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Connecting the dots in counterterrorism: The consequences of communication setting for shared situation awareness and team performance

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Shared situation awareness (SSA) is critical for counterterrorism teams. We examined whether a rich media condition (co-located face to face) and a lean media condition (distributed email) differentially influence SSA at levels 1, 2, and 3 and team performance, in 24 co-located and 27 distributed teams. SSA at level 2—knowing who the terrorist is and their location—mediated and SSA at level 3—projecting future terrorist actions—marginally significantly mediated, a positive relationship between media richness and team performance. SSA at level 1—knowing objects—did not mediate such a positive effect. A co-located setting leads to more convergence on situation awareness at levels 2 and 3, whereas a distributed setting leads to more convergence on level 1.

1 | INTRODUCTION

In a broad range of contexts, shared situation awareness (SSA) is critical for teams to adapt to dynamic challenges (Burke, Stagl, Salas, Pierce, & Kendall, 2006), such as railway operations (Roth, Multer, & Raslear, 2006), managing nuclear power plants (Waller, Gupta, & Giambatista, 2004), military teamwork, and crisis management (Kamphuis, Essens, Houttuin, & Gaillard, 2010). SSA reflect the degree to which all the team members accurately know the information required to reach the goals and subgoals associated with their joint task (based on: Burke et al., 2006; Endsley, Bolte, & Jones, 2003; Uitdewilligen, Waller, & Ziljstra, 2010). Knowing what is going on at a basic level, such as the location of fires in an area, is important, but to allocate resources efficiently, a more refined knowledge is needed, such as knowing where the main source of the fire is and whether the fire will spread to other buildings. When coordinating fire and medical units, there will be a need for more specific types of information, such as the number and location of people hurt by the fire.

Complicating matters further is the fact that developing SSA involves some use of communication media; for example, railway workers frequently use radio communication to develop SSA (Roth et al., 2006). When team members are not co-located (i.e., not communicating face to face), but are distributed (i.e., communicating through email), it has been noted that there could be an increased risk that they may wrongly assume that they share the same understanding of a situation (Cramton, 2001). It is thus critical to know how the type of media that crisis responders use to communicate among each other influences SSA and ultimately affects team performance.

One setting that exemplifies some of the critical challenges of communication and SSA is counterterrorism operations. Developing SSA in a counterterrorism team exemplifies both the interdependence among responders and the handling of dynamic situations. Terrorism is a security challenge that often crosses organizational and national boundaries (NATO, 2016). Developing an understanding of terror threats may require both communicating with the public (Coombs, 1995; Park & Avery, 2016) and communicating within counterterrorism teams (Christensen, Lægreid, & Rykkja, 2013; Gjørv, 2012; Schraagen, Huis in t'Veld, & de Koning, 2010). In general, Weick (2005) points out that it can be challenging to communicate about and understand information on terrorist threats. To this end, counterterrorism teams have been set up to develop SSA (Boin, Rhinard, & Ekengren, 2014; The Guardian, 2015). Level 1 situation awareness is awareness of elements in the area of interest; level 2 is knowledge of the relationship among the elements, that is, who is a "friend" and who is an "enemy"; and level 3 is anticipation of the future actions of elements (Endsley, 2000a).

An example may illustrate the development of SSA in counterterrorism teams further. Imagine a threat of a terrorist attack on oilrigs

in the North Sea in northern Europe. Some information may easily be shared within a counterterrorism team, such as the position of all the objects in an area, regardless of their identity (level 1 situation awareness). However, information about the terrorists' location may need to be synthesized from initial reports about the possible location of the terrorists and information about an object and its course that suggests that it is an enemy (level 2 situation awareness). For the team to consider the likely future course of action of the terrorists (level 3 situation awareness), more complex discussion of different views on the situation would be needed, for example, incorporating detailed knowledge of enemy intentions.

The literature on the development of SSA emphasizes communication as of key importance (Salas, Prince, Baker, & Shrestha, 1995). Yet few studies have investigated how a central aspect of communication, the communication media, influences the different levels of SSA. Counterterrorism teams can be co-located, distributed, or use a mix of media, and the medium of communication is a central factor influencing teamwork in general (de Guinea, Webster, & Staples, 2012). It could be suggested that levels 2 and 3 of SSA require a more complex and collective sensemaking activity leading to convergence of awareness than level 1 SSA (e.g., Weick, Sutcliffe, & Obstfeld, 1999). Yet, although some theorists suggest that media vary in their ability to support complex sensemaking activity (e.g., Dennis, Fuller, & Valacich, 2008), to our knowledge, we lack studies of how the communication media influence SSA at the different levels.

In this article, we focus on how the communication media influence SSA within counterterrorism teams and thereby affect team performance, for example, in hindering a terrorist attack. We define the communication medium as the physical channel through which information is transmitted among team members (Daft, Bettenhausen, & Tyler, 1995). We suggest that the different communication requirements needed for each level of SSA mean that each level could benefit from a different type of communication medium. We draw on media synchronicity theory and media richness theory, central theories on how the medium influences team collaboration, to explore this (Brown, Dennis, & Venkatesh, 2010). Dennis et al. (2008) suggests that shared understanding requires two processes: convergence, by which the members of a team come to agree on the meaning of diverse information; and conveyance, by which information is transmitted and understood. Convergence is thought to be supported through face-to-face communication and conveyance through lean media such as email. We therefore explored the following question: to what extent does rich and lean medium influence SSA at levels 1, 2, and 3, and through this affect team performance?

Knowing whether different media affect the different levels of SSA could be important to ensure that counterterrorism teams are set up with the required media capabilities. As suggested above, such knowledge could also be important for other crisis management organizations, as SSA can be critical in a variety of settings (Boersma, Wagenaar, & Wolbers, 2012; Burke et al., 2006; Crichton, Lauche, & Flin, 2005; Groenendaal & Helsloot, 2016; Hunt, Smith, Hamerton, & Sargisson, 2014). Exploring this could also extend theories of media and shared understanding (e.g., the media synchronicity theory of Dennis et al., 2008) by distinguishing between the influences of different media capabilities for specific types of SSA.

We investigated the effect of the communication media on SSA at levels 1, 2, and 3 and on team performance. We examined three-person teams taking part in a counterterrorism simulation. Some teams were co-located and so communicated face to face; some were in different locations and so communicated only by email. In study 1, we developed and validated the simulation, manipulations, and measures, and in study 2, we tested the hypotheses. Figure 1 shows the research model we developed.

2 | THEORY

2.1 | Media richness, media synchronicity, and team performance

We focused on a counterterrorism task, in which people held different information on the location of targets. This situation involves high equivocality, defined as an unclear situation resulting from differences in interpretation among team members (Coombs, 2015). We concentrated first on exploring how the communication medium used affected team performance under high equivocality. The communication medium may vary in several ways, such as in flexibility, integration of information, accessibility, and timeliness (see, e.g., Wixom & Todd, 2005), but we focus on how media richness and synchronicity affect team performance.

Media richness theory suggests that equivocality can be clarified by a rapid exchange of information and with rich detail so that team members can understand each other's messages and thus resolve the task (Daft & Lengel, 1986; Maitlis & Christianson, 2014; Te'eni,

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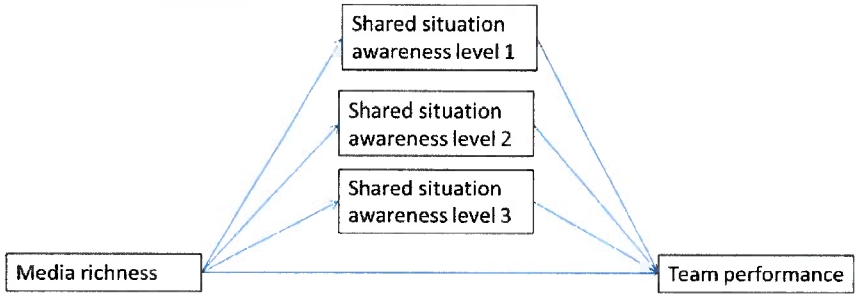

FIGURE 1 Research model

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2001; Weick & Sutcliffe, 2001). Media richness is defined as the ability of a medium to change understanding in a time interval (Daft & Lengel, 1986). A face-to-face setting is typically regarded as having higher media richness, as it has more cues and feedback, allowing for clarification of the situation, than distributed text media (Daft & Lengel, 1986).

Media synchronicity theory also suggests that co-located settings, which allow for face-to-face communication, can be central to accomplishing tasks where team members initially hold divergent information on a situation (Dennis et al., 2008). In a co-located setting, Dennis et al. (2008) argue that it is possible to receive rich cues and be able to convey information in various ways, with a high number of symbol sets, and to transmit messages rapidly, with a high transmission velocity. A co-located face-to-face setting is typically regarded as facilitating a high degree of synchronicity, a "shared pattern of coordinated behaviour among individuals as they work together" (Dennis et al., 2008: 575), and facilitating convergence. Electronic mail, on the other hand, is regarded as having a low degree of synchronicity, but could have the advantage of transmitting larger amounts of information.

Empirical findings have been mixed with respect to the effect of communication setting on performance (see, e.g., Dennis & Kinney, 1998). A host of factors, such as the expertise members bring to the team, the quality of leadership, and the interdependence of team members, could affect team performance (Burke et al., 2006; Haerem & Rau, 2007; Maynard & Gilson, 2014). Research has pointed to variety of electronic media as facilitating coordination (Kock & Lynn, 2012). Yet, a recent meta-analysis suggests that, where teams are newly established and the task is novel, being co-located typically enables information sharing that leads to high team performance more than being distributed (de Guinea et al., 2012). A co-located setting has also been seen as having a positive effect on team performance and decision accuracy in command and control tasks, where information needs to be integrated to solve the task (Hedlund, Ilgen, & Hollenbeck, 1998). We therefore argue that for ad hoc crisis management teams with initially divergent perspectives:

> *Hypothesis 1: Media richness positively influences team performance, such that there will be a higher team performance in a rich media condition than in a lean media condition.*

2.2 | Media and shared situation awareness

We adopt the much-used definition of SSA as the degree to which the information requirements of the major goals or subgoals associated with solving the joint task are accurately known to all team members (based on: Burke et al., 2006; Endsley et al., 2003; Uitdewilligen et al., 2010). Information requirements mean the dynamic information needs associated with the goals or subgoals for performing a task (Endsley & Rodgers, 1994). Thus, having SSA of such requirements means, for example, that the team members hold the same and accurate knowledge about who is the enemy in a specific operation (Endsley, 2000a). Furthermore, level 1 SSA can be a prerequisite for developing level 2 SSA, by providing an initial focus of where to search for the enemy for example, and then, level 2 SSA can be a prerequisite for developing level 3 SSA, in that it is the movement of some objects, that is, enemies, that are of interest (Burke et al., 2006).

We now elaborate on how SSA may be supported by both face-to-face and email communication by drawing on the sensemaking perspective and team research (Burke et al., 2006; Dennis et al., 2008; Weick et al., 1999). Weick et al. (1999) argue that developing SSA depends on information sharing and interpretation among individuals, in complex environments. Several researchers see communication as critical to enhancing SSA (Burke et al., 2006; Salas et al., 1995; Weick et al., 1999). Specifically, understanding of the situation may be enhanced by an exchange of rich cues and rapid feedback, for example, through face-to-face communication (Maitlis & Christianson, 2014; Weick & Sutcliffe, 2001).

Some empirical studies have found that using shared displays and being co-located enhance the individual situation awareness needed for the coordination of team tasks (Gergle, Kraut, & Fussell, 2012; Kraut, Fussell, & Siegel, 2003). Bolstad, Cuevas, Gonsalez, and Schneider (2005) found that SSA was higher the lower the physical distance among team members. Rahman, Cheng, and Bayerl (2013) found some support for media synchronicity increasing shared understanding of ideas in collaborative work.

Other studies have found that information exchange may have no clear influence on individuals' situation awareness (Buchler et al., 2016) and richness of information may not lead to higher team situation awareness—the degree to which every team member possesses the situation awareness required for her or his responsibilities (Van de Walle, Brugghemans, & Comes, 2016). Such conflicting findings may suggest that the communication medium influences the three levels of SSA differently.

Developing level 1 SSA may not be aided by being co-located, because the process of acquiring knowledge of the different elements in a situation could be seen as more a matter of conveyance (Dennis et al., 2008). Email, which supports a higher degree of information conveyance, could thus support level 1. Specifically, the ability of team members to process a large amount of information, by revisiting information that they have been sent, can be central.

Level 2 SSA, on the other hand, requires an understanding of the dynamics and cause–effect relationships in a situation, in addition to knowing the key elements (e.g., for the classification of enemy versus civilian). To this end, each team member must acquire detailed understanding of each of the other team members' abilities and limitations, and they must develop a common understanding of the threats and the coordinated strategy to hinder the terror attack. Being able to use communication media that allow the sending of information in a way that the other team members can accurately understand and rapidly clarify, for example, through co-located media such as face-to-face communication, could thus be central (Dennis et al., 2008).

Level 3 SSA requires knowing the dynamics and the causal relationships in a situation, but also being able to predict what might happen. For team members to develop shared level 3 situation awareness, we suggest that there is benefit in communication media that support convergence, as this level requires the integration of diverse sets of information. We therefore argue that a co-located setting would be more important for SSA at levels 2 and 3.

Summarized, this suggests different effects of media richness for level 1 versus levels 2 and 3 SSA, and we hypothesize that for ad hoc crisis management teams with initially divergent perspectives:

> *Hypothesis 2 a): Level 2 and level 3 shared situation awareness will be higher in a rich media condition than in a lean media condition. Hypothesis 2 b): Level 1 shared situation awareness will be higher in a lean than in a rich media condition.*

2.3 | Shared situation awareness and team performance

SSA at level 1 may be important for setting an initial focus for the resolution of the task. We suggest, however, that SSA at levels 2 and 3 is even more related to the team end goal. In our case, SSA at levels 2 and 3 directs specific attention to determining the identity of the enemy objects and considering what their future course of action might be. Corroborating this, Weick et al. (1999) suggest that the crucial aspects of situation awareness for complex teamwork go beyond perception and entail a more active interpretation of the situation. On this basis, we suggest that for ad hoc crisis management teams with initially divergent perspectives:

> *Hypothesis 3: Levels 2 and 3 of shared situation awareness will be more positively related to team performance than level 1 shared situation awareness.*

2.4 | Shared situation awareness as a mediator of the media richness and team performance relationship

The mixed findings with respect to a direct relationship between media richness and team performance could suggest indirect effects (Dennis & Kinney, 1998). Hedlund et al. (1998), for example, found support for the mediating effect of team informativity —the extent to which all information potentially available to the team is actually acquired by those staff members who need it— on the relationship between communication media and accuracy of decision-making. Based on the above hypotheses, we predict that SSA at level 1 will not be higher for face-to-face media than email. As simply perceiving the elements in a situation is not sufficient for coordinated action, we suggest that level 1 is not related to team performance. In addition, based on the prior discussion, SSA at levels 2 and 3 is key for coordinated action, as it relies on an integration of the opinions and knowledge of each of the team members. We thus hypothesize that only levels 2 and 3 SSA will mediate a positive effect of media richness on team performance for ad hoc crisis management teams with initially divergent perspectives:

> *Hypothesis 4: Levels 2 and 3 of shared situation awareness will mediate a positive relationship between media richness and team performance.*

3 | GENERAL OVERVIEW OF STUDIES AND METHODS

This article consists of two studies. In the first study, we develop and validate the simulation and the manipulation of media richness and measures, while we in the second study test the hypotheses.

3.1 | Overview of methods

To investigate our hypotheses about causal relations, the choice was between a field experiment and a laboratory experiment. While a field experiment has a high external validity, we wanted to make sure that we could measure our key variables with a high degree of internal validity. This suggested a laboratory experiment, as it was a feasible way of manipulating media conditions and measuring SSA and in a simulated task environment.

4 | STUDY 1: DEVELOPMENT AND VALIDATION OF SIMULATION, MANIPULATIONS, AND MEASURES

In study 1, we developed the simulation task, measures, and manipulations. In study 1a, we developed the manipulation of media richness, and in study 1b, we developed the measures of SSA. Experienced officers from the Norwegian defence forces took part in the study, and we analyzed data from military samples to ensure that the results had practical relevance in the counterterrorism domain.

4.1 | Simulated counterterrorism task

Firstly, we developed three scenarios for a command-and-control computer game, focusing on a dynamic targeting task central to counterterrorism (Joint Chiefs of Staff, 2013). Using a goal-directed task analysis (Bolstad, Endsley, & Cuevas, 2010), we described the main goals and subgoals of this task. We focused on one main goal of dynamic targeting: prosecuting time-sensitive targets. We focused on the find, fix, track, and target steps as subgoals of this main goal (see Appendix A).

The specific task in the game was to protect oilrigs or coastal voyage ships along the coast of Norway from possible attacks by terrorists. Teams of three people were set up; each team member commanded two of three complementary resources, each representing a different organization: Orion planes (Airforce) × 2; patrol boats (Navy Special Forces) × 2; and frigates (Navy) × 2. Optionally, a leader without own resources could monitor the team.

Each of the three scenarios lasted 20 min. At the beginning of each scenario, the players did not know which areas had to be protected. This information had to be logically deduced by integrating information distributed among the team members. Players in the game had to do the detection (the find step) by making vessels (objects) appear visually on the screen, search information to identify whether an object was friend or enemy (the fix and track steps), and attack enemy vessels (the target step) under conditions of time pressure. The roles of the three players were created so that they were dependent on each other. The Orions had the highest detection capacity, the patrol boats had the best information search capacity, and the frigates were the only resource with the capability to attack. All scenarios had the same number of friendly and unfriendly objects. The terrorists' target differed from scenario to scenario.

The computer simulation provided each player with a common operational picture (see Figure 2). The common operational picture consisted of a map showing: objects indicating legitimate fishing

LOW RESOLUTION COLOR FIG

FIGURE 2 Game interface. The picture at the top shows the map interface and the picture at the bottom the email interface

vessels; terrorists (disguised as legitimate civilian vessels) planning to attack oilrigs; oilrigs and coastal voyage ships; and the resources available to the players. All players had an email interface providing automated pre-formatted mission orders (sent by the simulation to all at the game's start), intelligence updates (as explained below, a different type was sent to each team member by the simulation, after about 2 min), and detection and information search messages (sent to the team member if they carried out detection or information search). The email interface could also be used to send and receive messages among the members of a team.

4.1.1 | Equivocal information about the situation

We provided the team members with differing intelligence updates from their respective organizations about the location of the terrorists, to induce a high degree of equivocality in the task (Katz & Te'eni, 2007; Schober & Brennan, 2003).

4.2 | Manipulation and measure development

4.2.1 | Participants

A total of 77 Norwegian military personnel from an Army battalion and the Airforce Academy participated in 11 co-located teams and 10 teams whose members were distributed in different locations. Fourteen teams had a leader in addition to the three members. Each team played two of the scenarios.

4.2.2 | Study 1a: Developing the manipulation of media richness

We chose to study extreme conditions of media richness, in which participants communicate either in a distributed email condition (lean media) or in a co-located face-to-face condition (rich media). The email system was a traditional one in which one could send messages to one or more of the other team members and forward and reply to messages. We pilot tested this manipulation with 56 male soldiers from the army battalion. The participants were randomly placed in 14 four-member teams, with the designated roles of Orion, Patrol, Frigate, and team leader. A team leader was included, so that the team conformed to one type of dynamic targeting cell that has a designated leader. However, such cells may also be set up without a designated leader; target engagement authority may for example be delegated to the lowest tactical level. In the other data collections, we chose to continue with three-member teams in the experiment (Orion, Patrol, Frigate), as this would allow us to increase the number of teams.

In study 1a, we assigned eight groups to the co-located setting, and six groups to the distributed setting. After playing the game, the participants answered questions on the perceived media richness scale of Dennis and Kinney (1998) that includes such items as "When we disagreed, our communication environment helped us come to a common position" and "I could easily explain things in this environment," scored on a 7-point Likert scale. The teams in the co-located setting perceived the media as richer than the teams in the distributed setting in an independent samples t test (4.18 vs. 3.37; $p < .001$, $r^2 = .15$) (see Table 1 for descriptive statistics). We also measured the perceived media richness in study 2, reported below. The difference between the two conditions in this study was similar to that in the validation study (3.5 vs. 2.32, $p < .001$).

We measured team performance as attacking the terrorists before they attacked the oil platforms. We subtracted points for attacking enemy objects without first positively identifying the objects as terrorists. We also gave negative points for attacking a friendly object. The correlation between media manipulation (0 = low media richness, 1 = high media richness) and team performance was positive ($r = .31$, $p < .001$).

4.2.3 | Study 1 b: Developing the shared situation awareness measure

We conducted the following steps for scale development, as suggested by MacKenzie, Podsakoff, and Podsakoff (2011): model specification, scale evaluation, refinement, and validation.

Firstly, we specified our model and domain of SSA. To measure SSA, we applied Endsley's conceptualization to our game (2000b). We conducted a goal-directed task analysis to identify SSA items (Bolstad et al., 2010; Strater, Endsley, Pleban, & Matthews, 2001). Each item had one right answer, and individuals got one point for being correct and no points for being incorrect. We constructed a composite variable of SSA for each of levels 1, 2, and 3, based on individually administered items (Edwards & Bagozzi, 2000; Matthews, Eid, Johnsen, & Boe, 2011; Saner, Bolstad, Gonzalez, & Cuevas, 2009). The situation awareness information requirements from the goal-directed task analysis are presented in Appendix A, with links to the items in Appendix B specified.

We evaluated this measure empirically by analysing the three different levels of SSA in the context of antecedent and outcomes in a partial least square analysis (Diamontopolous, Riefler, & Roth, 2008; Diamontopolous & Winklhofer, 2001). There are different methodologies for calculating SSA. Two of the most common are based on the mean of accuracy (Endsley & Jones, 1997) and on similarity in accuracy (Saner et al., 2009). Both operationalizations focus on differentiating high and low sharedness of situation awareness. For

TABLE 1 Descriptive statistics for the sample used for manipulation check of media richness in study 1a

Variable	Mean	Standard deviation	Standard error
Perceived Media richness in both media conditions	4.28	1.03	0.10
Perceived media richness in the co-located setting	4.12	0.80	0.16
Perceived media richness in the distributed setting	3.37	1.08	0.16

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both operationalizations, the element "accurately known" is emphasized. However, the latter method provides information on whether the team members had similar accurate responses, thus capturing the element "known to all the team members," which is central to our definition of SSA. In the results section of study 2, we tested the hypothesis, using both methods of calculating SSA.

To evaluate the scale, we used data collected from 21 cadets in the Royal Norwegian Air Force. The cadets were placed in 7 three-member teams with designated roles for Orion, Patrol, and Frigate. Three groups were placed in a co-located setting and four groups in a distributed setting. Measures were obtained after each scenario. In the empirical evaluation of the scale, we used Endsley and Jones's (1997) operationalization and calculated SSA as the mean of team members' scores on the SSA items. A number of respondents were above what is required for an individual level analysis, but on the low side with respect to the group level (Hair, Hult, Ringle, & Sarstedt, 2013). The results should therefore be seen as tentative and exploratory.

To test the validity of a formative model requires the inclusion of an antecedent and an outcome variable (Diamontopolous & Winklhofer, 2001; Diamontopolous et al., 2008). We examined coordination as an antecedent to SSA, as coordination is important to the updating of the team members' shared understanding (Burke et al., 2006). We used the perceived coordination measure developed by Lewis (2003), which is a five-item measure scored on a 7-point Likert scale. We expected coordination to be positively related to all levels of SSA. As the outcome variable of SSA, we examined team performance. We also examined outcome with respect to the number of enemy objects for which one had obtained information about their identity as an enemy. We expected SSA at levels 2 and 3 to be positively related to performance, whereas SSA at level 1 should not be (see Table 2 for descriptive statistics).

We ran a partial least square (PLS) model using SmartPLS version 3.15, as suggested by Wong (2013) and Diamontopolous and Winklhofer (2001). Given the strong loadings for the majority of items, the expected relation to antecedent and outcome (as indicated by the positive values on the arrows in Figure 3), the relative contribution of indicator to variable (as provided in Figure 3), the lack of multicollinearity, and the good model fit, we concluded that the measure would be valid for our purpose.

TABLE 2 Descriptive statistics for the sample used for development of shared situation awareness in study 1b

Variable	Mean	Standard deviation	Standard error
Mean standard deviation and standard error in both media conditions			
Coordination	3.62	0.85	0.20
Shared situation awareness (SSA) Level 1	0.78	0.30	0.05
SSA Level 2	0.49	0.43	0.07
SSA Level 3	0.53	0.36	0.06
Number of infosearched enemy	3.00	0.00	0.00
Team performance	3.41	2.36	0.35
Mean standard deviation and standard error in the email condition			
Coordination	3.25	0.77	0.27
SSA Level 1	0.67	0.32	0.06
SSA Level 2	0.36	0.40	0.08
SSA Level 3	0.46	0.36	0.07
Number of infosearched enemy	6.00	3.60	0.42
Team performance	5.00	3.00	0.48
Mean standard deviation and standard error in the face-to-face condition			
Coordination	3.92	0.83	0.26
SSA Level 1	0.94	0.17	0.04
SSA Level 2	0.69	0.40	0.10
SSA Level 3	0.63	0.34	0.09
Number of infosearched enemy	3.63	1.86	0.48
Team performance	4.06	2.02	0.51

5 | STUDY 2: TESTING OF HYPOTHESES

Having validated the simulation, as well as our manipulations and measurements, we turned to the testing of hypotheses in study 2.

5.1 | Method

5.1.1 | Participants and procedure

A total of 153 students at a business school, who were randomly assigned to 51 teams consisting of three members each (Orion, Patrol and Frigate), played the same simulation as in study 1, as part of their coursework. There were 24 co-located teams and 27 distributed teams. Within each co-located team, only 1.94 emails were sent in each scenario on average. In each distributed team, however, 27.73 emails were sent in each scenario on average. The teams received an initial brief about the differences in resources (the different team members' capabilities and assets) and were made aware of what resources their team members had. Each team then undertook a 15-min training scenario. The participants were 49% female and 51% male, with an age range from 19 to 53 years and a mean age of 24 years.

5.1.2 | Measures, manipulations, and control variables

We measured our variables after each of the three scenarios, thereby increasing the power to conduct a multilevel analysis. The research variables were operationalized as in study 1, and we used the team performance measure as the dependent variable. The shared situation awareness items were answered in an electronic questionnaire after each scenario. Communication in both conditions (email and face to face) was recorded. ~~Twenty seven teams were placed in a distributed condition, and 24 teams were placed in a co-located condition.~~

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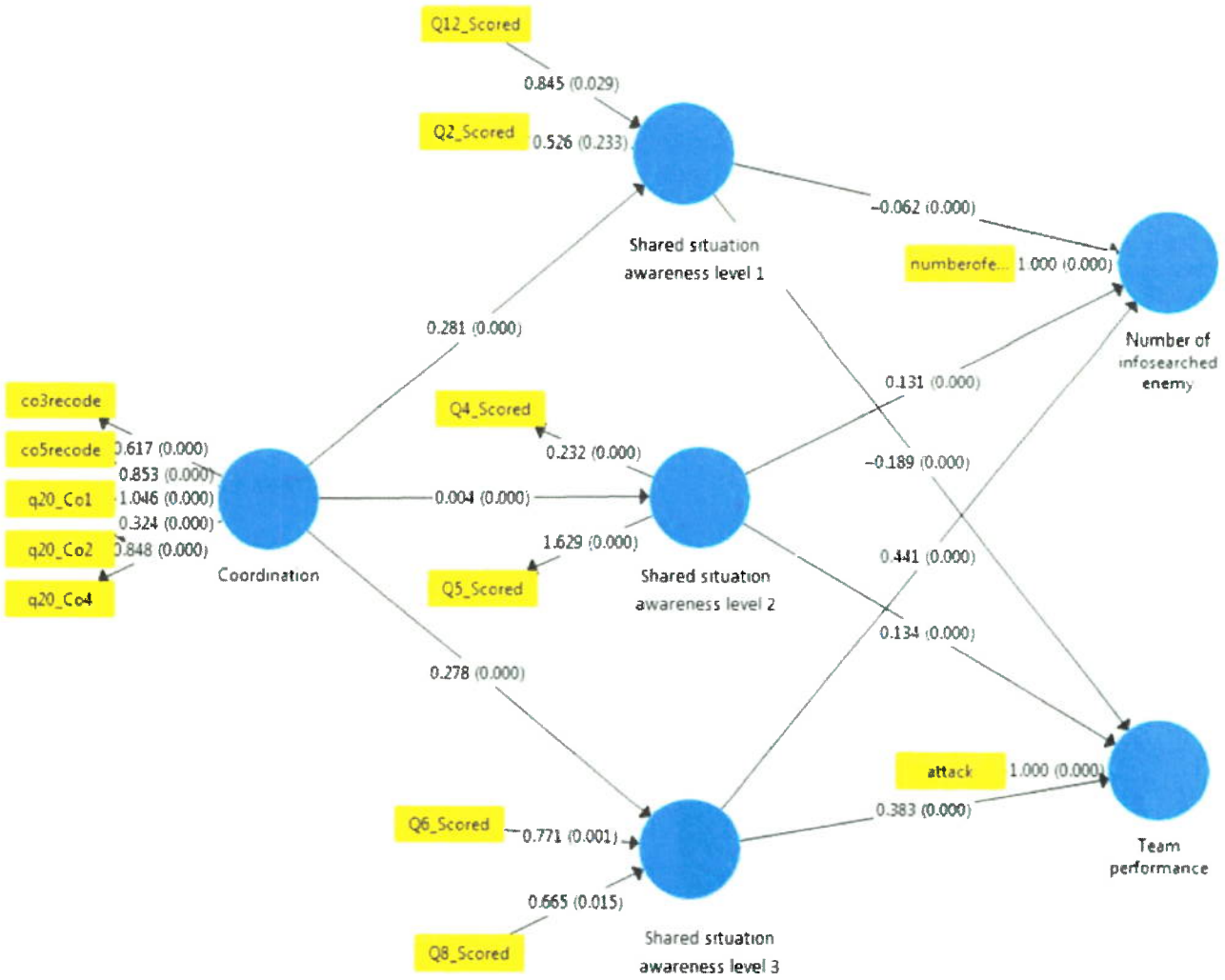

FIGURE 3 Partial least square model study 1b. The various items (yellow boxes) refer to shared situation awareness items (shown in Appendix B) and coordination items (Lewis, 2003) and to the two outcome variables. Q12_scored refers to Q1-3 (in the validation sample, we only included one item with respect to location of resources; in the sample for hypothesis testing we measured location of all resources), and Q2_scored refers to Q4 in Appendix B. Q4_scored and Q5_scored refer to Q6 and Q7 in Appendix B, respectively, and Q6_scored and Q8_scored refer to Q8 and Q9, respectively, in Appendix B. co3recode, co5recode, q20_Co1, Q20_Co2, and Q20Co4 refer to Lewis (2003) coordination items. The number on each arrow is the outer weights, that is, the relative importance of indicators to variables, and in parenthesis their level of significance

We assessed participants' familiarity with other team members by asking them to rate on a 7-point Likert scale from 1 (to a small extent) to 7 (to a large extent) how well they knew the other team members personally and how well they knew them professionally. We thought such knowledge could affect ease of communication, and we used the average score in the analysis (Cramton, 2001). Example items read: "How well do you know team member 1 professionally?" and "How well do you know team member 1 personally?" We also asked them about their crisis management experience and gaming experience, as we thought such experience could be beneficial in solving the game task. For crisis management experience, we asked "To what degree do you have real experience from crisis management (civilian or military)?" scored 1 (none), 2 (some), and 3 (a lot). For game experience, we used one item "Please indicate your prior experience with computer strategy games" scored from 1 (no experience) to 7 (extensive experience). These measures were used in the data analysis to control for the possible influences of past experiences with other team members, crisis management, and gaming.

6 | RESULTS

Media richness and SSA at levels 2 and 3 correlated significantly and positively with team performance, and SSA at level 1 correlated marginally significantly and positively with team performance (see Table 3).

The means of SSA at the different levels 1, 2, and 3 in co-located and distributed teams are shown in Figure 4. (It was possible

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TABLE 3 Descriptive statistics and correlations study 2

	M	*SD* Within	Std. error Within	*SD* Between	1.	2.	3.	4.	5.	6.	7.	8.
1. Know others	1.81	1.13	0.05	0.94		−0.20	−0.09	0.23	−0.23	0.02	0.08	−0.01
2. Crisis expertise	1.22	0.49	0.02	0.32	−0.07		0.16	−0.18	0.03	0.04	−0.11	−0.02
3. Game expertise	2.27	1.61	0.07	0.96	0.05	0.09*		0.18	−0.03	0.14	−0.04	0.20
4. Media richness[a]	0.47	0.50	0.02	0.50	0.15**	−0.08†	0.14*		−0.16	0.23†	0.27*	0.27*
5. Shared situation awareness (SSA) level 1[b]	5.81	3.69	0.15	1.46	−0.04	0.05	0.05	−0.04		0.13	0.25*	0.24†
6. SSA level 2	6.24	4.17	0.19	2.25	0.02	0.11*	0.17**	0.11*	0.08†		0.35**	0.81***
7. SSA level 3	7.27	3.23	0.14	1.31	0.04	−0.00	0.05	0.11*	0.20***	0.13**		0.41**
8. Team performance	29.51	20.94	0.97	13.94	−0.01	0.10*	0.10*	0.18***	0.07	0.54***	0.18***	

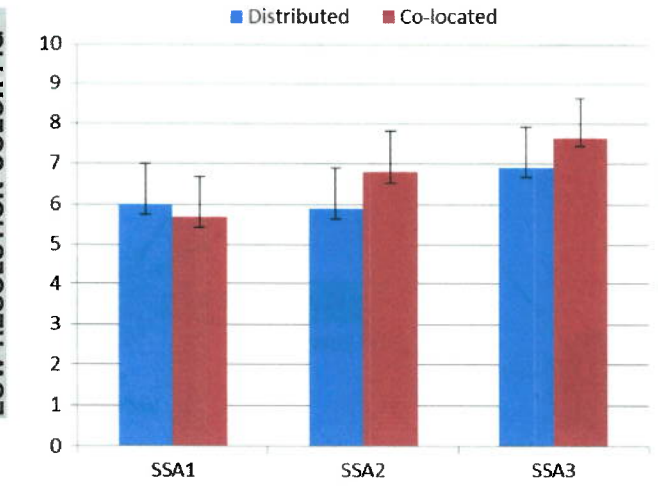

FIGURE 4 Mean of the levels 1, 2, and 3 shared situation awareness (SSA) in the distributed and co-located settings with standard error bars

to get a maximum of 10 points and a minimum of 0 points for each level of SSA.)

To investigate our hypotheses at a group level, while taking into account the variation at the individual level, we ran a multilevel structural equation model (MSEM) analysis in MPLUS (Ludtke et al., 2008; Preacher, Zhang, & Zyphur, 2011). We also needed to take into account this variation in the repeated measures over the scenarios, and to this end, we used latent growth modelling. Finally, we wanted to test the possible mediating effect of the three levels of SSA and therefore used multiple mediation analysis (Statmodel; Zhao, Lynch, & Chen, 2010). In this way, any effect of the various levels of SSA on other levels of SSA could be controlled for.

We ran two models—model 1 with only control variables, and model 2, which added the independent variables—to calculate the effect of media richness on the levels of SSA (see Table 4). None of the control variables was significantly related to team performance in model 2. The results from the MSEM analysis (Table 4 and Figure 5), indicated that the log likelihood decreased significantly from model 1 to the full model 2, indicating a good fit for the full model (Hox, 2010).

From Table 4 and Figure 5, we see that media richness was not directly related to performance ($\beta = -0.72$, $p > .10$). We therefore reject H1. Media richness had a significant effect on SSA at level 2 ($\beta = 1.08$, $p < .05$) and level 3 ($\beta = 0.73$, $p < .01$), but not at level 1 ($\beta = -0.73$, $p > .10$). These findings support H2a, but reject H2b.

Moreover, we found full support for H3, predicting that SSA at levels 2 and 3 are positively related to team performance ($\beta = 0.86$, $p < .001$, & $\beta = 0.73$, $p < .05$, respectively), while level 1 was not ($\beta = 0.24$, $p > .10$).

In support of hypothesis 4, we found a positive and significant specific indirect effect of media richness on team performance through level 2 SSA ($\beta = 0.93$, $p < .05$). The specific indirect effect of media richness via level 3 SSA was marginally significant in a two-tailed test ($\beta = 0.57$, $p = .09$).

We also investigated hypothesis 3, using a more conservative similarity score for calculating SSA (Saner et al., 2009). We used their standard similarity formula to assess the similarity of the levels of situation awareness exhibited by each individual participant in the pair, where p_1 and p_2 are the situation awareness measures of each participant (Ibid, 2009). The ratio $(p_1 - p_2)/(p_1 + p_2)$ represents the proportion of deviation between their scores. Similarity = 1 − absolute value of $[(p_1 - p_2)/(p_1 + p_2)]$ (Saner et al., 2009: 292). This is different from the Endsley and Jones (1997) formula used above, which simply averaged the scores in a team, as the Saner et al. (2009) formula calculates similarity scores for all combinations of team members. We added together the similarity scores of each pair in the team for all items for a level of SSA, and used this as the score of each level of SSA.

We used the PROCESS macro for multiple mediation (Hayes, 2014), controlling for the effect of scenario. This analysis and the MSEM analysis used above provided similar results. The *r*-squared was .28 for this model. For level 1 SSA, there was no significant indirect effect ($\beta = 0.64$, $p > .10$), whereas for level 2 SSA, there was a positive significant indirect effect ($\beta = 3.89$, $p < .05$), and for level 3 SSA, there was a marginally significant positive indirect effect ($\beta = 0.86$, $p < .10$).

TABLE 4 Multilevel structural equation modelling analysis study 2

	Dependent variable: Team performance	
Independent variables	**Model 1**	**Model 2**
Know others	1.34***	0.14
Crisis expertise	−8.91***	0.25
Game expertise	7.41***	0.02
Media richness[a]		−0.72
Level 1 SSA		0.24
Level 2 SSA		0.86***
Level 3 SSA		0.73**
Log likelihood	2,744.04	2,727.80**

	Dependent variable: Level 1 SSA	**Dependent variable: Level 2 SSA**	**Dependent variable: Level 3 SSA**
Media richness	−0.73	1.08*	0.73**

Notes: Group level $N = 51$. STD standardized loadings shown.
SSA, Shared situation awareness.
[a]0 = distributed, 1 = co-located.
†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Additionally, we wanted to explore whether sharedness of situation awareness at levels 1, 2, and 3 would be higher in a co-located setting than in a distributed setting. We explored this by testing the effect of media richness on SSA using the Saner et al. (2009) formula. We found that media richness affected SSA at level 1 negatively ($\beta = -0.07$ $p < .05$), whereas media richness affected SSA at levels 2 positively, and SSA at level 3, marginally significant and positively ($\beta = 0.13$ $p < .01$, & $\beta = 0.08$, $p < .10$, respectively). Situation awareness did not vary significantly across roles (one-way ANOVA).

7 | DISCUSSION

In this article, we examined the following research question: To what extent does rich and lean media influence SSA at levels 1, 2, and 3, and through this team performance? Our findings indicate support for the hypothesis that a positive effect of media richness (email versus face to face) on team performance is mediated by SSA at levels 2 (significantly) and 3 (marginally significantly), but not at level 1. Additionally, we found that level 2 and to some extent level 3 situation awareness was more shared in face-to-face teams than email teams, whereas at level 1 situation awareness seems to be more shared in the teams communicating by email than face to face.

7.1 | Theoretical implications

One of the key issues for team adaptability in general is the ability to develop SSA (Burke et al., 2006). One of the features of teams that could influence shared understanding in general, and SSA in particular, is the medium (Cramton, 2001). Yet, few have examined the role of media capabilities as a key aspect of what influences how teams understand the environment and develop their SSA (Uitdewilligen et al., 2010). The key contribution of the study is to differentiate between media capabilities and their influence on different aspects of SSA. This finding carries implications for the development of theory on media capabilities, team adaptability, and crisis management.

Our findings point to the importance of examining the role of contextual factors of team cognition; more specifically, we have found that media supporting convergence through co-located or rich media help SSA at levels 2 and 3. Our findings pinpoint that updating of SSA at levels 2 and 3 is particularly dependent on media that support convergence and thereby positively affects team performance in counterterrorism. This finding is in line with suggestions from sensemaking and media richness theory on the need for rich media to clarify equivocal issues (Daft & Lengel, 1986; Maitlis & Christianson, 2014; Weick & Sutcliffe, 2001). Media synchronicity theory suggests that developing shared understanding in newly formed teams depends on media that support convergence, for example, co-located communication (Dennis et al., 2008). Our findings add to this claim by suggesting that it is certain aspects of shared understanding, for example, SSA at levels 2 and 3, and not level 1, which is particularly helped by rich media.

Earlier research has produced mixed findings with respect to the influence of media richness on team performance in equivocal settings (Dennis & Kinney, 1998; Dennis et al., 2008). The mediating role of specific levels of SSA could perhaps partly explain why there is not always a positive effect from media richness on team performance in equivocal settings. Some teams may focus all their attention on building SSA at level 1, and focus less on levels 2 and 3, even if they are placed in a co-located setting. Such effects may explain why some teams in a co-located setting do not always have a higher team performance than teams in a distributed setting

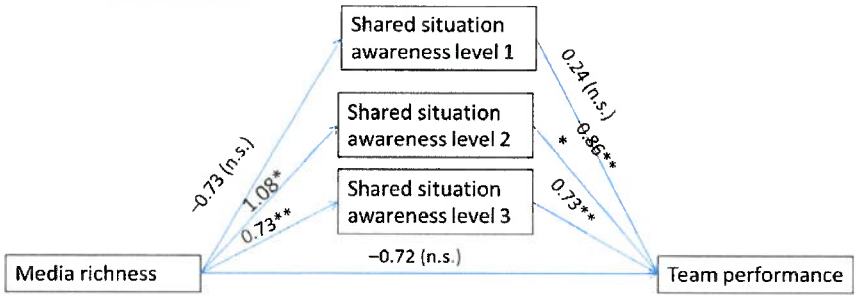

FIGURE 5 Structural equation model with path coefficients study 2

COLOR

(Dennis & Kinney, 1998). This is corroborated by prior research on crisis management indicating that high performing teams use co-located communication to update their shared mental model of a task after a surprise event, whereas lower performing teams do not engage in face-to-face communication to update their understanding of a situation (Waller et al., 2004).

7.2 | Limitations and future research

Future research could examine distributed communication with more advanced decision support. Such decision support may allow for richer communication, potentially helping SSA at levels 2 and 3, as well as capturing the way people interact through the media and their perception of it (George, Carlson, & Valacich, 2013; Kraut et al., 2003). Certain types of distributed media—traditional television and modern online websites—could also be important for conveying situation awareness information to the public (see, e.g., Park & Avery, 2016). Their effect on the different levels of shared awareness could be examined.

Using measures that capture SSA during decision-making could be important to pinpoint more precisely to which step in a task process the awareness relates. Also, SSA may be a too fixed and too much of a snapshot view of team processes, perhaps not capturing other important aspects of crisis management (Weick et al., 1999). Future research could, for example, investigate shared mental models, language, and leadership as moderators on the indirect relations proposed in this article (Burke et al., 2006; Eid et al., 2004; Lichacz, 2009; Lichacz & Bjørnstad, 2013). Future research could investigate whether leader emergence is affected by media and through this affects SSA.

To ensure better external validity, teams or multiteams with a mix of civilian and military members could be studied (Davison, Hollenbeck, Barnes, Sleesman, & Ilgen, 2012; Hansen, 2009; Majchrzak, Jarvenpaa, & Hollingshead, 2007). We measured some control variables to account for expertise, but these could be refined further to examine the effects more precisely (Haerem & Rau, 2007). Future research could also investigate whether SSA at levels 2 and 3 mediate a positive effect of media richness on team performance for other tasks with other levels of equivocality, to probe whether these effects can be generalized across types of tasks.

7.3 | Practical implications

Co-located communication could be a crucial for SSA at levels 2 and 3 in counterterrorism teams. Identifying the equivocal tasks that need a rich media could help such teams decide where to use co-located communication. Furthermore, enhancing media to support situation awareness at levels 2 and 3 could be critical for geographically distributed teams (Cramton, 2001; Katz & Te'eni, 2007; Parasuraman, Cosenzo, & De Visser, 2009; Weick, 2005; Weick & Meader, 1993). Visual aids that explicitly show the identity of objects and project their future movement may help to enhance SSA and team performance through distributed media (Durlach & Bowens, 2010; Durlach, Kring, & Bowens, 2008).

8 | CONCLUSION

SSA, in particular at levels 2 and 3, has been regarded as a crucial influence on team performance in general, and crisis management in particular (Burke et al., 2006). It has also been suggested that lean and rich media is a critical influence on shared understanding, such as SSA (Dennis et al., 2008). Yet, few have examined these assumptions in detail theoretically and empirically. In this study, we have suggested that rich media, through its capacity for synchronous communication, help convergence of SSA 2 and 3 and through this enhance team performance. Theoretically, this refines the models we currently have on the relation between media, SSA, and team performance. Practically it suggests that crisis management teams should pay particular attention to the media requirements underlying SSA at levels 2 and 3. Our findings indicate that the need for teams to use rich media in order to understand and project future events should not be underestimated.

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APPENDIX A

GOAL-DIRECTED TASK ANALYSIS*

Major Goal	Prosecute a time-sensitive target			
Subgoals	Find: Detect and characterize targets for further prosecution.	Fix: Determine the location and positive identification of the potential target for dynamic targeting and on-call target for deliberate targeting.	Track: Observe a target, monitor its activity and movement.	Target: Make a decision whether to engage the target in some manner to create desired effects and select and coordinate the means to do so as well as make collateral damage estimates.
Critical decisions	Where are potential targets located?	What object is target? Where is target located?	What role is best at providing sensor coverage of the target? When is it possible to strike target?	Where is precise location of target? What will be damage to target? What object is target?
Individual SA** information requirement Orion	Know if Orion sensor has covered area.	Know if Orion sensor has covered area.	Know if Orion sensor has covered area.	Know if Orion sensor has covered area.
Individual SA information requirement Patrol	Know if Patrol info search radius is within potential target.	Know identification information of all potential targets.	Know identification information of all potential targets.	Know identification information of all potential targets.
Individual SA information requirement Frigate	Know if potential target is within Frigate attack range.	Know if potential target is within Frigate attack range.	Know if potential target is within Frigate attack range.	Know if potential target is within Frigate attack range.
Shared SA information Requirements level 1	Location of friendly object potentially attacked by target (Q1). Location of team's resources (Q2, Q3, and Q4).			
Shared SA information Requirements level 2		Location of target (Q7).	Number of targets (Q6).	
Shared SA information Requirements level 3				Location towards which target is heading (Q8). Potential damage caused by target (Q9).

Notes: *The codes in parenthesis, for example (Q1), refer to the items in Appendix B.
**To clarify the distinction between shared SA and individual SA information requirements, we include examples of individual SA information requirements. SA = Situation awareness.

APPENDIX B

ITEMS

Shared situation awareness (example items from scenario 1)
Shared situation awareness Level 1
Q1—What is the approximate position of Oil Rig 2?
Just east of Iceland, Near Stavanger, East of the Faroe Islands, Just south of Svalbard, North of Russia
Q2—What is the starting position of Orion 1 and 2?
Iceland, South of Svalbard, Between Iceland and the Faroe Islands, South of Oslo, None of the answers above
Q3—What is the starting position of Frigate 1 and 2?
Iceland, Outside Trondheim, Outside Bodø, North of Murmansk, None of the answers above
Q4—What is the starting position of Patrol 1 and 2?
Iceland, Outside Trondheim, Outside Bodø, North of Murmansk, None of the answers above
Shared situation awareness level 2
Q6 How many enemy/terrorist ships did your team detect during the scenario?
0, 1, 2, 3, 4, 5
Q7 Where was the terrorist located?
East of Iceland, Near Stavanger, East of Faroe Islands, South of Svalbard, North of Russia
Shared situation awareness level 3
Q8—Which of the oil rigs was the target of the terrorists?
Oil rig 1, Oil rig 2 and 3, Oil rig 1 and 3, Oil rig 2, Oil rig 3
Q9—Given what you know: What will a likely outcome of the terrorist act against one of the oil platforms be?
One of the oil platforms is damaged, Transport helicopters en route to the platform will be damaged, Workers on the platform will be kidnapped, All oil rigs will be shut down, None of the answers above