Deriving user requirements for a CBRNE support system

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ABSTRACT

When an adverse event escalates into a criminal investigation, it becomes very difficult to control and combine information into a manageable format. The PROBE project addresses this problem by developing two generations of working prototypes capable of undergoing live field tests and evaluation by a wide-ranging community of CBRNE (Chemical, Biological, Radiological, Nuclear, Explosives) responders. The paper reports the derivation of preliminary user requirements for PROBE based on interviews and observations of a large-scale simulated CBRNE exercise. Five Human-Computer Interaction (HCI) researchers shadowed specialists representing different responder agencies (Emergency Medical Services, police, hazardous materials expert) during the three-hour exercise. Relying on cognitive ethnography, a variant of the concept of distributed cognition, video and audio recordings were merged with notes taken during the exercise and used to derive the preliminary user requirements. The study showed that these could be extracted from a relatively small set of behaviors and different types of utterances made by the active participants in the exercise. The paper concludes with a take-away message for researchers wishing to observe CBRNE exercises in which the command post event management team is collocated.

Keywords

CBRNE event, first responders, cognitive ethnography, Team Situation Awareness, distributed cognition

INTRODUCTION

Although the outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003 was not the result of a criminal act, the Canadian Public Health authorities experienced serious difficulties in their efforts to manage it effectively (Campbell, 2004). The episode clearly demonstrated the need for an application to support the management of large-scale adverse events where information becomes very difficult to control and combine into a manageable format.

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Funded by the Canadian Research & Technology Initiative (CRTI) of the Defence Research & Development Canada (CRDC), the PROBE project addresses this problem by developing two generations of working prototypes capable of undergoing live field tests and evaluation by a wide-ranging community of CBRNE responders. The field tests serve to develop, communicate, and publish requirements for a commercial CBRNE management support product.

The PROBE project combines existing software applications to create an integrated and expandable CBRNE Crime Scene Support Tool allowing Police, Emergency Medical Services (EMS) and Hazardous Materials (hazmat) personnel to communicate and share CBRNE event data and resources in real time. The portable and automated tool will provide a knowledge base and equipment to support rapid determination of the scale of an adverse event and mitigate the spread of CBRNE agents. It will provide responders with critical CBRNE information sources, standardized incident reporting forms and procedures, mass causality triage management and evidence tagging using RFID. This will assist in managing the crime scene by providing interoperability and data exchange between the agencies' responding personnel and mobile command control centers as well as improving responder safety. It will also provide long-term crime scene data and information for use in potential ongoing criminal investigations.

This paper reports Human Computer Interaction (HCI) researchers' observations from the first PROBE field test. The main HCI objective was to identify preliminary user requirements for PROBE, which would then be integrated into the second prototype to be field tested later. In order to do this such that the requirements could subsequently be verified with first responders and CBRNE team leaders, a suitable data collection and analysis method had to be found. Traditional user requirements methods include user interviews, surveys, observations, and task analyses on which to base the conceptual user interface model (Preece et al., 2007), culminating in user interface design (Hackos & Redish, 1998; Mayhew, 2004). Other methods include contextual design (Beyer & Holtzblatt, 1999), usage centered design (Constantine & Lockwook, 1998), and scenario-driven design methods (Rosson & Carroll, 2008). Triangulation of methods is the norm when specifying user requirements. The scenario that drove the process in the present case was prepared by the police event organizers to meet training objectives. The researchers thus had no control over the nature, the scope, or the content of the scenario. In preparation for the event, interviews were conducted with a CBRNE police commander and with a hazmat specialist. These gave the team some understanding of the responsibilities and roles that the various agencies play in managing a CBRNE event. While agency roles are stable, responder team members' tasks vary with the nature, location, and timing of an event. The simulated event reported here provided an opportunity to observe the unfolding of an entire scenario. Large-scale simulation events are very time-consuming, expensive, resource- and labor-intensive; they are not staged very often. Consequently, the research team attempted to maximize the learning possibilities offered by capturing as many data as possible.

The remainder of the paper is organized as follows. In the next section, a brief technical description of the PROBE prototype is presented. Then, the most suitable research methods are examined, namely Team Situation Awareness (TSA), distributed cognition, and cognitive ethnography. This is followed by a description of the methods adopted, and then by the details of the results, which are divided into categorization of observed behaviors and a description of the user needs uncovered in the exercise. Lessons learned are then discussed as well as reflections on the value of the data gathering method. The relationship between the behavior categories and the user needs categories is also explored. Finally, conclusions are drawn.

BRIEF TECHNICAL DESCRIPTION OF THE PROBE PROTOTYPE

The PROBE prototype is an integrated collection of CBRNE tools to aid responders in the identification, communication and mitigation of CBRNE hazardous materials increasing responder and public safety. The prototype consists of CRTI funded and commercial software, industry CBRNE materials as well as a self contained wireless network packaged into a portable laptop computer. Once deployed, PROBE readily provides the responder tools aiding the identification and handling of hazardous materials as well as deploys its own wireless network allowing communications on scene in absence of existing infrastructure.

SELECTING A DATA COLLECTION & ANALYSIS METHOD

Team situation awareness

The most important aim of a CBRNE management application is to facilitate Situation Awareness (SA) (Endsley, 1995; 2000) in the management team collocated in the central command post or, in larger events, in distributed command centers. Good SA enables team leaders to make accurate predictions and thus to make the best decisions about actions to be taken in the management process. One important characteristic of a complex and dynamic system such as a CBRNE event is that the system state changes both autonomously and as a consequence of the decision makers´ actions. In order to control the system therefore, several interdependent decisions must be made in real time and often in parallel (Brehmer, 1992). CBRNE events typically unfold very fast, requiring rapid situation analysis and decision making under severe time pressure (Cannon-Bowers & Salas, 1990; Orasanu & Connelly, 1993). Successful management of such an event therefore requires effective communication in the management team, between it and the operational first responders as well as with their base. When an individual has good Situation Awareness (SA), they know what is going on around them (Guerlain et al., 1995; Smith & Hancock, 1995). However, one problem is that SA may not always be consistent among all group members. In order to make sense of the situation, methods must be applied to assess SA in whole teams. Salas and his colleagues (1992) defined a team as “a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively toward a common and valued goal/object/mission, and who have each been assigned specific roles of functions to perform” (p. 4). In a dynamic system such as an unfolding CBRNE event, Wellens (1993) described Team Situational Awareness (TSA) as “the sharing of a common perspective between two or more individuals regarding current environmental events, their meaning and projected future” (p. 272). Salas et al. (1995) subsequently defined TSA as “at least in part the shared understanding of a situation among team members at one point in time” (p. 131). Finally, in an effort to emphasize the interpretative and distributed nature of TSA, Artman and Garbis (1998) defined it as “the active construction of a model of a situation partly shared and partly distributed between two or more agents, from which one can anticipate important future states in the near future” (p. 2). Whereas all of these acknowledge the importance of sharing information and perspective, Artman and Garbis’ definition also emphasizes the active, ongoing, and dynamic construction of a shared perception of the situation.

In TSA, the unit of analysis encompasses entire teams whose shared goal is to deal effectively with a given situation. In a CBRNE management team, each team member has his/her own area of expertise and responsibility (Heath & Luff, 1992). In Canada, one key function of CBRNE training is to ensure that all team members have a clear understanding of each other’s roles which, according to Son et al. (2007), does not appear to be the case everywhere. Each agency may limit its assessment to observations of direct consequence to the responsibilities without sharing or pooling such information. Poor coordination or poor communication between team members may limit the response operation effectiveness (Son et al. 2007). Since coordinated actions are often constrained by the situation and by other team members’ actions, examining coordinated actions may help identify communication roadblocks (Gorman et al. 2006). This can shed light on at least some of the user requirements for a CBRNE management support tool.

TSA requires articulation of each person’s activity “so that every team member can synchronize his/her actions with those of the others to reach a collectively shared goal” (Garbis & Artman, 2004). One critical factor in disaster management is to identify and share core information. The type and amount of information required differs by roles and responsibilities. For example, strategic level core information is broad, comprising mainly aggregate summary data (Gorman et al., 2006) whereas operational responders’ core information needs are highly specific. Core information changes dynamically as the situation evolves. Organizational response effectiveness depends substantially on communication, particularly obtaining and sharing of accurate information (Comfort et al., 2004) to support collective decision making and action coordination. Decisions are often made in parallel with actions in real time (Son et al., 2007). For example, while one agent is gathering information to assess the situation, another may be dispatching required resources. Assessment of the event and dispatching of medical resources, are thus highly relevant to TSA; both are achieved via mutual SA and joint situational assessment (Artman & Waern, 1999).

There is no agreed-upon theory of TSA, but some measurement techniques are evolving (Artman & Garbis, 1998). Opinions differ on which ones best capture the essence of SA (Durso & Gronlund, 1999). Techniques are either knowledge-based or performance-based. Knowledge-based techniques focus on knowledge structures, for example, by probing operators’ memory retrieval processes or by using query methods during task performance such as momentarily ‘freezing’ a situation. Clearly, that approach was not possible here. Knowledge-based techniques assume that some tasks require good SA to be performed well (Gorman et al., 2006). As these focus on outcomes, they give only the end result of a multiple cognitive processes. These could not offer much insight into user needs for an effective management support system. Although TSA is a valuable and necessary concept, it was not possible to apply it meaningfully in the present HCI task. Instead we applied Morgan et al.’s (1986) critical teamwork behaviors, organized around seven behavioral dimensions: giving suggestions or criticisms, cooperation, communication, team spirit and morale, adaptability, coordination, and acceptance of suggestions or criticisms.

Distributed cognition and cognitive ethnography

Sense-making in a teamwork context is believed to be a product of distributed cognition that focuses on a holistic understanding of an interactive situation (Gorman et al., 2006). Sense-making is thus a product of interaction: the cognitive system comprises team members and their artifacts (Artman & Garbis, 1998). In a case study performed over several years, Furniss & Blandford (2006) developed a method for describing an Emergency Medical Disaster (EMD) work system. It claims to enable identification of sources of weaknesses within the system, which would ultimately contribute to a better understanding of how technology can be better *utilized* in the redesign of EMDs. While that approach is relevant here, our observations are insufficient to construct a generalizable model of CBRNE responses. In order to derive preliminary user requirements here, we aimed to identify shortcomings and breakdowns in distributed team cognition. To do that, we decided to rely on a cognitive ethnography approach, evolved from Hutchins' (1995) distributed cognition framework. Cognitive ethnography theory is constructed from both internal and external resources, and the meaning of actions is grounded in the context of activity (Hollan et al., 2000). It employs traditional ethnographic methods to build an understanding of a community of practice and applies this knowledge to the micro-level analysis of specific activity episodes. Cognitive ethnography aims to reveal how goals are accomplished in real-world settings. It is event-centered and brings together many techniques, e.g. interviews, video and audio recording. It focuses on video and audio analyses (Goodwin & Goodwin, 1996) of the moment-to-moment development of activity. It thus describes how knowledge is constructed and used (Williams, 2006).

METHOD

In preparation for the simulation & training exercise, two research team members were invited to observe a two-day training course to introduce existing support software and the PROBE prototype to the command post management team. Five members of the research team were then invited to observe the half-day simulation exercise.

Participants

Active participants in the CBRNE scenario included the five command post team members who had taken the training course: two Emergency Medical Service officers, one explosives technician and one identification expert (both police), and one hazardous materials expert (firefighter). In addition, several teams of first responders (paramedics, police, fire fighters, hazardous materials experts) took active part. Two teams observed the entire simulation: the software developers and others from Amita, and the five researchers from Carleton University.

Materials

A tent had been erected a priori for the command post team and set up with laptop computers for each participating agency (EMS, police bomb technician, police identification, hazmat). Attempts were made to establish a satellite connection to Ottawa some 400km away for recording and monitoring activities on the PROBE prototype during the simulation. Unfortunately and possibly due to the very poor weather conditions, that connection was very unstable, making it difficult to obtain reliable, continuous signals. The active participants brought the equipment they would bring in response to an actual CBRNE call in the form of specialized vehicles, testing equipment, cameras and tags for identification of items of evidence, Personal Protective Equipment, and so on. Since our research focused on communication in the command post, our list of first responder equipment used outside of the command post is incomplete. Each of the five researchers was equipped with a digital video camera, a still camera, an audio recorder, and note paper as well as with informed consent- and debriefing forms as required by university ethics.

The simulation exercise

The active command post team members knew the general nature of the scenario and the location for the event, a major sports stadium in Toronto in which a baseball match was said to be taking place at the time. According to the scenario, an unknown object or objects had been thrown from above into a section of lower-level seats. An unknown number of people would need medical attention as well as decontamination as quickly as safety would permit. The command post team's task was to manage the situation. This included determining how to proceed, allocating resources, distributing manpower in the hot and cold zones, and so on, while ensuring rapid medical attention to the casualties, accurate record-keeping, and minimizing the risk of contamination of response team members.

Procedure

By the time the command post team members arrived on the scene, some EMS and police first responders were already inside the stadium. They provided first-hand assessments of the situation from the area that would eventually be declared the hot zone. All command post team members communicated with their respective first-responder teams and others at their home base throughout the exercise. Every team member had his own radio, and each agency communicated on a different frequency channel for clarity of communication. The hazmat specialist also communicated with specialist staff in the hazmat vehicle in which access to chemical databases is provided.

Three research team members each observed one of the command post agencies (EMS, police, hazmat) throughout. Another team member captured activities in the command post as a whole; the fifth member recorded first responder activities inside the stadium in the hot zone. In spite of Williams' (2006) warning that it can be a poor strategy to record everything during an event because it makes it hard to locate relevant episodes and to isolate the phenomena of interest, all researchers attempted to record as many activities as possible of the person(s) they were observing. With five channels of simultaneous data collection, it was impossible to keep track of all interactions and thus to identify weaknesses and communication breakdowns on the spot. Recordings included verbal and nonverbal interactions among command post personnel as well as with their responder teams in face-to-face encounters and via radio communication. The exercise took roughly three hours, followed by a one-hour briefing session.

RESULTS

Following a description of the way the data were prepared for analysis, the results are presented in two sections. In order to understand the computing needs of the different agencies/users and of different user roles, the verbal and non-verbal communication patterns and use of artifacts noted in the command post are outlined first, followed by a description of the categorization of user needs uncovered and the implications of these for the CBRNE management system. A sample of the preliminary user requirements is presented last.

Preparation of data for analysis

Each researcher transcribed their own video- and audio recordings ad verbatim, adding any notes taken during the exercise. Next, all the transcriptions were merged into a single file and arranged in a minute-by-minute fashion as recommended in the cognitive ethnographic framework in an effort to re-construct the entire exercise as accurately as possible. Table 1 shows an extract of the merged data file. The time of each observation is shown in the leftmost column, followed by the source of the original data (video, audio, notes), and then the data obtained from each agency. A unique ID was assigned to each media file, together with its duration in minutes, both shown in bold in the table (hazmat, 10:33; police 10:34). Written notes were inserted at the accurate time wherever possible.

Time	Source	EMS	Police	Hazmat
10:33	Video	SE's Radio: Right now we are looking at 2500 potential victims and that is a very small guesstimate. (SE quickly scribbling down message from radio) SE: Do we know what they are complaining of? SE's Radio: Itching, burning – nausea.		**File 141203 (8:10)** BH's Radio: Exercise, exercise exercise – HazXXY responding. (pause)
10:34	Video	SE to NP: 10:31 MC… SE's Radio: A white powder substance like talcum powder – about 200 people – some are coughing – some are itching and sore eyes…	**File 141203 (8:10)** NP to radio: So you are gonna have to update me – so what we got, Mate?	BH's Radio: The section has been locked down, over.

Table 1. Extract of the merged data file

Verbal communication patterns

Verbal face-to-face communication predominated throughout among members of the command post and their responder teams, or via radio and, in very few instances, via cell phones. First responders reported their observations by radio to their team leader in the command post. As the command post team members were collocated, they could overhear each other's radio conversations. Event-critical information was thus shared freely in the command post.

Relying on the cleaned data file in Table 1 above, the results were first sorted into different kinds of utterances to identify communication patterns that could help to understand user requirements within and/or between agencies. An utterance was defined as a word or sequence of words bounded by silence at both ends. Some 23 different types of utterances were thus identified. Two researchers then analyzed the data file independently, labeling and counting the number of instances of each type, and reaching a level of agreement of 92.5%. Inspection of these data revealed substantial variations in the number of utterances over the three hours of the exercise. The data file was therefore divided into six 30-minute segments. As indicated in the pre-study interviews, most activity occurred in the early phases of the exercise when the nature and scope of the attack were still unclear. The part of the analysis reported here therefore focuses on the first three 30-minute segments. Utterances were then sorted by agency for each of the three selected time segments. As Figure 1 shows, the number of utterances declined over time except for the police where a sharp increase occurred in the second time segment. This increase was counter-balanced by a decrease in the number of hazmat utterances from the first to the second time segment.

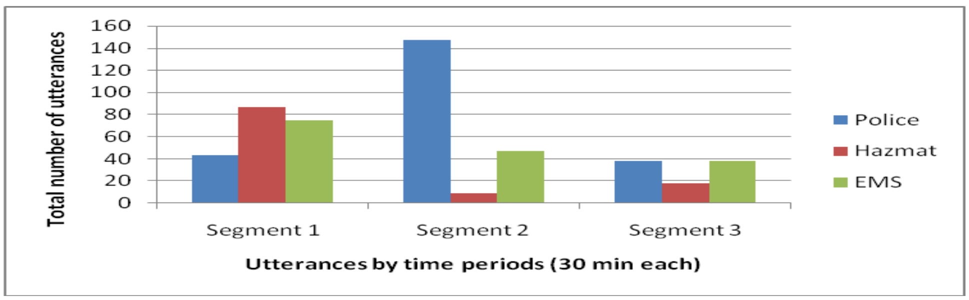

Figure 1. Total number of utterances across the three 30-minute segments

Next, an attempt to utilize Morgan et al.'s (1986) seven behaviors indicating critical teamwork features proved unsuccessful in the sense that only their dimensions of giving or accepting suggestions were relevant in the present context. Instead, it was decided that it would be more meaningful to shift the focus of the analysis to the *purpose* of each type of utterance. To do this, utterance-types sharing a similar purpose reduced the 23 original types to five behaviors. For example, the categories instruction, reminder, briefing, elaboration, and repetition were grouped into the behavior labeled 'giving/sharing information'. The five new behaviors were: (1) seeking information, (2) giving/ sharing information, (3) receiving information, (4) planning actions, and (5) making suggestions. A typical example of someone seeking information is shown in Figure 1 above, in which the police event manager requested an update from his responder team in the hot zone. The example was taken early in the exercise when the event management team was still trying to make sense of the situation: "So you are gonna have to update me – so what we got, Mate?". An example of someone sharing information was also taken from the early stages when the hazmat specialist had just received the first radio information about casualties' symptoms: "It just seems from the report that the only ones that are complaining [of symptoms] are the ones that actually got powder on them. No one else is complaining of respiratory..". An example of the team receiving information via the EMS radio concerned the affected location in the stadium: "Somebody at the 500 level tossed something down on the crowd on the 100 level in section 115". An example of a team planning action occurred when they had just decided where to set up the decontamination facility and were getting ready to collect samples of the unknown agent for identification: "Ok, so we will do that [set up decontamination outside] and you can send a team in there to see if we can figure out what this [the chemical agent] is". Finally, here is an example of the hazmat specialist making a suggestion, again talking about the casualties in the first time segment: "I would have the ones who are complaining, the ones who are burning… ushered to the washrooms right away and wash their face and hands".

The frequency with which utterances were made in these five categories is shown in Figure 2 below by time segment. Again, the general decrease of verbal exchanges over time is evident especially in Segment 3. As expected, the need to obtain (seek) and share (give) information was clearly the most important aspect of communication in the early phases of the exercise. As the event progressed and the scope became clearer and the casualties were beginning to be decontaminated, the number of suggestions increased (Segment 2), and once the situation was more under control as in time segment 3, they decreased. By contrast, instances of receiving information, mainly via the radios from the first responders in the hot zone, were most prominent in the first time segment. Not surprisingly, the same was true for the planning activities. Taken together, the data clearly show that the most urgent need for management support is in the early phases of a CBRNE event which is characterized by high levels of uncertainty and confusion. Consistent with information obtained in the pre-event interviews, they also suggest that the person in charge of managing an event has the greatest need to obtain and share information during those early phases.

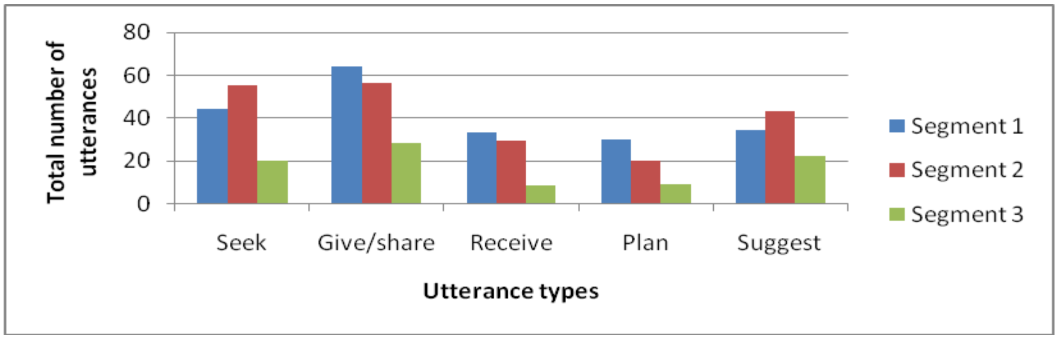

Figure 2. Total number of utterances by category

Nonverbal communication and use of artifacts

Save for the odd 'thumbs up' to signal acknowledgement of a verbal message sent by a management team member, the number of nonverbal communications was too low to warrant detailed analysis. Participants used a small number of artifacts. Each agency has its own data gathering and reporting requirements. The EMS team used their standard paper forms for recording demographic details of casualties, their symptoms, decontamination completed, any medical treatment given, and they took notes to facilitate writing their post hoc reports. The main reason for using paper rather than the application in the prototype was that they lost most of their team to actual CBRNE calls during the exercise. Other CBRNE-trained EMS personnel who had not taken the training course thus took over some of the EMS roles. The police officers used the prototype for their report notes. The hazmat expert used only his radio.

Agency-specific issues (n = 10) were relevant only to some command post team members. For example, at time 10:15, the police identification officer voiced a need to reorganize and view exhibits belonging together by time. If, say, a coat may be used as an exhibit in a later court case was found at time $t_{1,}$ and a set of keys were found in one of the coat pockets at time t_6, he needed to link the two items. This had two implications for the system. It should (1) assign an automatic time stamp to exhibits as they are entered; (2) allow sorting and linking of exhibits any time.

Communication issues (n = 13) took place within the command post as well as between each team leader and his responder team or his base. For example, utterances at times 10:41and 10:53, when some responders were called to a real CBRNE call, indicated a need for a feature enabling the command post team to create and update a map of authorized personnel on site and their roles both within and between agencies. This is currently done in the Toronto Fires Personnel accountability system but could be considered for inclusion in the support system.

Incident information needs (n = 3) concerned the need to know about concurrent CBRNE incidents (utterances at times 10:34; 10:41; 11:06). This required access to concurrent incidents in the region, including information about who is where at any time during an event.

Manipulation of content issues (n = 7) referred to traditional CRUD (Create, Read, Update, Delete) functions. For example, (utterances at times 10:34; 10:41; 11:03; 11:05) there was a need easily to enter, modify, see, and share updates to major incident actions and the action plan. The implication of this is that, whenever there is a change to these plans, a noticeable alert should be displayed on everyone's screen in the command post.

Personnel & equipment issues (n = 10) focused mainly on ensuring that everyone knows who is on site (time 10:53), the location of equipment/trucks/suits (time 10:48), who is online (time 10:25), and who was briefed when (time 11:07). For example, for safety reasons responders may only be in the hot zone for a limited period of time. It is therefore necessary to keep track of when each person entered it and who will replace him at what time, as is indeed always done now, but could still be considered for the support system.. Likewise, if an event escalates to be much larger than first anticipated, perhaps involving more casualties or repeated attacks in a given location (London Resilience Team, 2006), more personnel may be needed, which requires more frequent briefings and knowledge of what information has been shared with whom at what time. All issues in this category implied provision of time stamps, the ability to enter the movements and location of people and equipment, and easy identification of authorized personnel.

DISCUSSION

The verbal records were very important for understanding what was going on as the event unfolded and also for translating our understanding into preliminary user requirements. The fact that we relied on data obtained in only one half of the exercise despite recording and transcribing the entire event suggests that Willams' (2006) warning about collecting too much data is well justified. However, with each researcher having a different data-collection focus, and it being their first experience, it would have been too difficult to determine a priori who should record what when. The written transcripts were necessary to share the parts of the event that each researcher observed. For the next observation in the PROBE project, we know that the most important information emerges early in an event, at least when the management team is collocated and no additional events occur at the same time.

An effort was made to relate the emerging user needs categories directly to the observed team behaviors identified through the spoken utterances in interactive communications, but this was not always possible. For example, most of the agency-specific issues described above were voiced by a management team member to no one in particular in the course of the exercise. Thus, issues in this category related to planning reporting and archiving requirements, but they did not emerge through observation of interactive behavior. By contrast, communication information issues were clearly related to seeking and sharing information. Personnel and equipment issues were, likewise, related to seeking and sharing information, and they also referred to the planning of actions as well as to receiving information. Finally, the 'manipulation of content issues' were also partly voiced by the team members, partly observed through their behavior. Thus, although the needs categories did relate to the observed behaviors, there was no unique one-to-one connection between the two types of categories.

The frequency of occurrence of the different types of utterances was useful for revealing patterns of general information about the event manager's needs and the way that needs of the management team as a whole changed over time. However, as these mainly confirmed information obtained through the pre-event interviews, the value of repeating such an analysis in a future event is probably limited.

One challenge in interpreting the relative importance of different data types was that the event was both a simulation and a training exercise. For example, command post team members discussed at length where best to set up the decontamination facilities.

We had expected to observe many weaknesses and breakdowns in TSA. Yet, there were only very few examples of these; nearly all the time, everyone in the command post knew as much about the situation as everyone else. TSA was thus as close to perfect as one could hope, although the nature of the exercise made it impossible to measure it accurately. This high level of TSA was probably, in part at least, because of the collocated management team. It enables them to overhear most of each other's conversations with their responders and their base. It may also partly have been due to the fact that the stress associated with the extreme time pressure in a real event was absent.

The cognitive ethnographic framework was useful for selecting utterances for analysis. It helped our understanding of the actions and interactions observed in the command post and deciding which conversations to analyze. Some of the core principles of distributed cognition theory (Hutchins et al., 2000) helped to make sense of some episodes and much of the conversation. The tendency to off-load cognitive effort to the environment whenever practical was clear from the constant information-sharing within the command post and through regular briefings with first responders.

CONCLUSION

We believe that the behaviors and the types of utterances identified in the above exercise are generalizable to other CBRNE events, at least in situations in which the management team is collocated and the team members share all incoming information as willingly and naturally as was observed here. Whether the same would be true in a larger event with decentralized command posts, remains to be seen. A simulation and training event may not be optimal for studying actions and interactions in a CBRNE management team, but even with their obvious limitations, they do provide an excellent opportunity to observe behavior in situations that are as close to reality as can be artificially created, with participation of all the relevant first responder teams. Furthermore, for security and safety reasons, it would be most unlikely that researchers would be able to observe a real disaster. Since our user needs are grounded in original utterances, the interpretations and translation of these into user needs can be checked and verified with the relevant personnel. They are currently being implemented in the second PROBE prototype and will be tested in the next simulation exercise.

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