

# ENHANCING THEORETICAL MODELS OF ANAESTHETISTS' NON- TECHNICAL PERFORMANCE

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PERFORMANCE

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## ABSTRACT

A literature review on theoretical models of anaesthetists' performance reveal that these models allow for little integration by the individual of local and global knowledge of best practice whether set out as a guideline or an algorithm. Non-technical performance of anaesthetists that guide analytic reasoning and are linked to emotion and affect, it seems, do not have the same epistemological status as formal knowledge.

The aim of this research was to determine whether non-technical skills of Danish nurse anaesthetists that enhance overall performance, can be elicited. A further aim was to discuss how these skills help practitioners know and enact what is best practice for nurse anaesthetists.

The study has an exploratory and descriptive design. Eight Danish expert nurse anaesthetists participated and a semi-structured interview guide was used as a research method. It was based on a narrative approach that enabled participants to self-structure recollections of particular events or situations.

The majority of the nurses report the use and value of range of practice knowledge, perceptual cues and intuition, much of which is experientially based rather than research based. This is especially true in situations where nurse anaesthetists encounter inconsistencies between seen and monitored (technical) parameters and between written and otherwise experienced parameters.

The acceptance and utilization of perceptual cues in e.g. guidelines, would add an important and influential informal knowledge source that could enhance theoretical as well as practical models. Taking perceptual clues into account could improve control strategies and mechanisms intended to enhance safety in anaesthesia.

## TABLE OF CONTENTS

Abstract .....	3
Table of contents .....	4
List of tables and figures .....	5
Enhancing Theoretical Models of Anaesthetists' Non-Technical Performance .....	6
Background .....	6
Recap of literature review .....	6
Methodology .....	10
Design.....	10
Research question.....	10
Aim.....	11
Definitions .....	11
Subjects and recruitment .....	12
Demographic characteristics .....	13
Data collection and procedure.....	13
Data analysis .....	14
Results .....	15
Discussion .....	24
Main features.....	24
Personal, behavioural, and environmental influence .....	27
Why not accept intuition as informal knowledge?.....	28
Stress factors .....	30
Limitations of this study.....	32
Conclusion.....	34
Appendix .....	37
References .....	38

## LIST OF TABLES AND FIGURES

Table 1 .....	18
Critical Cue Inventory Table.....	18
Table 2.....	19
Initial Choice of Intervention .....	19
Table 3.....	20
Parameters Identified as Constituting Expert Knowledge .....	20
Figure 1. ....	21
Stress Factors According to Eight Danish Expert Nurses.....	21

## ENHANCING THEORETICAL MODELS OF ANAESTHETISTS' NON-TECHNICAL PERFORMANCE

### **Background**

#### *Recap of literature review*

In a review of Enhancing Theoretical Models of Anaesthetists' Non-Technical Performance, several of the models discussed there seem to detach emotion from cognition and analysis. These models also allow for little integration by the individual of local and global knowledge of best practice whether set out as a guideline or an algorithm. This is of interest because, as the review suggests, some theoretical models cannot achieve a complete picture of how the situation is understood and subsequently acted upon by anaesthetists even if they analyze all the elements of a situation. This highlights both the difficulties and the need to identify in particular what characterizes non-technical performance of anaesthetists. By this we mean those principles that guide analytic reasoning and are linked to emotion and affect.

The purpose of this review on how to enhance theoretical models of anaesthetists' performance was i) to investigate if existing models of anaesthetists' performance can identify significant non-technical skills of experienced anaesthetists that inform behavior in crisis situations where both lack of time and certainty often come into play, and ii) to understand what contributes to complex decision-making and problem solving. To what extent do the terms used in the models describe specific behavior of anaesthetists? In short can, i) the generic terms of situation awareness and decision-making by Klein (1993) and Endsley (1995) and four theoretical models reviewed here adequately describe or predict specific behavior of the anaesthetist? If this is not the case, is this because the models do not tell us enough about the characteristics of strategies they use to manage critical incidents or overall performance?

## Enhancing Theoretical Models

What follows is a summary of the findings of four central authors on what characterizes anaesthetists' performance (Gaba, David M., 1989; Helmreich, RL. Schaefer, H-G, Scheidegger, D., 1995; Woods, 1988; Xiao, Y, Milgram, Paul, Doyle, & John, D., 1997). Helmreich et al. (1995) believe that their findings, from the Operating Room Management Attitudes Questionnaire (QRMAQ) surveys (1993) and systematic observational data of operating rooms collected using Operating Room Checklist (ORCL) (1995), show that there is no agreement among individuals (nursing and academic staff, anaesthetists, and surgeons) on what constitutes appropriate management and behavior strategies, thereby they argue that focusing on individual perspectives is unlikely to be very useful. No subgroup they studied came close to an agreement on the parameters, including cultural ones, that they believed would theoretically optimize teamwork (Hofstede, 1991). This was due in part to the diversity in opinions found between subgroups and a large variability in attitudes within the subgroups on items relating to how optimal team performance could be achieved. However, even though the reviewed authors do not agree about this, they do agree that attitudes are, as a result, imperfect predictors and representations of behavior, that human decision-makers rapidly switch between different decisions strategies depending on the demands of the task, and that informants variably estimate both available time and risk.

Individual and distributed emergency decision-making research has stressed the importance of context dependencies and the need to identify the variety of different stressors that teams have to deal with. The reviewed authors also tend to emphasize different things regarding what optimizes the performance of anaesthetists. Safety would be enhanced by the elimination of rule-violation errors, by promoting the use of protocols, checklists and crisis management algorithms, and by making all OR personnel aware of factors and circumstances in which slips and errors are most likely to occur, claim Helmreich et al. (1995&1996). Contrary to this, Yan Xiao, Paul Milgram and John Doyle (1997) believe that research on decision aids

## Enhancing Theoretical Models

and training that emphasize procedures and diagnosis, fail to pay proper attention to preparatory activities, i.e., how participants actively anticipate problems and/or take measures to prevent problematic situations from arising. Their field study suggests that timely identification of concerns is often more valuable to practitioners than any in-place solutions, and that practitioners need more support in identifying potential problems than in solving them. Applying this argument to the field of anaesthesia, Gaba (1992) and Woods (1988) agree that anaesthesia is event-driven, with rapid time constraints and that the pace of decision is determined externally by events. Some events cannot be avoided, they believe, because they are inevitable side effect of procedures, which must be carried out sometimes due to medical necessity.

The review also reveals that research on human performance tends to rely on one of two perspectives that stress different aspects of human information processing. Most models detach emotion from analysis, and allow for little integration by the individual of local knowledge and global knowledge of best practice. It is generally believed that best practice can be represented or set out as a guideline or an algorithm.

In short, none of the researchers look into what may lay behind some of the input factors described in their models, e.g. attitude, personality, motivation, time pressure, organizational climate, and norms.

One thing they do agree on is that anaesthetists use strategies of satisfying rather than optimizing (Endsley, 1995; Gaba, 1992; Helmreich, 1995; Klein, 1989; Orasanu, 1995; Woods, 1988; Xiao, 1997). Meaning that in a dynamic problem situation, experts tend to generate one highly likely option and evaluate its appropriateness given the current conditions, and if it is found suitable (satisfying), it is implemented; if not, it is altered and another is created and the process repeated (Simon, 1995). In other words, it's not necessarily the best solution that is chosen, but the one that works. This is supported by Helmreich and

## Enhancing Theoretical Models

Davies (1996), who found that subjects do not use the same rule or rules from case to case, and judgment in second presentation of a case may differ considerably from the first time.

Consequently, behavior of individuals and teams are unpredictable and inconsistent, claims Woods (1988).

This puts the analytic focus on the allocation of attention and resources, and iterative problem solving, if we are to explain why an actor can switch rapidly between different decisions strategies depending on the task demands (Wahlstrøm, 1988). It seems then that local knowledge or context dependencies depend on global knowledge, and the other way around, as well as analytic reasoning depends on emotion and affect.

If humans have to perform in a complex and dynamic world, how do they cope with demands and complexity while performing work tasks adequately most of the time? This seems to be a question left unanswered in the literature on anaesthetists' performance. Further, how do anaesthetists integrate problem solving with other activities by local and global knowledge of best practice of set out as a guideline or an algorithm? Further, how do they allocate attention and resources in crisis situations where loss of control and limitations of time and certainty dominate? What characterizes non-technical performance of anaesthetists – those principles that guide analytic reasoning by emotion and affect? Can anaesthetists themselves actually describe what characterize their mental workload or strategies for managing critical incidents or overall performance?

This thesis hopes to find some empirical evidence regarding the characteristics that guide situation awareness and contribute to complex decision-making and problem solving in anaesthesia. To do this, one must study control and responsibility in a clinical setting and one has to expand the concept of agency beyond the individual to include organizational and social/cultural aspects.

### **Methodology**

#### *Design*

The study has an exploratory and descriptive phase. The semi-structured interview guide is based on a narrative approach to qualitative research. It is used here because this research strategy enables participants to self-structure recollections of particular events or situations (Hoffman, Crandall, & Shadbolt, 1998). This method allows for a retrospective interview strategy that applies a set of cognitive probes to actual non-routine incidents that required expert judgment or decision-making. Once the incident is selected, the interviewer asks for a brief description. The narrative is then followed by a set of queries intended to stimulate recall of salient cues – cues that enabled critical decisions in which the expert’s knowledge is stretched or their skills put to a test. These questions focus on a decision-making that altered the outcome, in which things would have turned out differently had the expert not been there to intervene, or in circumstances in which the expert’s skills were particularly challenged. Special focus has been placed here is on non-technical skills such as: communication, team working, leadership, and cognitive skills e.g. situation awareness and decision-making.

#### *Research question*

This research question has a number of different elements. But briefly, it is “What personal, behavioral and environmental influences determine how nurse anaesthetists learn how to exercise and assert some measure of control in crisis situations?”

## Enhancing Theoretical Models

### *Aim*

The aim of this research is to determine whether non-technical skills of nurse anaesthetists, ones that enhance overall performance, can be elicited. A further aim is to discuss how these skills help practitioners know and enact what is best practice for nurse anaesthetists.

### *Definitions*

In this study, non-technical skills are defined as ones that are used integrally with medical knowledge and clinical techniques. Behaviors in the operating theatre environment is not only directly related to the use of medical expertise, drugs or equipment, but encompasses both interpersonal skills e.g. communication, team working, leadership, and cognitive skills e.g. situation –awareness and decision making (Flin, 2008).

In this study, use of perceptual cues, ones defined as a non-technical skill, can inform knowledge available to the practitioner when handling patient care. The use of perceptual cues is also part of informal knowledge. Informal knowledge differentiates from formal knowledge like declarative and procedural knowledge. Declarative knowledge takes the form of explanations, lectures, argument and justifications. Procedural knowledge manifests directly itself in performance. “But there are important kinds of knowledge that do not show in these ways, and these are the kind of knowledge that most profoundly distinguish experts from non-experts”, claim Bereiter & Scardamalia (1993, p.43), and one is the use of informal knowledge. Informal knowledge is acquired through events that can be seen, felt, heard, sensed, or communicated verbally and/or non-verbally, and especially through social conditions that permit expertise to develop. Informal knowledge gained from perceptual cues, can be sensed e.g. through the observation of signs of anxiety of a patient, a physically disturbed patient, a sudden silence in the operating theatre (OR), a strained relations between

## Enhancing Theoretical Models

the surgeons, or absent of eye contact between surgeon and anaesthetist. Perceptual cues may then have no direct correspondence to propositions and rules. Further it is said that “when the knowledge attributed to experts is knowledge they may not even be aware of themselves and that often defies statement or description, some people start to get uneasy and others start to rhapsodize about intuition or “feel” (Bereiter & Scardamalia, 1993, p.49). This study will look at this question: do perceptual cues inform you how to do the job, or do they inform you how to manage yourself so that you can do the job?

### *Subjects and recruitment*

Eight expert anaesthetist nurses were invited to participate in the study. These nurses have been in practice for more than six years. According to the novice versus expert definitions described by H. Dreyfus and Dreyfus (1993), this means they are all experts. The head nurse was invited by mail to participate. Subsequently she identified other nurses to be interviewed. The interviews lasted three quarters to one hour long and were conducted away from clinical practice areas. Prior to the interviews, the nurses were informed by brief written information about the purpose of the study, and the technique used for elicitation of expert knowledge. The interviewer did previously not know six out of eight nurses. The reason to use participants not known to the interviewer was to avoid bias and any suggestion that these interviews were intended to evaluate these nurses’ daily work. All the nurses were informed that the responses would be treated confidentially and anonymously.

## Enhancing Theoretical Models

### *Demographic characteristics*

The nurses were recruited from three anaesthesia departments in three general hospitals in Denmark. These departments were selected randomly, and anaesthesia in each hospital linked to a variety of surgery specialties. The interview sample was as follows: n=8; sex 5 women, 3 men; mean age 46.3 years with a range of 40-52 years; mean number of years as nurse anaesthetist: 11.37 years with a range of 6-17 years.

### *Data collection and procedure*

Semi-structured interviewing was selected as the research methodology, because it allows the interviewees to structure what they themselves believe as the most important cues and elements in their story (Hoffman, Crandall, & Shadbolt, 1998). The self-structured narrative also allows the storyteller to decide how to portray the way particular situations were understood and acted upon. The technique chosen for elicitation of expert knowledge has its roots in Flanagan's (1954) Critical Incident Technique, and involves having experts recall information about past cases. The Critical Decision Method by Klein, Calderwood, & MacGregor (1989) is, a variation on Flanagan's model, and is used in this study to elicit expert knowledge of nurse anaesthetists. Additionally to focusing on the interviewee's past cases, the interview technique uses on a set of opening queries to stimulate recall of salient cues. A set of probe questions are used to elicit specific, detailed information about cues, knowledge, analogues, hypothetical, goals, expectations etc. (see Appendix for a complete list of CDM Probe Questions). This is done to identify decision points that influenced the outcome in a particular case or cases. The basis for this approach also stems from Klein's The Recognition Primed Decision (RPD) model (1989). This model treats decision making as a form of complex pattern matching where much of the expertise elicited appears as situation

## Enhancing Theoretical Models

assessment that we consider as representing the experts' understanding of the dynamics of a particular case.

Using this kind of cognitive task analysis yields descriptions of domain knowledge, reasoning, and task activity, and the technique focuses the expert on the elements of an incident that most affected decision-making. It also structures responses in a way that can be summarized along a specified set of dimensions while still allowing the details to emerge from the storyteller's own perspective. In this research, interview data will be used to elaborate a critical cue inventory (CCI) and will also focus on collecting the information either pinpointed by the interviewees or elicited and defined as expert knowledge. This will help us pick up some of the important cues that guide nurse anaesthetists' situation assessment or consideration of clinical options.

### *Data analysis*

The interviewer will transcribe the interview data. The main issue here is to clarify what eight Danish anaesthetist nurses emphasized as being important decision points – ones that subsequently determined their situation assessment or what they considered to be clinical options in particular instances. With respect to the open-ended questions, in the interview, subjects were asked to elaborate their statements by providing concrete examples. It has to be noted that the examples provided are directly translated from Danish to English by the interviewer and this might influence the exact meaning, and bias what was originally meant. The data was thematically categorized and systematized, and then compared to what the literature review identified to be important when describing what enhances anaesthetists' non-technical performance. In turn, the characteristics, cues or non-technical skills pinpointed or elicited, might tell us something about the interplay of personal, behavioral and environmental

## Enhancing Theoretical Models

influences that determine how nurse anaesthetists learn how to exercise and assert control in crisis situations.

In regards to data quality, it can be argued verbal reports by practitioners of past events necessarily involve distortion when recalling even central events, and that they can induce reasoning bias. To help address this issue, the technique of cognitive task analysis focuses the expert on those elements of an incident the most affected decision-making. The technique allows the researchers to get an inside-out view of nurses anaesthetist' work situation and so to begin to understand the various pressures and daily goal conflicts that exist in every day practice and how they pre-rationally influence what these actors see and believe as normal. The interviewer uses open ended but leading questions or indications like "what guided you to examine, or go deeper into the feeling that something was wrong". The interviewees are invited to discuss incidents that focus on their knowledge of procedures and perceptions – their so-called tacit knowledge. At the end of the interview, they are asked to confirm if some dimensions could fit into the category of tacit knowledge. This helps validate the content of the data. Finally, in regard to reproducibility, much of the literature has come out of research carried out in North American and German medical institutions. The clinical expertise, education, and task definitions of nurse anaesthetist are different in Denmark. In brief, direct issues of reproducibility can be only an issue when parallel studies are carried out in Denmark or perhaps the rest of Scandinavia on the clinical practice of nurse anaesthetists there.

## **Results**

Before a comparison of the incident accounts is presented, it is necessary to rank these accounts by time constants. A Critical Cue Inventory table was constructed from the interview data and it illustrates the types of assessment indicators that are seen as being significant in

## Enhancing Theoretical Models

informant's narratives (table 1). Table 2 shows what the initial choice of intervention is and how they were acted upon. A comparison of data from table 1 on assessment indicators and table 2 on initial choice of intervention shows when there is a correlation between assessment parameters valued in the narratives and the interventions they use when they have to handle a crisis situation.

Data from table 2 will be compared to kinds of judgments used in patient assessment; normative comparison (comparison between similar cases), ipsative comparison (comparison between the present and the previous status of the patient), or cue discrepancy (apparent discrepancies assessment indices). The intent here is to see if intervention as reported conflict with or supports the use of knowledge, or whether this kind of knowledge conflicts or supports the intervention.

Finally, interviewees statements on what constitutes an expert nurse anaesthetist (table 3), and what puts the interviewees under stress and subsequently determines decision points to take action (table 4), can help us understand the interplay of personal, behavioral, and environmental influences important to nurse anaesthetists when it comes to planning how to predict, prevent and control crisis situations. Further comparisons between data from tables 1, 2, 3, and 4 will throw more light on the issue of preparatory planning.

Using self-structured narratives allows us to understand how anaesthetist nurses interpret their own behavior. This is of interest because it links how they understand their environment to what for these practitioners constitutes risk evaluating and prediction. In this study it is emphasized in what is called decision points (table 4).

The eight interviews yielded a total of 10 incident accounts. Several interviewees recalled more than one account. The incidents reported range from immediately, life-threatening crises that require assessment and intervention within minutes to crises that might surface over a

## Enhancing Theoretical Models

period of hours. The majority of the accounts were narratives about crisis that surfaced over a period of hours. Only four incident accounts are narratives that describe an immediate life-threatening condition. This ranking suggests that time is not the most important factor in the interviewees' narratives. Also expressed as; "you do not have a chance to do anything if the situation is really bad, and you just think that you have all to win nothing to loose" (interviewee, 2010).

The accounts report include the following clinical events: esophageal intubation leading to cardiac arrest (n=1), neurogenic shock leading to cardiac arrest (n=1), a superficially anaesthetized patient (n=1), anaphylactic shock (n=1), cerebral bleeding leading to cardiac arrest (n=1), extensive surgical bleeding (n=2), non-visible intestine blood loss resulting in crisis after several hours (n=3).

Half of the narratives illustrate when ordinary practice and normative rule seem to be sufficient when supplemented by experience based knowledge. This is knowledge that has been accumulated over many years of experience in the field and through experiencing similar cases over and over again. The cases are recalled however because they developed over time differently than expected, largely due to an initial belief that everything was all right when it is was not. Or these narratives portray something like an incremental drift into failure. Only three of these cases involve knowledge-based skills. In these cases, cue discrepancy (something is not normal, but I do not know what it is) leads to more creative thinking, and intuition is mentioned to be a determining factor in how the situation is understood and acted upon (the three cases of hidden intestine blood loss). Only one case involves ipsative knowledge, where the knowledge in the case emerges from comparing between present and previous status of the same patient.

**Table 1**

*Critical Cue Inventory Table*

The CCI is a list of key elements mentioned by the eight nurses and ranked by priority in what constitutes parameters useful for patient status assessment.

Ranking in type of assessment indicators used by 8 expert nurses	Mentioned by no. of nurses	Rank by priority as a useful parameter for patient assessment
Monitor parameters	7	1. Priority: 1 3. Priority: 2 4. Priority: 4
Perceptual cues	8	1. Priority: 6 2. Priority: 2
Medical history	6	2. Priority: 1 4. Priority: 3 5. Priority: 2
Intuition	7	2. Priority: 1 3. Priority: 3 5. Priority: 3
Anaesthetic records	5	1. Priority: 1 2. Priority: 1 3. Priority: 1 4. Priority: 2

Table 1 suggests that the nurses acted upon perceptual cues when seeking information about the status of the patient. Second, in these cases, monitoring parameters or indicators are mentioned only in relation to gaining an initial all-round impression of the patient, and then only to see if their clinical judgment matches the monitor parameters, like when one interviewee say: “I’ll do a tour on all parameters” (2010). Formal information about the patient and the diagnosis are valued but are of less importance in these narratives when handling/managing crisis situations. Whether intuition is used or not, does not appear in table 1.

**Table 2**

*Initial Choice of Intervention*

What interventions did the eight nurses initially chose in order to provide what they valued to be important in accordance to their narratives.

Initial choice of intervention	Mentioned by no. of nurses/total no. of nurses	Rank order	
		Mean	SD
Further judgment by listen, see, feel and communicate with patient. Intervene from clinical judgment	8/8	1,00	0,00
Intervene from clinical judgment by perceptual cues	8/8	2,00	0,71
Review monitor parameters	7/8	2,57	1,76
Provide oxygen	3/8	3,00	0,00
Reflect, re-evaluate non-verbally	7/8	3,29	1,28
Provide liquid	3/8	4,33	0,47
Initial judgment followed up verbally	5/8	5,00	2,10
Review medical history	4/8	5,25	2,17
Communicate with surgeon	7/8	5,29	1,67
Contact doctor anaesthetist	5/8	6,20	1,17

SD: Standard deviation

Data from table 1 on assessment indicators and data in table 2 on initial choice of intervention are consistent. Clinical judgment seems to be triggered by perceptual cues, and this like judgment by listening, seeing, feeling and communicating with the patient is ranked the highest. Second ranking is given to monitor parameters.

What is significant when table 1 and 2 data are compared is that the nurses mention re-evaluating non-verbally clues as a means to determine what action will be next. This is followed by an initial judgment - verbally formulated to the personal in the OR. Interestingly, neither non-verbal nor verbal clues are mentioned as assessment indicators in table1 by any interviewee when they comment on which indicators help them assess patient status.

The importance placed on reflections not shared verbally is supported by data in table 2. The table suggests that communication, be it written or spoken patient evaluations or second

## Enhancing Theoretical Models

opinions of colleagues rank lowest in the kinds of information interviewees would rely on in crisis situations.

**Table 3**

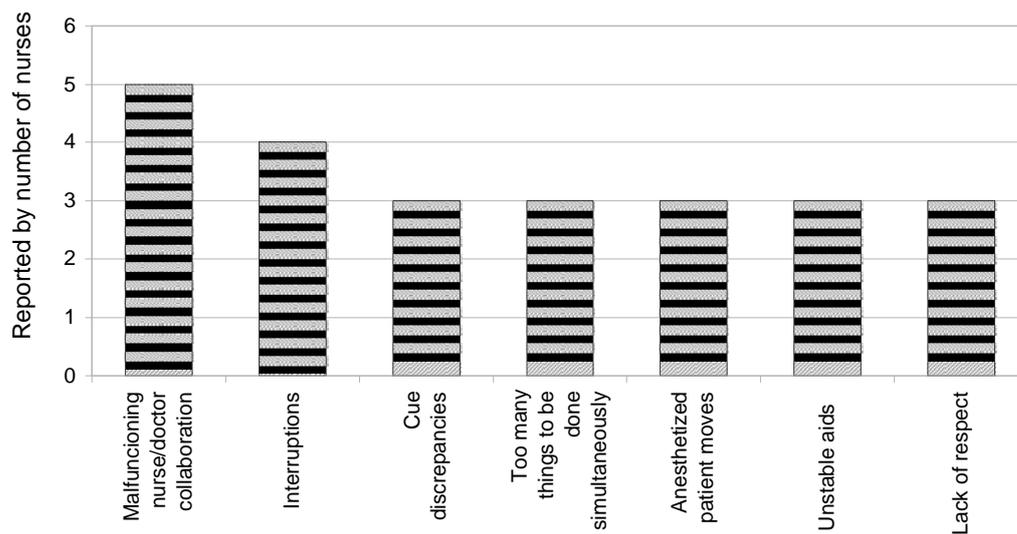
*Parameters Identified as Constituting Expert Knowledge*

Expert knowledge according to 8 expert nurses in anesthesia	Reported by no. of nurses/total no. of nurses
Experts practice from accumulated knowledge, experience based knowledge supported by perceptual cues	6/8
Experts use personal competences, life experience, personal background as a tool to get a mental picture of the patient	5/8
When cue discrepancies (something is not normal, but I don't know what it is) experts rely on:	
Knowledge based skills	5/8
Intuition	3/8
Enactment (intervention helps understand discrepancies)	3/8
Acting without conscious reflection/evaluating	5/8
In critical situations experts do:	
Forward thinking	4/8
Reflection afterwards	4/8
High reliance on skills when manipulating with practical tasks	4/8
Do experts have faith in overcoming problematic incidents	4/8

In table 3 nurses were asked what constituted expert knowledge, and the parameters identified by 6/8 nurses are identical to those found in table 1 and 2, i.e. experience-based knowledge helped identify when intervention was necessary and helpful. According to the interviewees, experience-based knowledge is supported by perceptual cues, which in table 2 are valued second by expert nurses in how they immediately evaluate patient status. Ranking first in table 2 is the use of sight, feel, and listen principles (physically visualizing the patient, touching the skin of the patient, communicating with the patient and so on). These principles are often mentioned as important in a clinical judgment of the patient. 5/8 nurses mention that experts use knowledge-based skills to re-evaluate patients, and 3/8 nurses claim experts rely on intuition when data sets and points does not match up. Interestingly, 5/8 nurses claim that

## Enhancing Theoretical Models

experts often act without conscious reflections or evaluation. Only 3/8 nurses describe that active intervention helps experts understand discrepancies in patient data (enactment). In short, nurses in crisis situations tend to rely on knowledge-based skills but often at non-conscious levels. This, it seems, cannot be easily reconciled by how these nurses report on whether experts do forward thinking or do reflections afterwards. 50 % of the replies suggest that experts do forward thinking, and the same percentage 50 % report that experts do patient evaluation and reflections afterwards. These same four nurses that do forward thinking state that enactment can be means to evaluate the patient. They ones doing reflections afterwards rate highly experts' practical skills and believe that in problematic situations practical skills are used first and then reflections on which intervention to employ next occur.



**Figure 1.**  
*Stress Factors According to Eight Danish Expert Nurses.*

In accordance to the narratives what did put the nurses under stress. List of decision points that influence situation awareness and decision-making on what constitutes risk evaluating and prediction.

## Enhancing Theoretical Models

What did put the nurses under stress reflect decision points that influence situation awareness and decision-making on what constitutes risk evaluating and prediction.

Where these expert nurses reported stress is linked to the nurse-doctor collaboration. This refers to nurse/doctor collaborations in which both parties lack knowledge of their respective competencies and/or when roles are not well defined. This occurs for example when experienced an nurse anaesthetist introduces a newly arrived anaesthetist doctors to the clinic, or nurses have to educate attending, or when “local domain expert nurse” are treated as subordinates or with lacking knowledge and expertise in regard to patient treatment.

Disagreements in which treatment should be carried out negatively impacts teamwork due to this. One nurse expressed it as disrespect of the specialty: “Doctors don’t have respect for potential problems, and they often underestimate risks, and do not ask questions of advise because of insecurity” (2010). Another nurse emphasized that experts are familiar with what is expected from them. This nurse reported a number of unsuccessful collaborations with doctors, and believed that nurse-doctor relations were seldom informed by mutual respect. 5/8 nurses experience these disagreements to be stressful. This is consistent with the low ranking in table 1 and 2 regarding calling for assistance or a second opinion when a patient’s condition deteriorates. How experts perform depend on what is seen as stressors and how these are controlled. One example came from a nurse who gave an example of a progressive incremental overload of assignments, ones that also had to be done simultaneously that led to situations where he as well was not able to inform the team that he could not cope. His opinion on what constituted an expert was, not surprisingly, defined as a person who could take leadership, communicate and define what things have been done, and what still needs to be done. He also mentioned the importance of verbal evaluation among and between team members. 5/5 of the nurses mention interruptions as stressful, “you lose attention on important tasks due the necessity to focus on other needs coming up” (interviewee, 2010) and this may

## Enhancing Theoretical Models

explain why further information gathering on patient data is limited to perceptual and monitor parameters (table 1 and 2).

A number of findings relate to gender. Male nurses believed that reflections by experts had to come before intervention. On the other hand, 4/5 women said experts tended to make reflections after the fact. One example of reflections before intervention, is from a male nurse doing preparatory work in regards to breaking down a task in subtasks and dividing task execution among members of the team: planning “who does what”. He acknowledged the flipside of planning when operators do not act as expected, resulting in an emergence of role confusion. Still it’s important for this male nurse to do preparatory work to get a mental picture of what will happen next. All the men directly linked increased understanding to intervention. In contrast, none of the women made this connection and 5/5 nurses believed intuition was an important reflection.

Male nurses also reported respect and pride issues led to a delay in calling for help from doctors. In one account it almost ended critically due to a reluctance to accept the need for help. A male nurse reported delayed respond from the surgeon to re-evaluate a bleeding patient in the recovery room, and felt that this was due to lack of respect for his work in the recovery room. Another male nurse described an incident in which the male doctor did not call for assistance due to what by the nurse was understood as complacency – a failure to recognize the gravity of a situation or to follow procedures or standards of good practice - simply because he did not call a nurse or a doctor for help. The male nurse felt offended. Further, and maybe because of feelings of pride and lack of respect by doctors, more often male nurses will call nurse colleagues than doctors to assist them.

### **Discussion**

*“Novices see patterns in colors of black and white, experts see the whole spectra”  
(interviewee, 2010)*

#### *Main features*

Perceptual cues were reported as the most important means used to handle crisis situations in the field of anaesthesia by the nurse anaesthetists studied. This is particularly true, when nurse anaesthetists encounter inconsistencies e.g. cue discrepancies (something is not normal, but I don't know what it is), or a mismatch between seen and monitored (technical) parameters and between written and otherwise experienced parameters. Perceptual cues are suggested to help nurse anaesthetists obtain a mental picture of the status of the patient, which subsequently enables them to take intuitive and creative clinical actions. “I better be careful with this patient, because he reacts more sensitive to a drug not normally so effective” (interviewee, 2010). This study suggests that perceptual cues are linked to intuition, but are perhaps better understood by nurse anaesthetists as informal knowledge that has become proceduralized. The term of proceduralized knowledge is conceptualized by John Anderson as knowledge converted into skill by being used to solve problems of procedures and to solve problems of understanding. Proceduralized knowledge is equated to clinical judgment by some of the nurses. It is how they express what is knowledge-based, not reducible to intuition though but represents instead accumulated, experience-based knowledge supported and informed by perceptual cues.

It takes formal knowledge to get formal knowledge; the vast store of information available in procedures etc is inaccessible to people who lack knowledge of the vocabulary and structure of the field. This is why, in especially situations of communication, teaching and learning, formal knowledge is highly valued (Bereiter & Scardamalia, 1993). Results from a literature review on how to enhance theoretical models of anaesthetists' non-technical performance,

## Enhancing Theoretical Models

reveal that perceptual cues do not have the same epistemological status as formal knowledge. It may be that the inclusion of perceptual parameters could enhance theoretical models of anaesthetists' non-technical performance, and this contributes to an overall positive change in the ways standards and procedures are conducted to meet goals of best practice. One issue that has to be discussed is how to incorporate such standards or goal with those linked to evidence-based practice. The development of broader more inclusive standards is supported by this study's results in which the majority of the nurses report the use and value of range of practice knowledge, much of which is experience based rather than research based (Egerod, 2006).

### *Measures of control*

*"The most critical incident can not be foreseen, because they are the ones least expected."*  
(Interviewee, 2010)

This quotation is cited because it explains why perceptual cues are such an important part of patient assessment. These cues help practitioners predict what could happen, if ... Perceptual cues make use of small number of values such as increase, decrease, no change or greater than, less than, equal. Scales like these embedded and confirmed by practice help practitioners understand both formal knowledge and what need to be done next for individual patients. Gaba (1992) and Woods (1988) claim that anaesthesia is an event-driven field of practice, with many rapid time constraints. The result is the pace and kind of decision- making in the field is often determined externally by events, or context dependencies. Some events cannot be predicted, because they are inevitable side effect of procedures. To cope with these demands, this research suggests that reformatting standardized knowledge in one way or another will not help practitioners cope with the side effects of formal procedures. For example this research suggest that the re presentation of standard knowledge as a guideline or

## Enhancing Theoretical Models

an algorithm is not an optimal solution. This is because strategies like these detach emotion from analysis, and allow for little integration by the individual of local and global knowledge of best practice.

This study suggests, that to continue the measures of control represented in checklists, procedures or algorithms that allocate attention and resources, have to include some kind of acknowledgement and taken into account practitioners' experience-based knowledge. If this is done, we would be able to create a more complete picture of the work these informants carry out and from this make practical and practicable suggestions regarding how to manage crisis situations in anaesthesia.

This argument is supported in literature of errors in medicine, patient safety and human factors, in which there is growing evidence that early detection and response to physiological deterioration, can improve outcomes for hospitalized infants, children, and adults. A rapid response system (RRS) is a multidisciplinary system to decrease the incidence of in-hospital cardiopulmonary arrests by detecting a crisis event and triggering a response and by dispatching a responding team. The system is designed to locate and respond rapidly to a suddenly critically ill patient who lacks necessary critical care resources. What is crucial when implementing systems like RRS is to understand what mechanism stimulates ward staff to activate crisis calls. The criterion for calling is when objective vital signs cross thresholds symbolizing a deteriorated patient. Still, early warning scores are better predictors of risk than objective vital sign thresholds, but are more difficult for staff to use (Sakai & DeVita, 2009). In Denmark the consequences has been to set up a criterion which allow staff to use crisis calls when they intuitively know that something is wrong, but can not tell exactly what. This is confirmed to a certain extent by Xiao, Milgram and Doyle (1997), who argue when it comes to patient safety more emphasis have to be placed on practitioners skill and how staff identify potential problems rather than skills of problem-solving. The literature has to

## Enhancing Theoretical Models

investigate for example what resources do these practitioners possess and use to prevent situations from spiraling out of control. Again this research suggests more attention should be paid to those cues that enable experts to spot potential trouble before it arises.

Are decisions taken in these situations, determined or influenced by limited information about the patient? This does not seem paradoxically to be the case because this issue is not mentioned as a problem in handling crisis patients. This also helps explain the low ranking in table 1 and 2 given to searching for additional information about the patient whether it be reviewing patient record or communicating with doctors or the surgeons to obtain additional patient information. Local knowledge applied to global knowledge seems to occur here in the way informal knowledge assists formal knowledge.

### *Personal, behavioural, and environmental influence*

As for what personal, behavioral and environmental influences determine how nurse anaesthetists learn how to exercise some measure of control in crisis situations, it seems that expert nurses assess patients in crisis situations mostly by a conscious use of perceptual cues. Perceptual cues for these nurses are equated with informal knowledge, not described in textbooks as stable facts and principles, but that, which is gained from many years of clinical experience.

In table 3, only 3 of 8 nurses state that experts are guided by intuition and feeling in situation awareness and decision-making, and 5 of 8 nurses believe that experts use knowledge-based rules when they meet inconsistencies in information about the patient's status. Intuition as an assessment parameter is reported low in incidence and importance (table 1). Still, table 2 makes it clear actions made without conscious reflections or evaluation often determine how

## Enhancing Theoretical Models

these experts interpret and address cue discrepancies. In table 3 too, 5 of 8 nurses report that expert nurses in crisis situations act instinctively due to good practical skills, their faith in their ability to overcome problematic situations, and that this reflects many years of experience-based knowledge. All these factors help determine how these experts make use of environmental factors in their decision-making.

Perhaps these nurses equate proceduralized knowledge with knowledge and medical science itself and this is why they so under report the role intuition plays in everyday practice. The role that intuition has is demonstrated by how these informants describe knowledge use in crisis situations. We practically relive events, because “past experience has made you what you are, and knowledge is an aspect of what you are” (Bereiter & Scardamalia, 1993, p. 46). Bandura agrees because, as he claims, human functioning is caused by external stimuli, and the affected inner processes in this context seen as transmitting rather than causing behavior (Bandura, 1986).

*Why not accept intuition as informal knowledge?*

*“I have seen this constant moving around in other patients, and it has turned out fatally.”  
(Interviewee, 2010)*

The use of perceptual cues can be defined as informal knowledge that supplements formal knowledge. It helps nurses “paint” a mental picture of the patient if this means that informal knowledge and experience based knowledge together enables them to gain a more accurate clinical impression of the patient. This research suggests that nurses do equate impressionistic knowledge with formal knowledge. One exception is the 3 nurses who link enactment to a clinical testing confirming their intuitive judgment of the status of the patient accords with measurable clinical findings.

## Enhancing Theoretical Models

Having said this, intuition is not reported in table 1 to be a type of assessment indicator. This may be because in most patient cases formal knowledge is sufficient and adequate, and time is not a significant factor. Or it could be that these nurses believe intuition and informal knowledge is much the same thing as “common sense”, because they all filter out for the knower what is obvious and what is not? “Sometimes I just intervene, and I know it’s the right thing that I do. I don’t even make considerations about it” (interviewee, 2010). Informal knowledge here seems to have no direct correspondence to logical propositions and rules, but rather allows nurses to “see the whole spectra, not only colors of black and white”, as one interviewee puts it.

This study suggests intuition and perceptual cues should be accepted as knowledge forms just as important in clinical practice as formal knowledge, simply due to be evidence of use, and importance of influence. This is possible as illustrated in the criterion for calling crisis calls in the RRS, which allows for an activation of alarm on an intuitively sensed basis. Patient safety can be improved by eliminating rule-violated errors, promoting the use of protocols, checklists and crisis management algorithms, as claimed by Helmreich et al. But to focus only on formal task executions, because informal rules are different to formulate seems to limit arbitrarily both what we can learn about clinical practice and how to improve patient safety. Further more, if the majority of nurses act similarly to these eight Danish nurses, they are highly dependent on perceptual cues not formalized rules or knowledge. Thus, eliminating rule-violation would only partially improve patient safety.

## Enhancing Theoretical Models

### *Stress factors*

What these nurses reported as stressful more than anything is linked to failure in the nurse-doctor relationships and collaborations. 5/8 experiences this as stress. This is collaborated by low ranking in table 1 and 2 given to calling for assistance or a second opinion when a patient's condition worsens. 5/5 nurses mention any kind of interruption in their work as stressful. This might help explain why further information gathering on a patient is limited to perceptual and monitor parameters (table 1 and 2). Anything more would add to the sum total of interruptions or failures in collaboration. It is interesting to note however, that time constraints and time pressure are not mentioned as being determining factors that stress the nurses. What they perceive as stress is related to high task demands or unsatisfying nurse-doctor collaborations.

Reflections, verbally or non-verbally, according to table 1, do not seem to contribute to stress, neither do they seem to be valued by any of the interviewees when reporting what indicators helps them assess patient status. Further, table 2 shows that 5/8 nurses believe reflections are made instinctively. In other words, while reflections are not deliberately applied in patient assessments, it is highly valued when an initial choice of intervention has to be selected.

Again the importance of reflection and informal knowledge are undervalued by these nurses because it seems too much like "common sense".

Bandura's Social Cognitive Theory (1986) states "cognition plays a critical role in people's capability to construct reality, self-regulate, encode information, and perform behaviors." For these nurses, this means your feelings about numbers and procedural rules can and do influence your behavior in large and small ways. These influence for example your mental state (what put you under stress and what are decision points that determine your actions) when trying to balance impressions of the patient against facts about the patient (informal supporting formal knowledge). They can also affect how you respond when someone poses a

## Enhancing Theoretical Models

numerical problem (answering questions from an interviewer on what characterizes nurse anaesthetist's non-technical performance). However, they are not usually part of your medical formal knowledge. Nevertheless for these nurses feelings are an essential and inseparable part of their clinical knowledge. This study suggests that while reflections are made instinctively, these nurses see them as part of, linked to and supporting their formal clinical knowledge. In task executions, self-regulation has taught nurse anaesthetists to focus almost all their attention on the immediate task, with just enough left to maintain an awareness of their immediate surroundings. This occurs for example when nurse anaesthetists use the sound from a pulsoxymetri to monitor the frequency of the heart rate, the sound from surgical suction to monitor amount of blood loss, or simply to assess if surgery is going on as expected by noting if there's small talk going on between surgeons. This is confirmed by research on this topic by Woods (1988) who claims that what is crucial is practitioners' ability to process an ongoing attention and to obtain an iterative problem-solving skill that fits dynamic and complex work settings.

On the contrary, Crisis Resource Management (CRM) principles described by Rall and Dieckmann (2005) on how to best manage critical situations and prevent errors in anaesthesia and intensive care medicine, instruct clinicians to allocate attention wisely due to the believe that our attention is very limited and humans are not good at multi-tasking. This is why the authors recommend clinicians to allocate attention repeatedly. Focusing on details and focusing on the big picture: "whenever there is a need to focus on a detail (e.g. a difficult intubation) try to force yourself to go back to the big picture" (p. 111). In order to reduce complexity of task execution and stressing elements of e.g. time constraints this study suggests that nurse anaesthetists intuitively use external cue to create internal mental pictures of the patient. They do multi-tasking by their pre-described definitions of what e.g. sounds

## Enhancing Theoretical Models

and visions normally mean in accordance to patient care. In this way they might predict potential threats and how to control these factors.

Attention regulation can be done by reducing information gathering in times of work overload. Or when this occurs, to rely solely on immediate perceptual cues. This informs how these nurses take precautions regarding task execution and why they omit calls to surgeons or anaesthetist doctors unless absolutely necessary.

Self-regulatory knowledge is self-knowledge relevant to performance and is domain-specific (Bereiter & Scardamalia, 1993, p. 59). This can mean that whatever works for one person in controlling attention may not work for another in more or less the same context. It could also be one reason why informal knowledge and self-regulative knowledge are not valued in anaesthesia. Informal knowledge after all is not stable. In effect, informal knowledge may simply be devalued because it cannot be expressed (or is at a far remove) from Baconian science where all that counts are facts that are tested against experience and written down in some procedural form. This in turn may be why scientific researchers cannot come to a common understanding of what optimizes team performance. In short, self-regulatory knowledge, regulation of attention, the capability to construct reality, encode information, and perform behaviors appear to help the studied practitioners to balance what according to them constitutes a complex work and helps them reduce what they find stressful in this workplace.

### *Limitations of this study*

*“The test of a study of cognitive work in context is: did you discover the significance of small details? The catch is that most details are not significant” (Woods, 2003).*

For these nurses what mattered was not how severe or critical the recalled incident was but to what extent they felt capable to manage clinical challenges that occurred in dynamic, complex situations. Nemeth, Cook, and Woods (1997) put it this way: “Confronted with different

## Enhancing Theoretical Models

evolving situations, operators navigate and negotiating all details to bridge gaps and to join together the bits and pieces of the system by the interactions in the system". Still, a limitation of importance in this study is how the interviewees do their every day task so well that the adaptations and effort disappear to the interviewer and the interviewee alike. That is the problem of the exotic. The interviewer's attention can be captured by more critical aspects of a work setting (here e.g. severity of the patient cases, time and information shortages), whereas interviewees' view all this as simply part of everyday nature of work.

Further, these are the issue of whether qualitative work can be used to generate knowledge applicable to other contexts no matter how similar.

The small number of participants (8) can hardly be said to be statistically significant. There is a need for future studies to validate these findings. Looking at the whole team, like the studies of Helmreich et al. (1995), could help bring into focus the importance of common perceptions because failure to share (or build) a common perspective can increase anaesthetic and surgical mishaps accidents.

Further so far only Mackenzie et al. (1994) have looked at the handling of a difficult airway in any detail. These researchers conclude that often anaesthetists like many professional are not very good at retrospectively describing how they make judgments. This has also been described in studies of other kinds of professional work. Further, both studies from a single view and from the social perspective, doing observations in the OR could add to the validity of this research.

There is a need to identify what characterizes non-technical performance of anaesthetists – those principles that guide analytic reasoning and how they are linked to emotion and affect.

While anaesthetists themselves can actually describe what characterize their mental workload or strategies for managing critical incidents, the question is how to include data of this in checklists and organizational procedures?

### Conclusion

Procedures, checklists, algorithms and other formal rule-sets, have been suggested to improve safety in healthcare settings. With a better understanding of anaesthetists' non-technical performance, establishment of standards and procedures could be strengthened with the intent to link best local practice in accordance to evidence-based practice.

This study suggests that perceptual cues inform nurse anaesthetists' situation awareness and decision-making. Should such factors be included in guidelines? What consequence does the sole reliance on formal knowledge in anaesthesia have for safe practice?

All interviewed nurses describe the use of a broad range of practice knowledge, much of which is based on experience rather than research. Not much interest has been shown this kind of practice knowledge in the safety literature. Similarly, the kind of high order self-regulatory knowledge which controls the application of other knowledge has not obtained much interest either. The newly established action cards for ward units staff states that a RRS can be activated if the ward staff has a feeling that something is wrong, but cannot tell exactly what. Here informal domain-specific knowledge not only has been institutionalized but can also enhance global know-how regarding what it takes to make anaesthesia a safer enterprise. On the other hand, licensing examinations in anaesthesia tend to overemphasize formal knowledge and "facts", in part because they are easy to test for and grade. But to equate this kind of knowledge with all necessary and useful information is to make a category error. Even Karl Popper, who argued for science as a strong objective method of verification, recognized, as he put it; "Formal knowledge is created through social processes of justification, criticism, and arguments."

This study suggests that one cannot validly talk about what constitutes safe parameters from which control strategies and mechanisms can be established to ensure optimal behavior and

## Enhancing Theoretical Models

performance of anaesthetists, without asking oneself the questions such as “for who”, and “for what”. For example, when one talks about complexity it is always necessary to explicitly state the characteristics of the system under consideration, e.g. referring to the operator who must carry out this task. The operator does not necessarily exactly perform the prescribed task, but redefines it by modifying the goal and/or the conditions (Hackmann, 1969). An analysis of the divergences between the prescribed task and the actual task often reveals how an operator understands, carries out and even reduced the complexity of the prescribed task (Leplat, 1988).

The findings of this study imply that learning a task, controlling and regulating activities, is done by reducing, what the operator perceives as task complexity. This is similar to what Rasmussen describes (1979) in his “Decision Ladder”. The three levels, which are distinguished - knowledge-based, rule-based, and skill-based - represent three ways of processing a situation. An operator can create processing instruments that allow him to eliminate a certain numbers of steps in the ladder, also called short cuts. Formal knowledge becomes proceduralized knowledge, intuitive knowledge becomes informal knowledge, here clinical knowledge or in Rasmussens’ terms use of short cuts. Use of perceptual cues or short cuts help staff predict what might be potential treats, and to determine how to control these factors often through self-regulating actions. The question this study raises is if these short cuts or expert identified cues could be represented in guidelines etc?

On the other hand, is it possible to identify and reproduce any universal factor of human behavior, especially ones that can help us predict and control crises events? According to Banduras’ Social Theory, this is impossible if not difficult to do for any number of reasons ranging from the methodological to the philosophical. In other words, it is an open question to what extent it is possible to predict human behavior.

## Enhancing Theoretical Models

This study's findings, while limited to a small set of nurse anaesthetists, is consistent with those of Helmreich et al. (1995), the Operating Room Management Attitudes Questionnaire (QRMAQ) surveys (1994) and systematic observational data from operating rooms collected using Operating Room Checklist (ORCL) (1995). All these studies report no or little agreement among individuals (nursing and academic staff, anaesthetists, and surgeons) on what constitutes appropriate operating room management and behavior strategies. This reflects diversity in opinions between subgroups as well as large variability in attitudes within subgroups on items relating to the ways in which optimal team performance could be achieved. Attitudes are, as a result, imperfect predictors and representations of behavior, because human decision-makers rapidly switch between different decisions strategies depending on the demands of the task, and variable estimates of available time and risk, they claim. As for how nurse anaesthetists exercise and assert some measure of control in crisis situations, this study concludes that there is no common agreement among Danish nurse anaesthetist on what it takes to control uncertainty. This tends to support an epistemological perspective, that interpersonal relations cannot be known, predicted and controlled. Finally, the acceptance and utilization of perceptual cues in e.g. guidelines, would add an important and influential informal knowledge source that could enhance theoretical as well as practical models. Taking perceptual clues into account could improve control strategies and mechanisms intended to enhance safety in anaesthesia, such as the newly introduced action card for Danish ward units staff. Finally, this study suggests that perceptual cues and intuition are highly adaptive mechanisms and ones, if better understood, could help reduce medical accidents and improve the theoretical models used today to understand human behavior, related to issues of safety. Intuition is a highly valuable control mechanism, still not fully accepted in the Western world as a powerful tool.

## APPENDIX

*Critical Decision Interview Probes are used as a set of opening queries that are to stimulate recall of salient cues.*

Probe Type	Probe Content
Cues	What were you seeing, hearing, smelling?
Knowledge	What information did you use in making this decision and how was it obtained?
Analogues	Were you reminded of any previous experience?
Standard scenarios	Did this case fit a standard or typical scenario? Does it fit a scenario you were trained to deal with?
Goals	What were your specific goals and objectives at the time?
Options	What other course of action were considered or were available?
Basis of choice	How was this option selected/other option rejected? What rule were being followed?
Mental modeling	Did you imagine the possible consequences of this action? Did you imagine the events that would unfold?
Experience	What specific experience or training was necessary or helpful in making this decision? What training, knowledge, or information might have helped?
Decision making	How much time pressure was involved in making this decision? How long did it take to actually make this decision?
Aiding	If the decision was not the best, what training, knowledge, or information could have helped?
Situation assessment	If you were asked to describe the situation to a relief officer at this point, how would you summarize the situation?
Errors	What mistakes are likely at this point? Did you acknowledge if your situation assessment or option selection were incorrect? How might a novice have behaved differently?
Hypotheticals	If a key feature of the situation had been different, what difference would it have made in your decision?

From Klein, Calderwood, and Macgregor's article on Critical Decision Method for Eliciting Knowledge (1989).

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