and once informed consent was obtained, the simulation commenced. The simulation was based on the response to an armed terrorist attack in a busy shopping centre on a Saturday evening in the run up to Christmas. Data were collected from three SCGs, each dealing with a different event phase in the incident: (i) incident ongoing; (ii) 48 hours after and (iii) three weeks after. Each phase of the simulation was tested in sequence with a short refreshment break in between. SCG1 lasted 81 minutes, SCG2 lasted 49 minutes, and SCG3 lasted 65 minutes. At the end of their testing session, participants were asked to complete a short questionnaire, collecting basic demographic information and the level of immersion they felt during the simulations as indicated by answering an open-ended question. 80% of participants reported feeling immersed in the simulation.

Simulation scenario. An approximate timeline of the incident was followed by the training coordinators for each SCG. Information was fed to participants at various time points during each SCG, dependent on the decisions made. Table 2 provides an outline of the key tasks in each SCG.

Data collection. Five Dictaphones were placed on the table in the middle of the testing room to audio-record communications between team members during each SCG. To aid with transcription, two video-recorders were placed at either end of the room to capture who was speaking at any one time. Recordings were later transcribed verbatim.

Data Analysis

Social network analyses. Communication data for each SCG were analysed separately using social network analyses (SNA). SNA was chosen because it provides a visual and quantitative representation of the social dynamics of a MTS, analysing the prevalence and frequency of interactions between individuals and across component teams (Driskell & Mullen, 2005; Fodor & Flestea, 2016). First, a communication matrix for each SCG was created from the transcribed data, noting the frequency of interactions between each participant. Consistent with prior research, we used degree centrality (centralisation) to explore communication processes in the MTSs (Fodoer & Flestea, 2016). Centralisation was calculated using Freeman's (1978) formula and reflects the extent to which interactions are concentrated within a small number of component teams (Wasserman & Fraust, 1994). The closer the value is to the upper bound of 1, the more central the communication network (i.e., a star shape where all communications pass through a central node).

The networks were directional (i.e., they showed the direction of interactions between team members), and so we computed out-degree network centrality (i.e., the distribution of outward links within the network) and in-degree network centrality (i.e., the distribution of inward links within the network). High out-degree centrality suggests a small number of agencies are sending out information to other nodes; whereas high in-degree centrality suggests most communications in the network are directed towards a small number of nodes (Scott, 2000). We calculated network density to show the proportion of network ties against the total number of possible ties (Wasserman & Fraust, 1994). Finally, to show how individual contributions changed across the SCGs, we calculated itemised (i.e., for each of the participants) indegree and outdegree centrality. Centralisation, in and out-degree centrality and density were calculated using R package "sna" (Butts, 2008). Gephi was used to create a visualisation of the communication networks between team members for each SCG (*see* Figures 1-3).

Thematic analyses. A thematic qualitative analysis was conducted on the transcribed data to identify verbal indicators of coordinating behaviours (Braun & Clarke, 2006; Nowell, Norris, White & Moules, 2017). An exploratory thematic analysis was chosen due to the lack of clarity in the MTS literature as to what behaviours constitute coordination (Wijnmaalen, Voordijk & Rietjens, 2018). While some studies have approached coordination as a single measured behaviour (*see* Firth et al., 2015), this fails to capture the complexities of coordination and how it changes during different event phases. Rather than viewing coordination as a single behaviour, it may be better understood as a series of behaviours that can serve to promote or disrupt system and component team performance dependent on demands within the environment (Rico et al., 2018).

As the focus was on verbal indicators of coordination in the current study, we aimed to capture instances of explicit coordination, as opposed to implicit coordination (e.g., team mental models) (Rico et al., 2018). Using communication to code for coordination is common practice in team research and relates to the fact that explicit coordination cannot occur without communication as it reflects the verbal interactions required to align the goals and priorities of different component teams (DeChurch & Marks, 2006; Stachowski, Kaplan & Waller, 2009). Analyses included identifying and coding behaviours that enabled team members to synchronise their efforts to achieve goal related outcomes (positive behaviours) and those that disrupted their efforts (negative behaviours). In taking this approach, we identified behaviours relevant to the goal of task completion (a process measure), rather than taking an objective measure of team performance (an outcome measure). Team performance measures can be difficult to devise or interpret in emergency response contexts in which decisions often have no right or wrong answer (Alison et al., 2015b).

Data were analysed using Braun and Clarke's (2006) six-phased method and combined inductive and deductive analysis (Fereday & Muir-Cochrane, 2006). Following familiarisation with the data, we drew on prior literature and theory to guide the analysis and develop the initial codes for the codebook (deductive). The remaining themes were identified inductively by the first author (see Table 3). The transcripts were coded for a second time by the first author to ensure intra-rater reliability (k =.74). A second coder was also trained in the coding dictionary and they used this to analyse 20% of the transcripts. An acceptable level of inter-rater reliability was obtained (k = .68) (Everitt, 1996).

A frequency count of the behaviours was calculated to compare coordinating behaviours across event phases in the simulated incident. To account for the different lengths of each SCG, proportional counts of behaviours were calculated as a percentage of the overall number of behaviours in each SCG, and these values were used in the main analyses.

Results

Communication networks

The results of the SNA show a downward trend in the total number of interactions (weighted edge) between team members from SCG1 to SCG2 to SCG3 (Table 4). The number of unique interactions (edges) remained similar across the three SCGs (Table 4), which is consistent with the network density results that remain consistently low. Results show that the networks were highly centralised throughout the simulation (Table 4), although there was a marked reduction in centrality in SCG2 and SCG3 in comparison to SCG1, as show visually in Figures 1-3. While out-degree centrality remained high throughout the simulation, in-degree centrality decreased. This decrease shows a greater number of team members being consulted in the latter SCGs and is consistent with the changes in the itemised in degree and out degree scores (Table 5) which show contributions from a greater number of team members over time. For example, in SCG3 we see 7 team members make 3 or more contributions whereas in SCG1 there are only 3 team members that do this. The results of the itemised in-degree and out-degree scores also suggest the downward trend in overall interactions (weighted edge) across SCGs is the result of greater in-going and out-going communications by the Police Chair in SCG1, which was higher than in SCGs 2 and 3.

Coordinating behaviours

A thematic analysis of communications during the SCGs identified three positive and three negative team behaviours (*see* Tables 3 and 6). Positive behaviours were: *joint decision-making*, *sharing resources*, and *sharing task related information*. Negative behaviours were: *role uncertainties; decision uncertainties and conflicting priorities. Joint decision-making* and *sharing task related information* were included in the initial codebook deductively as higher-order themes. Both are core principles of coordinated working in the emergency services and are identified in prior research as important for MTS coordination (JESIP, 2013; Davison et al., 2012; Wijnmaalen et al., 2018). The remaining themes were coded for inductively by the first author by searching for additional indicators of coordination that emerged from the data and collapsing these into higher-order themes. For instance, “indecision” and “missed information” were collapsed into the theme of *“decision uncertainties”*.

Joint decision-making. *Joint decision-making* refers to instances in which the MTS actively worked together to implement a decision. An example of this occurred in SCG1 when team members were discussing how to quickly move casualties from the incident site to nearby hospitals. The National Health Service (NHS) Director referred directly to the Police Chair to ensure that hospitals were identified that were secure and easily accessible *“we will need [to] disperse casualties outside of “Location A” so we need [to] ask for support to secure the hospitals in “Location B” and “Location C” in order to be able to take casualties there so we would ask for the support of Police forces in those areas” (SCG1, NHS).* In addition, when making a decision regarding their media strategy in SCG1, the Chair encouraged team members to act in a coordinated manner: *“…bring back to this group any intended messages that are going out so that we don’t have messages sent out in isolation that aren’t coordinated”(SCG1, Police Chair).*

Sharing resources. *Sharing resources* refers to instances in which agencies offered resources to assist other agencies within the MTS. An example of this was evidenced during SCG1, when the Government Liaison Officer offered support to Police in the early stages on the incident in contacting ministers and liaising with Military officials: *“In terms of government support, I’m happy to facilitate anything in terms of speeding up the military assistance and contacting ministers*” *(SCG1, Government Liaison Officer*). A further example was evident during SCG2 when discussing where to direct individuals wanting to make charitable donations. The Red Cross offered to help coordinate a central fund for the victims of the incident in conjunction with local councils: *“yes that’s very much something we will be able to offer support on” (SCG2, Red Cross).*

Sharing task related information. Instances in which team members actively sought to share agency specific information and improve shared situational awareness were coded as *sharing task related information*. In each SCG, the Chair encouraged team members to share information about their current situation: *"...an update on the current situation and any briefing from any individual agencies on where we are" (SCG3, Council D Chair).* In addition, the Chair sometimes requested an explanation of agency specific acronyms, for example the terminology used to describe the severity of casualty cases: *"if a health colleague could just explain the P2, P3 and P1, just so we are all aware of the terminology please" (SCG1, Police Chair).*

Role uncertainties. *Role uncertainties* refer to confusion about one's own role and/or the role of others. This can be exemplified in SCG2 and SCG3 in a dispute between NHS representatives and the Red Cross over who takes primacy in providing psychological support to those involved in the incident. During SCG3, the NHS are required to state their authority in a scenario in which the Red Cross imply setting a strategy of support: *"just to be clear on that... we will draw on colleagues from local authorities, but in terms of returning to normal, that responsibility sits within the NHS" (SCG3, NHS).*

Decision uncertainties. Instances when decision-making lacked clarity and discussions were delayed due to indecision were coded as *decision uncertainties*. An example of this was during SCG1 when there was a lack of decisive action about what to do with the 30,000 individuals who had self-evacuated from the incident site. The issue was raised on multiple occasions by the Head of Operations of the shopping centre, without an adequate response: *"There is a high demand for information, that we are not really able to respond to at this moment in time" (SCG1, Head of Operations)*. Another instance of decision uncertainty occurred during SCG2, when discussing an appropriate place to host a memorial site. Local council members identified a site where the memorial should be established, however this information was ignored by others, leading to a lengthy debate about other possible sites: *"I'm just conscious that we need to deal with this issue of a memorial, team. So it's… [location]. That's the scene of the memorial?" (SCG2, Police Chair).*

Conflicting priorities. When team members attempted to re-orient the conversation towards intra-agency priorities this was coded as *conflicting priorities*. During SCG1 there were several moments when discussions began to turn to intra-team tactical matters. The chair was forced to re-direct conversations to the strategic issues at hand: *"Folks, what I don't intend to do is to get tactically distracted as the updates come in. We have a tactical commander at this core who is taking care of that" (SCG1, Police Chair).*

Figure 4 shows the frequency of coordinating behaviours across the simulation. The proportion of positive behaviours showed an upward trend from 75.6% (SCG1) to 94.7% (SCG3); while the proportion of negative behaviours decreased from 24.3% to 5.3%. A chi-square test of independence compared the total number of positive and negative behaviours and indicated the differences were significant, χ^2 (2, n = 299) = 14.40, p = .001.

Discussion

This study addressed the question of how MTS communication and coordination processes evolve across different phases of a simulated emergency incident. It offered one of the first empirical tests of MTS theory to emergency responders and examined if emergency response can be dichotomised into response and recovery, as defined by changes in coordination and communication. The results of a social network analysis of MTS communications showed that while SCG1 was highly centralised with communications dominated by one team (the Police), SCGs2 and 3 were less centralised with more agencies involved in discussions. The thematic analysis identified six coordinating behaviours - three positive (*joint decision-making, sharing resources, and sharing task related information)* and three negative behaviours (*role uncertainties, decision uncertainties, and conflicting priorities*). Cumulatively, the results showed an increase in positive and a decrease in negative behaviours across each phase of the simulation. Our focus in the discussion is on the specific behaviours in which we saw a marked change - *joint decision-making*, *decision uncertainties* and *conflicting priorities*. Taken together findings illustrate the relevance of the MTS literature to emergency response teams and suggest the current response/recovery distinctions within procedural guidelines may not fit the nuanced context of emergencies.

The communication data showed that the MTS was centralised at the outset, with communication dominated by the Police. As the incident progressed and task demands changed, communication to and from additional agencies increased. Procedural guidelines in the U.K dictate that when firearms are present at an incident, the decision-making and strategy-setting for the response should be led by the Police (Cabinet Office, 2012). Findings from the network structure for Strategic Coordinating Group 1 (SCG) suggest this occurred and illustrated the central role that the Police played in the early phase of the response. This finding is consistent with the fluidity in the structural configuration of MTSs in which the relative importance of a component team (in our example the Police) may be more central to the achievement of system level goals at specific stages of teamwork (Luicano et al., 2018). Consistent with prior research, our data suggests that this negatively impacted team processes as the Police focused on the task at hand rather than maintaining clear communication channels with the other component teams (Fodor & Flestea, 2016; Luciano et al., 2018). For example, in SCG1 we noted the highest frequency of *decision uncertainties*, such as when the MTS continually failed to decide where to relocate the 30,000 individuals who self-evacuated from the shopping centre. Responders raised the issue to the Chair numerous times, but a decision was not implemented. The results suggest the Chair (Police Commander) was focused on delivering the overall strategy of the response and failed to attend to important information provided by inter-team partners. This is problematic in MTSs as component teams are unable to fulfil their role-specific responsibilities when they are relying upon information (to reduce decision uncertainty) from other component team members who are focused on another task.

We also noted a low incidence of *joint decision-making* in the initial response. This finding is also likely to reflect the structural configuration of the MTS with a high level of "power-distribution" resting with the Police leaving less room for inter-team decision-making (*see* Luciano et al., 2018; Zaccaro et al., 2012). Over-involvement of a single team may lead to a loss of expertise within the MTS as less focal teams make fewer contributions (e.g., representatives from the Shopping Centre [the site of terrorist incident] made minimal contributions in SCG1). The differentiation of skills across component teams is what makes MTS suited to complex environments and this should not be over-looked despite the urgency of an unfolding incident (Fodor & Flestea, 2016; Kerslake, 2018). A highly centralised power-distribution in a MTS erodes the main benefit of a MTS: having a distribution of expertise to inform joint working. Indeed, a report evaluating the status of inter-agency emergency management in the U.K found that, despite efforts to increase joint decision-making across agencies, many key decisions were still being taken by a single organisation (Pollock, 2017). If component teams are not actively engaged in inter-team decision-making, and communication is limited to a small number of focal teams, then the MTS is unlikely to function efficiently in the pursuit of shared objectives (Luciano et al., 2018; Shuffler & Carter, 2018). It is therefore unsurprising that we also found the highest frequency of *conflicting priorities* in SCG1. Identifying *conflicting priorities* as a barrier to coordination strengthens Luciano et al.'s argument that coordination in MTSs is disrupted when there are high levels of goal discordancy (i.e., conflicting priorities) between component teams

(Luciano et al., 2018) and is consistent with prior research that outlines the difficulties of establishing cohesive shared MTS goals in emergency response (Power & Alison, 2017a)

In the latter phases of the emergency (SCG2 and SCG3), the networks became less centralised. This is consistent with the structural fluidity predicted by Luciano et al. (2018), as we found that responders' behaviours changed when the imminent threat of the incident had subsided, consistent with the notion that MTSs adjust their behaviours in accordance with the demands of the task (Shuffler et al., 2015). When networks are less centralised, information can be transferred more easily across agencies (Wasserman & Faust, 1994), which increases shared awareness across component teams, reduces uncertainty around the task and ultimately improves coordination by providing more opportunities for collaborative working (Mathieu et al., 2001). The benefits that come from a less centralised structure were observed in the later phases of the emergency response with increased instances of *joint decision-making* and decreased instances of *decision uncertainties*. The findings therefore suggest that de-centralised networks can increase collaborative decision-making, providing support for the argument that decentralised network structures are well-suited to complex task environments (Schraagen & Van de Ven, 2011; Lanaj et al., 2013).

Practical implications

The differences we observed in communication and coordination across incident phases suggests that the response/recovery classification might not fit the nuanced context of an emergency. In our study, both SCG1 and SCG2 were classed as 'response' phases and so we expected them to have similar structures and thus to observe similar patterns in how teams communicated and coordinated. However, we found that communication and coordination during SCG2 (response) was more similar to SCG3 (recovery) than SCG1 (response). This suggests that demands present in the task environment (i.e., void of a live ongoing incident) may override procedural guidelines in shaping MTS response. Similar findings were noted by Choi and Brower (2006) who found perceived network structures during emergencies were different to those prescribed in emergency management plans. The markedly different network structure in the immediate phase (SCG1) raises the question of whether an additional phase that marks 48 hours after the incident (traditionally a response phase) could be introduced. This "resolve phase" would reflect a reduction in risk and illustrate a transition from responding to the immediate demands in the environment to ensuring any remaining tasks are being attended to (e.g., victim identification, collecting further evidence). Introducing a third phase may empower additional agencies to contribute earlier in the response, increasing opportunities for collaborative working across agencies and reducing the demands on a single team (e.g., Police).

Mapping communication networks as the incident evolved during different event phases illustrated the disconnect between component teams and demonstrated an over-reliance on the Chair to manage the flow of communications. This highlights the demand placed on central commanders during emergencies: they are required to simultaneously manage communications across the MTS and take the lead on key decisions (Kerslake, 2018; Waring, Moran & Page, 2020). One way to lessen the load on central commanders and increase the connectedness across component teams might be to assign a "boundary spanner" in the response to crises. Boundary spanners are designated team members, tasked with ensuring that information is relayed, and actions are coordinated across different component teams (Carter, 2014; Chaffin et al., 2017). Accordingly, an effective boundary spanner can ensure effective communication channels are maintained throughout the response and increase shared awareness across agencies. Further research is needed to explore if assigning this role to an individual would create more space for shared communication in emergency response and free up those in leadership to focus on decision-making and coordinated action.

The present study involved an in-depth qualitative examination of the behaviours that constitute coordination in MTS. Existing work has focused on single measured behaviours (*see* Firth et al., 2015), which fail to capture the complexities of coordination. By generating a deeper understanding of what behaviours constitute coordination in MTSs, it is possible to identify ways to improve MTS effectiveness (Mathieu et al., 2018). For example, we found that *role uncertainties* prevented the MTS from achieving a goal. One way to reduce these uncertainties is training component teams to build trust and understanding relating to a specific 'role' rather than a specific person, thereby facilitating the development of 'swift trust'. (Curnin et al., 2015; Power & Alison, 2017b). This focus on cognitive trust in a 'role' within a MTS rather than affective trust in a 'person' (McAllister, 1995) can support MTS coordination during emergencies as it means team can operate in the absence of previous interpersonal experience. Role clarification training has successfully improved performance in medical teams and future research might trial this intervention in multi-agency emergency response teams (Salas, DiazGranados, Weaver, & King, 2008). Relatedly, if roles and responsibilities are clearly defined, this may better equip MTS to adopt de-centralised structures earlier on in the response as there will be a greater awareness of who to go to for information (Luciano et al., 2018; Power & Alison, 2017b).

Limitations

Examining team processes during different simulated time-points of emergency response has allowed us to empirically support the use of MTS theory in practice and has given rise to the suggestion that the response to emergency incidents may be split into three phases rather than two. We used 195 minutes of rich data from a simulation with 30 experienced practitioners to reach these conclusions. While the use of a single simulation may have limited our findings in their generalisability, the parallels we observe between our findings and those published by others suggest that we are likely to observe similar effects in replication studies. For example, the coordinating behaviours we identified that related to *sharing task related information* and *role uncertainties* are receptively similar to Mathieu et al., (2001) who theorised coordination in MTS cannot occur unless component teams establish a shared understanding of the task environment and Waring et al., (2019) who cited role uncertainties disrupt coordination as they lead to a poor understanding about opportunities for collaboration and unrealistic expectations between team members. Further, the improvements we identified in coordination as the communications became less centralised ties in with the literature on sensemaking that suggests open and frequent communication is required during emergencies to establish the joint understanding and common ground needed to implement coordinated action (Cornelissen et al., 2014). This finding is also concurrent with research that emphasises the inextricable link between communication and coordination in MTSs - a MTS that fails to communicate effectively will struggle to coordinate their behaviour as they will be unable to establish a shared understanding of the event (Davison et al., 2012; Firth et al., 2015; Mathieu et al., 2001). Nevertheless, future work would benefit from replicating the effects we found here to solidify our suggestion that a dichotomised response to emergencies may not be suitable in practice. Future work might also consider if a three-phase structure of response is appropriate in other types of emergency events (e.g., flooding, major road traffic collisions) or if it is especially relevant in the response to terrorist incidents.

Our findings indicate that the improvement in coordination in the latter phases of the response was associated with the networks becoming less centralised. Due to our sample size, we were unable to test if this relationship was causal and it is therefore important to acknowledge confounding factors that may have been responsible for the changes in team processes across the simulation. Firstly, each SCG had a different Chair. While it is not uncommon to see different SCG Chairs in practice, it is possible that changes in communication and coordination observed in this Study were a result of changes in leadership style (*see* DeChurch & Marks, 2006). Future research might examine if certain leadership styles are more suited to different stages of incident response and establish what relationship, if any, leadership style has with changes in communication and coordination. Secondly, each simulated SCG took place on the same day and in quick succession. Compressing time in simulation studies of emergency responders is important to increase immersion and ensure participants remain engaged with the simulated incident (Alison et al., 2013). Nonetheless, it is possible the changes in behaviours we saw in the latter phases of the response were due to increased familiarity amongst team members improving team processes over time. For example, prior research suggests when component teams spend more time with one another, they identify more strongly with the MTS, which subsequently increases performance (Cujipers et al., 2016). However, any effect of familiarity on team behaviours is reminiscent of what we would expect to see in the response to genuine incidents, as SCGs happen regularly and on demand (e.g., sometimes hourly, daily or less) following major emergencies. The effect of familiarity might be examined in future studies of emergency response MTSs, to better understand how knowledge and experience of working with inter-team partners impacts processes across component teams.

Conclusion

Despite being defined as MTSs, there are very few examples in the literature that have examined emergency response teams through a MTS lens. In the current study we show the relevance of the MTS literature to understanding team processes in an emergency response context and demonstrate the applicability of theoretical frameworks in practice. Mapping the communication and coordination of the MTS at three simulated time-points indicated that the dichotomisation of "response/recovery" within emergency guidelines may not reflect the reality of responders' behaviours. Introducing a three-phase structure of "response/resolve/recovery" that acknowledges a shift in urgency between an ongoing incident (i.e., SCG1) and shortly afterwards (i.e., SCG2) offers a solution to this and may help to better prepare responders for incidents. The results also suggest that coordinating behaviours in the MTS improved as the network of communications became less centralised. It is possible that implementing decentralised structures in the early phases of incident response will lessen the load on focal agencies and increase opportunities to share information and coordinate decisions across inter-team partners. More broadly, the findings call attention to the importance of studying MTS as dynamic, complex structures, by evidencing how team processes changed as the demands of the incident evolved. As such, while the results indicate communication networks are likely to impact coordinating behaviours in MTS, we would argue that these team processes must be considered relative to changes in the stability and uncertainty of the environment. In highlighting the complex interplay in the relationship between team processes and evolving task demands, the findings emphasise the importance of future research studying MTS across time.

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