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The effect of time pressure on expert system based training for emergency management

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Abstract. In many emergency situations, human operators are required to derive countermeasures based on contingency rules whilst under time pressure. In order to contribute to the human success in playing such a role, the present study intends to examine the effectiveness of using expert systems to train for the time-constrained decision domain. Emergency management of chemical spills was selected to exemplify the rule-based decision task. An Expert System in this domain was developed to serve as the training tool. Forty subjects participated in an experiment in which a computerized information board was used to capture subjects' rule-based performance under the manipulation of time pressure and training. The experiment results indicate that people adapt to time pressure by accelerating their processing of rules where the heuristic of cognitive availability was employed. The simplifying strategy was found to be the source of human error that resulted in undesired decision performance. The results also show that the decision behaviour of individuals who undergo the expert system training is directed to a normative and expeditious pattern, which leads to an improved level of decision accuracy. Implications of these findings are examined in the present study.

1. Introduction

Expert Systems (ESs) are a class of computers that emulate the reasoning process of human experts in the area of their specialty (Hayes-Roth *et al.* 1983). The role of ESs has been in acting as decision aids in order to support humans in the cognitive requirements of a specific task (Pew 1988). The expert level assistance provided by ESs has improved decision-making performance in a wide variety of application areas, such as industrial supervisory control, medical diagnosis, and computer configuration, etc (Turban 1993).

However, there are a number of decision environments where the utilization of ESs as a decision aid would not be viable. These application scenarios, the interest of the present study, mainly involve emergency management of risks where human operators are required to make decisions under extreme time pressure. Moray (1988) noted that 'in many error situations . . . the time constants are such that there will be no chance to invoke the aid.' In light of the small opportunity to access ESs for advice in limited time situations, the merits of ESs under such circumstances thus clearly shift to reside in their utilization as a training aid (McFarland and Parker 1990, Sharit *et al.* 1993).

The attractiveness of using ESs to train for time-constrained emergency management stems primarily from the following rationale. First, in situations that permit no utilization of ESs as decision aids, the responsibility for decision making relies totally on the human operators themselves. Unfortunately, successful handling of emergency disturbances is likely to be hampered by the human's tendency to make errors in such situations (Rasmussen 1982, Reason 1990). Therefore, it is required that humans be adequately trained in order to develop effective programmes for emergency management.

Second, human decision making in emergency management is often characterized by the need to reason extensively over knowledge expressed in rule-based form (e.g. contingency procedures). Specifically, the rule-based decision task is carried out by recognizing system and/or environment symptoms and associating rules with those symptoms (Rasmussen 1986). This rule-based level of performance is consistent with the production system paradigm (Brownston *et al.* 1985) that underlies most ESs. Possibilities thus exist that ESs can potentially serve as a training aid to improve human rule-based reasoning in emergency management.

Third, ESs are distinct in being able to make the process of rule-based reasoning transparent to users through the so called explanatory facility (Luger and Stubblefield 1989). This feature enables a human–ES interactive environment where, from the explanatory feedback, people can learn how ESs conduct rule-based searches.

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In their exploratory work, Sharit *et al.* (1993) found supportive results for the use of ESs to train for emergency management. However, there is a fundamental limitation of the study that must be addressed. This inadequacy relates primarily to the lack of consideration of time constraints, which is the crux that gives rise to the viability of ES-based training in the emergency domain. It has been suggested that the transfer of training from ordinary conditions to those of time pressure situations might be poor (Zakay and Wooler 1984). In order to investigate further training methods with real-world implications, the present study is aimed at examining the effectiveness of ES-based training by taking into account the effect of time pressure.

Time pressure has been interpreted as one among a number of task characteristics that determine the costs and benefits of using particular strategies (Maule and Hockey 1993, Payne *et al.* 1988, 1990). In this conceptualization, costs refer to the mental resource implication of implementing a particular strategy, while benefits are considered as the values accruing to decisions made when using that strategy (Maule and Hockey 1993). The dominant theme has been that people appear to adapt to different strategies as a function of time pressure with a minimum of cognitive efforts in cost/benefit calculation (Beach and Mitchell 1978, Edland and Svenson 1993, Payne *et al.* 1988).

The human's adaptive decision behaviour in reaction to time pressure can be demonstrated by various aspects of adjustment (Maule and Hockey 1993, Payne *et al.* 1988). For example, under time pressure, people tend to accelerate their decision process by increasing the rate of information search (Ben Zur and Breznitz 1981, Maule and Mackie 1990, Payne *et al.* 1988). When time pressure is so pressing that acceleration alone fails to satisfy task demands, people adapt to time pressure by resorting to an increased use of heuristics-based decision rules. Payne *et al.* (1988) found that, under time pressure, intuitive strategies (e.g. the elimination-by-aspects rule) were adopted by subjects in place of normative strategies (e.g. the weighted additive rule). The employment of simplifying strategies under time constraints was also reflected in the human's adoption of filtering, in which selective processing of information occurs (Ben Zur and Breznitz 1981, Edland 1993, Svenson *et al.* 1990, Wright 1974).

Given this contingent nature, it is likely that the way people perform rule-based emergency management tasks will be in line with the adaptive mechanisms underlying time-constrained human information processing. Specifically, we predict that people will tend to rely on heuristics-based manipulation of rules, in an accelerating manner, when deriving rule-based countermeasures under time pressure.

The prevalent use of heuristics, however, often results in decision biases that eventually lead to severe human errors (Kahneman *et al.* 1982). In order to prevent potentially catastrophic susceptibility in decision making, several prescriptions, emphasizing training with normative decision procedures have been attempted and some of them were at least partially successful (Bell *et al.* 1988). For example, Fong *et al.* (1988) found that subjects who received formal statistical training enhanced their capability for averting reasoning errors that resulted from the use of statistical heuristics. In Zakay and Wooler's study (1984), the use of noncompensatory multi-attribute utility procedures led to improvements in the effectiveness of decisions made.

Considering these promising efforts, successful management of emergencies seems feasible if humans are trained with ESs which can derive solutions that are always normatively correct by employing formal Artificial Intelligence (AI) techniques (Luger and Stubblefield 1989). The ES-based normative search mechanism is expected to provide a resource to which humans can revert when the tendency towards heuristic processing of rule-based information is taking place. Therefore, we hypothesize that individuals who undergo ES-based training would be better equipped to make accurate and consistent rule-based decisions when emergency incidents have to be resolved under extreme time pressure.

2. Methodology

2.1. *Independent variables*

Given the purpose of the present study, time pressure and training were manipulated as independent variables. Time pressure was operationalized by two deadline conditions and was designed as a within-subjects factor in order to provide a strong test of the hypothesized adaptivity. The subjects in the 'no time pressure' condition were allowed to complete a task at whatever pace they wished, whereas the subjects in the 'time pressure' condition were required to finish a task within 90 seconds (the 90 second constraint was found to constitute time pressure in a pilot study). Training was designed as a between-subjects factor and defined by two treatment levels. The ES group received lines of reasoning generated by an ES. The control group, however, received no such information.

2.2. *Subjects*

Forty undergraduate students in industrial engineering at a major university served as subjects. Participation in the experiment earned credit toward fulfillment of a course requirement. None of the forty subjects had taken ES/AI related courses prior to participating in the experiment. The subjects were randomly assigned to one of the two training conditions, with each group receiving twenty participants. All subjects completed the experiment successfully.

2.3. *Expert system development*

An ES in emergency management of chemical spills (Johnson and Jordan 1983) was developed to serve as the training tool. The knowledge base of the ES consisted of fifty-two domain-specific rules, in the form of 'IF symptoms THEN action', that dealt with various aspects of spill management (see Appendix A for some sample rules). A 'HOW' explanatory facility (Luger and Stubblefield 1989) was programmed to demonstrate how the ES employs a normative search to chain relevant rules to prove a query. This facility is particularly significant because it is the reasoning lines generated by the justifier that serve as the prescription for debiasing intuitive processing. The ES also included an interface in which subject interaction with the ES could be conducted in a friendly, natural language environment.

2.4. *Stimulus material/query systems*

The query system represented a set of scenarios made up of queries and associated facts that simulated spill incidents (see Appendix B for a sample scenario). There were two sets of query systems. One was for training and consisted of four scenarios. The second was for experimental tests and included ten scenarios. Both sets of query systems were manipulated to chain the same number of rules (eleven) so that the fourteen queries were identical in terms of processing difficulty.

2.5. *Performance measures*

In order to test the aforementioned hypotheses, three aspects of rule-based performance were measured. The first measure was the average time spent in acquiring each item of rule-based information (i.e. each symptom value). This response measure was to test the hypothesis of acceleration of rule-based processing under time pressure.

The second measure examined rule-based processing in terms of the search pattern employed by the subject. The hypothesized rule-based decision behaviour concerned whether it was an ES-based search (Type E) or a heuristics-based search (Type H). The measure was thus defined by an index that calculated the number of Type E movements, minus the number of Type H movements, divided by the total movements of both types. This performance measure ranged from + 1.0 to – 1.0, with + 1.0 indicating 100% employment of ES-based normative strategies, and – 1.0, 100% employment of heuristics-based strategies.

The third measure related to rule-based performance in terms of the level of accuracy achieved. Accuracy was operationalized as the percentage of the rule-based queries that were solved correctly.

2.6. *Information acquisition methodology: the CRIB*

Information board methodology is a process tracing technique that offers great potential to capture human time pressure decision-making processes (Maule and Svenson 1993). A Computerized Rule-based Information Board (CRIB) was developed in the present study in order to collect data for examining the performance measures.

The CRIB system was programmed to run in a Microsoft Windows environment on an IBM PC. The PC was equipped with a mouse for performing a variety of functions. The system included a scenario window that displayed the test query system. Directly beneath the window was a panel that consisted of ten items in a 5×2 matrix. Each item included an attribute (symptom) and alternative values associated with that attribute. The item at the bottom of the screen provided choices for the decision outcome. Rule-based search activities performed by subjects were carried out through a sequence of information selection by clicking the mouse on appropriate symptom values and on a proper decision choice.

Each state value and the outcome choice could be repeatedly selected or deselected (e.g. to change previously entered values) until the 'STOP' button was clicked. The 'NEXT' button allowed the system to proceed to a new session (i.e. a new test query). The CRIB recorded, for each test query, the outcome choice, response time spent for processing each symptom value, and the order in which those values were selected.

Time constraint conditions were also controlled by the system through the deadline window. The window signaled a 90-second countdown as soon as a time-constrained test query was presented. When the countdown entered the last 15 seconds a beep sounded each second as a warning. The window displayed 'NULL' when a no time pressure session began. Figure 1 shows a completed session of a time-constrained test query on the CRIB.

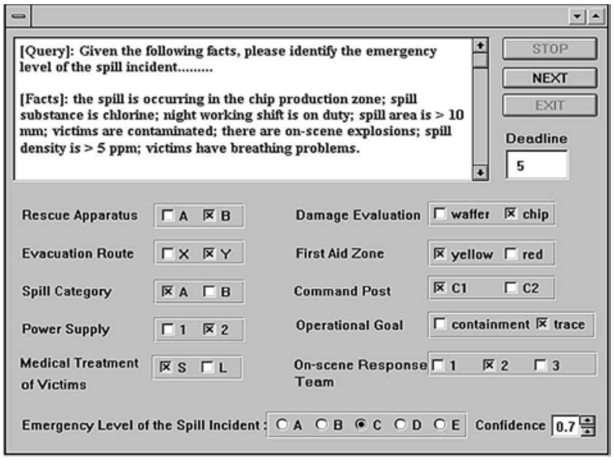

Figure 1. A completed session of a time-constrained test query on the CRIB.

2.7. *Procedures*

The entire experiment consisted of the following stages:

1. Memorization session: All subjects were required to memorize the fifty-two domain rules, with an emphasis on being able to recognize the association between the symptom values in the 'IF' section and the action in the 'THEN' section. This task was performed as a take-home assignment.
2. Pre-training memory test: All subjects were required to take a test in this session to demonstrate their knowledge of the rules. The test included twenty-two blank-filling questions in which the subjects were asked to provide associated 'IF' symptom values, given a 'THEN' section, or associated 'THEN' actions, given an 'IF' section. Only subjects who answered all the questions correctly qualified for the next training session. The adoption of such a strict measure was to exclude a possible extraneous situation where the failure in rule-based reasoning resulted from forgetting of the rules. Subjects who scored unsatisfactorily were instructed to review the rules and rescheduled for a make-up test.
3. Training session: This training session was conducted on a SUN computer workstation. Each subject in both training groups was instructed to open a scenario window that displayed the training query system. The ES subjects were then required to interact with the ES and the associated 'HOW' explanatory justifier to observe the normative reasoning process derived by the ES. However, instead of having access to the ES, the control subjects were required to derive solutions for the training queries by searching among the fifty-two domain rules, which appeared randomly in a rule window.
4. Test session: In this session, all forty subjects were required to solve the ten test queries on the CRIB. Three warm-up exercises and a leaflet of operational instructions were provided to allow the subject to become familiar with the system. The ten test queries were separated, by the time pressure variable, into two categories. One half of the queries were designated for the 90-second deadline condition and the other half for the no time pressure condition. The order in which these ten replicates (queries) were presented to the subject was randomized independently for each subject. All subjects were asked to enter the answer to the CRIB immediately on finishing each of the ten test queries.

3. Results and analysis

The means and standard deviations for the three response measures are summarized in table 1. Separate Analyses of Variance (ANOVA), with one within-subjects factor (time pressure) and one between-subjects factor (training), were performed on the three measures. Interactions were examined where appropriate. In-depth analysis of the interactions was conducted by the method of simple main-effects (Kirk 1995). Interpretation of simple main-effects results concerned, first, how subjects adapted to time pressure in symptomatic search of the rules, followed by an examination regarding the effectiveness of ES-based training.

The ANOVA results on accuracy showed that the main effect of time pressure was significant ($F_{[1,38]} = 71.06$, $p < 0.0001$) but there was no significant effect of training ($F_{[1,38]} = 2.21$, ns). However, explanation of the two main effects must be qualified since there was a significant time pressure by training interaction ($F_{[1,38]} = 4.44$, $p < 0.05$). The results of simple main-effects analysis revealed that, clearly, time pressure had a destructive effect on the performance of rule-based reasoning in terms of the level of accuracy. This was evidenced by the fact that the subjects in both training conditions suffered a significant decrease in accuracy when confronting time pressure ($M = 68\%$ vs. $M = 38\%$, $F_{[1,38]} = 55.52$, $p < 0.0001$ for the control group, and $M = 70\%$ vs. $M = 52\%$, $F_{[1,38]} = 19.99$, $p < 0.0001$ for the ES group). However, under the presence of a time constraint, the normative manipulation of rules ob-

Table 1. Means and (standard deviations) of performance measures for each training condition as a function of time pressure.

	No time pressure		Time pressure	
	Control	ES	Control	ES
Accuracy (%)	68 (18)	70 (17)	38 (23)	52 (20)
Search time (second)	9.38 (1.22)	9.07 (0.72)	7.52 (1.13)	6.66 (0.93)
Search pattern	– 0.36 (0.19)	0.35 (0.27)	– 0.45 (0.20)	0.11 (0.28)

served in ES training did exhibit its competence in sustaining a reasonable level of rule-based performance ($M = 52\%$ vs. $M = 38\%$, $F_{[1,76]} = 5.29$, $p < 0.05$).

With regard to the measure of search time, there was a significant effect of time pressure ($F_{[1,38]} = 288.24$, $p < 0.0001$) but the main effect of training was insignificant ($F_{[1,38]} = 3.86$, ns). However, the existence of a significant interaction ($F_{[1,38]} = 4.86$, $p < 0.05$) called for further investigation of the main effects. The simple main-effects analysis indicated that acceleration of rule-based searching was obvious with the presence of time pressure. This was confirmed by the evidence that the imposition of a deadline forced subjects to speed up their rule-based information processing, regardless of which training condition they were in ($M = 9.38$ s vs. $M = 7.52$ s, $F_{[1,38]} = 109.13$, $p < 0.0001$ for the control condition, and $M = 9.07$ s vs. $M = 6.66$ s, $F_{[1,38]} = 183.97$, $p < 0.0001$ for the ES condition).

On the other hand, expeditious processing of rule-based information was found to benefit from the experience learned from the ES navigation of rule searching, but only when time pressure was present. Under time pressure, the subjects who had received ES training performed rule-based reasoning more rapidly than those in the control group ($M = 6.66$ s vs. $M = 7.52$ s, $F_{[1,76]} = 7.13$, $p < 0.01$). The difference in processing speed between the two training groups in the no time pressure condition was, however, not significant ($F_{[1,76]} = 0.9$, ns).

With respect to the measure of the search pattern, the ANOVA results indicated that time pressure did have a significant impact on subjects' rule-based decision making where their search behaviour was dominated by heuristic-based processing ($F_{[1,38]} = 38.31$, $p < 0.0001$). On the other hand, training also demonstrated a significant effect on subjects in facilitating the use of normative rule-based reasoning procedures ($F_{[1,38]} = 75.06$, $p < 0.0001$). The results, however, required in-depth examination due to the presence of a significant interaction ($F_{[1,38]} = 8.26$, $p < 0.01$). The analysis of simple main-effects confirmed the human's adoption of heuristics-based strategy selection when under time pressure. It was found that subjects exhibited a natural tendency to use intuitive strategies to reason with rules, and this tendency became significantly stronger as a result of the subject's adaptation to time constraints ($M = -0.36$ vs. $M = -0.45$, $F_{[1,38]} = 5.49$, $p < 0.05$). Similarly, the adjustment towards increased use of heuristic rule processing under time pressure also occurred in subjects who received ES training ($M = 0.35$ vs. $M = 0.11$, $F_{[1,38]} = 41.08$, $p < 0.0001$).

The simple main-effects results indicated, however, that the tendency towards the reliance on heuristic searching of rules could be deterred to a considerable extent by normative ES training. The subjects in the ES group displayed a relatively normative type of rule-based reasoning behaviour when no time constraint was imposed, as compared to those in the control group ($M = 0.35$ vs. $M = -0.36$, $F_{[1,76]} = 83.24$, $p < 0.0001$). This decision pattern was also sustained when performance was examined under time pressure ($M = 0.11$ vs. $M = -0.45$, $F_{[1,76]} = 51.06$, $p < 0.0001$).

4. Discussion

Overall, the experiment results support our hypotheses. One of the primary hypotheses predicted an accelerating, yet intuitive decision-making pattern in the rule-based emergency domain and this prediction was confirmed. It appears this acceleration is a manifested strategy people adopt to complete a task before an imposed deadline. However, the subject's rule-based performance does not seem to capitalize on the increased rate of information processing. This is probably because the subject's rule processing is dominantly biased by simplifying heuristics. It has been suggested that some decisions are so important that exclusive use of intuitive strategies is highly inadvisable (Nisbett and Ross 1980). This is particularly true for emergency management of risks as this application area inherently bears safety-related consequences. In fact, the disadvantageous situations facing human operators who supervise emergency incidents are evidenced by the confirmed hypothesis that predicted a significant decrease in decision accuracy due to the detrimental impact of time pressure.

An analysis of the subjects' search movements on an individual basis will give us a more explicit understanding of the mechanisms that underlie the biased decision-making behaviour. We found that, under no time pressure conditions, 67% of the subjects in the control group chose to process those rules whose symptom values can be directly sampled from the scenarios, prior to considering any rules where the values of the antecedents need to be deduced. When time pressure was present, 87% of the control subjects resorted to the same approach in the manipulation of rules. This was also true for the subjects who received ES training. An increase of 23% (from 31% to 54%) of the ES subjects employed the strategy as a result of the imposition of time pressure.

These results appear to suggest that, due to the limited capacity of human short-term memory (STM) (Wickens 1992), people tend to employ the heuristic of availability (Tversky and Kahneman 1982) in the processing of rule-based information. This is done by assigning unwarranted weight to the rules that are prominent in terms of their availability to STM. The ease with which these rules can be brought into the human's cognitive resources make the mental shortcut an appealing strategy in adapting to time pressure, which explains the much stronger phenomenon of heuristics-based rule processing in the presence of time constraints.

Given this speculation, any contingency procedure/rule that is readily available to the decision-maker's mental resources can be the origin of biased decision-making behavior and therefore of possible human error. These rules may include, for example, rules whose symptom values are directly provided in an incident, and rules associated with high-frequency events.

Chances are that, biased by availability heuristics, people would get lost during their search process and never find a way out (i.e. fail to derive a correct solution), particularly when the rules selected on the intuitive basis disperse in the state space. This is very likely as real-life emergency tasks often demand a much larger scale of domain knowledge, and on-scene human operators are usually not so well prepared in rule memorization as the subjects are in an empirical setting. These findings undoubtedly demonstrate the vulnerability people are prone to in managing rule-based emergencies and justify the need for training in the time-constrained decision making.

Note that, in addition to the major implications, the results of the present study may also serve as a guideline for information display design. We suggest that rule-based information for emergency management should be presented to decision-makers with equal salience so that rules carrying cognitive availability will not be processed with unwarranted precedence.

The hypothesis on the effectiveness of ES-based training was also confirmed. In contrast to the intuitive selection of rules based on cognitive availability, the ES search mechanism paves a solution path along which rules are systematically chained in approaching the goal state (i.e. the answer to a query). Apparently, normative navigation proves to be an efficient strategy in processing rule-based information, especially when the answer has to be derived within a restrictive deadline. Meanwhile, ES-based reasoning makes the subject realize that the use of cognitive availability would eventually lead to a search dead-end. This interpretation appears to explain the significant effect of ES training in sustaining a normative pattern of rule-based decision making where intuitive processing would dictate otherwise. It appears that it is also the systematic navigation of rules that facilitates expeditious and fairly accurate performance under the imposition of deadline constraints. These results obviously exhibit the potential of ESs as an effective training prescription for rule-based reasoning under time pressure.

However, it should be noted that the supportive results do not imply that the use of normative algorithms to training can be applied universally. For example, Zakay and Wooler (1984) found that, for multi-attribute evaluations, the positive effect of normative training in ordinary conditions did not transfer to those of time pressure. This inconsistency seems to suggest that the advantages of decision training with normative models do not necessarily generalize across task domains. Therefore, it is necessary to investigate the nature of a specific task in order to define the strategy to be used under time pressure before we can postulate the training effect.

The justified paradigm of ESs as training devices does have a role to play in the development of training programmes for emergency management. Emergency training efforts have typically been focused on building simulators that simulate real-world emergency situations with various aspects of fidelity (Govindaraj *et al.* 1996). Simulator training has been employed for a number of applications such as marine power plants (Su and Govindaraj 1986), and commercial aviation (Flexman and Stark 1987). This methodology assumes that the scenarios humans are trained for can be identified in advance. In contrast, the primary benefits of ES-based training methodology lie in the concepts and strategies employed in the AI framework (e.g. forward/backward chaining). This ES/AI knowledge enables people to resolve emergency problems arising from a broad spectrum of situations that can not be classified beforehand. Therefore, ES-based training can be viewed as a complement to the conventional simulator training method.

It is also interesting to note that in the present study, the significant effects of ES training were achieved through a very small amount of training (i.e. only four training trials). These training trials, however, consisted of specific feedback regarding the exhaustive tracing of normative rule-based reasoning. This finding renders ESs as an appealing training option when the implementation of costly simulator training is not a viable alternative. Another implication of this finding is that feedback with a higher degree of specificity may represent a more powerful de-biasing technique for time-constrained decision making. It is suggested that in practice, more informative feedback should be given higher priority when a substantial amount of training is not possible.

5. Conclusions

Management of emergency situations often requires human operators to make prompt and accurate decisions under stringent time constraints. The present study intends to contribute to the human's success in playing such a role by examining the effectiveness of ES-based training under time pressure.

The results of this study imply detrimental effects of time pressure on successful management of emergency abnormalities. People are found to accelerate their decision process by putting unwarranted weight on rules that carry salience of cognitive availability. Decision quality suffers from such an intuitive decision pattern. However, this tendency towards heuristic searching of rules can be deterred by normative training where the formal deductive mechanisms ESs employ in rule processing are provided. People undergoing ES-based inference strategies are immune to the availability bias and are capable of deriving more expeditious and successful solutions.

While the present study provides some of the first findings regarding human rule-based reasoning under time pressure, and the effectiveness of ES training in improving such performance, there are limitations to this research which must be addressed. First, the knowledge base for the selected application domain in the experiment was kept monotonic and reliable. Although this simplicity was needed to control the scale of the tasks appropriate for the subject, the problems arising in real-world emergencies often bear data that are uncertain or incomplete. Future research calls for the need to incorporate uncertainty in domain knowledge in order to understand better the real-life implications of the issues examined in this study. This can be done by training people with an ES built with models that handle uncertainty, such as fuzzy logic (Zadeh and Kacprzyk 1992), and the certainty factor theory (Buchanan and Shortliffe 1984). Secondly, most emergency problems differ in the degree of processing difficulty. Task difficulty may play an important role in influencing humans' rule-based performance under time pressure (Sharit *et al.* 1993). Therefore, it is necessary to differentiate the number of rule chaining to investigate the hard-easy effect in future research.

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Appendix A: Some sample rules of the ES knowledge base

Rule 4:	IF	(victims are contaminated) AND
		(victims have blood circulation problems)
	THEN	(perform treatment S on the victims)
Rule 7:	IF	(the spill area is > 10 mm) AND
		(the spill is classified as type A)
	THEN	(establish command post C2)
Rule 24:	IF	(the spill substance is chlorine) AND
		(the spill density is > 5 ppm)
	THEN	(classify the spill as type A)
Rule 37:	IF	(perform treatment S on the victims) AND
		(take evacuation route X)
	THEN	(assign the victims to the RED first aid zone)

Appendix B: A sample spill scenario/query system

[Query]: Given the following facts, please identify the emergency level of the spill incident . . . A, B, C, D, or E?

[Facts]: the spill is taking place in the chip production zone; spill substance is chlorine; night working shift is on duty; spill area is > 10 mm; victims are contaminated; there is on-scene explosion; spill density is > 5 ppm; victims have breathing problems.

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