Eliciting Information Portrayal Requirements: Experiences with the Critical Decision Method

William B.L. Wong Philip J. Sallis

Department of Information Science
University of Otago
PO Box 56 Dunedin
New Zealand

Phone: 64 - 3 - 479 8322
64 - 3 - 479 8143
Fax: 64 - 3 479 8311

e-mail: william.wong@stonebow.otago.ac.nz
psallis@commerce.otago.ac.nz

David O'Hare

Department of Psychology
University of Otago
PO Box 56 Dunedin
New Zealand

Phone: 64 - 3 - 479 7643
Fax: 64 - 3 479 8335

e-mail: ohare@psy.otago.ac.nz

Abstract:

This study is part of research that is investigating the notion that human performance in dynamic and intentional decision making environments, such as ambulance dispatch management, can be improved if information is portrayed in a manner that supports the decision strategies invoked to achieve the goal states of the process being controlled. Hence, in designing interfaces to support real-time dispatch management decisions, it is suggested that it would be necessary to first discover the goal states and the decision strategies invoked during the process, and then portray the required information in a manner that supports such a user group's decision making goals and strategies.

The purpose of this paper is to report on the experiences gleaned from the use of a cognitive task analysis technique called Critical Decision Method as an elicitation technique for determining information portrayal requirements. This paper firstly describes how the technique was used in a study to identify the goal states and decision strategies invoked during the dispatch of ambulances at the Sydney Ambulance Co-ordination Centre. The paper then describes how the interview data was analysed within and between cases in order to reveal the goal states of the ambulance dispatchers. A brief description of the resulting goal states follows, although a more detailed description of the goals states and their resulting display concepts has been reported elsewhere (Wong et al., 1996b). Finally, the paper concludes with a set of observations and lessons learnt from the use of the Critical Decision Method for developing display design concepts in dynamic intentional environments.

Keywords: display design, cognitive task analysis, Critical Decision Method, ambulance dispatch management.

Introduction

Designing computer displays that support diagnosis and control of real-time and dynamic processes is more than just presenting the data model in a form that supports the workflow of the process operator. To enable effective diagnosis, researchers have found a need to portray the information in a manner that supports the achievement of higher order constraints and operator goals (Kaempf et al., 1996; O'Hare et al., 1994; Pawlak et al., 1996; Rasmussen et al., 1995; Vicente et al., 1995; Woods, 1995). This finding is particularly significant in situations where the operator is performing at the extremes of his or her performance envelopes. Such conditions are typical of naturalistic decision making environments where time is constrained, information is incomplete and uncertain, decisions are inter-dependent, and where the stakes are high (Brehmer, 1990; Cannon-Bowers et al., 1996; Orasanu et al., 1993; Skriver, 1996; Zsambok et al., 1992).

This paper reports on the use of the Critical Decision Method (Klein et al., 1989) to identify goal states and the decision making strategies invoked during emergency dispatch management. This is the second time this technique has been used in this manner. The outcome of the first investigation has been reported in (Wong et al., 1995) . In the current study, five dispatchers from the Ambulance Co-ordination Centre of the New South Wales Ambulance Service in Sydney, Australia, participated in the study. Detailed descriptions of the goal states and resulting display concepts have been reported elsewhere (Wong et al., 1996b).

The Sydney Centre is responsible for co-ordinating the movements of two rescue helicopters and about 130 ambulances deployed across 45 stations in an area of approximately 14, 000 square km of 4 million people. In addition to routine jobs like patient transfers, the Centre responds to 295,000 *emergency* calls annually.

The rest of this paper will describe the Critical Decision Method, and how it was used to model and understand the model of goal states and decision strategies which were then used to develop display concepts. Finally this paper will report on the lessons learnt from this experience.

The Critical Decision Method

The method used in the study is known as the Critical Decision Method or CDM (Klein et al., 1989). It is a retrospective cognitive task analysis interview technique and an approach to analysing the data. This method has been used for eliciting expert knowledge (Militello et al., 1995), decision strategies and cues attended to, and system in naturalistic decision making environments design (Militello et al., 1995; Kaempf et al., 1996; Miller et al., 1992).

The technique relies on participants recalling a particularly memorable incident they had experienced in the course of their work. Participants are probed to identify the decisions that they made and how these decisions were made. The amount of information elicited was found to be of sufficient detail to determine the strategies used in making these decisions, the cues attended to, the reasons for performing particular actions, and the goals they were trying to achieve. For instance in this study, participants were able to recall the number of ambulances dispatched, the sequence in which the ambulances were dispatched, the stations from which the ambulances came, or what happened when there were not enough ambulances.

Conducting the Interviews

Five dispatchers, each with between 5 to 9 years of experience in dispatch management were interviewed in this study. Each interview lasted about an hour and each session was tape-recorded. The tapes were subsequently transcribed resulting in a very large and rich data set for qualitative analysis. The interviews were organised into the following four parts:

a. Describe the incident and identify functional processes.
b. Organise the incident on a timeline.
c. Probe to understand the processes.
d. Compare performance with novice or expert

The rest of this section will briefly describe what these parts addressed during the interviews.

Describe the incident and identify functional processes.

In this first part of the interview, participants were asked to think back to a particularly memorable resource allocation incident in which they were involved. Once an incident had been agreed upon, the participants were then asked to briefly describe what the incident was about, when the incident occurred, and what the general situation was like at that time. e.g. a major motor vehicle accident that occurred on the Princess Highway near Lakehurst on the outskirts of Sydney. The caller reported that many people were injured and trapped in the wreckage. A major incident like this suggested that a number of ambulances would be required to attend to the accident, posing a significant resource allocation challenge, forcing the dispatcher to operate at the limits of his or her performance envelope. These are the situations that would provide useful insights into the dispatch management decisions. Furthermore an actual situation also provided a context to ask subsequent questions and to understand the events that occurred at that time.

Having some idea of the incident, the next step is to ask the participant the following question, "If I were there with you when that yellow slip arrived in your conveyor belt, what would I see you do and hear you say?". This question was found to be more useful to start the participant off to identify the functional processes, tasks, actions and decisions than a question like, "Please tell me what happened when the yellow slip arrived".

During the interview the information was written down on Post-It™ papers, and randomly stuck on an A3-size sheet. The objective here was to identify the processes and not the sequence. Attempting to put the Post-It™ papers in the proper sequence at this stage would require additional questions to be asked and would distract the participant as he or she attempted to recall the sequence rather than concentrating on recalling the processes, events and decisions. Additional probes used during this stage included what did you write down? what charts were you looking at? and what actions or options were you considering? These probes were used to identify some of the information that was used by the participant during each process or decision.

Organise the incident on a timeline.

In the second stage of the interview, the participants are then invited to help sequence the events and decision points by re-arranging the Post-It™ papers. As they re-arranged the Post-It™ papers, the participants would remember other details which would then be added to the diagram, e.g. any information that was used or referred to, people or agencies contacted. The Post-It™ papers were re-arranged until the participant believed that the diagram appropriately represented the situation at the time of the incident. The next stage is to probe the participant for more details concerning each major decision point.

Probe to understand the processes.

At this stage, the participant together with the researcher would identify the major decision points. The following probes were then used to elicit more detail about each of these decision points. The probes addressed the cues used or attended to, the knowledge needed to make that decision, the way in which the information was presented, the appropriateness of the information format, the goals, what situation assessment was made, what options were considered and the basis for the final choice, what-ifs, and what additional training or knowledge or information would have been be useful in that situation.

Compare performance with novice

In the fourth and final stage, the participants are asked to give their opinion on the expected performance of a less experienced dispatcher when faced with the same situation. This final question seeks to identify the mistakes that would have been made by a less experienced dispatcher, or the information that might have been missed or events mis-interpreted. It was anticipated that the answers from such a question would identify shortcomings in training or the system itself.

Approach to the Data Analysis

This section will describe the procedure taken to systematically extract the goal states and decision strategies from the interview transcripts. The analysis framework was based on the relationship between cues, the situation assessment that was derived from the cues, the actions taken, the rationale for the actions, and the purpose those actions served. Key features of the decisions and decision strategies were extracted from each interview and integrated into a model of a dispatcher's decision goals and strategies.

Fig 1 Stages in the Analysis of Incidents Using the Critical Decision Method

The transcripts and other data collected during the interviews are analysed in the five stages as illustrated in Figure 1 and are discussed below.

Stage 1: The Decision Flow Chart

From the Post-It™ paper analysis of the decision process documented at the interview, a decision flow chart is developed which extracts the key decision points and the considerations and the thinking necessary for the interviewee to reach a conclusion. Part of such a Decision Flow Chart is illustrated in Figure 2.

Fig 2 An example of a Decision Flow Chart showing the components of the chart

A decision point is an activity where the operator needs to make a decision about a situation or action. These decision points are drawn along a horizontal timeline and are numbered from left to right to facilitate the reading of the chart. Events that occur in between decision points are also represented in the same way. Events are included as they provide the reader with a context of the situation which is useful for interpreting or appreciating the considerations or actions taken.

The considerations and thinking that arise from each decision point are drawn downwards from a decision point. This progressively depicts how the various aspects of each decision point are considered. This progressive decomposition of the considerations is called "progressive deepening" (Thordsen et al., 1990). It is a useful way of depicting the depth and complexity of the decisions being made.

Although this progressive deepening of decisions appears as a tree, it is not a decision tree in the sense that each branch represents the outcomes of a yes-no decision. Instead each branch indicates the factors that were considered and how that consideration was developed and concluded.

The final level of the chart represents the outcomes of the considerations, i.e. which choices were made, or what was concluded after evaluating the issues. The decision flow chart does not include the cues used or associated with each decision point. The analysis of cues is performed after summarising the incident.

Stage 2: Incident Summary

Based on the Decision Flow Chart and further readings of the transcripts, the incident is then summarised by describing what is thought to have happened at each decision point. This description provides the reader with additional details that cannot be easily captured in the Decision Flow Chart. See Figure 3.

Figure 3 Part of an Incident Summary

Stage 3: Decision Analysis

Each decision point was analysed to identify the Cues, SAs (Situation Assessments) and CoAs (Courses of Action). This section will first define cues, situation assessments and courses of action, and then discuss the cues analysis process, and explain how the Decision Analysis Tables are to be interpreted.

Cues

Cues are factors considered in order to make an assessment of the situation. Cues are information stemming from events or actions that initiate consideration about a particular occurrence. E.g. the yellow emergency request slip that arrives in the conveyor belt is a cue that initiates a series of actions that result in the dispatch of emergency vehicles.

Cues may take the form of:

a. information collected from various display sources like a vehicle status board.

b. information obtained from communications sources, like the phone or radio communications.

c. information that may have been derived from other cues.

d information contained in the spatial arrangement of physical objects, e.g. job slips taken out of the status board and placed on the right-hand side of the desk indicate these are jobs where the vehicles have reached their destinations (e.g. hospital) and are or will be returning to their stations. This is an indication of their availability (Hoc, 1995) . Another example is the arrival of a yellow slip in the conveyor belt signals the start of an emergency incident.

Situation Assessment (SA) and Course of Action (CoA)

A Situation Assessment (SA) is the outcome of an appraisal of the information that describes a situation. It represents the appraiser's understanding of the situation before him. The SA should clearly describe the elements of the situation as they are, i.e. the *who, what , where, when,* of the incident and help him make decisions about the resources to send, which represents the Course of Action or the plan he or she develops once he or she has understood the situation and its implications.

For example, in one incident there was a casualty with a compound fracture of the right ankle. The casualty is three hours walking time into the bush. The accident had occurred several hours ago, but the person who raised the alarm had only just been able to contact the emergency services. While the casualty is seriously injured, his injuries were not considered life-threatening. Coupling the above information with the dispatcher's knowledge of the area, the dispatcher concluded that the terrain would be difficult to access and also to extricate the casualty. From his experience, a rescue helicopter with a special casualty access team would be appropriate, but if that was not available, the situation could become a protracted incident extending over many hours. The operator's understanding of the local geography also helped him determine that the Richmond ambulance station is closest to the incident site.

This decision process modelled during the investigation appears consistent with the Recognition-Primed Decision model (Klein, 1993). The RPD model explains that decisions in the real-world are not made in the classical decision-making manner where many options are derived and then evaluated and finally one is selected. Instead, based on the decision maker's understanding the situation, he develops a course of action, modifies it until the decision maker believes it is capable of achieving the goals governing the situation. He then implements the action.

The Decision Analysis Table

The Decision Analysis Table is illustrated in Table 1. Each key decision point is investigated to identify the cues that triggered the event or that were attended to during that event. The next step is to identify what was the other information and factors considered or had influenced the interpretation and assessment of the state of the situation.

CUES	SIT. ASSESSMT	ACTIONS	Why?	What for?
<u>Yellow slip on conveyor belt</u>	• An emergency.	• Pick up slip. • Read contents / details of the job. • Assign job number.	SOP - To determine nature of problem, and location of problem.	To determine what resources are needed - how many and what types. *(Determine what resources are needed)*

Table 1 Decision Analysis Table for Reporting the Analysis of Cues, SAs, and CoAs.

The situation assessment resulting from that appraisal process is next identified. The courses of action that resulted from that situation assessment is also determined. To gain a better understanding of the courses of action adopted, it is also necessary to identify the rationale for that course of action, and the higher purpose that the action was to achieve. This information may provide insights about how the decision strategies invoked by the dispatcher used the information provided by the cues and the factors. This process is illustrated in Fig 4.

Fig 4. The Decision Analysis Process

Stage 4: Identify Goal States

The goal states in each incident were identified through the analysis of cues, situation assessments, and courses of action reported in the Decision Tables. The analysis of goal states involved two steps:

a. Extraction of goal states and their statements of purpose from individual incidents,

b. Comparison of identified Statements of Purpose,

Extraction of goal states and their statements of purpose

An example of how the goal states for individual incidents were extracted is shown in Figure 5. It lists the goal states and the statements of purpose extracted from the Cowan Railway Station incident.

Figure 5 Sample Goal states and Statements of Purpose

The goal state represents what the dispatcher was attempting to achieve in order to adequately perform his or her dispatch task. The goal states are inferred from the statements of purpose reported by the interviewee. The statement of purpose indicates what a dispatcher was attempting to achieve during a particular decision or task. At times these statements are very clear and may be found in a single sentence. However, more typically, the purpose of a set of actions spans several sentences or text units. As such the purpose has to be interpreted within the context of the discussion. Once this has been interpreted, this statement is written in summary form and documented in the *"What for"* column of the Decision Analysis Table.

Comparison of Statements of Purpose Across Cases

This is an intermediate step. It involves bringing together all the statements of purpose into a format that facilitates inspection for commonalties. The common statements of purpose are then identified and grouped. This is illustrated in Figure 6.

Figure 6 Sample segment of the format used to compare statements of purpose

Stage 5: Compare Goal States Across Cases.

Once common statements of purpose have been identified and grouped, each group is then given a short meaningful description that attempts to capture the essence of the goal the

		Cases	
Goal States	Mt Wilson	Princess Highway	Westfield's
		single hospital in event of major incidents.)	
Get resources moving	To get initial response of required resources moving as soon as possible while additional resources are being considered and re-deployed.	To get medical aid to the scene ASAP	To get a vehicle on the scene ASAP to: a. start treatment b. get initial report

Figure 7 Grouping and naming of Statements of Purpose

dispatcher was trying to achieve. This is illustrated in Figure 7. Through this analysis, the goal states of the dispatch management process are identified. The next section briefly describes what these goal states are.

The Results: Goal States of the Dispatch Management Process

Goal states are the higher-order constraints that the dispatcher must attempt to achieve in order for the process to operate at an acceptable level of performance. The study resulted in the identification of five goal states. These goal states together with the strategies invoked and an appreciation of the situational factors involved should then drive the design of the display formats. For completeness, these goal states are briefly described below but see (Wong et al., 1996b)Wong et al., 1996b, for more details on the design concepts.

(1) Notification of emergencies

This goal state represents the need to be notified quickly of any emergencies. In this study, the dispatchers were notified by the emergency yellow job slip arriving in their respective segments of the conveyor belt system. This segment is immediately next to where they are seated. Because of the way the conveyor belt is made, job slips arriving in the respective segments were heard to make a scratchy noise that serves to alert the dispatcher to its presence. However, this method of notification was also observed to have gone unnoticed because of ambient noise or due to the dispatcher attending to other competing activities. Notification designs need to overcome these situational factors.

(2) Maintain situation awareness

Display designs for situational awareness need to portray information such that it enables the dispatcher to develop and maintain a highly dynamic mental representation of critical aspects of the environment so that he or she may effectively

a. Co-ordinate activities within and between boundaries
   What is going on in one region may affect outcomes and resource allocation in another region
b. Globally optimise the use of resources
   What resources are available globally before planning deployment of vehicles in a major incident. This includes knowing what jobs are outstanding so as to trade-off emergency and medical cases, and also to balance the ambulance coverage of the immediate area.
c. ensure compliance to instructions
   Following up of decisions to ensure that assigned tasks are being implemented, and to monitor if is performance is in line with goal expectations. The information that is communicated is information about the status of these decisions rather than resource-type information

(3) Planning resource to task compatibility

This goal state requires the dispatcher to determine what the needs of a situation are, and to find an appropriate match between available resources and these needs. Achieving this goal involves the following tasks:

a. Locating available resources.
   In one case, the dispatcher had to refer to multiple sources of information in order to locate and assemble specially trained personnel into a SCAT (Special Casualty Access Team) team. Having identified the SCAT officers, the dispatcher then had to determine which of these officers were closest to the accident scene. Becuase the appropriate officers were part of separate double crews at two different stations, these crews had to be dis-banded in order to establish one SCAT Team.
b. Translating the need into resrouces to send.
   Part of planning. The dispatcher has to tranlsate what has happened into the number of resources to send. Receiving accurate information about the incident is very important to organising an appropriate response to the incident. However this cannot be gauranteed, but the interpretation errors can be reduced by reducing the number of people an in-coming call has to go through before a decision is made.
c. Minimise disruption to on-going activities.
   One major consideration that influences the number of ambulances to send is the concern with sending too many ambulances as excess vehicles become unavailable to to other incidents. Over-estimating the number of ambulances

needed during periods where resources are stretched may require pulling ambulances off other less life-critical but necessary jobs, or delaying them, to the inconvenience of the patients.

d. Planning ahead.
Two planning horizons: In real-time planning the concern is with which ambulance is to be sent now or in the immediate future to an incident; and planning ahead involves predicting what the future state of the ambulances will be and to match that to a forecatsted set of activities.

e. Planning to fill gaps in ambulance coverage.
Ambulance coverage in an area could be badly depleted such that it may take a unacceptably long time for an available ambulance to respond to an emergency. Such depletions are called ‘gaps’ or ‘holes’ in the coverage. To fill these gaps, ambulances from neighbouring areas are usually re-deployed to cover the gaps, called ‘balancing the region’.

The display concept needed to support this goal state requires to display more than just the status and location of the ambulances at the time of request, but it needs to also present information about their planned future taskings to allow these factors to be taken into consideration.

(4) Speedy response

Another goal state of the ambulance dispatch process is that of attaining a speedy response to emergency calls. The Co-ordination Centre has a requirement for a vehicle to be on the road within three minutes of receiving the emergency call. In all cases interviewed, all dispatchers were concerned with getting medical aid to the scene as soon as possible in order to start initial treatment, and to receive an initial report about the severity and extent of injuries at the accident.

(5) Maintain history of developments

Although reported in only two of the five interviews, the need to maintain a history of what had happened cannot be overlooked. The main use of these histories is to assist legal investigators re-contruct events from job slips and other operational documents in order for investigators to determine what had happened and when it happened. While an important goal in itself, it is not considered directly relevant to the design of how information should be portrayed in dynamic decision making environments.

Lessons Learnt

In reflecting upon the procedure employed in this investigation, the following lessons were learnt.

Goal States and Display Concepts.

The identification of the goal states is a critical step towards the development of display concepts that support decision making. Decisions are not made in isolation but within the context of a situation such that the resulting actions may satisfy the over-riding goals. As goals may be achieved in a variety of ways, it is necessary to consider the design of displays together with the decision strategies invoked by the dispatchers. The decision strategies then guide and constrain the development of display concepts aimed at supporting specific goal states.

Goal states are not obvious.

Dispatchers do not explicitly think about all the goal states they are trying to achieve. They need to be drawn out. Simply asking why he or she acted in a particular manner only provides the immediate reason for the action or decision, e.g. it could be standard operating procedures. The dispatcher has to be probed further to reveal what, for example, is the purpose of that standard procedure. In other instances, the purpose of a set of actions had to be inferred during the data analysis phase as the dispatchers were unable to articulate it clearly, or were not explicitly aware that they are attempting to serve that purpose.

Cues analysis and perceptual organisation.

The cues analysis does not reveal the perceptual order or arrangement of the data on a display. The analysis only indicates what cues were used or attended to, and how individual cues logically relate to one another. Although some research is being conducted into a formal method for how these cues should be perceptually organised on a display (Wong et al., 1996a), display concepts at the moment are still determined through a combination of researcher's appreciation of the decision strategies and goal states, and his experience.

Behavioural and Cognitive Task Analysis.

A strictly behavioural approach to task analysis would not have identified the ways by which dispatchers considered the information or the ways in which decisions were made. The cognitive task analysis approach focused on *how* those decisions were made rather than on just what decisions were made and the information needed. While it may be argued that a good behavioural task analysis could reveal such insights about the decision process, that is not its purpose nor are its tools designed to elicit such information. Whereas it is more probable that a well executed cognitive task analysis would reveal those specific insights. The difference between the two approaches lies in the skilful application of the cognitive probes. From experience, simply asking, "What did you think about at this decision point?" had resulted in a blank face. Cognitive probes need to be phrased in a manner that help the interviewee tangiblise the process of thinking about a decision. When appropriately applied, the cognitive probes provided valuable insights into the way dispatchers thought about the decision process, how the information cues influenced the decision process, and how well the information is organised or presented to support the decision, e.g. did the dispatcher actively search for the cue or was the cue present in a readily accessible location or format.

Selecting incidents.

It is worthwhile spending a few minutes at the start of the interview determining whether the incident being considered by the interviewee is appropriate before proceeding with the interview. In determining this, we need to appreciate the scope of the incident, e.g. was it a single incident or many incidents spread over a long time period, and what was the interviewee's involvement in the incident, i.e. was the interviewee the main co-ordinator or did he or she help another co-ordinate the incident. There will be a difference in the information recalled because of the different perspective, e.g. a supervisor who helped co-ordinate the incident would not remember the specific planning and movement of vehicles under the control of the co-ordinator who actually controlled the incident.

Visualisation of the decision process.

The use of sticky PostIt™ papers was found to be very useful in encouraging interviewee participation and in setting them at ease. Recording the processes and functions down without concern for the sequence they occurred at the start allowed the interviewee to concentrate on what happened. The Post-It™ papers could then be quickly re-organised in the proper sequence once all the main functions were documented. At this stage, more details could then be elicited, using the properly sequenced Post-It™ papers as a framework for investigating each decision point.

In Conclusion

The investigation has provided many useful insights into the use of the CDM. The study has also suggested the need for further adaptation or extension of the method so as to allow its outcomes to be used directly and objectively for the perceptual organisation of display designs.

Acknowledgements

We would like to thank Mr Peter Payne, Communications Superintendent, Mr Alan Reinter, Senior Supervisor, Mr Stuart Greenshields, Supervisor, and staff of the Ambulance Co-ordination Centre, Ambulance Service of New South Wales, Sydney, for giving us many hours of their time and co-operation without which this study would not have been possible.

References

Brehmer, Berndt. (1990). Strategies in real-time, dynamic decision making. In R. M. Hogarth (Ed.), Insights in Decision Making, (pp. 262 - 279.). Chicago: University of Chicago Press.

Cannon-Bowers, Janis A., Salas, Eduardo, & Pruitt, John. (1996). Establishing the boundaries of a paradigm for decision-making research. Human Factors, 38(2), 193-205.

Hoc, Jean-Michel, Cacciabue, Pietro C., and Hollnagel, Erik. (Ed.). (1995). Expertise and Technology: Cognition and Human-Computer Interaction. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Kaempf, George L., Klein, Gary, Thordsen, Marvin, & Wolf, Steve. (1996). Decision making in complex naval command and control environments. Human Factors(Special Issue).

Klein, Gary A. (1993). A Recognition-Primed Decision (RPD) Model of Rapid Decision Making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), Decision Making in Action: Models and Methods, . Norwood, NJ: Ablen Publishing Corp.

Klein, Gary A., Calderwood, Roberta, & Macgregor, Donald. (1989). Critical decision method for eliciting knowledge. IEEE Transactions on Systems, Man and Cybernetics, 19(3), 462-472.

Militello, Laura, & Lim, Leona. (1995). Patient assessment skills: Assessing early cues of necrotizing enterocolitis. The Journal of Perinatal and Neonatal Nursing, 9(2), 42-52.

O'Hare, D., Wigins, M., Batt, R. , & Morrison, D. (1994). Cognitive failure analysis for aircraft accident investigation. Ergonomics, 37, 1855-1869.

Orasanu, Judith, & Connolly, Terry. (1993). The re-invention of decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), Decision Making in Action: Models and Methods, . Norwood, NJ: Ablen Publishing Corp.

Pawlak, William S., & Vicente, Kim J. (1996). Inducing effective operator control through ecological interface design. International Journal of Human-Computer Studies, 44, 653-688.

Rasmussen, Jens, & Pejtersen, Annelise Mark. (1995). Virtual Ecology of Work. In P. H. John Flach, Jeff Caird, and Kim Vicente (Ed.), Global Perspectives on the Ecology of Human-Machine Systems, (Vol. 1, pp. 121-156). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Publishers.

Skriver, Jan. (1996). Naturalistic decision making. Report on the NDM Panel discussion held at the 1996 Annual Conference of the Psychological Society. The Psychologist(July 1996), 3321-322.

Thordsen, Marvin, Galushka, Joseph, Klein, Gary A., Young, Saul, & Brezovic, Christopher. (1990). A knolwedge elicitiation study of military planning (Technical Report 876): United States Army Research Institute for the Behavioural and Social Sciences.

Vicente, Kim J., Christoffersen, Klaus, & Pereklita, Alex. (1995). Supporting operator problem solving through Ecological Interface Design. IEEE Transactions on Systems, Man, and Cybernetics, 25(4), 529-545.

Wong, William B.L., O'Hare, David, & Sallis, Philip J. (1996a). Experimental Transformation of a Cognitive Schema into a Display Structure. Paper presented at the The First Asia Pacific Conference on Computer Human Interaction APCHI '96, Human factors of IT: Enhancing productivity and quality of life, Singapore, pp. 455-468.

Wong, William B.L., O'Hare, David, & Sallis, Philip J. (1996b). A Goal-Oriented Approach for Designing Decision Support Displays in Dynamic Environments. Paper presented at the OzCHI '96, The Sixth Australian Computer Human Interaction Conference, Hamilton, New Zealand, pp. 78-85.

Wong, William B.L. , Sallis, Philip J. , & O'Hare, David. (1995). Information Portrayal for Decision Support in Dynamic Intentional Process Environments. Paper presented at the OZCHI '95, The Fifth Australian Conference on Computer Human Interaction, University of Wollongong, Wollongong, Australia, pp. 43-48.

Woods, David D. (1995). Toward a Theoretical Base for Representation Design in the Computer Medium: Ecological Perception and Aiding Human Cognition. In P. H. John Flach, Jeff Caird, and Kim Vicente (Ed.), Global Perspectives on the Ecology of Human-Machine Systems, (Vol. 1, pp. 157-188). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Publishers.

Zsambok, Caroline E., Beach, Lee Roy, & Klein, Gary. (1992). A literature review of analytical and naturalistic decision making (Final Technical Report): Research, Development, Test and Evaluation Division, Naval Command, Control and Ocean Surveillance Centre.