Patterns of Group Information-seeking in a Simulated Emergency Response Environment

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ABSTRACT

Groups in emergency response environment may be confronted with problems that cannot be solved by following predefined procedures. They must therefore engage in a collective search for relevant information, cooperating and collaborating as they move towards the deadline. Information technologies and expertise may help shape group information seeking and determine its effectiveness. By understanding how response personnel search for information in emergencies and extending the findings to determine demands on information systems, we may begin to understand how to support and train for skillful information seeking in emergency situations. Accordingly, this research evaluates the impact of decision support systems and member expertise on group information-seeking behavior in a simulated emergency response environment. The results of the evaluation are then used to identify how information technologies may further support information seeking in emergency response.

Keywords

Emergency response, information-seeking, expertise, decision support systems.

INTRODUCTION

Emergencies may perturb the physical environment and induce the reconfiguration of organizations. Response personnel must therefore be able to seek out and process information about the impact of an emergency in order to address it. Their information needs are associated with the goals of the task and its context, including the group's need to achieve coordination amongst members. Different factors affect different stages in the information seeking and decision making processes (Ramirez, Walther, Burgoon and Sunnafrank, 2002). To improve decision quality, factors such as available decision support technologies and group member expertise must be managed over time, despite conditions of (possibly escalating) risk. This research develops and evaluates a set of hypotheses about the impact of decision support technologies and member expertise on group information seeking behavior in a simulated emergency scenario. The results are investigated to provide implications for the design of information systems to support group information-seeking in emergency response.

BACKGROUND

Risk and time constraint are endemic to emergency situations. Risk is present as possible threats to life or property; time constraint arises from factors such as a threat of building collapse or policy constraints on minimum response time (Mendonça and Wallace, 2002). Under time pressure, decision makers use an "acceleration and filtration" information processing strategy (Maule, Hockey and Bdzola, 2000) to make decisions, speeding up their information processing and becoming more selective in choosing which information to process. As time pressure increases, they may switch to simpler search strategies and decision rules. Risk, whether at escalating or constant levels, may exacerbate acceleration and filtration processes. Emergency response personnel may therefore shift their information-seeking strategies during the emergency response process. Their information-seeking process is a dynamic process interacted with the context, the tasks and the outcomes of previous information search.

Information-seeking is a multi-stage process (Ellis, 1993; Kuhlthan, 1991). The decision making process can also be considered as involving the successive stages of consideration set formation and final choice selection (Levin, Huneke and Jasper, 2000). Information seeking activities are likely to be concentrated in the first stage than in the second one. When under time pressure, emergency response personnel are likely to devote more time to evaluating on-hand information and finalizing decisions, thus leading to a decrease in information-seeking activities.

Various factors may influence different stages of the information search process, depending on the factors present during search and the feedback of previous information-seeking activities (Leckie, Pettigrew and Sylvain, 1996; Ramirez et al., 2002). These factors can be technology-related, information-related, goals-related, situation/context-related and communicator-related (Ramirez et al., 2002). Failure to satisfy information needs leads to the adjustment of information-seeking strategies. Though some factors influencing individual information-seeking behaviors have been explored, relatively little is known about how and to what extent these factors affect group information-seeking processes, particularly under conditions of risk and time-constraint.

Decision support systems

The use of computer technologies in a group setting can influence information-seeking processes in a variety of ways. Because the focus of this paper is on group information seeking, the communication and coordination functions provided by decision support systems are emphasized. With certain group support systems (GSS), all group members can contribute information at the same time and share with all others immediately, all information stored in the computer can be referred by group members later in the discussion, and anonymity motivates participation thus improving information exchange (Dennis, 1996). GSS can also influence groups' search for information. Groups may be said to show preference for common information (i.e., information originally known to all group members) over unique information (i.e., information originally known to only one or a few members). For example, common information may be substantially more recalled and repeated in the decision making process than unique information (Dennis 1996; Dennis, Hilmer, Taylor and Polito, 1997). The bias favoring common information can be reduced both by use of GSS in group discussion (Dennis et al., 1997) and by expert-role assignment (Stasser, Vaughan and Stewart, 2000). Members who are explicitly assigned roles at the beginning of group discussions will recall more unique information than those who are not assigned roles. The introduction of Group Decision Support Systems (GDSS) in group decision making may impact both information recall and information exchange. Group members using a GSS may be expected to exchange more information, especially unique information.

Member expertise

Expertise can improve group performance by increasing each member's ability and judgment; task experience can improve group performance by facilitating problem recognition and utilization of relevant knowledge (Grønhaug and Haukedal, 1995; Littlepage, Robison and Reddington, 1997). The discovery of expert/novice differences has been instrumental in uncovering skills and knowledge that enable high performance. Such study has been found in a variety of areas, from individual physics problem-solving (Simon and Simon, 1978; Larkin, McDermott, Simon, and Simon, 1980) to group decision making in complex tasks (Bonner, Baumann and Dalal, 2002; Ahituv, Igbaria and Sella, 1998). Experts are expected to spend less time on a problem, to memorize more relevant information and process information faster than novices (Simon and Simon, 1978; Chase and Simon, 1973; Larkin et al, 1980). Research on skilled memory theory (Ericsson and Staszewski, 1989) argued that experts' rapid processing of information was due to the use of a hierarchical knowledge structure established in memory; such structure and organization of knowledge is established from intensive practices in certain domain.

Moreover, experts are more consistent in applying their decision rules (Galletta, King and Rateb, 1993) and have a higher level of confidence in their choices (Simon and Simon, 1978) than do novices. For example, a study on the decision making of air commanders in a dynamic environment under very limiting time constraints reveals that experienced commanders tend to make less decisions within a given time interval and process additional information better than less-experienced commanders (Ahituv et al., 1998). Differences also emerge in information seeking behaviors of experts and novices (Saito and Miwa, 2002). Experts' information seeking behaviors are well organized according to sets of basic units while novices' are characterized by depth-first and breadth-first search, suggesting that experts utilize known facts more effectively than novices, since in the same circumstances novices may need more cues to solve a problem. However, experts and novices do not always have significant differences in performance. An exploratory study on information-seeking behavior in emergency management (Gu and Mendonça, 2003) reveals that both experts and novices look for similar information resources in emergency scenarios.

METHODS

This study uses a simulated emergency scenario to investigate how decision support and expertise can influence group information seeking behavior.

Research hypotheses

The two factors investigated in research are decision support, which indicates whether or not the groups had access to a computer-based decision tool, and member expertise, which reflects the work experience and domain knowledge of individual decision makers. Decision support may facilitate decision makers to seek more information, especially unique information. Experts' knowledge helps them locate the relevant information more efficiently than novices (Barrick and Spilker, 2003), thus leading to reduced search effort. When provided with decision support, novices are expected to rely more on the recommendations from the system, especially under time constraint. However, experts' confidence on their own professional judgments may make them prefer making decisions on their own, regardless of the systems' recommendation (Arkes, Dawes and Christensen, 1986). Hypotheses H1 through H3 are therefore proposed:

H1: Groups with decision support engage in more information-seeking activities than do groups without decision support.

H2: Novice groups engage in more information-seeking activities than do expert groups.

H3: The increasing of information-seeking activities with the availability of decision support is higher in novices groups than that in expert groups.

Problem description

Data used to investigate H1 through H3 were drawn from a series of studies on group decision making in simulated emergency response scenarios (Mendonça, Beroggi and Wallace, 2001; Mendonça et al, 2002). Groups worked on two separate emergency response-related cases, drawn from reports of actual technological disasters. Case One concerns a cargo ship fire with an oil spill; Case Two concerns a collision between two ships with a resulting chemical emission. Each group had five participants: one group coordinator (CO), who served as a facilitator, and four who represented the emergency services of the Police Department (PD), Fire Department (FD), Medical Officer (MO), and Chemical Advisor (CA). The group's task was to make decisions about how to allocate available resources in order to meet the goals of the response.

Implementation

Each group met in a room that was equipped with one laptop computer per participant (see Figure 1). Information on the case was provided through a computer interface, which described the nature and geographic location of available resources. Each non-CO member could view only the resources at the sites belonging to that role. All members could access information on resources (such as gymnasiums and supermarkets) that were not controlled by a particular service (i.e., alternative resources). The CO had accessibility to all sites in each case. Individuals therefore had incomplete information locally but complete information globally. Participants were also free to ask questions of each other. Figure 2 shows the computer interface for Case One. The map at the left side displays the locations of resources and the incident location. As time passed, every minute spent on planning was one less minute available for execution. Therefore, certain resources became infeasible even as the situation worsened. Decision support was provided to some groups when certain resources became unavailable but other alternative resources could be used. The system recommended procedures involving these resources, which then had to be assembled to form a solution. Unsupported groups received no such assistance.

Expert participants were students at the U.S. Federal Emergency Management Agency's National Fire Academy; novice participants were college students enrolled in business or engineering programs at a top 25-rated engineering university. Groups were randomly assigned to use the decision support tool or not for each of the two cases. The number of groups under each condition is shown in Table 1.

Figure 1. Layout of the experimental session

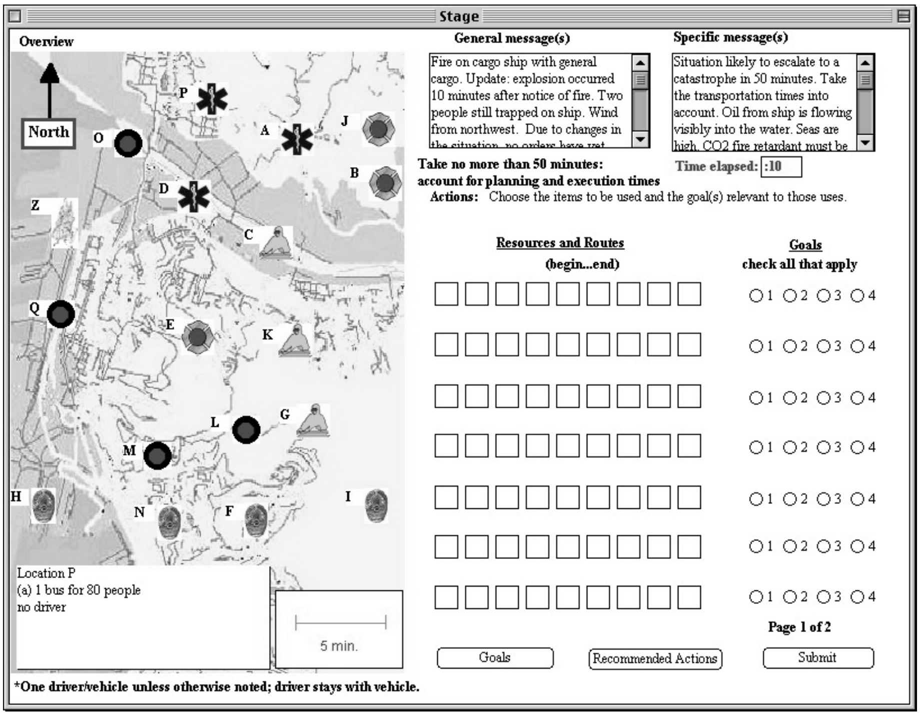

Figure 2. Computer Interface for Simulated Emergency in Case One

		Novice	Expert
Case 1	Support	2	3
	No support	2	4
Case 2	Support	2	3
	No support	2	4

Table 1. Number of groups in each condition

Data source

To provide traces of information seeking and decision making, various data streams were captured, all of which were time synchronized for analysis. Computer logs recorded which information was sought by individuals through the interface, and what decisions were made by the group. A sample record from a computer log is shown in Table 2. It shows that participant CA in group A from session NFA1 clicked site C at 7:33:36 PM (the ticks value of 148132 is a more precise measurement of time, with one second equaling 60 ticks). The record is interpreted as a request for information by CA about the resources available at site C. The stream value of P means this event is part of the information seeking process.

Session	Group	Participant	Stream	Time	Ticks	Event
NFA1	A	CA	P	7:33:36 PM	148132	C

Table 2. Sample records from computer log file

Measures

Four separate measures are used to characterize information seeking. The first measure is the frequency of searches for information (M1), which is tabulated as the average number of clicks on sites within a minute made by each group. One typology of information is common versus unique. In this study, alternative resources (AR, i.e., resources that were not controlled by a particular service, such as gymnasiums and supermarkets) are globally accessed by all group members, and thus are regarded as common information. Non-AR sites are controlled by individual services and can only be viewed by the site's owner and the CO, and are therefore regarded as unique information. Clicks on AR sites are therefore counted as searches for common information; clicks on non-AR sites are counted as searches for unique information. Accordingly, variable M2 represents the frequency of searches for common information. Similarly, variable M3 represents the frequency of searches for unique information. Variable M4 measures the proportion of number of searches for unique information. M4 represents the allocation of the search activities between different types of information. The measures are summarized in Table 3.

Variable	Name	Description
M1	#Total	Average number of clicks on sites within a minute made by each group
M2	#Common	Average number of clicks on AR sites within a minute made by each group
M3	#Unique	Average number of clicks on non-AR sites within a minute made by each group
M4	Proportion of unique	$\#Unique / \#Total \times 100\%$

Table 3. Information-seeking Measures

The research hypotheses are then specified according to these measures (see Table 4).

No.	Hypotheses
H1	$M1_S > M1_U$
H2	$M1_N > M1_E$
H3	$(M1_S - M1_U)_N > (M1_S - M1)_{N\ E}$

where S=Supported groups, U=Unsupported groups, N=Novices and E=Experts.

Table 4. Summary of the hypotheses

RESULTS

Descriptive Statistics

The mean and standard deviation of each measure from the decision support and expertise manipulation are summarized in Table 5. Groups with decision support engaged in more search activities than did groups without decision support. Novice groups sought information more frequently than did expert groups. For novice groups, the availability of decision support increased groups' search frequency for both types of information. However, for expert groups, the availability of decision support decreased groups' information search frequency, especially for unique information. The search activities are allocated almost evenly between searches for both types of information in expert groups with decision support, but are preferred to unique information in other three conditions (novice without decision support, expert without decision support and novice with decision support).

Mean (STD)	Unsupported		Supported	
	Novice	Expert	Novice	Expert
M1	10.5 (9.3)	5.0 (4.8)	14.2 (10.0)	4.3 (3.5)
M2	3.1 (3.5)	1.5 (2.0)	4.8 (4.6)	2.1 (2.4)
M3	7.4 (7.3)	3.5 (3.8)	9.4 (7.2)	2.2 (2.4)
M4 (%)	67.7 (32.7)	70.7 (33.9)	67.1 (28.7)	52.6 (41.9)

Table 5. Mean and Standard Deviation of M1-M4

Hypotheses Testing

An ANOVA analysis was performed (α=0.05) to determine the main effects of decision support and expertise, and the interaction effect of these two variables on group search behavior. The results (p<0.05) are listed in Table 6.

Results for Hypothesis 1

Decision support had a significant impact on the frequency of searches for common information (M2), thus Hypothesis 1 was partially supported. Moreover, results for M4 suggest that decision support had significant effect on the allocation of the search activities between common and unique information. The proportion of the number of searches devoted to locating unique information is greater in unsupported groups than that in supported groups.

Results for Hypothesis 2

Expertise had a significant impact on the frequency of searches for information (M1). Novice groups clicked more than expert groups did, thus lending support to Hypothesis 2. Moreover, novice groups' search frequency for common information (M2) and unique information (M3) are both significantly higher than expert groups'.

Results for Hypothesis 3

The interaction effect of decision support and expertise was significant on searches for total information (M1), searches for unique information (M3), and the proportion of number of searches for unique information (M4). Availability of decision support would increase novice groups' information-seeking activities for (unique) information but reduce expert groups' seeking activities for (unique) information. Hypothesis 3 was not supported.

	Support		Expertise		Support×Expertise	
	F value	*p* value	*F* value	*p* value	*F* value	*p* value
M1	1.60	-	92.26	<.0001	7.70	0.0059
M2	8.43	0.0039	38.29	0.0001	2.33	-
M3	0.00	-	81.73	<.0001	7.63	0.0061
M4	8.63	0.0035	1.16	-	4.60	0.0327

Table 6. Results of ANOVA

The results suggest that member expertise had a significant impact on groups' search behavior, and that decision support had a significant impact on (i) groups' search for common information and (ii) the allocation of search activities between common and unique information. These results are now discussed in detail.

DISCUSSION

Effects of Decision Support

Groups without decision support show a higher proportion of the number of searches for unique information than groups with decision support, which seems inconsistent with the prior result that group's search preference for common information can be reduced by introducing group support systems (Dennis et al., 1997). One explanation is that emergency response is quite different from a common problem-solving task. With risk and high time pressure, group members tend to use familiar facts that can be recalled easily from their memories (Rice, 1987), thus strengthening their preference for common information. Moreover, the use of decision support to search and communicate under time pressure is constrained by users' familiarities with the system. Group members may abandon communication channels with which they are not familiar.

It is observed that the frequency of searches by supported groups was higher than that by unsupported groups in the very first stages, but after that both supported and unsupported groups tended to behave similar and the search frequency of unsupported groups will finally over that of supported groups in the last stages of information-seeking process. These observations help to understand the effects of decision support on group information-seeking behavior may vary in different stages of the information-seeking process (Kuhlthan, 1991; Levin et al., 2000). In the initiation and information set formation stages, the major task of the group is to form its information base for addressing the case. Each group member contributes the information thought to be useful and tries to obtain information for making judgments. Therefore, decision support should help group members concentrate on group communication and information gathering activities. In later stages, as time to implement decreases, response personnel have to make decisions based on the information at hand. The problem they face is not lack of information but how to distinguish relevant from irrelevant information in time to make final decisions. In such stages group members, with the aid of a decision support tool, focus on recognizing the most relevant information and considering possible solutions recommended by the system. Thus the impact of decision support tool on group information-seeking behavior is not likely to be significant.

Expert vs. Novice Differences

The results suggest that novice groups search for information more frequently than do expert groups. The difference is more prominent in the first half of the case, particularly for unique information. Several factors may explain this result.

First, emergency management is a complex task, requiring decision makers with professional ability and group coordination experience to react successfully. Novices have to obtain domain knowledge through seeking for unique information but expert groups do not have such kind of deficiency. Therefore, novice groups should have a greater need for unique information than expert groups, resulting in novices' search behavior being different from experts' at the beginning of the process.

Second, though both novice and expert groups may benefit from the use of decision support tool, the interaction effect of expertise and decision support on group information search is complicated. A higher confidence level within groups may induce them to spend less time on information-seeking activities. In other words, the more confident the groups are with their decisions, the less effort they are likely to spend on collecting information. This effect would make expert groups reduce their searches for information, especially unique information, with the availability of decision support, while novice groups increased their information searches when provided with decision support.

CONCLUSIONS AND IMPLICATIONS

Implications of these results are now considered which should help lead to systems that more effectively support group information seeking and decision making.

One suggestion of this research is that information systems should be able to accommodate a range of tasks in response to the decision makers' information needs at all stages in the information-seeking process. Functions required by users in the different stages of information-seeking and decision making process vary. For example, from initiation to information formulation stages systems may provide more comprehensive and uncommon information, information tracking and group communication would be needed. With passage of time summary information and recommendations of possible solutions may take more proportion of the amount of information offered by the systems, information filtering and decision aid are therefore functions need to be incorporated into the system design.

A second suggestion deals with the group search effort devoted to different types of information. Although group support systems can reduce group preference for common information, such an effect may be countered by the impact of high time pressure. When a time constraint is present and unique information is critical for decision making, information systems promoting unique information search and exchange may be of great value for decision makers, especially for novice groups. The presentation style of information provided by the information systems may be designed to highlight those types of information with higher priority and to enable categorization and sorting of information for fast tracking and locating.

One observation from this work is that time impacts patterns of information-seeking both for expert and novice groups. Information from the same resource may not be the same as time passes; meanwhile, groups spend a decreasing time and effort on information search. The cost of spending limited effort on unavailable information resources may not be affordable for emergency response groups. A third suggestion, then, is that the design of the information systems recognize different states of the tasks and corresponding goals, and support (i) information presentations on update of the information status and (ii) filtration to present most related information for group members.

The last suggestion concerns group memory. Functions of information systems will not be fully used if users are not familiar with them. Under time constraint emergency response personnel will easily abandon the functions/systems they are not familiar with and thus cannot benefit from the facilities information systems may bring in. Simulated scenarios and actual cases need to be incorporated into the systems for interactive exercises and testing on a regular basis. In terms of this research, how to maintain the information systems to train and support skillful information-seeking is an issue. The information searched by experts may be compared with that searched by novices, and the differences can be presented to the users and recorded for later interactive training in similar scenarios so that possible relevant categories of information may be located fast in emergency response.

Future work in this area includes the investigation of how information—once found—is used, and how time constraint, decision support and expertise can impact information use.

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