A comparison of decision-making by “expert” and “novice” nurses in the clinical setting, monitoring patient haemodynamic status post Abdominal Aortic Aneurysm surgery

Kerry Hoffman, RN.

Bachelor of Science, Graduate Diploma (Education),

Diploma of Health Science (Nursing), Master of Nursing.

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CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of the candidature for any other degree.

I also certify that the thesis has been written by me and that any help I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

Signature of Candidate

Preface

This study arose out of a continuing interest in clinical education and the education of nurses in general. During time spent teaching clinically and in educating undergraduate nursing students, I have had a continuing interest in how nurses make decisions and what can be done to help improve nurses' decision-making, both in the clinical arena and in the area of undergraduate studies. The Problem Based Learning (PBL) in which I have been most often involved, is believed to develop important and transferable skills such as critical thinking and decision-making. However, this has seldom been evaluated and more can be done to improve the delivery of learning materials aimed at improving these important cognitive skills. A starting point is to begin to understand how novice and expert nurses use cognitive strategies during decision-making and how these differ. New graduate nurses are increasingly entering nursing in areas such as critical care and it is especially important to understand nurses' decision-making in this area.

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Executive Summary

Effective high-quality decision-making is important in nursing to ensure that nurses' decisions positively affect patient care. This is particularly important in critically ill patients such as those being managed and monitored in Intensive Care Units (ICU). Increasing nursing shortages worldwide are leading to greater demands for new graduate nurses to enter directly into areas such as ICU, and the education of graduates needs to prepare them for the demands of this area, particularly in relation to the development of cognitive skills such as decision-making. Examination of the cognitive processes of nurses as they decide on care for patients in ICU can help in not only understanding how nurses make decisions about care, but can also lead to improvements in educational methods to develop such skills. Comparing the decision-making skills of novice and expert nurses can help illuminate the differences between these two groups and lead to methods to best assist novice nurses towards expertise.

Much of our reasoning is invisible and examination of it requires methods that can illuminate our thinking. The information-processing framework seeks to explain the unseen processes as they occur in the mind and envisages a model of the mind as a processor. The think aloud (TA) method of data collection and the corresponding verbal protocol analysis from this theoretical framework were chosen for this study and allow for in-depth, rich descriptions of a participant's cognitive processing as s/he reasons about care. Collection of such data in the natural setting can expand the knowledge of cognitive processing in decision-making and the real world of practice was used for this purpose.

Eight ICU nurses, four novice and four expert, comprised the sample. The nurses thought aloud (TA) for two hours while caring for patients who had undergone an elective Abdominal Aortic Aneurysm (AAA) repair. The patients were all cared for within the first 24 hours post-operatively. The participants were subsequently interviewed as soon as the transcripts of the data were available after the TA session. Transcripts were analysed using Problem Behaviour Graphs (PBG) and content analysis, and the problem

space identified by describing the tasks attended, cues gathered and information sources used. The cognitive operators and processes used were also identified.

There were differences in both cognitive operators and processes used by novice and expert participants. Expert participants, in contrast with some previous studies, collected a greater range of cues than did novice participants and had an extensive repertoire of known cues, which they were able to relate together more often than were novice participants. The difference in novice and expert nurses' decision-making may be as much due to the way expert nurses put pieces of information together as it is to how much information they have. This study was completed in the real world of practice. Expert participants appeared to be anticipating problems and collecting cues that may indicate these problems. Expert participants also used the cognitive operators "match" and "predict" more often than novice participants did and appeared to match current patient situations to previous patients and experience. Expert participants used more forward reasoning in hypothetico-deductive reasoning, possibly as they could anticipate problems, whereas novice participants used more backward reasoning in hypothetico-deductive reasoning, working back from problems they identified. Novice and expert participants used if/then statements and novice participants reported they had been taught some of these by more experienced nurses. This type of reasoning in decision-making, although mentioned in the nursing literature, has not been identified as a process in nursing studies.

Understanding how novice and expert nurses' reasoning during decision-making differs can be used to further develop undergraduate education programmes. It can also help those who mentor novice nurses better understand and model decision-making. Adoption of teaching and learning methods within Problem Based Learning (PBL) programmes, such as concept maps to plan care, may help students and novice nurses better understand how to gather and relate cues and information to plan care.

Chapter One

Introduction

Nursing involves understanding and managing a person's health and response to illness and the delivery of care in relation to physical, psychological, social and spiritual domains (Taylor, 1997; Redden and Wotton, 2001; Botti and Reeve, 2003). The delivery of care occurs mainly in complex environments with increasing levels of technology, which present nurses with many challenges as well as a variety of different roles (O'Shea, 2003). One important aspect of the multidimensional role of nurses is the observation of patients, and in this role they are often the first to detect patient deterioration (Bakalis and Watson, 2005). To competently manage a patient's health and response to illness and to detect possible deterioration in the clinical arena, nurses need to have a blend of technical skills, knowledge, and experience (Winslow, Dunn and Rowlands, 2005) as well as a caring and respectful attitude towards their patients. While psychomotor skills are important to the delivery of nursing care, these are constantly changing with new technologies and from site to site (Pardue, 1987; Bucknall, 2003). The knowledge required for the delivery of care is also constantly changing and nurses need to be equipped with cognitive skills to continue lifelong learning and to maintain up-to-date, evidence-based practice.

The cognitive skills developed by nurses need to be transferable across a range of settings to allow effective processing of vast amounts of information and the selection and implementation of appropriate and timely interventions (dela Cruz, 1994). Of these cognitive skills, critical thinking and decision-making are necessary for effective practice (O'Neill and Dluhy, 1997). This is increasingly important as nurses are called upon to make more complex decisions for patients with higher acuity. This is especially so in areas where patients are critically ill and at high risk and nurses are required to make rapid, complex decisions about a patient's physiological and psychological status, such as in critical care units to ensure positive patient outcomes (Currey and Botti, 2003).

Research in nursing is beginning to demonstrate the impact that nurses can have on patient outcomes, resulting in a decrease in complication rates for patients (O'Connell and Warelow, 2001; Spilsbury and Meyer, 2001; Dang, Johantgen, Pronovost, Jenckes and Bass, 2002; Aiken, Clarke, Cheung, Sloane and Silber, 2003). In the United States of America (USA), a large study across 168 hospitals in one state demonstrated the link between the care of post-surgical patients by degree-educated nurses and lower rates of mortality (Aiken et al., 2003). The authors concluded that as well as adequate staffing levels, good nursing clinical judgment and decision-making are important in ensuring patient safety (Aiken et al., 2003). Degree-educated nurses were described as being better at clinical judgment and decision-making, hence rescuing patients from complications. The term "failure-to-rescue" was used to refer to a situation in which patient complications were not prevented and good patient outcomes were not ensured (Clarke and Aiken, 2003).

Nurses were also shown to deliver better patient outcomes in a study comparing the management of intensive care unit (ICU) patients by nurses and doctors. Intubated patients in ICUs managed by nurses had mechanical ventilation ceased and were extubated earlier than those managed by registrars, reducing complication rates and ICU stays (Curley, 2002). Again the difference was attributed to the clinical judgment and decision-making skills of the nurses.

The decision-making and clinical judgment skills of nurses may contribute to better patient outcome by nurses anticipating and preventing complications. The ability of nurses to prevent complications was demonstrated in a study that related the rates of complications of patients following Abdominal Aortic Aneurysm (AAA) repair to the staffing ratio of Registered Nurses (RNs) to patients (Dang et al., 2002). The staffing of American ICUs differs from Australian ICUs in that the former have nurse-to-patient ratios ranging from 1:1 or 1:2 RNs to each patient to 1:5 RN for a patient supported by respiratory assistants and other licensed assistive personnel. Australian ICUs usually have a nurse to patient ratio of 1:1, although patients not requiring mechanical ventilation are often cared for with a ratio of one nurse to two patients. The study of Dang et al. (2002) demonstrated that the risk of complications was cut when the ratio of RNs to patients was 1:1 or 1:2. The authors attributed this result to the higher level of reasoning and decision-making skills of the better educated RNs and the greater level of monitoring that occurred, resulting in earlier detection of problems and earlier intervention (Dang et al., 2002). Ratios of 1:5 involved less educated personnel having more direct care of patients, with RNs overseeing the patients. Pending problems were recognised less often in these circumstances, possibly due to the less educated staff not being sure how to interpret patient information and hence not reporting important indicators of change. Decreasing nurse staffing levels led to an increased risk of complications. The authors appear to attribute better patient outcomes for post-surgical AAA patients to improved skills in monitoring patients. Both the study by Dang et al. (2002) and Curley (2002) point to nurses' clinical judgment and decision-making skills as positively influencing ICU patient care, however, it needs to be considered whether other influencing factors in these complex environments may also play a part.

The interpretation from the above studies may be too simplistic, as many factors other than nursing care may contribute to patient outcomes (O'Connell and Warelow, 2001). Critical care environments can be particularly turbulent and this may have an impact on outcomes. The large study by Aiken et al. (2003) with post-operative surgical patients, while collecting information on patient outcomes, also collected information on a wide range of characteristics of the treating hospitals, addressing O'Connell and Warelow's (2001) concerns of accounting for contextual variables. Even when contextual variables were accounted for statistically, there was still a link between having nurses with higher educational levels caring for patients and improved patient outcomes (Aiken et al., 2003).

Nurses appear in some situations to contribute to better outcomes for patients, although this has been difficult to demonstrate and needs further studies that are carefully designed to control confounding variables. In ICUs, nursing care has been demonstrated to make a difference to the extubation of patients and also to the prevention of complications in post-operative AAA patients (Curley, 2002; Dang et al., 2002). The prevention of post-operative complications depends on nurses' ability to detect impending problems. Early detection of problems often relies on the skilful interpretation of the monitoring parameters by nurses' processing of technical information from various sources, and their clinical observations and assessments and effective CDM skills can help in this (Aitken, 2000; Currey, Botti and Browne, 2003). Expert nurses caring for critically ill patients are believed to be able to avert problems and deliver better quality care, but how they do this is not well understood.

Understanding how expert nurses deliver better care is becoming increasingly more important as the nursing workforce changes. The growing worldwide nursing shortages and the consequent demand for newly graduated nurses to quickly become competent decision-makers has increased the emphasis on developing decision-making skills in novice nurses (Cornock and Goodman, 2002; Binnekade, Vroom, de Mol and de Haan, 2003; Ihlenfeld, 2005; Leners, Roehrs and Piccone, 2006). There is also a constant call from nursing managers for new nurses who can "hit the ground running", with added demand that these nurses be equipped with the skills and knowledge that enable them to make good clinical decisions. The nursing shortage is also leading to newly graduated nurses entering areas such as critical care, including various unit types such as Cardiac Care Units (CCU) and ICU earlier in their careers, sometimes as their first area of practice as an RN (Messmer, Jones and Taylor, 2004; Ihlenfeld, 2005). There is also a growing trend in nurse education to expose nursing students to critical care rotations earlier to enhance recruitment into these areas (Ballard and Trowbridge, 2004; Gross and Anderson, 2004). This is coupled with a growing emphasis on quality decision-making as health care focuses more on customer-focused care and consequent methods of improving patient outcomes (Bradshaw, 1995; Mallory, 2003; Frampton, 2005; Lindley, Glaser and Milla, 2005). Ensuring newly graduated nurses deliver quality decision-making in critical care units is important.

There is little consensus on the meaning of quality decision-making, but authors such as

Elstein (2000) suggest there are three important elements. A decision must deliver good clinical outcomes, must be based on the best available evidence and must be acceptable to the patient. Nursing authors such as Higgs and Jones (1995) have described quality decisions as those that are defensible, presumably based on sound reasoning and evidence of some kind, and should not harm the patient or deliver ineffective outcomes. This is similar to the sentiments being espoused in medicine by authors such as Elstein (2000), except that, interestingly, the statement of Higgs and Jones (1995) leaves out patient input. The general consensus is that quality clinical decisions deliver good patient outcomes, and that expert nurses do this well. However, what expert nurses are actually doing during CDM needs further explication, to enable development of decision-making skills in novice nurses. Nurse education has attempted to develop cognitive skills such as decision-making using either traditional curricula and nursing process, or by using Problem Based Learning (PBL).

Traditional curricula have attempted to develop cognitive skills in a linear fashion using the prescriptive nursing process and have also tended to focus on content rather than process, which is problematic in today's world, in which knowledge changes rapidly (Brooks and Thomas, 1997). Traditional curriculum approaches to teaching decision-making have also not accurately reflected decision-making as it occurs in the real world of practice. In contrast to traditional approaches to nursing education, PBL aims to present learning situations that better reflect the realities of practice and have an emphasis on process rather than content.

PBL approaches have been shown to result in better problem-solving ability than traditional approaches to learning (Sankar and Raju, 2001; Bowers, 2004; Uys, Van Rhyn, Gwele, McInerney and Tanga, 2004). PBL focuses on process, using case studies and the development of cognitive skills such as decision-making. There is a pressing need to understand the cognitive processes used by expert nurses during decision-making and to also understand how these differ from those of novice nurses to ensure that PBL approaches accurately present decision processes (Watkins, 2000; Van Gessel, Nundaz, Vermeulen, Junod and Nu, 2003).

Novice/expert differences have been examined in nursing and descriptions of the differences developed. These descriptions are useful but do not give an in-depth understanding of the processes expert nurses are using during decision-making. Few guidelines exist for educators to help novice nurses build their skills towards expertise (Chartier, 2001).

In conclusion, there is a pressing need to understand the cognitive processes used by nurses during decision-making, especially in critical care areas where complicated decision-making occurs in very complex environments and where newly graduated nurses are increasingly being placed. Such understanding will ensure that the education of nurses prior to entering these areas, and the ongoing mentoring after entrance, is appropriate and quickly develops competent decision-makers capable of delivering high-quality care. It is particularly important to understand the differences between novice and expert nurses in the real world of practice, especially in relation to the important role nurses have in the detection and prevention of patient problems. Many of the studies of CDM in nursing have used simulations that are meant to reflect real-world situations, but these do not adequately capture real-world decision-making. Studies in actual clinical situations are needed to more accurately reflect decision-making as it occurs during the delivery of care.

Aim

The study aims to examine the cognitive strategies and decision processes used by novice and expert nurses during CDM in the real world of practice in one critical care area, the ICU, whilst monitoring patient haemodynamic status following Abdominal Aortic Aneurysm surgery. Specifically the study will include examination of contextual aspects such as description of decision tasks, cues collected and information sources used. In addition a method that traces decision processing will be employed. The processes uncovered in the study will be considered in relation to their implications for nursing education, practice and research.

1.2 Overview of thesis

Chapter One outlines the importance of CDM to patient care in areas such as CCU and ICU, where nurses making good decisions have been shown to improve patient outcomes by preventing complications. The consequent need to examine the decision-making of expert nurses in relation to novice nurses is also outlined, particularly in relation to problem-based courses which aim to develop transmissible cognitive skills in students and novice nurses.

Chapter Two outlines decision-making approaches and definitions and considers the suitability of different approaches to uncover cognitive strategies and processes during decision-making. The different approaches are also examined in relation to their suitability to uncover decision-making processes in the real world of practice. The main approaches examined mirror those outlined in psychology and include decision analysis, information-processing theory, interpretive approaches such as phenomenology and grounded theory and naturalistic decision-making (NDM). Some of the processes and cognitive strategies or operators described using the different approaches are discussed and include processes such as hypothetico-deductive reasoning, intuition, pattern-matching and cognitive operators such as “plan”, “interpret” and “relate”. The theory of information-processing and the evolving work within this theory including that referred to as unified cognition are also examined. The mechanisms and how they account for the processing of information during problem-solving and decision-making are considered.

Chapter Three examines the research to date in critical care decision-making, considering factors such as the clinical environment and tasks of decision-making and the decision-making processes identified. The clinical environment of the ICU is unique and often involves rapid decision-making under much stress. Many decision tasks centre on monitoring patient status. The care and monitoring of patients post abdominal aortic aneurysm surgery is examined. The differences in expert and novice nurses’ decision-making is discussed, particularly the differences in processes used and aspects of decision-making such as cue perception and knowledge sources. Conflicting results from various studies are reviewed.

Chapter Four examines the methodology of information-processing theory, namely thinking aloud (TA) and verbal protocol analysis. The use of TA in simulation studies is compared to studies in the real world of practice, as are issues with using TA and verbal protocols in the real world of practice. The coding of operators used for TA studies is also discussed and common operators from nursing studies are compiled and compared.

Chapter Five presents the methodology for this study, beginning with a description of the pilot study. The methodology for the main study is then discussed, as is the development of the schedules used during analysis. The method of Problem Behaviour Graphs (PBG) used for the analysis in this study is discussed in detail. Issues of an ethical nature are then considered, as are issues of validity and reliability.

Chapter Six presents the findings from the study, including those describing the problem space, which consists of the task environment, cue usage and information sources. The differences between expert and novice nurses are highlighted and include differences in tasks and cue usage, as well as cognitive operators and processes. The themes developed from content analysis are also presented.

Chapter Seven presents a discussion of the findings, particularly in relation to cognitive operators and processes. The implications for nursing practice, nursing education and nursing research are also represented. Chapter Eight concludes the study and discusses the important findings in relation to nursing practice, education and research.

Abbreviations used in the study are presented in Appendix 1 definitions in Appendix 2.

Chapter Two

Examining Decision-making

To examine what is happening at the process level of decision-making in the real world of practice appropriate research methodologies need to be used. An explication of what is meant by decision-making is also needed as an array of contrasting definitions are used in nursing research, due to the different theoretical approaches in use. The different approaches also need to be examined in light of the purpose of any study and the suitability of the methodology to determine processes of decision-making in real settings. Comparison of different approaches may also help to illuminate some of the contradictory findings in decision-making research in nursing.

2.1. Definition of clinical decision-making

In the nursing decision-making literature, terms for decision-making are often confusing, due to the interchangeable use of terms for the same phenomena (Thompson and Dowding, 2002). Terms used interchangeably include clinical judgment, clinical reasoning, diagnostic reasoning, and clinical problem-solving (Elstein, Schulman and Sprafka, 1978; Corcoran, 1986; Benner and Tanner, 1987; Jones, 1988; Grobe, Drew and Fonteyn, 1991; Gordon, Murphy, Candee and Hiltunen, 1994; Radwin, 1995; Alexander 1997; Tanner, 2006). In psychology decision-making, problem-solving and judgment are separate areas of study but in the real clinical world they cannot be separated, and this may have contributed to the confusion of terms in the research into decision-making in the clinical domain (Elstein et al., 1978).

Decision-making in nursing is variously described, but most definitions involve an idea of reasoning about patients and their care, concluding with the best course of action. Decision-making can be described as simply as the formulation of patients' problems (diagnosis) and the selection of appropriate interventions (treatments) (dela Cruz, 1994) or as consisting of stages: gathering of information in the form of cues or data, handling the data in some way and evaluating the cues or data to diagnose or decide on patient problems and then evaluating the alternatives to formulate a plan of action (White, Nativio, Kobert and Engberg, 1992; Radwin, 1995; Hallet, Austin, Caress and Luker, 2000; Kraischsk and Anthony, 2001; Lauri et al., 2001). These stages are similar to the nursing process and most are reflected in the various approaches to decision-making.

Definitions of decision-making however, are usually operational and reflect how decision-making is viewed: terms for decision-making are theory laden (Benner, Tanner and Chesla, 1996). Some definitions of decision-making will be examined in relation to this and the definition chosen for this study will also be explained in relation to its operational and theoretical framework and suitability for examining processes of decision-making.

2.2 Decision-making approaches

The approaches to examining decision-making in the discipline of psychology are examined first, then the approaches that have been used most commonly in the discipline of nursing.

2.2.1 Approaches in psychology

The development of methodologies in health care to examine clinical reasoning and decision-making have followed from developments in other fields, mainly psychology where a variety of methods have been used, leading to a pluralism in approach. According to Patel and Arocha (Higgs and Jones, 1995), this methodological pluralism is healthy and useful for generating knowledge, as long as methods used are designed for the questions they ask and their limitations are acknowledged.

In line with methodological pluralism outlined by Patel and Arocha (Higgs and Jones, 1995) decision-making in psychology has been examined using two main approaches, the rational or analytical and the interpretive. The prescriptive or normative, as in decision analysis theory and the descriptive, as in information-processing, are often referred to collectively as analytical or rational methods. The study of interactions as a form of reasoning and understanding, is often referred to as the naturalistic or interpretive approach and is also descriptive. The first approach uses analytical or rational models of decision-making, which are empirical in intent and attempt to predict and model how reasoning during problem solving and decision-making occurs (Newell and Simon, 1972). The second approach involves the naturalistic perspective which views decision-making as a subjective, individual process grounded in experience and attempts to inductively generate descriptions of decision-making (Hanna, 1993; Zsambok and Klein, 1997; Hedberg and Larsson, 2003). The methods used in nursing will be examined and outlined in relation to this pluralism.

2.2.2 Approaches in nursing

The approaches in nursing mirror the pluralism seen in psychology, with rational/analytical and interpretive being the most common (Aitken, 2000; Bucknall, 2000) (see Figure 1). Alternative names for the two main approaches are systematic/positivist and the intuitive models (Thompson, 1999), scientific/rational and intuitive models (Luker, Hogg, Austin, Ferguson and Smith, 1998) and analytical and naturalistic (Hedberg and Larsson, 2003) instead of rational/analytical and interpretative. A dichotomy is usually described, with rational/analytical approaches on the one hand and intuitive or interpretive on the other.

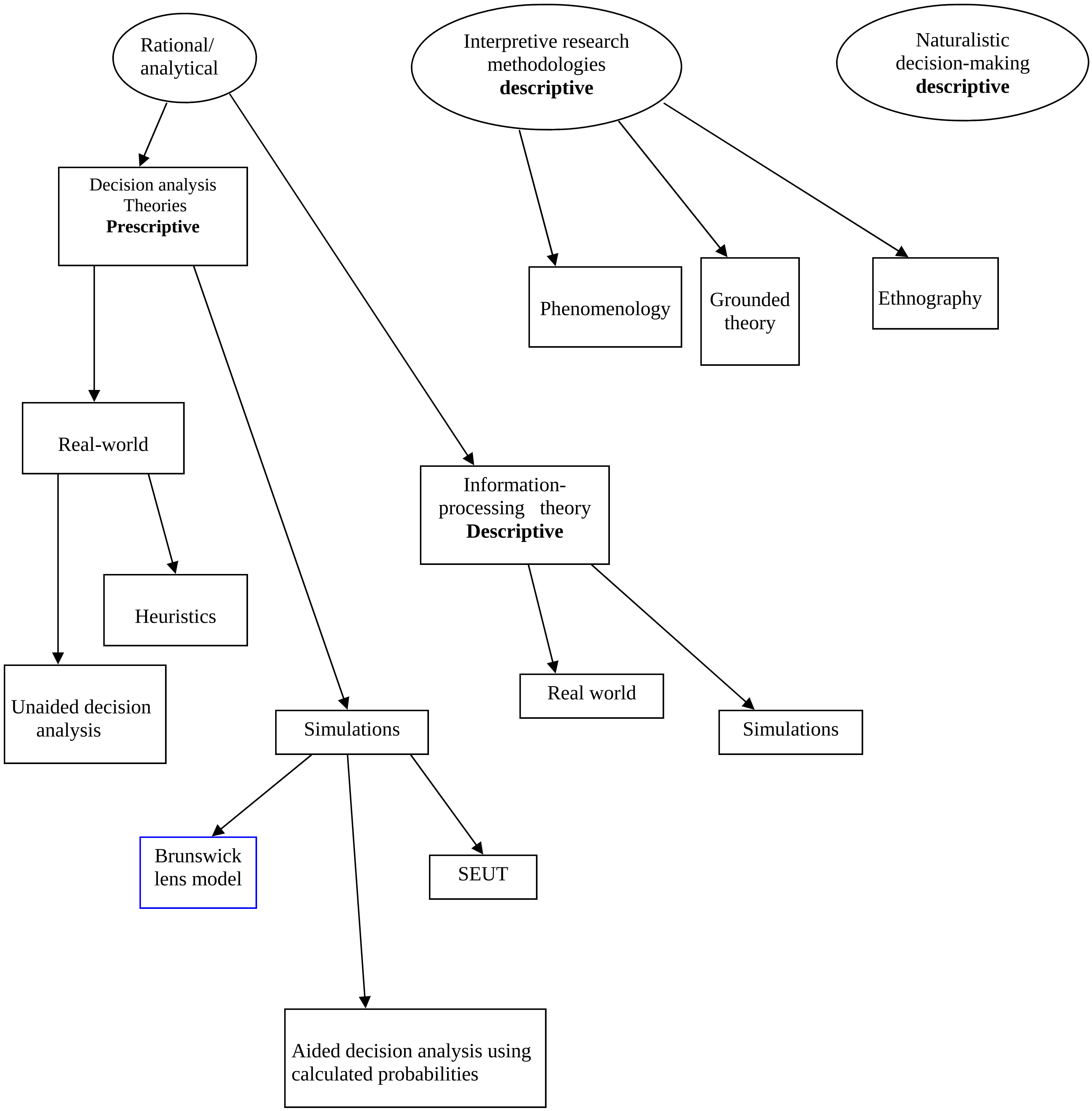
Other nursing researchers have outlined two major theoretical perspectives or approaches and described them as the decision theory, including expected utility theory, the Brunswick lens model and Bayem's theorem, and the information-processing theory (Taylor, 2000; Pierce and Hicks, 2001). These are both nominated as analytical by other nurse academics. In other fields there is a dichotomous approach as well, with both analytical and intuitive being described. Analytical, as used in military decision-making for example, describes the use of decision aides, while intuitive denotes real-world decision-making (Bergstrand, 1998), which differs from the usual meaning in nursing. Patel and Arocha (Higgs and Jones, 1995) state that in medical decision-making the approaches used in the real world of practice are termed qualitative, including information-processing, text comprehension and ethnography. This is in contrast to nursing, where information-processing is described as rational/analytic. An array of terms are used with some differences in decision-making research, however, the main approaches reflect the different perspectives that occur in nursing, with a dichotomous debate permeating much of the decision-making literature.

The analytical/rationalist theories in nursing include approaches that are either prescriptive in that they indicate how a decision ought to be made, or descriptive, in that they outline how a decision is actually made (Thompson and Dowding, 2002) (see Figure 1). Thompson and Dowding (2002) use normative where others use prescriptive, and they reserve the term prescriptive to refer to decision aides such as algorithms and flow charts. Nursing researchers are also using the NDM approach, which aims to examine decision-making in real-world contexts (see Figure 1). This approach in nursing appears to stand apart from the dichotomous debate surrounding the rational/analytical and interpretative approaches.

2.2.3 Rational/analytical: the prescriptive approach

The normative or prescriptive approach is grounded in Artificial Intelligence and the efforts to computerise decision-making to produce decision aides, as well as the early work on game theory (Elstein et al., 1978; Offredy, 1998; Thompson and Dowding, 2002). In health care it is based on the idea that there is a correct or optimal answer to a clinical problem that should be reached by a clinician, with a belief that informal or unaided decision-making often leads to a less optimal decision than the normative approach (Jones, 1988; Thompson and Dowding, 2002). The approach attempts to aid judgment in risky decision-making situations by developing a model of the most rational decision for a situation (Cioffi, 1997). Decision-makers are viewed as irrational if they do not use the calculated decision path. Criticism has been directed at prescriptive decision theories on the basis that it is not always rational to calculate probabilities for a decision situation, and hence probabilities cannot always be taken as a prescription for

Figure 1. Diagram showing overview of theoretical background of Decision-making



action. Within aided decision theory there are models such as the Bayesian model, the Brunswick lens model and subjective expected utility theory model which provide insight into ideal decision-making (Thomas, Wearing and Bennett, 1991). Bayem's theory is a statistical model that can show how judgments are revised in light of new information to determine by calculation the likelihood of clinical meaning (Taylor, 2000). The theorem uses statistical inferences to offer odds on particular events occurring from the known data (Thompson and Dowding, 2002).

The Brunswick lens model is used in clinical situations where the state of the patient is unknown and can only be inferred from cues that the patient displays, and this relationship is likened to viewing an object through a convex lens (Taylor, 2000). The uncertain and probabilistic relationship between the criterion event (environment, patient state) and the judge (person) is calculated by relating cues that can be perceived probabilistically to both the judgment and the patient. Good judgments occur when perceived cues reflect the real situation (Thompson and Dowding, 2002). The same situation may be judged differently by different judges, depending on how they weigh (attach importance to) the same available information.

Utility theory describes how a set of actions is determined according to objective or subjective assignments of values to alternative outcomes. A decision task is broken down into steps with nodes, where decisions need to be made between alternative choices. A decision tree can be used to represent the progress of the decision. The choices at the nodes are evaluated and weighted and the best alternative generated (Offredy, 1998; Taylor, 2000). Probabilities are assigned either objectively when known outcome data, such as treatment success exists, or subjectively, by participants' estimates of the value of outcomes. To calculate subjective probabilities, participants are asked to generate a series of attributes and rank them in order of importance or preference. These are weighted to determine their utility (value) as well as probability. The probability is then multiplied by the utility to determine the expected value of outcomes. The optimal choice is the outcome with the highest value.

These models all make use of explicit numerical values for evaluating decision-making that assume the decision process is linear and that all information is available to allow the selection of alternatives (Higgs and Jones, 1995). Both of these factors may be unrealistic in dealing with real-world decision-making. Heuristics may allow a better understanding of decision-making in the real world (Harbison, 2001). The study of heuristics, mental shortcuts in grappling with estimating probabilities, is described as subjective probabilistic decision-making in risky situations and allows unaided probabilistic decision-making in real-world settings (Cioffi, 1997).

A definition of decision-making based on the decision analysis framework involves envisaging decision-making as gathering evidence and generating alternative paths, reflecting on the alternative paths and analysing them, balancing risks of the alternatives, and considering potential consequences of each alternative, then synthesising to make a decision (Panniers and Walker, 1994; Eddy, 1996). This type of definition reflects a logical, analytical approach that prescribes the optimal decision.

Some areas of nursing such as wound care and pain relief (Lamond, 2000) and management of cardiac arrest (Fonteyn and Cahill, 1998) lend themselves to the use of decision aides such as algorithms or decision trees. Nurse decision-making in the real world may also occasionally use processes similar to decision analysis with the apparent use of decision trees when nurses reason using formal or informal algorthims (Offredy, 1998). Most everyday CDM however, is “messy” and best made without decision supports (Lamond, 2000). Research in cognitive psychology has shown that the tradition of describing human judgment by weighting and mathematical models has not been able to accurately describe judgment (Ericsson and Simon, 1993). The generation of judgments by both expert decision-makers and mathematical models may have similar outcomes, but the models have been shown to be qualitatively different in the processes outlined from those collected by verbal protocols of human judgment (Ericsson and Simon, 1993). In nursing, studies using aided decision theory have compared decisions generated by decision analysis to decisions generated informally by clinicians, termed intuitive decisions, with significant disagreement being demonstrated between intuitive decisions and quantitatively derived decisions (Panniers and Walker, 1994; Kostbade Hughes and McQuaid Dvorak, 1997; Hicks, Merrit and Elstein, 2003). Further, decisions generated by decision analysis have shown reduced consistency (Hicks et al., 2003). Examination of decisions as they ought to be made has little practical application in examining real-world decisions. Descriptive theories are much better suited to examining decision-making in the real-world.

2.2.4 Rational/analytic: the descriptive approach

CDM takes place in environments where there is interaction with others and a large array of contextual variables impinge on the decision-making, and may differ from prescriptive decision-making that accounts for a limited range of variables impacting on the decision process. Descriptive theories in the rational/analytical approach include the information-processing theory which developed in cognitive psychology and this differs from prescriptive theories in that it aims to describe decision-making as it actually occurs, rather than as it should ideally be. The information-processing theory has methods that aim to uncover and trace actual decision processing as it occurs, whereas interpretive approaches aim to develop rich descriptions of decision-making. Information-processing is described firstly, then interpretive approaches. Information-processing was developed in cognitive psychology which aims to examine how the mind works.

Cognitive psychology has developed as a separate field of enquiry from earlier approaches that examined the mechanisms of the mind. At the turn of the twentieth century gestalt psychologists examined the mind for what happens during reasoning by employing introspection (Simon, 1993; Weiten, 1995). This involved the researcher observing his/her own thought processes by focusing on and becoming aware of thoughts as they came to mind. Introspection was replaced by behavioural studies and the stimulus response approach, which attempted to determine how the mind worked by examining an organism’s response to stimuli (Simon, 1993; Weiten, 1995).

Cognitive psychology developed as a field of enquiry in the 1950s due to the work of researchers such as Newell and Simon, Hammond, Brunswick and Tolman (Weiten, 1995) and, according to Patel and Arocha (Higgs and Jones, 1995), early studies either traced processes for computer simulation or examined problem-solving and decision-making for concept formation. The main idea of the cognitive psychologists was to explain how information is perceived by an individual and then processed in the mind to lead to an outcome and this was accomplished by the individual vocalising thoughts as they arose. Having thoughts come to light by vocalising contrasts to the introspection of gestalt psychologists and response to stimuli in behavioural studies.

The main approach in cognitive psychology, the information-processing theory, is an approach which is empirical and seeks to explain cognitive processes as they occur. Actual processes that produce the thinking behaviour of man are detailed, as are the internal structures responsible for the processes (Newell and Simon, 1972; Ericsson and Simon, 1993; Taylor, 2000). Information-processing has been used to examine cognitive processing in many reasoning situations such as problem-solving, decision-making, skill acquisition and expertise, learning and perception.

The information-processing theory proposes that the mind acts like a central processor or computer, which receives input data from both motor and sensory sources and processes the information with pre-existing knowledge in the form of production rules to produce an output (Newell and Simon, 1972). The activity of the mind that produces the output is seen as a dynamic flow of information, a sequence of internal states that are successively transformed by a series of processes (Ericsson and Simon, 1984; Greenwood and King, 1995). Each new state in a time sequence is seen as a function of the immediately preceding state of the organism and its environment (Newell and Simon, 1972). This occurs in the processing system, comprising a large memory of symbolic structures, a serial processor for accessing and restructuring this memory, and some input-output structures (Newell, 1966). Information enters the working system, the central processor, from both the environment and from storage areas such as the long-term memory, and allows cognitive functioning such as problem-solving and decision-making (Jones, 1989). Problems are solved or decisions made by movement through a problem space (sets of alternative states of knowledge). The problem space consists of states of knowledge about a problem or decision, and the problem-solver moves from an initial state to a desired state, the problem solution, through a problem space using search (Newell, 1966; Taylor, 2000). The choice of paths through a problem space reflects the individual's reasoning and is influenced by what the subject is attending to, either knowledge, objects or concepts. The problem space is not given to the problem-solver; s/he generates it herself/himself to solve a problem (Newell, 1966). As such, each individual's problem space for a task may differ and the search through the space may also differ. Progressing through a problem space involves moving successively from one knowledge state to the next as the reasoning progresses, and this is accomplished by operators. An operator can be identified that links each knowledge state to the next and transforms each one (Newell, 1966; Ericsson and Simon, 1984; Jones, 1989; Markman and Gentner, 2001). The problem-solver selects the operators used to transform each state of knowledge during the problem-solving, although the problem-solver is often not conscious of the selection (Newell, 1966). Processes are aggregates of operators that represent patterns of reasoning, such as hypothetico-deductive reasoning.

The information-processing theory also proposes that while attending to decision tasks, cognition can proceed routinely if the decision task is known, but impasses are encountered when something unexpected or new occurs (Newell, 1966). Cognitive processes or strategies come into play to resolve the impasse and the problem is solved. There can be many impasses in a decision task requiring cognitive processing to successfully complete the task. The processor responsible for cognitive tasks has been outlined and elaborated by researchers using the information-processing theory.

Physiological evidence suggests the processor presumably exists in the central nervous system or mind (Newell and Simon, 1972; Ericsson and Charness, 1994; Anderson et al., 2004), however, the information-processing theory does not necessarily state that the central nervous system is involved (Newell and Simon, 1972). The traditional model of the processing outlines two main memories: the short-term memory (STM) and the long-term memory (LTM) (Miller 1956, Newell and Simon, 1972). Incoming information in the form of stimuli or cues is perceived and enters the STM, where it is processed. The STM has a small working capacity but it is very fast, ensuring the information is available almost immediately (Newell and Simon, 1991). The STM, which is likened by Ericsson and Simon (1984) to a central processor, is seen as having limited capacity to handle information (bounded rationality) and also limited duration (Newell and Simon, 1972). Data are collected serially to represent a problem and are combined into four to seven chunks to overcome the small working capacity of the STM (Miller, 1956, Elstein and Bordage, 1991). The chunks drop out of attention as new incoming stimuli are perceived (Newell and Simon, 1972).

The mind also has a memory called the LTM, in which knowledge and experiences are stored. The LTM has a very large capacity to handle information and has relatively permanent storage capacity but is slower than the STM. Knowledge stored in the LTM can be unlocked by stimuli coming into the STM and is used to aid the processing in the STM (Newell, 1966, Newell and Simon, 1972, Thompson, 1999).

Problem-solving and decision-making, like any other cognitive activity, are acquired skills (Newell, 1980; Newell, 1990; Kirschenbaum, 1992). Acquired skills develop with expertise and the information-processing theory has been used to examine the acquisition of such skills, with a belief that the traditional information-processing system and its elementary processes and basic capacities remain intact during skill acquisition. It is further believed that outstanding performance results from an incremental increase in knowledge and skill explained by the mechanism of chunking where, with practice, experts in a discipline encode information into chunks of increasing size (Ericsson and Charness, 1994; Ericsson and Kintsch, 1995).

However, most investigators using the theory of information-processing now argue that the working memory capacity must be far greater than the four to seven chunks of the traditional model of the STM, especially in relation to the acquisition of expertise (Ericsson and Kintsch, 1995). Anderson, in some models of processing, found up to 20 active units (chunks) at one time, in contrast to the traditional four to seven (Anderson et al., 2004). Research has also shown that experts in a field can improve their own performance on tasks by more than 1000% and researchers have stated that this cannot be explained as theorised by the traditional model, as four to seven chunks would not be able to handle information of this size (Ericsson and Kintsch, 1995). Researchers have postulated instead that these findings may be due to the acquisition of memory skills in such a way that individuals are able to store information in and use the LTM as a working memory, bypassing the constraints of the STM (Ericsson and Charness, 1994). The long-term working memory has been termed LT-WM. Distraction or dual task studies also support the existence of LT-WMs (Olive, 2004).

Distraction studies present an expert with a cognitive task and then present another task designed to distract her/his train of thought from the first task in order to eliminate any continued storage in the STM. Experts in a discipline have been found to be able to continue working on a task after the distraction, and this further suggests that the traditional model of information-processing is limited in ability to explain some aspects of the memory and skill acquisition of expertise (Ericsson and Charness, 1994). If the STM processes information serially and new incoming information displaces that held for a short time in the STM, then expert performers would not have the ability to resume without loss of train of thought after a deliberate distraction. The findings suggest that processing may occur in more than one working memory. Both the faster reasoning of expert performers and their ability to handle more than one task concurrently as in distraction studies can be explained by refinements of the information-processing theory which were described by Newell (1990) in his work entitled “The unified theory of cognition”.

The traditional model of the information-processing theory has been expanded on and explained in more depth, with variations occurring as to how processing occurs. A unified theory of cognition was first proposed by Newell (1990) to unify the variations under the one umbrella in the information-processing theory. Newell (1990) outlined that a model was developed to unify and replace the polarisation occurring in cognitive theory and decision-making, such as the serial/parallel debate in processing. However, he did not describe this theory as the final theory for unified cognition, as work is continually evolving in this field (Simon, 1993). The theory has been expanded on by other investigators such as Anderson et al. (2004), who propose a general cognitive architecture for information-processing, unifying a range of cognitive phenomena with a single set of mechanisms operating in the mind (Newell, 1990; Polk and Newell, 1995). The theory of cognition proposed by Anderson is the Adaptive Control of Thought (ACT). The first version of this theory was given the acronym ACT*; this has since been revised, with the latest versions being given the acronyms ACT-R and ACT-R 5.0 (Anderson et al., 2004). Other theories put forward are the EPIC (a name, not an acronym) and CAPS (capacity-constrained collaborative activation-based production system) (Anderson et al., 2004). The work of Ericsson and Charness (1994) and the Soar (name not an acronym) architecture also add to the understanding of information-processing.

These are all production systems reflecting Newell's original production system, are all based in information-processing and have many similarities, and can hence be viewed as minor variations of the information-processing theory (Simon, 1993). The common architecture being proposed by these investigators operates as a processor for reasoning, perception, memory, learning, decision-making, problem-solving and the study of skill acquisition and expertise. All these models have the advantage of allowing the study of real-world problems as they attempt to account for cognition as a whole (Anderson et al., 2004).

In the theory of ACT and later versions such as ACT-R and ACT-R 5.0, the basic architecture consists of a central processor that has working memories, a number of modules with "buffers" that interact with the central processor, and a discrimination net, that allows perception (Anderson et al., 2004) and these reflect the traditional model of information-processing. The mechanism of ACT is similar to that proposed by Soar (Newell, 1990). In the Soar model of processing, there is more than one type of LTM, the long-term working memories (LT-WMs), and these can rapidly process incoming information. The LT-WMs are envisaged as being built up of chunks, which are procedural, as in ACT, and which are also domain-specific (Newell, 1990). The LT-WMs act similarly to the traditional STM as a form of fast-acting working memory (Ericsson and Kintsch, 1995). In contrast to the relative slower processing of the traditional STM, the LT-WMs allow much more rapid access to chunks in memory by activation of production rules set off by incoming patterns of information (Ericsson and Kintsch, 1995). In both ACT and Soar there is more than one working memory, and chunking is believed to be the main mechanism of learning and skill acquisition. Chunks contain knowledge which is domain-specific and are evoked in any situation where elements match the conditions of a chunk (Newell, 1990; Knoblich, Ohlsson, Haider and Rhenius, 1999). Expertise is believed to develop as repeated use of chunking strengthens productions in working memories and builds domain-specific working memories that can be accessed quickly by conditions in a presenting situation (Newell, 1990).

The Soar model also proposes that the STM could in fact consist of multiple STMs and these could be different for different types of processing, such as perceptual, cognitive and motor processing, similar to the function of the buffers in ACT. The multiple STMs are termed ST-WMs (short-term working memories). The Soar architecture has great flexibility and the multiple memories of the ST-WMs and LT-WMs allow for working in multiple problem spaces, which may lead to the ability to handle more than one task at a time, hence explaining the ability of expert performers to process information rapidly and the findings of distraction studies (Simon, 1993). Similarly, the multiple working memories of the ACT model can account for this aspect of expertise. The distinguishing features of expertise may be a large store of domain-specific memories in the LT-WM and the linking of these together into meaningful chunks which are readily activated by incoming patterns of cues (Ericsson and Charness, 1994; Ericsson and Kintsch, 1995).

Definitions of CDM using the theory of information-processing see cognitive activities such as decision-making as a type of processing somewhat similar to the processing of data by a computer. Decisions are the outcomes of cognitive processes and their contents are based on the knowledge of the decision-maker and the information collected by the decision-maker (Lauri et al., 2001). Important aspects to consider when examining decision-making therefore, are the actual processes that are occurring in the STM, ST-WMs or LT-WMs and the operators that are the elements of the processes. It is also important to examine the knowledge that the problem-solver or decision-maker is accessing from the LTM or LT-WMs to help in the processing, as well as the nature of the cues or incoming information perceived (see Figure 2). While making a decision or problem-solving, the decision-maker moves through a problem space which is unique to each problem or decision, and identification of the tasks and subtask of a problem space is useful in the explanation of decision processes (Newell, 1966). Some processes identified in information-processing are discussed below.

2.2.4.a Processes identified in information-processing

The mechanism of processing discussed above can explain the different types of decision processes that are described in the information-processing theory. The main process explicated in medical and nursing research is hypothetico-deductive reasoning, which is often referred to as hypothesis generation in nursing, and is often described as an analytical process (Elstein and Bordage, 1991; Thompson, 1999; Taylor, 2000; Offredy, 2002; Coderre, Mandin, Harasym and Fick, 2003). Pattern recognition or pattern-matching, as well as insight or intuition, have also been identified (Jones, 1989; White et al., 1992; Offredy, 2002; Coderre et al., 2003).

The clinical reasoning of nurses and doctors has been examined and described as consisting of cue acquisition, hypothesis generation, cue interpretation and hypothesis evaluation (Offredy, 2002). These four aspects of decision-making are similar to diagnostic reasoning and have been referred to as hypothetico-deductive reasoning, which is a commonly described decision-making process in the information-processing theory.

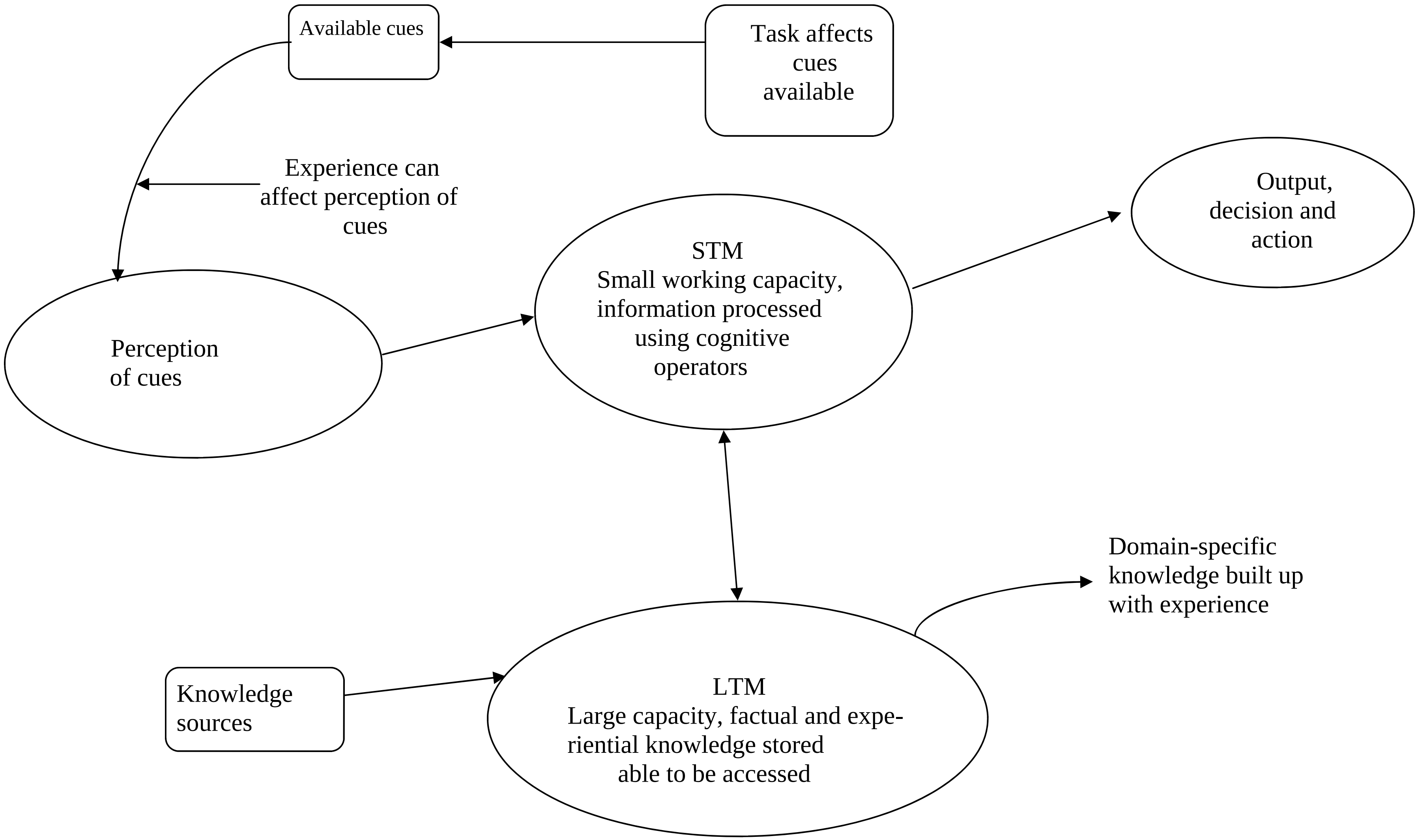


Figure 2: Information processing -theoretical model

This process was also identified in a study of nurses' reasoning about haemodynamic status (Aitken, 2003). Hypothetico-deductive reasoning has often been referred to as rational/analytical and described as being linear. However, Aitken (2003) found that hypothesis generation which is similar to hypothetico-deductive reasoning was not always linear, but revolved around a few central concepts.

The hypothetico-deductive process involves data collection, recognising cues, linking or grouping cues, developing hypotheses, testing hypotheses and then taking action (Thiele, Holloway, Murphy, Pendarvis and Stucky, 1991; Taylor, 1997; Thompson, 1999). The gathering of cues, which is the perception of external stimuli, occurs in the STM and leads to the generation of initial tentative hypotheses, which occurs as cues link to knowledge in the LTM. Four to seven cues can be handled sequentially in the traditional model (Elstein and Bordage, 1991; Thompson, 1999). Once hypotheses are generated, the cues are interpreted either by being considered confirming, disconfirming or non-contributory (Thompson, 1999). Diagnosis, drawing a conclusion on the definitive nature of a hypothesis may follow hypothesis generation, but hypothesis generation does not always lead to a diagnosis. The capacity to handle cues can be increased by LT-WMs and chunking and the process of pattern-matching.

Pattern-matching has been identified as a decision-making process in nursing studies employing the information-processing framework. Pattern-matching has been described as a process whereby nurses appear to selectively consider information given, evoking patterns in their memory which they use to identify specific client problems and focus plans of care (Fonteyn, Kuipers and Grobe, 1993; Radwin, 1998). Further pattern recognition or pattern-matching may lead to early activation of an hypothesis during care planning (Offredy, 2002). Fonteyn et al. (1993), Offredy (2002) and Radwin (1998) offered descriptions of pattern-matching using methods that did not directly trace reasoning. Instead nurses were asked to describe their reasoning processes. Inferences were made by the researchers from the nurses' descriptions and it was concluded that the nurses were using pattern-matching but no understanding of how this process proceeds was offered. In medicine Coderre et al. (2003) also did not directly trace reasoning during decision-making but in contrast to Fonteyn et al. (1993), Radwin (1998), and Offredy (2002) stated that it is difficult to identify pattern-matching as a decision-making process, as participants could not outline their reasoning during this process. There is contention around whether the process of pattern-matching can be identified using the methods of the information-processing theory, but directly tracing processes rather than asking participants to describe their reasoning may offer the best method to examine this. Chunking and schema have been outlined as mechanisms important in pattern-matching (Taylor, 1997).

In the information-processing theory, pattern recognition is seen as an arrangement and rearrangement by individuals of patient cues and a comparison with known patterns in the LTM or recognition of patterns of retrieval cues in LT-WMs. Individuals are described as developing schema, mental representations of objects into concepts and the schema can be matched by incoming cues and activated automatically (Greenwood, Sullivan, Spence and McDonald, 2000). Patterns built up by experience may not necessarily be accessed by conscious clustering of cues, but clusters of incoming information may become triggers for patterns in domain-specific LT-WMs.

A third process identified in information-processing theory in medical decision-making is scheme-inductive reasoning (Coderre et al., 2003). This process was seen to involve reasoning that appeared similar to inductive trees, with decisions being made at the forks of the trees. This involved crucial tests to exclude some alternatives and adoption of what is left. The test may be based on evaluation of signs or symptoms. This type of reasoning is believed to be used when faced with large unbounded problems. There appears to be greater diagnostic accuracy when scheme-inductive reasoning is used (Coderre et al., 2003). Similar to the scheme-inductive process described by Coderre et al. (2003), nurses were described by Offredy (2002) as employing decision trees. However, even though nurses in Offredy’s (2002) study used decision trees, they did not calculate probabilities for treatment options as is prescribed in decision analysis.

Another analytical process uncovered using the information-processing framework is the if/then process outlined by Newell and Simon (1972) during an examination of participants problem solving simple crypto-mathematic and other domain-free problems. If/then reasoning during decision-making involves following a set of rules that have propositions such as if the patient is in pain then give pain relief. However, this process has seldom been identified in decision-making research in nursing and medicine. The processes identified by Coderre et al. (2003), Offredy (1998) and Aitken and Mardegan (2000) that may appear at first glance similar to if/then procedural processes identified by Newell and Simon (1972), namely scheme inductive reasoning, decision analysis and decision trees differ from if/then procedural rules in that the decision-maker is not following a set of if/then rules, but pausing at certain points to consider alternatives and choosing one. Similar to if/then production rules is trial and error, in which a participant uses if/then steps to determine whether something works. However no predetermined set of rules is being followed and in this respect it differs from if/then production rules. A minor process described is a form of intuition, termed insight by Ericsson and Simon (1984).

Intuition was reportedly used by participants in studies employing the information-processing theory. Insight or intuition, in terms of information-processing, is described as a process in which tasks become so automatic from constant repetition that individuals become unaware of them (Ericsson and Simon, 1984). The process is also sometimes described as automaticity. The example of driving and suddenly realising you can't remember driving the last ten miles has been given to illustrate this point (Ericsson and Simon, 1984). This is believed to occur as memory retrieval becomes faster from repeated practice, with additional instances being stored in the memory until responses are determined entirely by memory retrieval alone (Palmeri, 1997). It is believed that there is direct access to pre-existing cognitive structures in the LTM, or possibly domain-specific LT-WMs. Insight or intuition may differ slightly from automaticity in that automaticity refers more often to the internalisation of sets of procedural rules whereas insight or intuition involves reasoning about situations that are well known and where some reasoning is occurring seemingly without conscious awareness.

Studies employing interviewing and the information-processing framework have described intuition by stating that nurses describe a feeling of something being not quite right without being able to articulate more specifically what constituted intuition (Offredy, 2002). The study by Offredy (2002) used retrospective interviewing and hence did not directly access the nurses' reasoning and this may explain the nurses' inability to explain intuition in detail. In a study of Australian nurses' decision-making using TA to trace actual decision-making as it occurred, participants' reasoning around issues of concern to them could be followed and intuition identified (Aitken, 2003). This would suggest that careful examination of decision-making as it occurs with methods that allow processes to be illuminated can demonstrate the reasoning of expert nurses in what has often been referred to as unconscious, intuitive reasoning.

Information-processing has also been used to examine decisions for cognitive operators. Operators are cognitive strategies that represent each step of a person's reasoning during the decision-making process. Some of the operators identified are "collect data", "choose", "review data", "interpret data", "relate data", "diagnose" "act" (Jones, 1989), "study", "explain" and "conclude" (Fonteyn et al., 1993) and "read" (Lamond, Crow and Chase, 1996). Many of the operators identified correspond with the decision processes detailed in the information-processing theory. The operators "collect", "choose", "study" and "read" correspond with cue acquisition, "conclude" and "diagnose" with hypothesis generation and "explain" "review data", "relate data", "interpret data" with cue interpretation. Operators and cognitive strategies are discussed in more detail in Chapter Four in consideration of the coding of operators and in relation to simulated and real-world studies.

The conclusions from studies in nursing and medicine employing information-processing appear to indicate that there are different processes used during decision-making, such as hypothetico-deductive reasoning, pattern-matching and intuition and possibly processes similar to decision analysis without probabilistic weighting of alternatives. There is also disagreement around whether or not pattern-matching could be identified as a process and whether the elements of intuition can be identified. Some of these different findings may be due to the use of either simulations or real-world studies or to the way information is collected and analysed in a study. This is considered in further detail in Chapter Four. Differences between novice and expert nurses for these identified processes are considered in Chapter Three.

Using methods from information-processing theory such as verbal reporting via TA which allows decision tracing, decision processes and cognitive operators can be identified and an explanation offered as to how decision-making occurs in the mind. In contrast, the interpretive approaches describe decision-making processes such as intuition and pattern-matching, but do not explain how they occur.

2.2.5 Interpretive approach: phenomenology

The interpretive research methodologies seek to describe experiences as they are lived and have been used by researchers to describe the experience of becoming an expert decision-maker (Benner, 1984, 2001; Burns and Grove, 1995). In phenomenology the everyday experiences of practice are often investigated and meaning becomes very important. Meaning is that which is shared between individuals and situations and is transactional (Street, 1992; Tolley, 1995). Meaning is knowledge, and to explain is to make meaning as explicit as possible. Meanings are not held to be rules or laws; they are context-specific and derived from everyday experiences.

Definitions of CDM using interpretative approaches often involve describing decision-making as an in-depth knowing of the patient with the use of tacit knowledge that allows the nurse to make decisions with a sense of salience and in a concerned and involved manner. This is reflected in the definition of decision-making espoused by Benner et al. (1996) and Benner (2001) in their examination of CDM using phenomenology. They describe decision-making as practical reasoning which is an holistic and intuitive response, and not the disengaged, scientific reasoning described by cognitive theorists. It is not seen as a logical, analytical, linear process but as a flexible, engaged approach.

Phenomenology is considered useful by those employing it for uncovering not only the taken-for-granted-knowledge found in practice but also the processes of decision-making (Benner, 1984, 2001; Parker, Minick and Kee, 1999). The main process described using interpretive methods is intuition, which is often linked to expertise. Intuition has been outlined as reasoning without knowing, coming to an immediate realisation without conscious gathering of data (Benner, 2001; Benner et al., 1996). It is seen as consisting of six main aspects, including pattern recognition, similarity recognition, common sense understanding, skilled know-how, a sense of salience and deliberative rationality (Ruth-Sahd, 1993). Intuition involves the detection of missing data, gaps in information or hidden relationships within the whole and takes place at the subconscious level (King and Appleton, 1997).

Pattern-matching has also been outlined using interpretive methods. Pattern-matching is a process whereby judgments are made on the basis of a few critical pieces of information which can also be used to predict how a patient will respond or what will be needed (Crow, Chase and Lamond, 1995; Offredy, 1998). In phenomenological studies, nurses are described as not being aware of either intuition or pattern-matching at a conscious level but of being aware of them at a subliminal level only (Offredy, 1998). Interpretive studies often use interviews and narratives to elicit meaning (Benner et al., 1996). Such studies are retrospective and rely on recall, which may not always be entirely accurate (Ruth-Sahd and Hendy, 2005). In contrast, studies using the information-processing theory and methods such as TA have shown that seemingly unconscious processes such as insight or intuition can actually be reported if the methodology allows this, but recall in interview often does not lead to such reporting.

Using TA it has been shown that participants in decision-making studies have been exposed to the information needed to reason about a situation in supposed incidences of insight or intuition, but have forgotten they have done so when interviewed. This may be due to absence of the intermediate stages of acts of recognition in the part of the mind responsible for perceiving incoming data and failure to report the transient contents of this part of the mind. Insight or intuition may involve direct access to pre-existing cognitive structures stored in the mind and develops slowly with concealment of the background period of work, with realisation seeming to occur suddenly (Anderson et al., 2004). Careful tracing of decision-making can show how some seemingly non-conscious decisions were actually reached and offer an explanation for such processes. Studies using verbal reporting and the information-processing theory often can outline the actual processes used in this supposedly non-conscious reasoning and the difference may be due to the fact that verbal reporting allows direct access to retrieval cues and hence reasoning processes, whereas interviews do not allow this direct access (Ericsson and Simon, 1993).

Questioning in some phenomenological studies may also direct participant responses and lead to selected outcomes such as the description of intuition. In a study of decision-making Parker et al. (1999) asked participants if they had a sense of something about to happen (which reflects the definition of intuition in this paradigm). This may direct participants to describe situations in such a way as to be interpreted as intuition.

The approach taken in interpretive studies as in other studies may colour the way the process is described. This has been suggested by some nurse academics (Harbison, 2001) and examination of reported dialogue and events from studies appears to lend some credence to this. In studies where decision-making has been described as holistic and intuitive, participants have often been asked to retrospectively describe a situation in which they made a difference, as well as describing the experience of making a decision. Feelings of uneasiness, instinct, gut feeling and the patient not acting like her/himself have been reported (Ruth-Sahd, 1993). The participants have also been directed in what type of incidents to report and often negative incidents are not recorded or reported (English, 1993).

An example, described in the work of Ruth-Sahd and Hendy (2005), outlines how a nurse prepared epinephrine, sodium bicarbonate and lidocaine and placed these at a patient's bedside in case of arrest. This was used as an illustration of intuitive decision-making where the nurse had a supposed feeling of something wrong and prepared herself for an adverse event. Whether the patient actually arrested is not discussed and no conclusions can be drawn as to the validity of the nurse's feeling at the time. The illustrated behaviour however, could also be explained by anticipation in the information-processing framework, whereby an experienced nurse recognised stored patterns of previously seen patients and prepared and anticipated for possible problems that had occurred in the past.

Intuition, as used in some studies, may also be explained by processes in the information-processing theory, such as hypothetico-deductive reasoning. In a study by Hallett et al. (2000) examining the decision-making of community nurses about wound care, decision-making was described as intuitive and the actual conversation of the nurse reported. The nurse reported:

> Well, there's something ominous about this, you know. I wonder whether they could have a biopsy done and whatever or, you know, wound swabs. I mean sometimes it's blatantly obvious it's infected isn't it?

This excerpt can also be explained in terms of information-processing as hypothetico-deductive reasoning, including hypothesis generation and testing. A hypothesis is suggested by this nurse that the patient has an infection, then two alternative courses of action are suggested, biopsy or wound swabs, which could confirm or refute the hypothesis and lead to a possible diagnosis.

The descriptions of reasoning and decision-making generated using interpretive approaches can also represent "preferred accounts" of nursing. Indeed, the received truths from interpretive research may not actually represent decision-making or expertise as it occurs (Nelson and McGillion, 2004). This may have arisen as interpretive theories are not value-neutral and the values expressed by participants may be those the nurse researchers want placed on expertise. In the work of Benner (2001), nurses were asked to give a first-person narrative of clinical incidences to elicit the features of expertise. Nelson and McGillion (2004) criticise these first-person narratives on the basis that they offer the nurses' preferred account of events, just one amongst other possible versions, and further state that this has led to a preferred account of expertise in nursing. Nelson and McGillion (2004) further state that the nurses in Benner's (1984) study were coached and drilled in what constituted acceptable expertise, by being given explicit instructions during carefully controlled group processes and by questioning around hunches and intuition. They were also discouraged from thinking of situations that might be ordinary or unpleasant (Nelson and McGillion, 2004). This led to a narrative of expert nurses as heroes relying on intuition and always knowing what to do (Nelson and McGillion, 2004). It is difficult from these stories to discern what actually constitutes expertise, as there is no actual information on what they did or what they knew (Nelson and McGillion, 2004).

The interpretive approach lacks insight into how a person reached a decision, a process which is largely invisible and ways of showing this are needed (Lamond, 2000). If understanding is developed as to what nurses are actually doing during decision-making, this knowledge can be transmitted to others. What is needed are ways of distinguishing processes such as intuition from other things that resemble it such as prejudice, whim or habit (Paley, 1996) as well as methods to specify the processes as they occur in actual practice so that omissions, discrepancies and faulty logic in retrospective interviews can be recognised and dealt with (Jones, 1989). To determine the actual processes used during decision-making and problem-solving, methods that allow direct access to nurses' cognition are necessary. Information-processing was developed in cognitive psychology for this purpose and is useful in nursing to determine decision-making processes.

The information-processing theory and interpretative theories have both been used to examine decision-making in nursing and have often been seen as opposing or dichotomous theories. Attempts have been made to reconcile this dichotomy and are discussed below.

2.2.6 The "middle ground": cognitive continuum and classification theory

Debate permeates the nursing literature on decision-making, with comparisons being made between intuitive decision-making of the interpretive researchers and the analytical/rationalistic decision-making of those using frameworks such as information-processing and decision analysis. The two dichotomous theories are frequently presented as contrasting and incompatible ideologies, although both have the same aim of developing an understanding of decision-making (Redden and Wotton, 2001). The debate has polarised around extremes and it has been suggested that nursing should adopt the middle ground (Thompson, 1999; Harbison, 2001). The middle ground is seen as being Hammond's cognitive continuum (Thompson, 2001; Cader, Campbell and Watson, 2005) or classification theory (Buckingham and Adams, 2000).

In the theory of cognitive continuum there are not totally distinct, different ways of reasoning, such as intuitive or analytical reasoning, but cognitive processes exist which vary on a continuum from analysis (a logical step-by step process) to intuition (no logical, step-by-step process) with intermediate forms existing which have elements of both (Hammond, 1996; Thompson, 2001; Cader et al., 2005). There is a link between the nature of tasks and the type of cognition used with analysis-inducing tasks and intuition-inducing tasks. As well as a link between type of task and cognition induced, the theory also proposes six different modes of inquiry that are employed during decision-making, and the nature of a task will determine the particular mode of thinking in the decision-maker (Hamm, 1991). The cognitive modes proposed by Hammond (1996), which range from intuitive (with little information) to scientific (analytic with much readily available formal literature), however, do not suit a study examining decision-making in the real world, where clinicians often have little ready access to formal, scientific research knowledge as they plan and carry out routine care. This is not to suggest that practice should not be based on the best scientific evidence, but merely that in much of the routine care provided by practitioners, they will not have the immediate benefit of formal, abstract reasoning. Identifying the task of decision-making as analysis-inducing or intuition-inducing also makes it very difficult to adopt this framework for a real-world study. However, the main idea of this theory, that there are different types of cognition on a continuum, is useful, and this idea is becoming more accepted. In contrast to the cognitive continuum theory and its range of proposed cognitions is the classification theory, which proposes one process that can explain all of the observed cognitions of decision-making.

The framework of psychological classification can highlight similarities between intuitive decision-making and rational approaches such as hypothetico-deductive reasoning, as there is a general structure to decision-making that transcends disciplines and domains and which can link theoretical approaches together (Buckingham and Adams, 2000). The classification activities in this model consist of cues which bring to mind potential outcomes, which can be termed hypotheses, categories or classes and, as expertise develops, cues and outcomes are linked directly and automatically (Buckingham and Adams, 2000). The classification behaviour approach, however, attempts to cancel out the differences between analysis and intuition and explain them as one fundamental process, which is in contrast to other theories of cognition and may not be useful for examining the range of cognitive processes that can occur during decision-making.

Another approach taken by some nurse researchers to combine analysis and intuition when examining different decision processes is an eclectic approach, which differs from the two approaches described above. An eclectic approach involves adopting frameworks incorporating processes identified in different paradigmatic studies, such as analytical/rationalistic processes from information-processing and intuitive processes from the interpretive framework and has been employed by researchers in decision-making (Lamond et al., 1996; Fonteyn and Cahill, 1998; Offredy, 1998; Redden and Wotton, 2001; King and Clarke, 2002; Coderre et al., 2003; Higgins and Tully, 2005). The use of an eclectic approach may involve combining intuition as identified in the work of Benner (1984, 2001), and hypothetico-deductive reasoning as described in the information-processing theory along with knowing the patient as identified in grounded-theory studies. Using an eclectic approach, whereby the definitions of different decision-making processes are taken from different paradigmatic stances, may not provide the information sought. The use of a framework, such as the information-processing theory, which has an underlying architecture and mechanism of action that explains differing cognitive process, may be more useful to examine decision processes. Using a unified approach such as the information-processing theory to examine processes is not eclectic as described by Offredy (1998) but an acknowledgment of the diversity of decision-making processes or cognitions that can exist within the one theoretical framework.

Researchers have also examined decision-making using other theoretical frameworks such as grounded theory and ethnography which examine the social underpinnings of decision-making and situate decision-making in its social environment. Descriptions of decision-making as a social process have been developed.

2.2.7 Interpretive approach: grounded theory and ethnography.

Grounded theory seeks to develop theory from data and seeks to explore how individuals define reality and how their beliefs are related to their actions (Burns and Grove, 1995). Ethnographic approaches seek to examine culture and the interactions of people during nursing care and the patterns that influence that care (Burns and Grove, 1995). A characteristic description of decision-making identified in nursing studies using these methodologies is "knowing the patient", whereby nursing decisions are made with an extensive knowledge of the individual patient's patterns of behaviour (Jenks, 1993; Radwin, 1995). In terms of the information-processing theory, "knowing the patient" may be similar to a type of individual pattern-matching where the nurse is observing and storing information about the patient and by chunking can access this stored patient information.

The methodology of grounded theory relies on verbal feedback from nurses during interviews, field logs and observation, chart review and focus groups (Jenks, 1993; dela Cruz, 1994; Radwin, 1995; Peate, 1996; Chase, 1995; McCutcheon and Pincombe, 2001; Burman, Stepans, Jansa and Steiner, 2002). These retrospective, self-reports may under or overestimate the nurses' behaviour or lead nurses by the type of questioning to concentrate on selected aspects of decision-making (Bucknall, 2000).

Data in such studies are mostly analysed using some form of constant comparative method (dela Cruz, 1994; Radwin, 1995) or thematic analysis (Peate, 1996; Chase, 1995). The processes identified usually offer a description of the decision-making as it is situated in the social context. This is valuable information for nursing and it illuminates the effect that context and social milieu can have on decision-making, but it does not illuminate how decision-making actually takes place.

The main process explicated, "knowing the patient", is based on a nurse's need to develop personal relationships with the patient/family (Radwin, 1995; Jenks, 1993; McCutcheon and Pincombe, 2001). It describes the important element in nursing of developing individual care based on the nurse/patient relationship. Knowing peers and physicians has also been proposed as a process and this helps to establish group decision-making (Jenks, 1993). Other environmental or social aspects that have been shown to affect nurses' decision-making as a process are such things as mechanical factors and patient condition (Peate, 1996), social roles and hierarchies (Chase, 1995), as well as peer and physician communication (Chase, 1995).

Some of these studies have explained decision-making processes in the frameworks of established theory. For example, Burman et al. (2002) propose one major theme of clinical decision-making as "putting the pieces together" and described this as pattern-matching. They also described how some nurses use hypothesis-testing for pattern-matching, and saw nurses as using more than one type of decision-making process. The process of pattern recognition was identified and the elements of it were said to be searching for red flags, using cognitive schemas, testing hypotheses and using intuition (Burman et al., 2002). Pattern-matching was accomplished by looking for patterns that fit with previous cases. The elements identified in this study seem to have characteristics of other clinical processes, such as testing hypotheses and intuition, which are identified by others as separate processes, not strategies of an overall pattern-matching process. The authors seem to be asserting that pattern-matching is the main process and it has strategies within it that are actually identified by others as processes in their own right. The participants in this study were from America where intuition is widely recognised as a process, used by expert nurses and this may have influenced the study.

Many of the studies using grounded theory and ethnography are descriptive and do not examine actual reasoning. They also rely on retrospective recall through interviews. Real-time observations are recorded as field notes by the researchers and any thinking by participants is not directly recorded but inferred and may not be useful to uncover actual decision-making processes. Another approach used to examine decision-making processes is naturalistic decision-making (NDM).

2.2.8 Naturalistic decision-making

NDM is descriptive but is often considered in nursing apart from the interpretative approaches. NDM concentrates on the recognition and assessment of a situation in which experience is important, especially the ability to recognise a situation. Naturalistic decision-making uses observations and can offer a rich perspective on complex decision tasks and decision-making behaviour (Currey and Botti, 2003). NDM has been used to observe behaviour in real-world situations, in which it can illuminate such effects as the environment on decision-making (Hedberg and Larsson, 2004), the types of decision activities exhibited by nurses (Bucknall, 2000) or group decision-making (Currey and Botti, 2003). The types of decision activities used by nurses have been described, but the actual processes have not been detailed (Bucknall, 2000). NDM is valuable for illuminating how contextual factors affect decision-making, however, it does not illuminate cognitive processes and is unsuitable for such purposes (Bergstrand, 1998). In contrast, information-processing theory aims to uncover how decision-making operates at a process level.

Information-processing theory describes a mechanism of the mind and offers an account of how this mechanism allows for cognitive processes of decision-making. It also places the processes of decision-making as centrally important and attempts to detail these processes as they occur, rather than just describing decision-making. As such it is useful for tracing decision processes. The method of TA allows for the tracing of decision processes in the mind and is the main method of data collection in studies employing information-processing theory to examine decision-making processes. Chapter Four examines the method of TA and verbal protocol analysis and the development of operators in studies employing this methodology. How the operators reflect the processes identified in the information-processing theory is also discussed in Chapter Four.

The next chapter reviews the literature in relation to the examination of decision-making in critical care and also differences in expert and novice nurses' decision-making in relation to processes identified and aspects of those processes such as cue-gathering and knowledge base. The environment, type of work and tasks to which ICU nurses attend are examined to develop an understanding of contextual features of ICU decision-making and to help develop descriptions of the types of tasks novice and expert nurses undertake in ICU. The processes identified in nursing research into CDM are also examined.

Chapter Three

Decision-making in critical care.

Research has shown that nursing care can influence the outcome of patients in ICUs, particularly post-operative AAA patients (Dang et al., 2002). Decision-making in ICUs is related to the environment of these units, the care required by these patients and the types of nursing tasks undertaken by ICU nurses. These characteristics are discussed in this Chapter. Understanding the types of decisions ICU nurses make, as well as the knowledge used and the processes employed, is important to fully comprehend what is occurring during decision-making in ICUs. Research has examined these elements in ICUs either by studying nurses as a whole group or by comparing them by two levels, expert or experienced to novice or inexperienced. This chapter begins with a discussion of what is known of the tasks attended to in ICU, as well as the type of work nurses do in this area. The discussion will examine both what is known of nurses as a cohesive group and also what is known about the differences between novice and expert nurses. The process that both novice and expert nurses use during decision-making is also discussed.

3.1 Critical care environment and impact on decision-making

Understanding decision-making in any context is facilitated by an exploration of the climate or environment of the area, the tasks to which decision-making refers and the nature of the work in the area. The critical care environment is different from other nursing environments, as it is designed to care for seriously ill patients, who are in need of rigorous monitoring and aggressive therapy (Bucknall and Thomas, 1996). Such critically ill patients require high levels of intervention and there are extraordinary levels of uncertainty (Kostbade Hughes and McQuaid Dvorak, 1997). The patients are often in physiological crises. Hence the most important objective of care in ICU is stabilisation of the patient by ensuring airway is protected, respiration is maintained, circulation is adequate and fluid balance is maintained, to ensure adequate cellular metabolism (Harrison and Nixon 2002). According to Patel, Kaufman and Madgar (Ericsson, 1996), the second objective is to treat the underlying problem, and the third to plan a longer course of action. Concurrent care of the family is also important, as the families are often in psychological crises at this time (Harrison and Nixon, 2002).

These activities need to be accomplished in an environment that is dynamic and stressful, with high levels of noise from multiple sources including alarms (Bucknall and Thomas, 1997; Bucknall, 2003). The alarms signal an alteration in patient status that often requires a rapid assessment and clinical judgment. In the ICUs clinical judgments are usually concerned with questions of patients' physiological and psychological stability, the need for invasive technology and the use of potent medications and mechanical support, all of which require early detection of problems (Chase, 1995).

The critical care area is also characterised by constant interruptions and the potential for crises and there can be many distractions for nurses caring for patients under such circumstances (Bucknall, 2003). A study of various nursing environments in Sweden determined that interruptions to work procedures by persons and technology were common for nurses and that these could impact negatively on the nurses' work and on decision-making activities (Hedberg and Larsson, 2004).

Other factors in this environment that impinge on decision-making have been investigated in Australia, mainly employing NDM and observation. Three environmental factors that can affect decision-making are the patient situation, physical and personnel resources and interpersonal relationships (Bucknall, 2003). The patient situation can determine the speed and complexity of decisions: the more unstable the patient the more quickly the nurse needs to think. This may have implications in the ICU when a patient's condition deteriorates, requiring faster thinking that is also effective. As well as the patient situation, the personal resources of nurses, such as familiarity with patient situations, can affect decision-making, unfamiliar tasks having a greater impact on the nurse's decision-making ability.

Task complexity can affect decision-making, especially if a situation is unusual. Under such conditions the nurse is often slower in decision-making, as s/he may be taking time to consider options (Bucknall, 2003). Nurses may experience less trouble with decision-making around routine care and known patient responses and be challenged when care is not routine or when patient response is out of the ordinary. Encountering unfamiliar tasks may pose more of a problem if the nurse needs to concurrently think faster, due to deteriorating patient status. The organisation of a ward area may either help or hinder in situations where nurses are required to think rapidly when undertaking unfamiliar tasks, as can the availability or otherwise of nursing peers. Having knowledgeable staff close at hand can act as a resource for decision-making (Bucknall, 2003).

As well as examining the environmental factors affecting critical care, social factors have also been investigated. The social relations in an open heart surgery unit in America have been examined using ethnography (Chase, 1995). Clinical judgment in the context of the group was examined, as clinical judgment mostly occurs as joint decision-making (Chase, 1995). The study found that critical care nurses function in social hierarchies with assigned roles and that this serves to check decisions. This is the same in Australian critical care units, where nurses are organised by junior and senior roles and seniors are asked to help junior nurses (Bucknall, 2003). Junior nurses are often supervised by more senior nurses and this acts to ensure patient safety, as senior nurses often intervene when the situation is beyond the knowledge and skill of the more junior nurse.

Nurses in Australian ICUs also work in teams and carry out group decision-making (Currey et al., 2003). Group decision-making involves decisions with input from various members of a team as the nurses work together. There is conflicting evidence about the unity of the critical care nursing teams in the decision-making process, with some studies describing decision-making teams working well together while caring for patients following surgery and others describing teams that did not work well together. One Swedish study attempted to explain what nurses were doing for ICU patients returning from theatre following AAA surgery (Wikstrom and Larsson, 2003). The study employed fieldwork and participant observation and the main findings point to intensive-care work often involving routine practices. Nurses worked in groups and work proceeded harmoniously without problem. This contrasts to an Australian study that examined team decision-making for patients after cardiac surgery using NDM and participant observation (Currey et al., 2003). This study identified two types of decision-making teams: those that were integrated and those that were not. The non-integrated team had implications for patient management and mainly consisted of an inexperienced nurse and experienced nurses, with care being confused and less efficient. Neither study, while describing teamwork and routines, shows how the nurses reason or make decisions.

As well as working in teams, nurses work individually and make decisions individually (Currey et al., 2003). The relationship between nurses' level of appointment and the decisions they made individually has been examined in Australian ICUs (Bucknall and Thomas, 1996). This study concluded that nurses practising at a higher level made more decisions than those practising at a lower level, and that there was considerable variability in nurses' participation in decision-making (Bucknall and Thomas, 1996). How they made such decisions was not examined, but more junior nurses appear to make fewer decisions. This may be due to junior or novice nurses being dependent on others (Boychuk Duchscher, 2001), feeling fearful of doctors (Boychuk Duchscher, 2001), and often focusing more on doing than reasoning. They may also experience more anxiety when making a decision, which restricts decision-making behaviour (Erlen and Sereika, 1997). However, Boyle, Popkess-Vawter and Taunton (1996) disagree with this premise, stating that novice and experienced nurses suffer similar levels of anxiety in relation to decision-making. The study of Boyle et al. (1996) however, asked participants to complete questionnaires to assess aspects of socialisation such as anxiety, rather than directly observing decision-making behaviour (Bucknall and Thomas, 1996) or examining the stress of ethical decisions (Erlen and Sereika, 1997).

Another factor that affects ICU nurses' decision-making is the approach the nurse takes to decision-making. Studies have examined differences in ICU nursing across five countries, including North America and European countries, and found some differences

(Lauri et al., 1998, Lauri et al., 2001). The authors attributed the differences in decision-making approach to the type of education the nurses had, linking the decision style to whether the education prevalent in their country stressed intuition or nursing process. Culture and everyday work practices were also suggested as possible reasons for the differences. The context of a decision and the culture of a nursing care unit are recognised as factors that can influence CDM (Tanner, 2006).

In summary, the fast-paced and demanding clinical environment of critical care requires nurses to make decisions quickly, often under stress, due to the instability of patients. Nurses appear to support each other in this work, with senior nurses supporting more junior nurses and helping in their decision-making to a greater or lesser extent. Much of the work can be routine and centres on monitoring patient status, however, situations can arise that require rapid interventions often leading to better outcomes for patients. Experienced nurses practising at higher levels are widely believed to be better at making decisions under such conditions. A variety of factors can also impact on the decision-making of nurses in this area and include a range of both personal and structural factors. Consideration of the factors influencing decision-making is widely held to be important, as is the type of work that nurses undertake in ICU nursing. The type of work and tasks in ICUs may influence the type of decision situations that ICU nurses face. To begin to understand how nurses make decisions for patients in ICUs, a deeper understanding of the work to which ICU nurses are attending, and the types of decisions and tasks they undertake as they carry out their work, is needed.

3.2 Nursing work in ICU

The need to examine nursing work and tasks in detail to better understand decision-making, particularly in areas such as ICUs has been outlined (Benner, Hooper-Kyriakidis and Stannard, 1999), but very little research exists into the nature of such work and tasks in ICUs in Australia. Elsewhere, research has begun to identify the actual work done by ICU nurses. The activities of nurses working in a general intensive care unit has been examined in England using observation and videotaping and was accomplished using time sampling (Harrison and Nixon, 2002; Adomet and Hicks, 2003). A classification schedule was used to analyse the videos in one study (Adomet and Hicks, 2003), while a log of every sampling period was kept during the observation of nurses during the other study (Harrison and Nixon, 2002). English ICU nurses were found to spend 85% of their time in four main activities (Harrison and Nixon, 2002). Twenty-four per cent of their time was spent giving direct patient care, 17% in clerical duties, 38% in patient assessment and 6% in patient-focused activities. Forty-four per cent of the time was spent observing patients, which was described as monitor gazing and was composed of assessing patients 38% and patient-focused activities 6%, and is similar to the finding by Wong et al., (2003), that nurses spend 40% of their time assessing patients.

A study in England also examined both the types and tasks of decision-making using observation, and decisions have been categorised as either evaluative, causal, inference or descriptive (Lamond, Crow, Chase, Doggen and Swinkels, 1996). Evaluative decisions involved evaluating a patient’s condition, causal decisions involved giving a reason or cause, and inference and descriptive decisions involve inferring from data and describing respectively. This work was executed in medical/surgical nursing units (Lamond et al., 1996), but similar results were found in critical care (Bucknall, 1996).

Decisions were examined using event sampling observation and categorised in Australia for ICU nurses (Bucknall, 2000). The categories were described as intervention (doing interventions), communication (communicating with patient, peers, families and other health team members) and evaluation (evaluating patient status). The category evaluation described by Bucknall (2000) is also common to medical/surgical nursing in England (Lamond et al., 1996) and accounts for approximately 50% of nurses’ decisions (Lamond et al., 1996; Bucknall, 2000). Interestingly, this figure very nearly corresponds with the reported 53% of time spent by nurses in detecting and reporting problems in a study of nurses’ work and patient-sensitive outcomes (Stetler, Morsi and Burns, 2000), as well as the findings by Harrison and Nixon (2002) and Adomet and Hicks (2003), that nurses spend much of their time evaluating patients’ physiological and psychological status.

Many nursing decisions in different areas would appear to centre on evaluating patient status, and this corresponds with the finding that approximately 44% of a nurse's work is involved in assessing patients and attending to patient-centred activities (Harrison and Nixon, 2002). There was no difference found between the frequencies of evaluative decisions used by expert and novice nurses in ICU (Bucknall, 2000).

Although not extensive, some studies have examined the type of tasks that nurses carry out during decision-making, often in relation to their role. A person's pattern of behaviour results from the constructs held to a specific position in society and influences roles in that position (Strasen, 1992; Feist, 1994; Augoustinos and Walker, 1995). In nursing, the role value that nurses hold to their work can influence decision-making behaviours. The examination of nurses' roles in various areas in critical care has revolved around the tasks included in pain assessment and management, blood-pressure monitoring, and management of patients with tachycardias, as well as care in emergency situations (Aitken, 2000; Bakalis and Watson, 2005). The role conception of new graduate nurses during such tasks may differ from that of experienced nurses and impact on decision-making. As well as tasks for the nursing role in ICUs, some studies have attempted to list nursing actions during care situations.

The actions or decisions during management of a simulated patient in a cardiac case study were listed for nurses in coronary care units (Thompson and Sutton, 1985). These actions were seen as representing alternative courses of action a nurse may take during cardiac arrest. Eight decisions were listed in order from most frequent (assessing vital signs) to least frequent (administering nitroglycerin), and Thompson and Sutton (1985) concluded that time and resources, as well as education and experience, may determine how nurses select alternative courses of action. There was a common list of tasks for this specific care episode, and the tasks involved with monitoring vital signs were the most frequent, concurring with findings that the majority of work in ICUs is involved with patient monitoring and assessment.

Efforts have also been made to describe the frequency of types of decision tasks in ICUs. The frequency with which nurses reported they made decisions was examined for critical care nurses in Australia on ten critical care tasks (Bucknall and Thomas, 1996; Bucknall and Thomas, 1997). The decisions included decisions such as “to alter a patient’s mechanical ventilation after arterial blood results” and “to extubate patient without medical approval”. Some nurses were found to be making decisions that were out of the realm of nurses and these were more likely to be experienced nurses.

Using observation in the clinical setting, ICU nurses were found to make frequent decisions, approximately one every 30 seconds (Bucknall, 2000). In contrast, surgical nurses were observed in the clinical setting as they planned care and a frequency of approximately 18 decisions in a two-hour period was recorded, much less frequent decision-making than that noted for critical care nurses (Watson, 1994). This could be due to the definition of what constitutes a decision by both researchers or to the higher acuity and need for more frequent monitoring and intervention in ICU. However, the frequent monitoring of patients makes up a large part of the ICU nurses’ work and this is carried out by nurses also considering ethical issues and their patients’ interests. The monitoring of patients in ICUs involves a combination of aspects, with haemodynamic stability forming a very important part. A description of aspects of haemodynamic monitoring common to ICU nursing can further illustrate the areas of decision-making required of ICU nurses.

3.3 Monitoring patients for haemodynamic status

Monitoring for haemodynamic status in ICU often includes invasive blood-pressure monitoring, determinations of pulmonary artery pressure, continuous electrocardiograms (ECGs) and arterial oxygen saturations (Guiliano and Kleinpell, 2005). Haemodynamic monitoring has been investigated by Aitken (2000) and it was found that cardiac critical care nurses focus on four main concepts while reasoning about haemodynamic status. The concepts are preload, cardiac output, blood pressure (BP) and accuracy of pulmonary artery pressure monitoring. These concepts are likely to be common to ICU nurses as well, especially when caring for patients who may experience haemodynamic instability.

An example of the type of monitoring required in ICU is in the maintenance of haemodynamic status for patients in septic shock. Haemodynamic monitoring forms the main therapeutic clinical monitoring practice employed by nurses when managing such patients in ICUs (Guiliano and Kleinpell, 2005). This was ascertained in a study of ICUs in the USA, in which both doctors and nurses were surveyed about the main parameters they use while monitoring for shock (Guiliano and Kleinpell, 2005). Invasive blood pressure and pulmonary artery wedge pressures were considered the two most important physiological monitoring parameters by the participants (Guiliano and Kleinpell, 2005). Reasoning and decision-making about the parameters are essential to the interpretation of physiological data for diagnosis and treatment of patients especially, as the early intervention by nurses to prevent complications is critical.

3.4 Importance of early detection of problems

The nurses' role in monitoring patients is important in ensuring patient safety and well-being for patients with unstable physiological parameters. This creates a high frequency of decisions and ensures early detection of problems (Prowse and Lyne, 2000; Bucknall, 2003). The detection and prevention of problems, if successful, may be unnoticed by others as the patient remains stable, however it is an important nursing role (Lamond et al., 1996). Decision-making in post-anaesthesia units has been examined in order to determine the important aspects of vigilance by nurses in making decisions at critical points in care that ensure safety for patients (Prowse and Lyne, 2000). Important in the early detection of problems is knowing the patient and being able to recognise subtle changes over time (Peden-McAlpine and Clark, 2002). Also important is the observation of the patient, which can be seen in expert nurses as a highly tuned skill whereby attention is not only paid to changes in clinical parameters, but also to the many subtle non-verbal aspects of patient communication (Hardy, Garbett, Titchen and Manley, 2002). These results were reported from studies employing interpretative methods to examine expertise and again highlight the important role nurses have in monitoring and assessing patients in ICUs. While these descriptions provide a valuable indication of how monitoring by expert nurses differs from that by novice nurses, the precise procedure is still not clear, although there is beginning information.

Less experienced nurses have been described as spending more time evaluating patients and defer implementing a treatment or communicating a problem until they are certain a trend is occurring (Bucknall, 2000). They also tend to refer patient problems on to a more experienced nurse (Bucknall, 2000). This hesitation may contribute to delay in treatments and lead to a "failure to rescue" patients as early signs of impending complication go unnoticed. In contrast, experienced nurses were found to make many more communication decisions than novice nurses and this may have led to a difference in care by novice and expert nurses (Bucknall, 2000). Monitoring and observation of patients led to expert nurses formulating decisions and communicating these to peers or medical personnel. These communicated decisions often involved identified problems and expert nurses attended to more of these decisions. Effective nursing is seen as an integration of constant surveillance with good clinical judgment and an ability to distinguish the beginning of a life-threatening crisis from routine discomfort (Kitson, 1997). Much of the detection and prevention of problems involves nurses making good evaluative decisions, and experienced nurses are described as being able to do this well (Lamond et al., 1996). Both effective cognitive processes and domain-specific knowledge is required for good evaluative decisions and very little is known of either.

ICU presents nurses with particular work and tasks, often centred on patient instability and propensity for rapid deterioration. Monitoring patients forms an important aspect of the care of ICU patients and early detection of problems is believed to distinguish experienced or expert nurses in this area. Expert nurses are believed to ensure a better outcome for patients and there is a large amount of knowledge embedded in the practice of expert decision-makers that needs to be explicated. The competencies needed for administering and monitoring therapeutic interventions often involve tasks requiring more complex skills than have been taught to the new graduate nurse in a laboratory, and this presents a problem for new graduate nurses on commencing their nursing practice (Benner, 1984, 2001). There are few descriptions of expert critical care nursing practice in the clinical arena (Benner et al., 1999). In particular, there is a limited description of the tasks that require expert judgments, such as titration of multiple vasoactive medications and the concurrent intensive monitoring, and this further complicates the issue of how and what to teach new graduate nurses to be competent practitioners. The knowledge and decision-making processes used during such aspects of care are not well understood and need further explicating.

Understanding how expert nurses' reasoning differs from novice nurses' in relation to an aspect of ICU nursing, where it has been shown that nurses can prevent patient complications, may begin to explicate the differences in expert and novice ICU nurses' reasoning during decision-making. One such aspect is the care of post-operative AAA patients (Dang et al., 2002). Understanding what is involved in the care of such patients can support specific education of nurses entering critical care areas. A description of what is involved in AAA surgery helps illuminate the care required by nurses in this aspect of care.

3.5 Elective AAA repair

An aneurysm of the aorta, the main artery carrying blood from the heart to the body, is more likely to occur in the abdominal region, with 80% occurring here (Fellows, 1995). An aneurysm can be defined as a local irreversible enlargement of an artery and presents a danger in that rupture of the aneurysm can be fatal (Fellows, 1995). Lifestyle factors such as smoking, as well as co-existing vascular, cardiac and respiratory disease, have been shown to increase the risk of experiencing an AAA, as well as risks associated with its repair (Fellows, 1995; Bick, 2000).

AAA repair involves incising the aneurysmal segment of the aorta and inserting a synthetic graft (Fellows, 1995; Bick, 2000). The operation also requires moving the bowel out of the way, during which time it is placed in a sterile bag, and fluids can be lost through the bowel during this procedure (Fellows, 1995; Bick, 2000). To control bleeding, the aorta must be clamped above and below the aneurysm and involves either the iliac or common femoral arteries (Fellows, 1995; Bick, 2000). Anticoagulants are used during the surgery to prevent thrombi in the graft and can affect patient haemodynamic status (Fellows, 1995; Bick, 2000). Clamping of arteries during the operation can cause after-load and upper body blood pressure (BP) to rise and lessen venous return; this can trigger arrhythmias (Fellows, 1995; Bick, 2000). After the clamp is released and blood flows back to the vascular system, hypotension can occur and again can trigger arrhythmias (Fellows, 1995). The haemodynamic disturbances during clamping and unclamping can lead to myocardial ischaemia or infarction (Fellows, 1995). Intra-operative blood loss can also lower BP and cardiac output, leading to further cardiac instability and this is often treated post-operatively with ionotropes, vasodilators and volume-loading (Fellows 1995; Bick, 2000). Hence, such patients usually require intra-arterial pressure monitoring, central venous pressure (CVP) monitoring and continual cardiac monitoring and ventilation in the ICU (Bick, 2000).

Ten per cent of patients who have undergone AAA repair may have required clamping of the aorta above the kidneys and consequent interruption of circulation to the kidneys, which can tolerate 60 to 90 minutes ischaemia before damage occurs (Fellows, 1995; Bick, 2000). This may lead to temporary or permanent renal failure and patients need to be monitored postoperatively for renal function and urinary output. The bowel can also be similarly damaged from lack of circulation during the operation, so there is a need to monitor for bowel functioning post-operatively. The most common post-operative complications of AAA surgery are myocardial infarction, renal failure, blood loss, respiratory problems such as pneumonia. Other problems include paralytic ileus and ischaemia of feet or toes (Liston, 1997; Bick, 2000).

Management of patients post-operatively requires a range of interventions, including:

- monitoring of haemodynamic status through monitoring of vital signs, including heart rate (HR), BP, central venous pressure, temperature, respiration rate and peripheral perfusion, all of which indicate problems with cardiovascular status

- monitoring for factors that may impact on cardiovascular status. These include respiratory function, as hypoxia may affect cardiac output by affecting HR, consequently oxygen saturations and arterial blood gases need to be monitored (Currey and Aitken, 2005)
- monitoring and treating pain, as this may also affect HR and cardiac output
- monitoring for fever and anxiety and medications such as beta blockers, as these can also affect HR and cardiac output (Currey and Aitken, 2005)
- assessing for mental status
- making patients as comfortable as possible and positioning to ensure rest and adequate lung expansion
- monitoring for fluid status of the patient, as cardiac status is altered by factors that can also alter fluid distribution in the body (Liston, 1997; Currey and Aitken, 2005)
- administering fluids as appropriate
- administrating and titrating medications to maintain haemodynamic stability
- ensuring ongoing patency of lines, checking effect of positioning and transducer leveling on accuracy of transducer readings, interpreting readings of transducers
- monitoring for alterations in patients' limb observations, as there is a possibility of disruption to blood supply to the feet
- providing psychosocial care to patient and family.

Skill and knowledge are needed by nurses to rapidly and accurately detect insidious causes of haemodynamic instability in AAA patients (Currey and Botti, 2003). Nurses must be able to interpret intra-arterial and central venous pressure monitoring readings and relate them to other information about the patient, such as laboratory and physical data (Currey and Botti, 2003). They also need to constantly monitor technological equipment to ensure that it is working effectively. Both novice and expert nurses need to have knowledge of many factors which can impact on the haemodynamic instability of

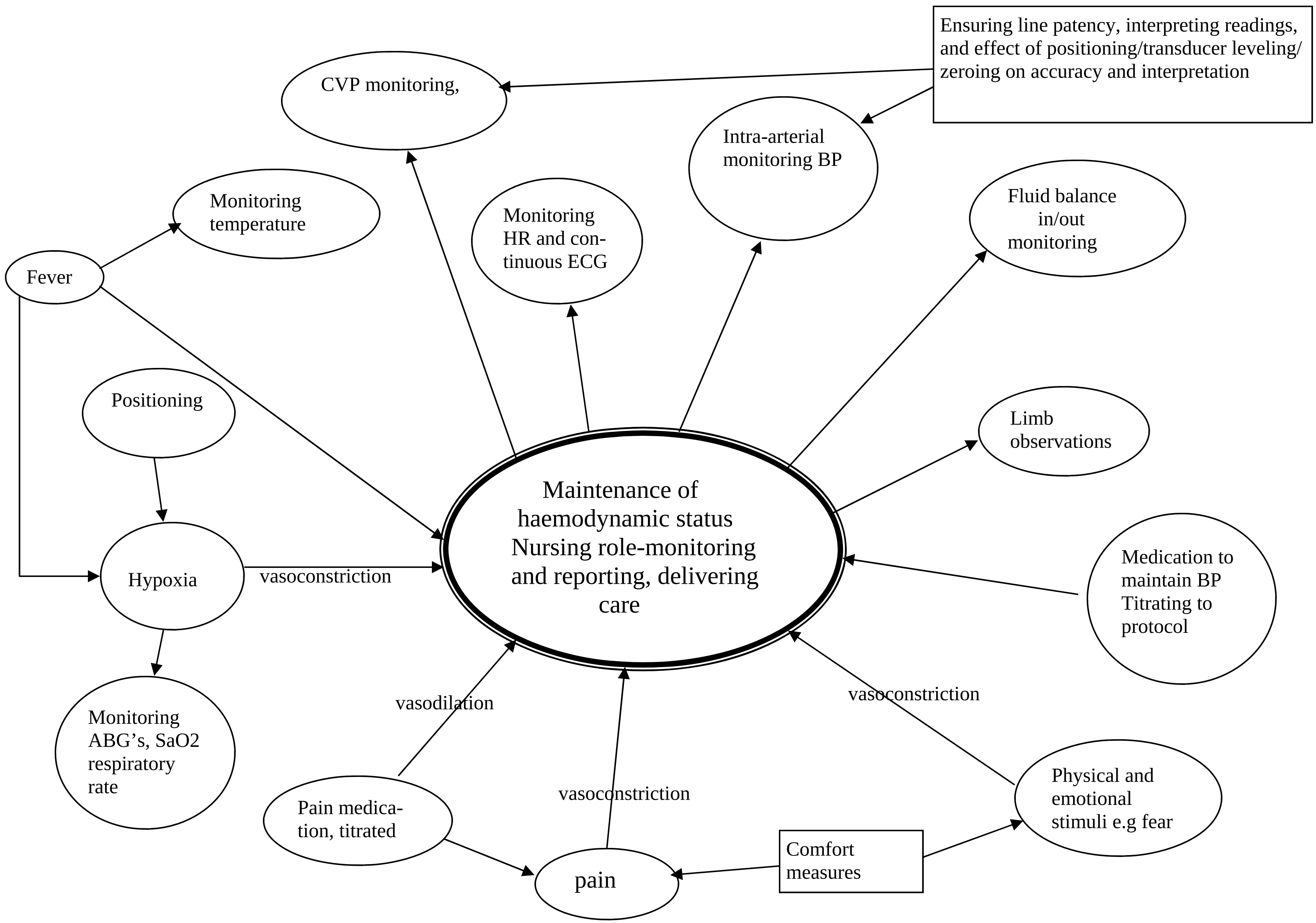


Figure 3:Monitoring Haemodynamic status for post operative AAA patientss

patients and these are summarised in Figure 3, page 55. Interpretation of what the physiological monitoring data means and implementation of interventions requires the use of complex cognitive skills, especially decision-making. Expert nurses are believed to perform differently from novice nurses during decision-making, and research into some of these differences is discussed below. Understanding the differences is important to educate nurses.

3.6 Differences in decision-making by novice and expert nurses

The cognitive processes that novice and expert nurses use during decision-making have been investigated using different approaches and with some varying results. Before examining expertise, a workable definition of an expert decision-maker is needed.

The most common method of examining expertise has been the contrastive method based on the original work of De Groot (Eddy, 1996). The contrastive method compares expert and novice decision-makers to determine differences. The other method is to study only expert decision-makers. However, arguably this misses many important differences in decision-making that have arisen due to the acquisition of expertise.

The description of an expert decision-maker varies from study to study, with some merely describing an expert decision-maker as someone who has had experience in a field of practice (Redden and Wotton, 2001). This implies expertise is due to the length of time in a discipline. However, expertise is more than just the number of years spent engaging in nursing practice (Darbyshire, 1994). It is also the incorporation of new knowledge with experience to develop further skills (Krol, De Bruyn and van den Bercken, 1992).

Expertise has also been determined differently depending on the field of study. Psychologists examining skill acquisition often determined expertise by measuring performance on standard measures, for example, chess experts were described as those who perform two standard deviations above the norm on a chess skill. However, in nursing, it is very difficult to measure performance on the tasks of the domain, instead, in-depth descriptions of expert and novice performance have been more often used. An expert nurse has been described as an individual who possesses a large body of knowledge and procedural skill (Lamond and Farrell, 1998). Expert nurses have also been described as those who are recognised by others for their performance and who identify themselves as expert nurses (Benner, 2001). This is socially recognised expertise and it is easier to determine expertise this way than on specific measurable performance standards (Ericsson and Charness, 1994). A novice performer is described as a beginner, a person whose performance lacks the speed, accuracy and efficiency of the expert performer. The novice is defined in relation to the lack of characteristics of the expert. Differences have been found between novice and expert nurses for decision-making processes, as well as on a range of other factors impacting on the decision-making process such as cue collection, knowledge source and approach to decision-making. Few studies have examined the difference in cognitive operators or strategies used by novice and expert nurses, with very few being implemented in Australia and none examining ICU nursing.

3.6.1. Hypothetico-deductive reasoning

Using the information-processing theory in CDM, one of the main cognitive processes described is hypothetico-deductive reasoning, and this decision process has been identified in a range of fields including psychology, fire-fighting, medicine and nursing (White et al., 1992). Hypothetico-deductive reasoning involves collecting information, generating tentative hypothesis, gathering more data to confirm or disconfirm an hypothesis and making a conclusion or coming to a diagnosis. Examination of hypothetico-deductive reasoning has involved the examination of different approaches, the correctness of the hypothesis and examination of the various aspects such as gathering of cues and confirming and disconfirming cues.

The processes that critical care nurses in Australia use while reasoning about third space fluid shift were identified and compared to those used by gastrointestinal surgical nurses (Redden and Wotton, 2001). The study used a semi-structured interview and TA, within the framework of information-processing, as the participants analysed scenarios. Thematic analysis was used to analyse the data. The main process identified in this study by the authors was hypothesis generation. It was found that hypotheses were generated early in the reasoning process and that nurses used information to rule their hypothesis in or out. Only expert nurses were examined and the decision-making processes of novice nurses were not considered.

The number and type of hypotheses generated during decision-making has also been investigated and expert and novice decision-makers compared. Expert decision-makers are believed to entertain a wider range of hypotheses than novice decision-makers (Elstein et al., 1978). Expert decision-makers are also able to use their knowledge, which is domain-specific, to generate more reasonable hypotheses (Botti and Reeve, 2003) and can generate several hypotheses concurrently and link them together (Taylor, 2000). Expert nurses link data directly with treatments and side-effects during hypothesis generation, hence moving over some of the steps of the process (Corcoran, 1986; Grobe et al., 1991).

Expert decision-makers are also better able to produce correct hypotheses than novice decision-makers and this is believed to be related to their ability to use disconfirmatory cues in hypothesis generation (Elstein et al., 1978). Using case studies and information-processing theory Elstein et al. (1978) were able to judge the accuracy of the physicians' hypothesis generation leading to a diagnosis against what was expected for that case and allowed such a conclusion to be drawn. However, studies in nursing such as Benner's (2001) seminal work, even though it implies that expert nurses are better at decision-making, used a methodology whereby no attempt was made to compare the correctness of decisions.

One study in nursing, however, has examined the correctness of diagnosis for simulated patients by comparing hypotheses generated to accuracy of diagnosis for family nurse practitioners and obstetric/gynaecological nurses (Haggerty and Nuttall, 2000). The obstetric/gynaecological nurses made more correct diagnoses than the family nurse practitioners and the inaccuracy in diagnoses was explained by the participants not being able to interpret the test results of pelvic wet preps. The obstetric/gynaecological nurses were presumed to be more expert in this area of practice than the family nurse practitioners, so accuracy of diagnosis was related to expertise. Interpretation and understanding of physiology and laboratory results was important in making correct diagnoses, and obstetric/gynaecological nurses had more knowledge in this area, so knowledge was important in accuracy. This study only examined expert nurses, without comparison to novice nurses.

The generation of hypotheses involves two types of inferences, forward and backward reasoning, which can be seen as either data-driven (forward) or hypothesis-driven (backward) (Jones, 1988; Lamond et al., 1996; Botti and Reeve, 2003). Forward reasoning or goal-driven reasoning occurs where data are collected and the cues gathered trigger a hypothesis. Different patterns of cues will be linked with different hypotheses (Jones, 1988). Backward reasoning occurs when a hypothesis is the beginning point for the gathering of cues to support it and a search is made for possible causes or conditions. Forward reasoning is associated with more accurate diagnoses used by expert decision-makers (Botti and Reeve, 2003). Novice decision-makers are believed to use more backward reasoning or mean end reasoning, which may be due to the fact they have less domain-specific knowledge and only search for information once an issue is identified (Kahney, 1993).

The work of Elstein et al. (1978) demonstrated that expert and novice decision-makers use the same process in medical problem-solving, hypothetico-deductive reasoning, but that expert decision-makers use the process more efficiently. Recent studies in both nursing and medicine have determined that decision-makers use other processes while decision-making in clinical practice, such as pattern-matching and intuition, and these are discussed in the next section (Benner 1984, 2001; Offredy, 1998; Burman et al., 2002; Coderre et al., 2003).

As well as differences in processes research has also shown some differences in cognitive operators used by decision-makers, although the operators or cognitive strategies used by nurses in decision-making have not been extensively examined. In written protocols in a real-world study of nurses' notes, the operator "description" was used 79% of the time, and the order of the other operators from most to least was "selection", "inference", "synthesis", and then "verification' (Higuchi and Donald, 2002). This contrasts with the findings from a simulated study of nurses' reasoning that found the operator "collect" was most frequently used (Jones, 1989) and suggests that there are differences in real-world and simulated decision-making processes and operators. There have also been few comparisons of the use of operators by novice and expert nurses, however, two studies by Greenwood and King (1995) and Greenwood et al. (2000) in Australia found that novice nurses used the operator "collect" more often than expert nurses. Both of these studies were conducted in the real world, one in orthopaedic nursing and one in neonatal intensive care nursing.

3.6.2 Intuition

Benner's (2001) seminal work in critical care nursing was based on the work of Dreyfus and Dreyfus (1986) and examined the decision-making stages that nurses move through outlining the differences between expert and novice nurses (Benner, 1984, 2001). Two distinct and separate types of cognition, intuition and analysis, were described in the Dreyfus and Dreyfus model (1986) and identified by Benner (2001) in nursing.

Novice nurses were described as using analysis, whereby they relied on abstract principles while making decisions, whereas expert nurses used intuition and used concrete past experiences as paradigm cases. The Dreyfus and Dreyfus Model of Skill Acquisition described intuition as being unavailable to non-expert nurses, with the implication that intuition represented a better mode of cognition (Paley, 2002). Novice nurses were also described as detached observers, who rely on seeing a situation as a compilation of equally relevant parts. Expert nurses were described as being involved in a situation and hence see situations as complete wholes rather than as a compilation of

separate parts. Lauri et al. (1998) add to this by explaining that novice nurses analyse isolated problems, whereas expert nurses rapidly analyse the entire situation.
As expertise develops, nurses move from using rule-based decision-making to intuitive decision-making. Benner's (2001) assertion that novice nurses are rule-dependent is mirrored by Elstein et al.'s (1978) statement that novice decision-makers are more rigid and adhere to protocols and rules. Expert decision-makers can tell when an expected picture does not materialize, as they perceive all of a situation using intuition, whereas novice decision-makers using rule-based reasoning only perceive part of a situation. Contrary to the findings of Benner (1984, 2001), McCutcheon and Pincombe (2001) found that novice nurses reported that they did use intuition and these authors suggested that this needs further investigation.

As well as contention around which group of practitioners use intuitive or analytical (rule-bound) processes, Hamm (1991), using information-processing and cognitive continuum theory, associated the use of either analysis (rule-bound) or intuition with the task at hand rather than the level of experience of the practitioner. Corcoran (1986) concurred with Hamm (1991) and found that expert decision-makers used more logical analytical processes in the least complex cases. In other words, the task was determining the approach, not the fact that the nurse was an expert.

Using a decision-analysis framework, CCU nurses were examined for consistency of decision-making across tasks of different complexity, and it was found that intuitive decision-making led to better interventions in more complex tasks than decisions generated by decision analysis (Hicks et al. 2003). As above, the task was determining when intuition or analytical reasoning was used, not the level of expertise. Other studies have determined that analytical reasoning and intuition are used by all nurses from different areas, and that intuition often precedes analysis.

The process of intuition and its use in clinical practice was examined for Australian critical care nurses and compared to surgical ward nurses, using a constructivist approach

(King and Clarke, 2002). Intuition was described as a non-conscious awareness that was often used to identify the source of concern about the patient, with the nurse then employing analytical processes to determine the problem. It may have been that intuition was the process used in the study by nurses for hypothesis generation, followed by analysis to confirm or disconfirm any hypotheses generated, and this needs considering.

Nurses were found to use indicators of expertise that differentiated four levels of expertise (King and Clarke, 2002). The four levels described were advanced beginners, competent, proficient and expert. Benner's novice level was not observed (Benner, 2001). Both analytical reasoning and intuition were being used by all nurses, however, the study did not differentiate between novice and expert nurse, but compared nurses from different areas, and then grouped them during the study into levels of expertise depending on their responses (King and Clarke, 2002). There is contention in the above studies about the use of the process of intuition, when it is used and whether it is solely used by one group or by all nurses.

3.6.3. Pattern-matching

As well as the processes of hypothetico-deductive reasoning and intuition, pattern-matching, whereby expert decision-makers can match a patient with similar patients they have nursed before, has been identified as an important aspect of expertise (Thompson and Dowding, 2002). Expert nurses in CCU nursing are more likely to use pattern recognition or matching and they recognise more meaningful patterns of information in their own domain due to past experience (Burman et al., 2002; Botti and Reeve, 2003). They are also able to retrieve these patterns quickly and efficiently and this is due to the ability to recognise groupings of meaningful cues (Thiele et al., 1991; Botti and Reeve, 2003). Expert nurses are also able to identify particular chunks relating to diseases seen more often and this occurs in non-problematic situations (Offredy, 2002). It is believed that pattern recognition is not available to novice decision-makers, as it requires extensive experience (Coderre et al., 2003). However, students in a study in the USA identified a decision process they were using which appears to be similar to pattern-matching

(Fonteyn and Cahill, 1998). Pattern-matching may not be solely restricted to experts in a field.

According to Offredy (1998), pattern-matching can be intuitive or analytical, depending on the paradigm the researcher is using. If it is explained analytically it refers to information-chunking to match existing patterns of previously seen patients (Offredy, 1998). If it is intuitive, it refers to the grasping of a situation as a whole. In either case, research evidence demonstrates expert nurses are better at pattern-matching, as they have a larger repertoire of previously seen patients against which to match the current case. In the analytical theories such as information-processing, chunking is believed to enable pattern-matching.

3.6.4. Chunking

Chunking is the ability to recognise well known patterns of information, especially domain-specific information. Chunking is believed to occur during information-processing and early hypothesis generation is believed to aid in this (Taylor, 1997). Expert nurses are good at chunking information and recognise familiar patterns well, while also having the ability to ignore less important information (Bergstrand, 1998). Early work using the information-processing theory examined expert chess players and how they remembered patterns of chess pieces. Expert chess players were found to be able to remember patterns of chess pieces from a game better than non-expert chess players, but could not recall random patterns better than others. This suggests that chunking is a mechanism that works with domain-specific knowledge allowing experts to build up patterns of repeatedly seen pieces in moves during games. However when presented with a new random pattern their memory of it is no better than non-expert chess players (Kahney, 1993). The same was found in the field of computer programming, where an expert programmer was no better at remembering meaningless lines of data than a novice programmer but was much better at remembering actual programmes. It appears that expert programmers order knowledge into schemas and have highly organised schemas to call on (Kahney, 1993). These are believed to develop over time as expertise develops and allow for pattern-matching.

Expert nurses were also described by White et al. (1992) as being able to cluster information efficiently with specific patient representations, which is similar to the description of chunking. However, the authors used Benner’s (2001) description of expertise and explained clustering as the moving ahead quickly on the basis of less subjective information, rather than chunking, and no explanation was given as to how clustering of information was accomplished. Pattern-matching and chunking or clustering of information are recognised as features in expert decision-making, but how they occur is explained differently, depending on the theoretical approach of the investigator.

A process similar to chunking was identified for expert nurses in an Australia ICU (Aitken, 2000). A combination of strategies was used by the expert nurses, mainly focused gambling, with the strategies of conservative focusing and simultaneous scanning being used less often (Aitken, 2000). However, the focus gambling strategy described in the study was compared to chunking, whereby practitioners base decisions primarily on previous experience.

3.6.5. Schemata and scripts

Larger chunks which represent well-organised concepts that help in the understanding and management of complex situations are called schemata and everyone possesses a vast number of these schemata (Gellman, 1994; Anderson, 1995). Schemata are mental images constructed by the mind that represent concepts of objects and experiences and allow for the prediction of others’ behaviour (Greenwood et al., 2000; Roberts, While and Fitzpatrick, 1996). All complex adaptive systems acquire information about their environment and their own interaction with the environment, identify regularities in that information and then condense these regularities into schemata or models that are stored in the mind. Individuals then learn from experience to choose schemata that work and they look for patterns that they know are linked to a schema. A schemata can be conceived as a conveyor of memory, and it allows the grouping of experiences so that an individual can easily recognise similar experiences and access a framework containing similar frameworks. This allows the utilisation of skills, procedures or rules for which the framework is relevant (Offredy, 2002).

Expert nurses are described as possessing more highly developed schemata or cognitive structures and rely more on these (Roberts et al., 1996; Thompson and Dowding, 2002). Action schemata represent procedural knowledge or what to do and are called scripts (Greenwood et al., 2000). Scripts are activated by an environmental trigger (Greenwood et al., 2000). An Australian study found that nurses used scripts to direct care of neonatal patients, for example, the script midday cares and minimal handling (Greenwood et al., 2000). In this script the trigger "midday cares", triggers actions that entail minimal handling of the patient at this time. These scripts had tasks that were triggered automatically. The nurses in the study were all inexperienced neonatal nurses and it was suggested that experienced nurses also use such scripts to direct care. The use of schemata and scripts are believed to be a feature of pattern-matching.

3.6.6 Eclectic approach

Many studies of decision-making have identified one decision process; however, some studies are beginning to recognise that nurses may use an eclectic approach and use more than one process during clinical reasoning (Bucknall, 1996, Lewis, 1997). This is supported by others who state that intuition and analysis can and do appear side by side in decision-making (Lauri and Salantera, 1995) and that nurses use intuition and pattern-matching as well as hypothesis generation together in decision situations (Bucknall, 1996, Redden and Wotton, 2001). In medical decision-making, practitioners also use hypothetico-deductive reasoning and pattern recognition concurrently (Piele, 2004). The studies that have identified an eclectic approach to decision-making have found that more experienced nurses are more likely to use intuition and pattern-matching over other types of processes, especially with familiar cases where they are likely to look for a red flag that leads to more in-depth assessment using other cognitive processes (Offredy, 1998;

Burman et al., 2002). The use of hypothetico-deductive reasoning, were hypotheses are generated, has been linked in such studies with unfamiliar or complicated cases (Offredy, 1998).

Expert nurses are also able to vary their approach to decision-making according to the complexity of the task presented, whereas novice nurses do not appear to be able to achieve this (Corcoran, 1986). Expert nurses were found to be more flexible and to have the ability to pursue more strategies in decision-making (Offredy, 1998). Expert nurses are also said to "jump around" when pursuing more complex cases, whereas novice nurses have used fewer approaches to decision-making and usually have an opportunistic approach (Corcoran, 1986; Aitken, 2003). Expert nurses are also reportedly better at monitoring their own progress and recognising errors and therefore selecting more appropriate approaches (Weiten, 1995).

3.6.7 Use of production rules

Following abstract rules of inference or production rules is a process not often used in nursing and medical decision-making (Noyes, 1995). Noyes (1995) gives the example of a nurse reasoning about pain (if in severe pain give morphine, if this fails then give a further dose) but did not investigate whether nurses were using these rules. Expert nurses are believed to proceduralise rules until they become automatic, whereas novice nurses follow the rules slowly and deliberately, however, this has not been examined extensively. Procedural rules probably represent internalisation of action schemata. The other important aspect to understand when considering processes of decision-making is how information is gathered by nurses to be processed to make a decision. This involves an examination of cues and cue usage.

3.6.8 Gathering Cues

3.6.8.a. Cue collection, number and type

The way nurses use cues has been examined in CCU and ICU settings. Cue usage in diagnostic expertise was examined by comparing expert and novice nurses' reasoning about simulated patients (Reischman and Yarandi, 2002). The emphasis here on diagnosis reflects the greater emphasis placed on it in the USA compared to countries such as England, where nurses are more often described as assessing and managing patients and are hence more likely to use the nursing process to plan care (Lamond et al., 1996; Lauri et al., 2001). American nurses place greater emphasis on diagnostic classification and have developed an extensive classification system of nursing diagnoses. Nurses in England and Australia, while aware of nursing diagnoses, tend to implement these less often.

During the study by Reischman and Yarandi (2002), coding of audio-taped verbal protocols from a study of expert and novice nurses reasoning resulted in a comparison of the diagnostic accuracy of expert and novice nurses. Expert nurses were more accurate in diagnosing, as they were able to select relevant cues better. This concurs with Elstein et al. (1978) and Lamond and Farell (1998), who state that expert nurses are much more selective in cue collection and concentrate on more relevant information. This is also similar to Benner's (2001) assertion that expert nurses identify and concentrate on a problem better. The studies by Elstein et al. (1978) and Reischman and Yarandi (2002) used simulated patients, whereas Benner's study used narratives of real patients the participants had cared for, however, the different approaches resulted in similar findings. Expert nurses were also found to have domain-specific knowledge and could focus rapidly on highly relevant cues to access procedural memory, where it is believed domain-specific knowledge is located and this may increase diagnostic accuracy (Lamond and Farell, 1998).

The better selection of critical cues by experts is a common finding in several studies and disciplines (Elstein et al., 1978; Lamond and Farell, 1998; Benner, 2001). The explanation of cue-gathering offered by Benner (2001) differs from that offered by those using information-processing theory (Elstein et al., 1978; Lamond and Farell, 1998). Benner (2001) describes the cue collection and decision-making of expert nurses as an immediate and complete grasp of a situation as a whole, whereas in information-processing it is often described as a better ability to identify and list relevant cues (Elstein et al., 1978). The statement by Benner (2001) that expert nurses use fewer cues than novice nurses differs from the assertions by Elstein et al. (1978) that expert doctors select more cues. Both agree on the better selection of cues, but there is seen to be a difference in the number of cues gathered. This difference may be due to the use of simulations, as compared to real-world studies.

There is disagreement around this aspect of decision-making for novice nurses as well. Novice nurses were said by Thiele et al. (1991) to over-select cues and collect irrelevant information, whereas an Australian study found that novice nurses note minimal cues and use single cues to trigger a hypothesis, while ignoring cues which do not fit (Taylor, 1997). A similar result was identified by Tanner, Padrick, Westfall and Putzier (1987). The over-selection of cues by novice nurses appears to be related to greater inaccuracy in diagnosis (Klein, 1989; Thiele et al., 1991). There is agreement on the issue of novice nurses not using cues as effectively as expert nurses, but disagreement on the number they select.

The way cues were used was also different for gastro-intestinal surgical nurses and critical care nurses (Redden and Wotton, 2001). Critical care nurses clustered cues better and used pivotal cues to refine their hypothesis during hypothesis generation. Critical care nurses could also give a rationale for their actions and the cues they collected and understood what they were doing, whereas gastro-intestinal surgical nurses could not. This may be related to the types of cases used in this study, which involved fluid shifts and fluid management, with the critical care nurses being more familiar with such cases. Whether novice and expert nurses have differences in the way they rationalise their decisions is not known.

There is contention around the selection and usage of cues by novice and expert nurses and this may be due to the differences in methodology used in the various studies conducted to examine this aspect. Some studies used interpretative approaches, while others used methods from the information-processing framework and this may have had an effect. The use of different approaches to study decision-making was discussed in Chapter Two. Some also used simulations, while others examined decision-making in the real world of practice and this may also have had an impact. This is examined in Chapter Four.

3.6.8.b Cue collection, following rules

Novice nurses have little or no experience of a situation in which they are expected to perform and have to be taught to recognise features of a task world that they can use to guide them (Benner, 1984, 2001). Hence novice nurses have to be told how cues shape decisions and the connections between cues and outcomes given as rules to follow (Benner, 1984, 2001). This would imply that nurses do use production rules to make decisions, although this has not been extensively tested. Novice nurses rely on rules that are context-free, whereas expert nurses rely on acquired aspects that they have gained from experience and which are context-dependent.

Experienced nurses also appear to automatically associate cues with outcomes, rules become redundant and they appear to be able to link concepts together better (Corcoran, 1986; Grobe et al., 1991, Buckingham and Adams, 2000). This suggests that the key to expertise is the efficient linking of cues to outcomes and concepts together and the internalisation and automaticity of this process (Ericsson and Simon, 1993). Expert nurses use more strategies to manipulate the information they possess, hence relating more concepts or items of information together and, as a consequence, were seen to link information together more effectively in this study (Greenwood and King, 1995). Interestingly, the study by Aitken (2003) into concepts used by critical care nurses in Australia found that nurses relied mainly on “numbers” and less on clinical assessment and that they did not often relate the two. Whether expert nurses relate concepts together better is contentious.

3.6.9 Collection of information; assessment for decision-making

The assessment during decision-making about care planning by expert nurses differs from that of novice nurses. Expert nurses implement a more comprehensive examination compared to less experienced nurses and conduct what is termed an “expanded physical” examination whereby they collect information about the patient other than just a “symptom-driven” examination (White et al., 1992). The expert nurses collect information on a wide range of aspects in addition to the patients’ presenting symptoms and illness, whereas the novice nurses tended to concentrate on only the presenting symptoms.

In contrast, using grounded theory methodology (Hanneman, 1996) and also by using the Delphi technique (Nojima, Tomikawa, Makabe and Synder, 2003) expert nurses’ assessment was found to be more focused than that of novice nurses. In a study in the USA using participant observation and unstructured interviews, expert nurses were found to be independent practitioners and to be guided in their practice by a focused assessment (Hanneman, 1996; Nojima et al., 2003). This was described as a contextual way of being with the patient and expert nurses were described as instantly knowing the patient after scanning her/him. Further, expert practice was described as exhibiting early and aggressive interventions which could prevent patient complications and problems. In contrast, novice nurses have dissociative practice with disintegrated, linear, unfocused assessment reliant on policy, procedure and orders from others (Hanneman, 1996; Nojima et al., 2003). This is corroborated by the study of Nojima et al. (2003) which describes expert nurses as identifying and treating problems swiftly and comprehensively.

Expert nurses also often use touch effectively, whereas novice nurses do not (Hanneman, 1996). Expert nurses know what to pay attention to and to ask the right questions (Hardy et al., 2002), notice features of the care environment and understand what needs to be done (Arbon, 2004). In contrast, novice nurses usually are focused on basic nursing activities and the use of technology (Arbon, 2004) and tend not to concentrate as much on the patient and family. This maybe due to their lack of experience and their need to concentrate on learning, as well as their inability to divide their concentration at this time.

3.6.10. Differences in novice and expert nurses' use of knowledge

3*.6.10.a. Expert nurses' use of knowledge*

Studies have determined that more experienced nurses have more knowledge, which allows them to be more systematic and accurate than novice nurses (Thompson and Sutton, 1985; Greenwood and King, 1995; Lauri and Salantera, 1995; Lauri et al., 1998; Lauri et al., 2001). In addition, the knowledge expert nurses use is often acquired or refined in the clinical area and consists of clinical knowledge, which is referred to as tacit knowledge or skilled know-how (Benner, 1984, 2001). This knowledge cannot be taught in a classroom but is acquired through practice (Benner et al., 1996). Elstein et al. (1978) refer to expert decision-makers as having more domain-specific knowledge, which mirrors Benner's (2001) report of the rich tacit knowledge that expert nurses have.

As well as a better knowledge base, expert nurses are reported as having a better memory store of past, similar and contrasting situations, which allows reliable, rapid retrieval (Elstein et al., 1978). This is also aided by expert nurses effectively organising knowledge to allow efficient retrieval, which also leads to the skills of anticipating and planning ahead and reasoning selectively. The knowledge base of expert nurses is more highly structured in a way that allows pattern-matching, which is the basis of anticipation and forward planning (Bergstrand, 1998; Thompson and Dowding, 2002). Although this is not the same explanation given by Benner (2001), it mirrors her proposal that expert nurses build paradigmatic cases to which they compare the current case.

Interestingly, the main problems that nurses report with decision-making in critical care settings were found to be "due to knowledge base", "lack of time to make decisions", "lack of time to implement decisions", and "personal value conflicts with other staff" (Bucknall and Thomas, 1997). This Australian study surveyed 230 ICU nurses about their perceptions of problems with decision-making in ICUs. Nurses valued having a good knowledge base, and saw a lack of knowledge as impacting negatively on the care of patients.

3.6.10.b Pooled knowledge

Most of the research into the knowledge used by nurses has examined the individual's knowledge base, however, a collective development of knowledge in clinical practice has also been described. An examination of community nurses' decision-making regarding wound assessment found that nurses often rely on what was termed "pooled knowledge" (Hallet et al., 2000). This occurs where nurses seek information and advice from colleagues and was seen as beneficial to nursing. This is also described by Benner et al. (1996), who point out that nurses work in teams and that they consult each other and hence pool knowledge.

3.6.10.c. Sources of information

Research in nursing has also been carried out to determine the sources of knowledge that nurses use to carry out clinical care. Expert nurses are more likely to access multiple sources of information prior to caring for a patient, whereas novice nurses access less preparatory information and link information gathered from fewer resources (Taylor, 2002). As well, nurses develop situational knowledge, knowledge they gain from repeated exposure to local content (Bucknall, 1996). This knowledge consists of who to ask and who to trust and can develop with experience in an area. The information that nurses access can be from handover, patient documentation, previous contact with the patient and a variety of other sources, and handover information is more important to expert nurses than novice nurses, for whom it means little (Taylor, 2002). This differs from Lamond et al. (1996), who discuss how handover information can direct novice care and focus their reasoning on certain issues, to the detriment of others.

3.7. Summary

The clinical environments of CCU and ICU are different from other clinical areas, and the tasks and decisions made during the care of patients in these areas present particular challenges to nurses. Decision-making occurs in a fast-paced, distracting environment where patients may deteriorate rapidly. About half of the decision-making of CCU nurses centres on monitoring patients and making good evaluative judgments. Nurses delivering optimal care can positively influence patient outcomes and it is believed that making good decisions allows for this. However, the understanding of how nurses make such decisions is limited and contradictory. Research has been instigated to examine decision-making in CCU and ICU by contrasting novice to expert nurses and by examining expert nurses only. Some of the differences in decision-making by novice and expert nurses are presented below in Table 1.

Some differences have been found in hypothetico-deductive reasoning by novice and expert nurses, with expert nurses more likely to generate hypotheses early, more likely to reason forward to a problem and more likely to have a wider range of more correct hypotheses. Expert nurses are also believed to use pattern-matching and intuition more

Table 1: Summary of differences in decision-making of novice and expert nurses.

Novice	Expert
Consider fewer hypotheses that cover a smaller range, fewer correct hypotheses generated	Consider a wider range of hypotheses, more correct hypotheses and consider more hypotheses
Select more cues which are less relevant	Select critical cues better
More rigid and rule-dependent, more likely to use same approach	More flexible approach
Poorer at pattern-matching	Better at pattern-matching, good at chunking
Not good at recognising errors	Better at monitoring progress and recognising errors
Use more abstract principles	Use past concrete experiences as paradigm cases
Situation seen as made up of equally relevant parts	Situation seen as a whole
Isolated problems analysed	Rapidly analyse as a whole
Need to be taught cue recognition	Recognise cues better
Use analytical processes	Use intuition
Make a less comprehensive assessment	Use a more comprehensive assessment
Limited ability to anticipate problems	Anticipate problems and plan ahead for same
Less knowledge, particularly tacit knowledge, tend to rely on theoretical knowledge	Greater knowledge base and knowledge more structured

often. However, much of the research has not compared novice and expert nurses and little has been done in critical care in Australia. The Australian study by Aitken (2000) examined expert nurses only, whereas King and Clarke's (2002) study compared surgical nurses to critical care nurses, as did the study of Redden and Wotton (2001). The Australian study by Taylor (1997, 2000) examined medical and surgical nurses, while Greenwood and King (1995) and Greenwood et al. (2000) examined novice and expert nurses in orthopaedic and neonatal nursing respectively. Research has also been inconclusive on a number of points, including the type and number of cues collected and also the types of processes used and when. More research is needed, particularly into the processes used and aspects of the processes such as cue-gathering and knowledge base and the nature of the tasks of the decision-making instances. How expert and novice nurses approach decision tasks has also not been well explicated, especially in CCUs. Much of the research has also concentrated on describing decision-making. Simply describing decision-making does not help in providing guidelines to nurses for developing decision-making skills. Information-processing theory can be used to develop an understanding of what is actually occurring during the processes of decision-making. Process tracing using information-processing theory has been used to illuminate invisible cognitive processes and to determine the cognitive strategies or operators used by nurses. A common method used in studies employing information-processing is think aloud (TA) and this has been used in some nursing studies to investigate various aspects of decision-making.

TA has been used by nurse researchers such Corcoran (1986), Jones (1989), White et al. (1992), Grobe et al. (1991), Tschikota (1993), Offredy (2002) and Cioffi and Markam (1997) with simulations, however, very little research has used TA in real-world settings. TA has been used in only a few studies in actual clinical practice, four of these in Australia. Mardegan (Aitken and Mardegan, 2000) examined the decision-making of CCU nurses about pain and Aitken (2000) examined the decision-making of ICU nurses about pulmonary artery wedge monitoring and examined concept attainment and processes of expert nurses, but did not examine both expert and novice nurses together. Greenwood and King (1995) examined the care planning of orthopaedic nurses and examined the concept levels used by both expert and novice nurses. Greenwood et al. (2000) examined the care planning of neonatal nurses and examined the scripts and schemata they use, as well as exploring some sources of information used. The processes as novice and expert nurses manage the care of AAA postoperative patients in ICUs have not been examined previously using TA. An examination of this can lead to important information for educating nurses entering the critical care area, especially in relation to the important aspect of care centred around monitoring and managing haemodynamic status. Research has shown that nurses' decision-making in this aspect of care can improve patient outcome by early detection of complications. The use of information-processing techniques is discussed more fully in the next Chapter, as well as the methods of information-processing, such as TA, to collect data and methods to analyse such data.

Chapter Four

Techniques to examine decision-making

The examination of research into decision-making in CCU and ICU covered in Chapter Three has shown that there are some contentious findings centred on the problem-solving or decision-making processes of novice and expert nurses. These cover the processes of hypothetico-deductive reasoning, chunking and pattern-matching, as well as perception and use of cues. After examination of the different approaches to studying decision-making in Chapter Two, information-processing theory was determined to be best suited for this study to examine the unseen processes of decision-making, as it can help illuminate the cognitive mechanisms and structures responsible for decision-making. This chapter examines some of the methods employed and issues around these in studies using information-processing theory. The issues considered are the use of either simulated case studies or real-world situations to examine decision-making, collecting data either by concurrent or retrospective protocols, analysing the protocols and development of the operator coding systems. Examples of studies investigated using various methods and approaches are included to illustrate points discussed.

4.1 The use of simulation and real-world settings

Studies in decision-making using real-world situations as opposed to simulated case studies have shown some contradictory results. As outlined in Chapter Three, there is a difference in the reported number of cues used by expert and novice nurses using simulations and real-world studies (Elstein et al., 1978; Tanner et al., 1987; Thiele et al., 1991; Benner, 2001). There is also a reported difference in the type of assessment used by expert nurses and the use of some cognitive operators by nurses in studies using the two approaches (White et al., 1992; Hanneman, 1996; Higuchi and Donald, 2002). Studies employing information-processing to examine decision-making can be approached either with set tasks in a laboratory, simulated case studies or real-world situations.

Traditionally, studies examining decision-making were conducted in laboratory settings. They were originally designed in cognitive science to eliminate the effects of experience and prior knowledge on memory tasks and hence introduce control, allowing generalisation of results to other populations. Early studies often examined inexperienced decision-makers completing predetermined laboratory tasks with no domain-specific or contextual knowledge (Ericsson and Kintsch, 1995; Hedberg and Larsson, 2003). Tasks such as the Tower of Hanoi which were unfamiliar to all study participants were used for this purpose. The Tower of Hanoi involves moving coloured quoits from one peg to another until they are ordered in size. This task requires no domain-specific knowledge and can be attempted by anyone. All participants were also given the same problem to solve in order to standardise studies.

Studying decision-making using such set tasks, however, sacrificed the critical interplay of capabilities developed in the past by individuals and knowledge, which is the hallmark of competent decision-making in real life (Elstein et al., 1978; Bergstrand, 1996). It also ignored the contextual features of decisions. Studies that are conducted in strictly controlled laboratory settings can only be generalised to other such settings which in no way reflect the world of real-life practice (Elstein et al., 1978; Aitken and Mardegan, 2000). CDM is never decontextualised, as it takes place in the natural setting (Lauri and Salantera, 1995). Studies of decision-making in real social settings where there are differences in the tasks attended and in clinicians' knowledge base and experience are important to understand CDM in relation to contextual variability (Elstein et al., 1978; Clark, Potter and McKinlay, 1991; Lauri and Salantera, 1995; Greenwood and King, 1995; Bergstrand, 1998; Aitken, 2000).

In medicine and nursing, simulations mimicking the natural world have often been used in decision-making studies to conduct research under realistic conditions, while at the same time controlling for extraneous variables (Thomas at al., 1991; Lamond et al., 1996). Controlling for extraneous variables was instigated to maximise external validity and ensure generalisibility (Thomas et al., 1991). To increase the external validity of simulations, steps were taken to increase the representativeness and realistic nature of the tasks presented to participants (Fonteyn et al., 1993). Such tasks were termed Patient Management Problems (PMPs).

PMPs are complex case studies mirroring real clinical settings and often involve transforming an actual situation into a case study. One arguable advantage of using PMPs is that it may be unethical to study real cases in natural settings (Jones, 1989; Roberts et al., 1996). Another advantage is that PMPs reportedly offer a standardised case for all participants, hence allowing comparison of performance across subjects (Roberts et al., 1996; Taylor, 2000). PMPs also allow the researcher to control cues presented to participants and to ensure reproducibility (Aitken and Mardegan, 2000; Taylor, 2000). In order for PMPs to be effective, they need good construct and content validity as well as external validity. They must demonstrate high fidelity (realism of the task) (Thomas et al., 1991). Some investigators suggest improving the content validity of case studies used in simulations by referring them to expert decision-makers in the area. However, the external validity of case studies is often questionable, as is the fidelity (Thomas et al., 1991). This occurs as case studies do not always represent the variety and complexity of real-world situations and may not capture important aspects of the real world. As well, concentrating on narrowly bound, discrete decision-making imposed by case studies and vignettes does not identify the processes used in everyday clinical decision-making (Patterson, Russell and Thorne, 2001).

The alternative approach to using simulations is to examine decision-making as it occurs in real settings (Greenwood and King, 1995; Aitken, 2000). According to Jones (1989), this poses problems and should be avoided. The first problem is the issue of unethical behaviour, whereby the use of TA in real settings exposes patients to a nurse’s cognition, some of which might be undesirable (Jones, 1989). The second problem is the inability to control the research setting, which may introduce variability between subjects and lead to contamination of the research process (Aitken and Mardegan, 2000).

The ethical problems suggested by Jones (1989) have been addressed by researchers such as Greenwood and King (1995) and Aitken (2000) in Australia and will be discussed later in relation to issues arising from TA. The second problem, the contamination of the research in natural settings by interruptions which may alter the decision-making in unpredictable ways, has also proven to be more advantageous than disadvantageous, as capturing such contamination can show how real decision-making can be influenced (Aitken and Mardegan, 2000). Although the use of natural settings leads to an inability to control the research setting and hence extraneous variables, it does provide an opportunity to study decision-making as it occurs in normal clinical practice (Aitken and Mardegan, 2000). This can allow the examination of decision-making during routine care, as well as during times of unexpected events and complications, all of which greatly increase knowledge of clinical decision-making. Examining similar care episodes for patients undergoing the same procedure over approximately the same time period can be used to control for some of the variability in decision-making in natural settings by ensuring more or less that decision episodes are standardised and reproducible. To collect data in studies using information-processing, TA has been used and is discussed below.

4.2 Verbal reports and thinking aloud

Verbal protocol analysis (VPA) and TA constitute a process-tracing technique developed in psychology to elicit cognitive processes that are happening in the unseen world of the mind (Ericsson and Simon, 1993; Thomas et al., 1991). TA represents the continuous verbal behaviour of a subject operating under instructions to “think aloud” and generates verbal reports that are a decision-maker’s account of her/his own mental processing (Newell, 1966; Taylor and Dionne, 2000). The verbal report is a step-by-step progression as the participant moves towards an outcome and is hence a time sequence of events (Jones, 1989). VPA is used to analyse observable behaviours recorded by TA and allows for an identification of the production rules moving the decision-maker from one state of knowledge to the next (Barber and Roehling, 1993). The production rules tell the central processor what action to take (what operator to employ) when dealing with a knowledge state.

Verbal reports have the basic assumption that verbal behaviour can be analysed like other behaviours and offer more direct evidence of the decision processes under investigation than some other methods such as observation or interviewing (Barber and Roehling, 1993; Aitken and Mardegan, 2000). Verbal reports are also open-ended and impose little structure on participants and can be used to examine decision-making as it occurs in the real world (Barber and Roehling, 1993). The verbal protocol, which is a self-report, can be of two main types, concurrent or retrospective, and is often used concurrently with observation (Ericsson and Simon, 1993; Johnson, 1993).

Concurrent verbal reports are collected as the decision-making actually proceeds, whereas retrospective verbal protocols use questioning to gather data after decision-making has occurred (Ericsson and Simon, 1993; Taylor and Dionne, 2000; Aitken and Mardegan, 2000). During concurrent TA, participants verbalise their thoughts directly as they enter their attention, and the thoughts are taken to represent what is occurring in the STM as well as the knowledge being accessed from the LTM (Ericsson and Simon, 1993; Greenwood et al., 2000). During retrospective TA, participants access information in the LTM, information that has been stored as a result of processing during a decision task (Aitken and Mardegan, 2000). The verbal protocols generated either concurrently or retrospectively are analysed to understand both the content and process of decision-making (Davison, Vogel and Coffman, 1997). According to Kassier, Kuipers and Gory (Ericsson, 1996), this is particularly important, as participants can offer inaccurate or misleading inferences when recalling their own thought content and processes, and concurrent verbal reports can help obviate this problem. Observation is often used as well, with both concurrent and retrospective protocols, to increase the depth of data collection. There have been some methodological concerns with VPA and TA that requires addressing in all studies employing these procedures. TA and VPA will be discussed, then methods of observation will be addressed in the following sections.

4.2.1 Verbal reports and small numbers of participants

The information-processing theory and its methods differ from true experimental approaches in that no control is employed and small samples are used. Individual instances of problem-solving or decision-making are examined and each individual study of a decision-making task is considered a microtheory (Newell, 1966). Examination of a number of microtheories, centred on the same or similar decision task, leads to more general theories of what mechanisms of decision-making are possibly common to humans across problem-solving and decision-making tasks (Newell, 1966).

The small number of participants, however, is seen by some as a disadvantage and this type of research, along with other research methodologies that recruit small numbers, has been criticised for its inability to allow representative sampling and generalisation (Yin, 1989; Taylor, 2000). Representative sampling and the use of parametric statistical procedures are valued, as they allow generalisation to a population as a whole (Burns and Grove, 1995). The argument that studies using small numbers are not as valuable as large, generalisable studies is countered by the ideas of replication logic and theoretical generalisation (Yin, 1989). Replication logic is the logic of experimentation, whereby experiments are repeated many times to test results. In studies employing TA, the many decision-making instances recorded are similar to repeating an experiment many times and represent replication logic. Theoretical generalisation means generalising to existing theory and not to populations. Even though TA and VPA do not offer statistically defined differences in populations at the more abstract level, they can be used to make class predictions which are useful for comparing groups (Newell and Simon, 1972). To be useful in this way, potential weaknesses in TA need to be addressed.

4.2.2 Issues with verbal reporting and TA

Verbal reports and TA have some potential weaknesses which need to be acknowledged and dealt with in designing research using this method (Johnson, 1993). These perceived weaknesses include concern that many forms of rapid, skilled, perceptual-motor performance or highly automated, intuitive processes would not be captured by the verbal report (Ericsson and Charness, 1994), possible increased reaction times during TA (Johnson, 1993) and concern that verbal reporting will change the underlying processes

(Ericsson and Charness, 1994). The large amount of data also presents a drawback, as it requires a great deal of time to analyse (Taylor, 2000). Concerns about the issues of validity and reliability have also been raised, as has the issue of the required length of time for data collection and how best to collect data (Taylor, 2000). These are discussed below.

A major concern is that only heeded traces of thinking will be verbalised. Heeded traces involve those that the participant is attending to and is aware of. Automated or parallel processing, which the participant may not be aware of, may not be reliably reported (Taylor and Dionne, 2000). This raises the issue of whether or not the automated intuitive processes, believed to be involved in expert practice, are detectable using TA (Barber and Roehling, 1993). Observation by the researcher during the concurrent verbal reporting has been suggested to help identify processes that may not be verbalised. Observation can help overcome the problem of highly automated processing by allowing the researcher to view non-verbalised behaviors, such as pauses, that can be explored later in an interview (retrospective recall) (Newell 1966; Coderre et al., 2003).

The problem of unverbalised decision behaviour can also result when well-known decision tasks are part of a study. Tasks can influence the verbal report and a familiar task or tasks that are simple can induce well-learned or automaticised routines that may not be heeded in the STM (Taylor, 2000). This can lead to meagre verbalisations that do not cover some of the participants' automaticised routines. The decision-making that occurs in everyday nursing care will contain some instances of this type of verbal report and observation may also be useful to overcome this.

There has also been some concern that using TA alters the content of thought and the speed of task performance (Fonteyn et al., 1993; Taylor, 2000). Studies have shown that in the examination of tasks such as simple addition and gambling risks, accuracy and response are affected by TA (Johnson, 1993). In more natural tasks, however, Fonteyn, (1998) reported that a study by Henry, Lebreck and Holzemer did not find that TA affected accuracy and response. This study compared the performance of three groups with a simulated case; one group was instructed to think aloud, one group was instructed to recall thinking and the last group was given no instructions. There were no differences in performance for the content or speed of processing between the three groups. However, others have stated that more time can be spent making verbalised decisions as opposed to silent decisions (Johnson, 1993). Again, observation may be useful to detect any decision-making behaviour that is not recorded in a verbal protocol.

TA has also been criticised on the grounds that participants are instructed to describe cognitive processes and this does not accurately represent the thinking of participants and may in fact alter their cognition (Ericsson and Simon, 1993; Barber and Roehling, 1993; Taylor and Dionne; 2000, Taylor, 2000). However, a study by Johnson (1993), comparing young and old decision-makers, found that the TA instructions did not affect cognition during the decision-making of either group. Further, a study by Barber and Roehling (1993) examining the affect of TA on task performance had two groups with different means of reasoning about a task. One group was asked to verbally reason about tasks and one group was asked to give written responses about similar tasks. No significant differences were found between performances for the two groups, leading the authors to conclude that TA does not affect the performance of tasks. It has also been found that TA does not affect the decision outcomes or the type and amount of information requested in studies using simulations and verbal reports (Johnson, 1993).

The study by Barber and Roehling (1993) also examined the effect of prompts on performance during TA and found no differences between the control and study group, allowing the researchers to conclude that prompts do not interfere with task performance (Barber and Roehling, 1993). It is suggested, therefore, that to overcome any effect on decision-making, researchers need to carefully instruct participants to only verbalise the thoughts as they come to mind and not to try and explain their thinking (Ericsson and Simon, 1993; Aitken and Mardegan, 2000; Taylor and Dionne, 2000). The participants are also asked to practise beforehand to get used to doing this and often the type of problem used to practise is an exercise such as count the number of windows in your house (Ericsson and Simon, 1993; Aitken and Mardegan, 2000; Taylor and Dionne, 2000). Practising verbalising ensures that both the researcher and the participant have the same understanding of what is required during the data collection and also reduces anxiety. It has also been suggested that the same instructions are given to all participants. Researchers may also need to prompt participants to continue verbalising thoughts by using instructions such as, “keep talking”, during the collection of data.

Another issue that has been expressed is concern about the reliability and validity of the data generated using TA (Taylor and Dionne, 2000). The use of both concurrent and retrospective reports is believed to increase the reliability of access to cognitive processes, as both methods can supply different, complementary sources of information. Although retrospective recall is considered of lesser value than concurrent TA, the use of both is advocated to increase the overall depth of data collected (Ericsson and Simon, 1984, 1993; Fonteyn et al., 1993; Greenwood et al., 2000). The use of both can also increase reliability, as there is often considerable overlap of both types of protocols (Taylor and Dionne, 2000).

In a study by Taylor and Dionne (2000) using both concurrent and retrospective recall, there was a high level of agreement reported between both types of reports, with no incidents or situations solely being reported in one or the other, and this was taken as indicating a high level of validity and reliably for the methodology. Consistency and reliability in data collection can also be improved by having one researcher collect and analyse all data (Aitken and Mardegan, 2000).

The use of retrospective reports has special problems that need to be taken into consideration in research. There is a concern that retrospective reporting can lead to participants reconstructing accounts rather than reporting accounts of cognitive processing (Taylor and Dionne, 2000). The information may also be a generalised conceptualisation of the type of processing task rather than an account of a single episode

(Taylor and Dionne, 2000). The information in retrospective reports may represent the problem-solving strategies of the participant but not necessarily what happened in the task under investigation. To counter this, it is suggested that the probes and questioning in retrospective protocol sessions are appropriate and designed to stimulate recall of specific incidences of the concurrent session. To achieve this, the researcher is advised to review the concurrent protocol as soon as possible after the session and it is recommended that the retrospective interview is held close to the time of concurrent session, a maximum of two to three days after, if possible (Ericsson and Simon, 1993).

There is also a chance of bias in retrospective reporting, as the participant may anticipate what the researcher wants to hear and report this (Ericsson and Simon, 1993; Taylor and Dionne, 2000). Participants may outline strategies or change their processing to make themselves appear more rational to the researcher (Johnson, 1993). To overcome possible bias, the questions and instructions for retrospective reporting need to be kept neutral, be based on the concurrent reporting and be as brief as possible, and again the retrospective reporting needs to be collected as close as possible to the concurrent report (Ericsson and Simon, 1993). The questions used as probes in retrospective reporting can act as retrieval cues and should be in the form "Can you recall what you were thinking when …." (Ericsson and Simon, 1993). Care needs to be taken that probes do not ask for more information than is needed or create bias by asking leading questions (Taylor and Dionne, 2000).

There is further concern that, during concurrent reporting, the fact that participants are asked to think aloud and that they are being tape-recorded will lead to a social desirability bias (Barber and Roehling, 1993). This can lead to participants being self-conscious and unwilling to verbalise all their thoughts completely. However, if participants are allowed to practise first and to get into the flow of reporting all thoughts, then this becomes less of an issue.

The collection of data obtained during TA allows a very detailed examination of decision-making. This has led to debate over how long the TA sessions should be to give rich, detailed data and how best to collect such data. The time used should be long enough to allow the collection of rich data and, to ensure this, Aitken and Mardegan (2000) allowed two hours for data collection in natural critical care settings, while Greenwood and King (1995) allowed 10-20 minutes. Greenwood and King (1995) were examining the planning of care and this may have been long enough for the purpose of their study; two hours are probably needed for many other purposes.

To collect data, usually the verbal protocol is produced by tape-recording and transcription either concurrently or retrospectively and by a record of relevant non-verbal behaviours using methods such as observation (Newell, 1966). It has been suggested that transcription of the protocol is best undertaken by someone familiar with the tasks and language of the field being investigated to allow for accurate transcription (Fontyn et al., 1993). Someone familiar with the field has also a better understanding of tasks performed and is more likely to accurately record behaviours noted by observation. TA has been used in this way in real-world settings, however, there is concern that the use of TA in real-world settings may negatively impact on patients and this needs to be addressed.

4.2.3 Potential risks of TA in real settings

Using TA in real settings could have potential risks in research, one of these being the exposure of patients and their relatives to information about the patients' condition that could potentially distress the patients. This could be potentially more damaging in the ICU setting where patients and families are particularly vulnerable, due to the serious nature of the patients' illness.

Steps have been taken in studies using TA in real-life settings to successfully limit the harm to patients and families. A study undertaken in ICU used TA in real-life situations to examine the concepts and processes used by nurses while monitoring patients with a pulmonary artery catheter (Aitken, 2000). In this study the patients were not considered to be participants, however, steps were taken to ensure that the data collection respected the patients and did not upset them (Aitken, 2000). It was explained to the patients before data collection began that the nurses would be talking constantly. This was undertaken for both conscious and unconscious patients and their relatives. It was further explained that the patients could ask for the data collection to be stopped at any time if they found it was upsetting them. This option was not taken by any of the patients (Aitken, 2000).

The talking that occurs during TA sessions is similar to the discussion normally occurring between nurses and clinical educators during clinical teaching (Greenwood and King, 1995; Aitken, 2000). In normal ward situations, consultation between nurses and peers and physicians is also a regular feature and is again not dissimilar from the talking experienced in TA sessions (Greenwood and King, 1995). As TA was similar to normal discussions that occur at the bedside, it was not seen as being a problem in the studies by Aitken (2000) and Greenwood and King (1995). Both Fonteyn et al. (1993) and Aitken and Mardegan (2000) found that patient care was not compromised by the TA procedure in critical care areas: nurses stated the data collection did not interfere with ward routine or patient care.

Another tactic taken to limit harm to patients from exposure to detrimental data was to instruct nurses to not verbalise any information that they felt could possibly distress the patients or their families (Aitken and Mardegan, 2000; Greenwood and King, 1995). The nurses were either encouraged to verbalise such information away from the bedside where the patients or families could not hear what was being said or to discuss any information left out later in retrospective interviews (Aitken, 2000). Gaps in the tape which occurred due to nurses ceasing TA were also explored in the retrospective interviews. Another option offered to the nurses was to be able to start and stop the taping as they chose, to avoid collecting any information that they considered to be inappropriate, and not in the patients' interest (Greenwood and King, 1995).

Nurses planning care in an ICU in Australia were observed and while TA was not used, the researchers used observational recordings of what was happening (Bucknall, 2000). Ethical considerations, for privacy and anonymity of patients, were ensured by deleting from transcripts any identifying data. Patients were not asked to provide consent in this study, as again any discussion by the study nurses with other health-care team members was considered not dissimilar from the normal consultation that occurs while caring for patients.

The issues concerning collection of data using TA can be managed by various procedures discussed above, as well as by observation, which has been used with TA to help increase the depth of data collected and to detect any non-verbalised behaviours. The methods common in observational studies are reviewed before examining the analysis of TA transcripts.

4.2.4 Observation

Observation is useful in verbal protocol recording to increase the understanding of behaviour (Newell, 1966). It is suggested that observations and the recording of body language, as well as context, can help in the interpretation of TA transcripts and in the recognition of non-verbalised behaviour that may indicate automatic processing (Newell, 1966). Observation is also a valuable research method to collect real-time data of the types of decisions that nurses actually make in day-to-day practice. This is important, as it has been noted that nurses' recall of what they did may not match what actually happened (Watson, 1994; Bucknall, 2000; Thompson and Dowding, 2002).

Observational studies can involve two main types, unstructured and structured (Burns and Grove, 1995). Unstructured observation involves spontaneously observing and recording what is seen with minimum prior planning (Burns and Grove, 1995). The researcher enters the field without specific hypotheses or preconceptions (Morse and Field, 1996). Field notes are taken either while in the field or immediately after. Videotaping and audio-taping can be used in conjunction with the field notes (Burns and Grove, 1995). Field notes of unstructured observations and post-observation interviews which are semi-structured have also been used in research studies examining decision-making in real-world settings (Watson, 1994; Benner et al., 1999; Kennedy, 1999).

Unstructured observations with event sampling have been used in an intensive care setting to examine the types of decision activities of nurses (Bucknall, 2000). Event sampling involves recording events of interest as they are happening; this differs from time sampling during which observations are made at predetermined intervals (Burns and Grove, 1995). Unstructured observation has been combined with TA to enable exploration of non-verbal and apparently intuitive, unconscious decision-making behaviours which were explored with study participants at subsequent interviews (Greenwood et al., 2000, Coderre et al., 2003).

In busy clinical areas, using field notes may lead to a tendency to over-collect and to focus on irrelevant information. Selective observation may also be a problem in busy areas and consists of noticing some people and events while ignoring other people and events, based on prior experience, attitudes or values (Neuman, 1994). Individuals may be biased in what they notice and only select and collect that data. In contrast to unstructured observations and field notes, structured observations can allow the focusing on data of interest. Structured observation, in natural settings, represents an efficient method of collecting information on specific aspects of the environment and can help focus data collection.

Structured observation involves defining carefully before data collection what is to be observed and constructing a method of recording the observations (Burns and Grove, 1995). For structured observations, a system based on written rules, which explain how to categorise or classify, needs to be developed. In most studies a categorical system or tick boxes are developed for organising and sorting behaviour.

The Hawthorne effect, whereby participants in a study act differently because they are being observed, has been a problem in observational studies (Burns and Grove, 1995).

This needs to be considered in observational studies and has been managed in nursing studies employing observation by accepting that the behaviours of nurses observed in the clinical area represent the best practice of which the nurses are capable.

Verbal protocols (VPs) generated by TA, combined with observation, are an effective method to collect data on the unseen decision processes as nurses care for patients in the real world. VPs can be analysed in different ways, as can observational data, and these are discussed.

4.3 Analysis of data

The analysis of data collected by observation is considered first, then the analysis of data collected by TA. Observation is used to record instances of non-verbalised behaviors, as well as to increase the depth of data collected.

4.3.1 Analysis of observational data

Data from structured observations are often analysed using content or thematic analysis (Offredy, 1998; Bucknall, 2000). Manifest content analysis consists of analysing for key words, phrases, descriptors and terms central to the research which can be tabulated and then analysed using descriptive statistics (Morse and Field, 1996; Denzin and Lincoln, 2000). Examining for patterns of words and phrases often in the concepts arising from the data can help to develop themes (Morse and Field, 1996; Denzin and Lincoln, 2000). Once categories have been developed in the analysis, relationships can be explicated by using such procedures as matrix formation (Morse and Field, 1996). Categories can also be related to established theoretical concepts. The categories and themes developed from analysis of observational data can be used to complement the data from the analysis of TA protocols and help to better understand decision-making in context.

4.3.2 Analysis of TA protocols

TA protocols can be analysed in a number of ways, depending on the purpose of the study for which they are employed; however, the analysis of verbal protocols usually involves some form of coding technique (Ericsson and Simon, 1993). Coding can be used to analyse for content or it can be used to model a decision, determine conceptual links or trace decision processes (Barber and Roehling, 1993). Three main coding methods are the use of decision trees, concept or semantic maps and Problem Behaviour Graphs (PBGs).

4.3.2.a Decision trees

Decision trees can be used for modelling of decisions and this works best for the type of decision that has a yes/no answer. Data are coded in the form of decision trees that have nodes and alternatives which can be followed during a decision. A search tree can be developed, with the nodes of each tree representing a knowledge state (Wong and Chung, 2002). A similar approach was used in a study of Australian critical care nurses to analyse pain management episodes (Aitken and Mardegan, 2000). Probabilities were calculated for the frequency with which each nurse carried out specific aspects of pain assessment or pain management and a decision tree was developed. This methodology is suitable for studying such specific tasks, but other methods can be used to examine differing aspects of decision-making, such as concepts used during decision-making.

4.3.2.b Concept or semantic nets

A method from text comprehension that involves segmenting text into clauses and determining the propositions in each clause was employed by Patel and Arocha to examine the concepts used by medical practitioners during decision-making (Higgs and Jones, 1995). Semantic or concept nets were developed that showed concepts and propositions from the clauses and the relationships between them. Concepts were represented as nodes and relations as links between the nodes. A study of Australian critical care nurses' decision-making also used concepts maps and mapped relationships between the concepts used by nurses during decision-making (Aitken, 2000). This type of analysis is useful for analysing relationships between concepts used during decision-making in clinical situations, while PBGs are more suitable for tracing the steps of a decision and elucidating a decision process.

4.3.2.c Problem behaviour graphs

The most influential coding technique for determining processing models is the use of PBGs (Newell and Simon, 1972; Ericsson and Simon, 1993). The coding technique used in PBGs provides a detailed analysis of TA protocols and a step-by-step process of the participants' reasoning can be represented diagrammatically (Jones, 1989; Greenwood and King, 1995). A graph is constructed which represents concepts or knowledge states down the vertical axis and the operator that moved the reasoning from one concept or knowledge state to the next across the horizontal axis. This allows identification of each knowledge state during reasoning, as well as the operators that moved the reasoning from one knowledge state to the next.

A common approach in analysing verbal protocols using PBG is to firstly segment the verbal protocol in some way. This can be done following the natural contours of speech into meaningful phrases (Greenwood and King, 1995). These meaningful phrases are then numbered A1–An for participant one, B1–Bn for participant two and so on. The next step is to then to construct the problem space for each protocol, and this usually involves some partitioning and description of the sections of the problem task (Newell, 1966). This may involve dividing each protocol into sections that reflect subtasks in the overall task protocol and describing the subtasks briefly. For example, in the domain-free Tower of Hanoi task, in which participants are asked to rearrange coloured quoits from one peg to another until they are in order from largest on the bottom to smallest on the top, problem subtasks may involve the movement of each of the coloured quoits. Outcomes can also be described for each subtask and add to the construction of the problem space (Newell, 1966). Any other information that helps in the description of the subtask can be used to further outline the tasks. Some of this information may have been gained from observation. The whole script can then be described in terms of what the participant is doing in the subtasks (Newell, 1966). Segmentation of the total protocol behaviour into subtasks allows for regularities such as patterns of processes to be found. The next phase of analysis involves the use of three stages, as outlined below.

In analysis using PBG there are three stages,: the referring phrase analysis, the assertional phrase analysis and the script phrase analysis (Newell and Simon, 1972; Fonteyn et al., 1993) (see Appendix 9 for a summary of the process as used in this study).

4.3.2.d Stages of PBG analysis

- Referring phrase analysis: During this analysis the meaningful segments of each subtask, which have been numbered subsequent to segmentation into meaningful phrases, are examined in detail. For each meaningful phrase its referent, the information that the individual is concentrating on or holding in the STM while reasoning, is identified (Grobe et al., 1991). A referent can be a concept or object, and is considered a knowledge state. During reasoning participants concentrate on successive knowledge states as the reasoning moves from one referent, concept or object, to the next.
- Assertional phrase analysis: The concepts identified in the referent phrase analysis provide a conceptual vocabulary for the next stage of the analysis, the assertional phrase analysis (Greenwood and King, 1995). This stage examines the relationships between objects or concepts identified in the referent phase analysis (Fonteyn et al., 1993). An operator moves the reasoning from one referent phrase (knowledge state) to the next, and identification of the operators constitutes the assertional phrase analysis.
- Script phrase analysis: Script analysis involves identifying (coding) the cognitive processes the participants use to manipulate the concepts in their reasoning (Jones, 1989). This stage of the analysis aims to develop overall explanations from the referring and assertional phrase analysis.
- Creating the graphs: Each referring phrase segment which has been numbered A1–An, B1–Bn and so on, is then plotted on a vertical axis in sequence with the time scale running down the vertical axis (Newell and Simon, 1972; Jones, 1989). The operators identified in the assertional phrase analysis are then added down the graph between the referring phrase or knowledge state they change to the next referring phrase or knowledge state. The vertical axis shows how the subject moves from one line of enquiry to another and reflects the sequential concepts that are attended to, and the operators show how each referent phrase is related to the next (Jones, 1989) (see Appendix 11 graph 1 for example).

In nursing, referring phrase analysis which examines concepts on which participants concentrated, has been approached in different ways depending on the objective of the study. In a study by Higuchi and Donald (2002), the aim was to use TA to analyse diary entries kept by nurses of their reflections on their reasoning over time. The researchers used a referring phrase analysis that examined the TA script for verbs that denoted tense to determine whether the participants were reflecting on the past or future or mainly the present. They also examined the script in this stage for nouns used, to determine the types of thinking and cognitive processes the participants were describing.

The patient problems and interventions on which nurse participants were concentrating constituted the referring phrase analysis in a study of nurses' care planning and were represented by such concepts as medication compliance, insomnia, something for sleep (Grobe et al., 1991). Referring phrase analysis can differ between studies, as it reflects the main focus of the study (Grobe et al., 1991). In contrast to the problems and interventions of referring phase analysis in the study of Grobe et al. (1991), the referrant phrase of a study of nurses' assessment involved the activities of daily living (Jones, 1989), as did a study of neonatal nurses while caring for patients (Greenwood et al., 2000).

The concepts listed by researchers in nursing often have many similarities but also some differences, according to the area of enquiry. Common concepts from nursing studies appear to be aspects of respiration and breathing, observations including temperature, circulation and pain, anxiety, eating and appetite, hydration and intravenous therapy (IV), pressure area care, mobility, elimination including urinary output and constipation, life patterns and home circumstances, sleep and hygiene (Jones, 1989; Greenwood et al., 2000). This holds true for both simulations and real-world decision-making. The common concepts occurring in varied research situations should probably be considered in decision-making studies as they are fairly representative of common concepts that nurses will need to consider during care. Once concepts or knowledge states are identified, the next stage of the analysis identifies how the participant moved from one knowledge state to the next by identifying operators.

The analysis in the assertional phrase analysis can be accomplished in a number of ways as well, by either describing the relationships between concepts or identifying the operators moving the reasoning from one knowledge state to the next. The relationships between concepts were described by Greenwood et al. (2000) in Australia and Fonteyn et al. (1993) in the USA. Both researchers used practising nurses, one in a real-world setting (Greenwood et al., 2000) and one using simulation (Fonteyn et al., 1993). The relationships were described as connative, indicative and causal. Connative assertions referred to meaning, indicative assertions referred to relationships of significance, while causal referred to cause and effect (Fonteyn et al., 1993; Greenwood et al., 2000). The relationships describe how assertions in the text are related together and give an idea of how participants are linking concepts on which they are concentrating.

The use of operators in this stage of analysis has also been used in order to determine how a participant moved from one knowledge state to the next by examining the operators that transformed each phrase or segment (Jones, 1989). The operators identified for a study can vary depending on the field of study and this is discussed in more detail in the next section. The relationships, however, are inferences made by the researcher, as TA protocols do not collect information on the actual reasoning processes, only what the subjects verbalise as they reason; the researcher then interprets the change in knowledge states in the form of relationships (Ericsson and Simon, 1993). This may mean that coding cannot be made totally objective and sound, as coding depends on the researcher's inferences (Ericsson and Simon, 1993). The verbalisations of the subject, however, correspond to what s/he is thinking about and the inferences coded by the researcher are tested for reliability by the use of inter-coder reliability, such as Kappa, to determine the degree of agreement between two or more independent coders (Taylor and Dionne, 2000). The coding can also be assessed for reliability by having clearly defined coding grids illustrated with examples (Taylor and Dionne, 2000). Developing codes of operators is discussed in Section 4.4.

In the script phrase analysis, overall processes can be analysed and described. The processes described by Jones (1989) were backward and forward reasoning, while Greenwood and King (1995) identified codes for cognitive processes in this stage, consisting of reviewing information and patient data, planning, providing rationales for actions, interpreting particular patient information in light of both general and patient-specific information, and diagnosing.

Content analysis can also be employed during the script phrase analysis to determine such things as knowledge types and source (Lamond et al., 1996). The script can also be examined to develop overall themes by thematic analysis or determine how cues are used by participants. Again the purposes of a particular study will dictate the approach or approaches taken in this stage of the analysis.

Verbal protocol analysis can also be used to carry out a more global analysis, to compare decision behaviours across participant groups (Ericsson and Simon, 1993). Categorisation and then aggregation become necessary to show differences between participants. Aggregating can be undertaken to compare novice and expert decision-makers (Ericsson and Simon, 1993). The relative frequency of processes for each participant can be obtained and analysed using descriptive statistical techniques (Ericsson and Simon, 1993)

The operators used in PBG can be developed in different ways and often differ according to the field of inquiry or type of problem. Operators can be developed either *a priori* from theoretical concepts or during the analysis of transcripts, and are discussed below.

4.4 Coding of Operators

The basis for the coding of operators can be developed in two main ways. Coding can be extracted from the protocols themselves by the researcher or they can be based on *a priori* theoretical concepts (Ericsson and Simon, 1984, 1993). Coding categories that are derived from theory are often, according to Ericsson and Simon (1993), infected with theoretical assumptions. This is sometimes unavoidable but necessary if testing theory using this method (Ericsson and Simon, 1984, 1993).

Operators have been developed either in relation to problems requiring domain-free knowledge or those requiring domain-specific knowledge. Operators developed for domain-free problems are designed to elicit general problem solving abilities common to all. An example of a domain free problem is simple mathematical or crypto-arithmetic problems (Ericsson and Simon, 1984, 1993). In crypto-arithmetic problems, participants work out which letters a set of numbers represent and the operators reflect these tasks. The operators identified by Ericsson and Simon (1984) were intentions representing goals and future states, for example, shall, will, cognitions, information based on attention to selected aspects of current situation, planning, if/then propositional statements, evaluations and comparisons of alternative “yes”, “no” statements. As well as if/then production rules, some aspects of the use of trial and error wherein solutions are tried and evaluated were uncovered, as were surveying information, and generating new information. In nursing, Jones (1988) discussed the use by nurses of if/then statements or production rules in clinical problem-solving that is reliant on domain-specific knowledge and gave the example “If the patient is frail, then the level of mobility is decreased, if the level of mobility is decreased then the risk of pressure sores is high”. This was, however, a proposed mechanism and whether nurses really do use such rules in the clinical setting has not been ascertained. In contrast to the domain-free problems used in simple mathematical problems, operators have been developed for domain-dependent problems, such as for historians and nurses.

A study of historians’ decision processes while reasoning about historical situations used operators developed for the tasks (Wineburg, 1991). The operators developed were description, describing the situation, reference, statements that referred to other documents or related some aspects to the individuals’ mental model, analysis statements that related points of view, or intentions and qualification statements that qualified other statements (Wineburg, 1991). A miscellaneous category was also created to categorise statements about the tasks such as, “What am I going to do?”. Novice and expert historians used operators differently in this study.

The operators used in nursing have varied based on the speciality setting, whether a specific episode is being examined, which country provides the setting for the research, whether a real or simulated environment is used and what level of nurses are involved

(Jones 1989; Greenwood and King 1995; Lamond et al., 1996; Greenwood et al., 2000; Higuchi and Donald, 2002). The operators described for studies are examined below in light of the similarities and differences with reference to the type of task, area of practice, country of origin and how the operators were developed for each study (see Table 2).

Studies in England have used the operators “collect data”, “choose”, “review data”, “interpret data”, “relate data”, “diagnose” and “act” (Jones, 1989) as well as “goal”, “reason” and “predict” (Lamond et al., 1996). Both these studies used simulations but may have had some differing operators, as Jones (1989) examined a specific instance of care, pressure ulcer prevention and Lamond et al. (1996) examined care planning at the beginning of a shift (see Table 2).

Table 2: Operators used in studies employing PBG

Higuchi and Donald, (2002)	**Jones (1989)**	**Lamond et al., (1996)**	**Greenwood and King (1995)**	**Greenwood et al., (2002)**	**Fonteyn et al., (1993)**	**Wong and Chung (2002)**
Description	Collect	Read	Observe cues		Study	Collect
	Review			Review		Review
		Goal				
Representation		Reason		Rationale	Explain	
Selection	Interpret	Interpret		Interpret		Interpret
Inference	Relate,infer					Relate
		Predict				
Synthesis					Choose	
				Diagnose	Conclude	
	Act	Plan	Action			Action
Verification		Evaluate	Confirm information			

The operators identified in England are similar to those used in a study in the USA, which included “study”, “choose”, “explain” and “conclude” (Fonteyn et al., 1993) with “explain” being similar to “interpret and relate data” “conclude” to “diagnose” and “choose” to “collect”. The operators are also similar to those from a study in Hong Kong, except that this study also included “entry”, “exit”, and “infer” (Wong and Chung, 2002) (see Table 2). “Collect” was the most frequently used operator in all these studies which used simulations, with “act” being used infrequently. “Act” may be more common in real-world studies.

Two studies examined planning care in real situations and used the operators described above by Jones (Greenwood and King, 1995; Greenwood et al., 2000) (see Table 2). In these real-world studies, “collect” was also the most common operator and novice nurses used the operator “collect” more often. Nurses may spend much of their reasoning time employing this operator that is, gathering information and data about patients. These two studies used operators developed from previous studies in nursing. However, a different approach was taken by Higuchi and Donald (2002) in the USA. They examined protocols in the form of written progress notes rather than verbal reports. They developed the operators used for the examination of the transcripts from a model describing higher order thinking skills used in a university (Higuchi and Donald, 2002). The operators were classified under six categories in order from lower to higher order thinking skills, these being “description”, “selection”, “representation”, “inference”, “synthesis” and “verification”. The category “description” involved listing facts, goals and conditions, “selection” involved identifying relations, “representation” involved portraying a situation, “inference” involved interpreting and drawing inferences, “synthesis” involved combining information and “verification” involved judging coherency and accuracy. Operators identified in other studies were similar in many respects and often involved describing, relating, making inferences, putting information together and evaluating (Table 2 lists the operators from various studies and compares those that are similar).

In the studies examining decision-making and cognitive operators used, there are some common operators, such as “collect” or “review data”, “describe”, “interpret”, “rationale” or “give cause”, “conclude” or “diagnose” and “act”. These operators are common to studies in different countries and across different areas of practice and there is no reason to suggest these would not be in common in Australian ICUs as well. The cognitive operators used by Intensive Care Nurses, while reasoning about care for patients in real-world situations, has to date not been examined. Another method often employed in analysing TA transcripts, either alone or combined with PBG, is content analysis.

4.5 Content analysis

The transcripts from TA, both concurrent and retrospective, can be analysed by content and thematic analysis to answer the questions of the research and to develop themes from the data. Content and thematic analysis has been discussed in Section 4.2.2. in relation to analysis of observational data; the general principles also apply to analysis of data gathered by verbal protocols. When content and thematic analysis are used to answer the questions and aims of a research project, the assumption is that codes of interest have already been discovered (Robson, 2002). Themes, words, descriptors or phrases can be entered into a matrix to determine the number of times each is used by different participants or groups of participants (Denzin and Lincoln, 2000). For example, themes could be compared by the group, expert or novice.

A range of themes can be generated inductively from data (see Table 3). A study of nurses' reasoning during decision-making used content and thematic analysis to inductively identify the themes History, Examination, Intuition and Listening and then quantify the themes by counting the frequencies of each (Offredy 1998). Content and thematic analysis was also used inductively by Fonteyn and Cahill (1998) to explore the reasoning strategies of student nurses using written clinical logs. The thinking strategies described were recognising a pattern, forming relationships, generating hypotheses, providing explanations, drawing conclusions. Although the analysis employed content and thematic analysis, the themes developed are similar to the operators identified in studies using PBG, with recognising a pattern varying from previously reported thinking strategies and representing a further category of decision-making processes.

Content analysis was also used to examine the verbal transcripts of student nurses on simulated patients and the elements of decision-making identified inductively. These were combined to form processes that are somewhat different from the above but also show some similarities (Tschikota, 1993). The elements identified were stimulus response, listing, reviewing/summarising, non-decision structuring, hypothesis-testing and hypothesis treatment.

Table 3: Thinking strategies from studies using inductive content analysis

Tschikota (1993)	Offredy (1998)	Fonteyn et al. (1998)
Stimulus response	Cue acquisition	Recognising patterns
Listing	Hypothesis generation	Forming relationships
Reviewing/summarising	Cue interpretation	Generating hypothesis
Non-decision structuring	Hypothesis evaluation	Providing explanations
Hypothesis-testing		Drawing conclusions
Hypothesis treatment		

4.6 Summary

The operators used in Section 4.4 and 4.5 were developed *a priori* for each of the nursing studies. The main definition of decision-making used in the majority of these studies was that of hypothetico-deductive reasoning, which included operators such as collect information, interpret information, form conclusions, perform an action, carry out an evaluation. There have also been descriptions in decision-making research of the process of pattern-matching. For example, the study by Fonteyn and Cahill (1998) used content analysis to describe a decision strategy or process similar to pattern-matching which was entitled pattern recognition. No studies in nursing, however, have employed *a priori* operators for pattern recognition or pattern-matching to examine transcripts for pattern-matching. Few nursing studies examining decision-making have employed the use of PBG and cognitive operators and none have done so in ICU. Few studies have examined differences between expert and novice nurses, although some have examined decision-making in varying nursing specialties. This study was implemented to begin to address some of these gaps in the knowledge of novice and expert decision-making in ICU.

4.7 Aim

The purpose, as outlined in Chapter One, was to examine the cognitive strategies and decision processes of novice and expert nurses during real-world decision situations in critical care nursing, represented by AAA patients being cared for postoperatively in ICU. To accomplish this, the specific aims of the study were to:

1. Describe the tasks involved during the decision-making of expert and novice nurses while monitoring patient haemodynamic status and caring for patients post AAA surgery;
2. Describe the use of cues for making decisions by expert and novice nurses while monitoring patient haemodynamic status and caring for patients post AAA surgery;
3. Examine the sources of information used by expert and novice nurses to make decisions during monitoring patient haemodynamic status and caring for patients post AAA surgery;
4. Examine the cognitive operators used by nurses of differing experience levels to make decisions while monitoring patient haemodynamic status and caring for patients post AAA surgery;
5. Examine the processes used by nurses of differing experience levels to make decisions while monitoring patient haemodynamic status and caring for patients post AAA surgery;
6. Determine whether there are any differences between novice and expert nurses for all of the above.

Chapter Five

Methodology

This Chapter describes the methodology of a study examining clinical decision-making in ICU in one hospital in a regional area of NSW. The study investigated how nurses make decisions about patient care in the real world of practice. The study investigated a previously unexamined area of ICU decision-making in Australian nursing, monitoring haemodynamic status post AAA surgery, and had as study participants both expert and novice nurses. The study examined the cognitive processes used by nurses while delivering care. The nurses' decision-making occurred over a two-hour time period during the actual care of post-operative AAA patients and data were collected using concurrent TA protocols and observation. Retrospective TA protocols were then collected during interviews. Analysis involved the use of PBG to graphically represent the participants' progress through decisions and content analysis to investigate and describe the problem space of the particular decisions. Describing the problem space involved examining task characteristics, cue usage and sources of information. Thematic analysis was also employed to elaborate on the task and cue usage, as well as the decision-making of participants.

This Chapter also explains in detail the development of a schedule to identify the concepts used in the analysis of the transcripts, as well as a schedule to identify the operators and processes used for the study. These were all developed from the literature and refined in the pilot study. The analysis by PBG and content analysis is also discussed in relation to the literature and the pilot.

The pilot study is discussed first, particularly in relation to the changes that consequently were made to the tools, followed by the main study. The discussion covers participants, definitions used to guide the study, procedures, schedules and development of these for the analysis phase of the study. Ethical issues are also to be discussed, particularly the issues presented by the method of data collection used in this study, TA. The methods to achieve reliability and validity are also outlined. Definitions used in the study are located in Appendix 2.

5.1 Method

The study was an empirical, descriptive study that investigated the decision-making of both expert and novice nurses during the care of patients post AAA repair. The study employed methods from information-processing theory, both TA and verbal protocol analysis, as well as content and thematic analysis, and did so in the real world of practice. Both TA and verbal protocol analysis are commonly employed in cognitive psychology to trace decision-making. The operators and cognitive processes used during reasoning and decision-making about haemodynamic status were the main focus of the study. Task characteristics, cues and cue usage, and information sources used were also examined to illuminate the operators and processes used. Descriptive statistics were employed to compare frequencies of operators and processes for participants, as well as cue usage and types of task.

5.2 Research questions

Research questions were developed to address the general aim of the study, to determine the cognitive strategies and decision-processes used by novice and expert nurses during decision-making in ICUs. The study was conducted using the information-processing framework and the research questions address aspects of decision-making in this framework that contribute to the use of different cognitive strategies or operators and decision processes. This study was designed to answer the following research questions:

- What are the tasks attended to by novice and expert nurses while monitoring patient haemodynamic status post AAA surgery?
- Are there differences in the types of tasks for novice and expert nurses while monitoring patient haemodynamic status post AAA surgery?
- What are the cues collected by novice and expert nurses while making decisions about the management of patient haemodynamic status post AAA surgery?

- Are there differences in cue usage for novice and expert nurses when making decisions about the management of patient haemodynamic status post AAA surgery?
- What information do expert and novice nurses use when monitoring patient haemodynamic status post AAA surgery?
- Are there differences in the information used by novice and expert nurses while monitoring patient haemodynamic status post AAA surgery?
- What operators do expert and novice nurses use when making decisions about the monitoring of patient haemodynamic status post AAA surgery?
- Are there differences in the operators used by novice and expert nurses when making decisions about the monitoring of patient haemodynamic status post AAA surgery?
- What processes do expert and novice nurses use when making decisions about the monitoring of patient haemodynamic status post AAA surgery?
- Are there differences in the processes used by novice and expert nurses when making decisions about the monitoring of patient haemodynamic status post AAA surgery?

5.3 Design

The study examined in depth the decision-making of nurses in a real clinical setting and this involved examining the reasoning of a small group of participants to elicit rich data from individual nurses. Expert nurses were compared to novice nurses on aspects of decision-making to make explicit any differences between the two groups. A criterion was used to identify expert and novice participants for selection into the study; this is described below in Section 5.3.1.

The decision-making examined in the study centred on haemodynamic status and included reasoning around interlinked concepts that have a direct or indirect impact on haemodynamic status. This included decision-making about haemodynamic status, management of pain, limb observations, comfort and measures to relieve anxiety (see

Figure 3). Only the decision-making around these interlinked concepts were included in the analysis.

Data were collected using TA to generate verbal protocols, and observation by the researcher of the participants' verbalisations. The protocols collected were both concurrent and retrospective transcripts. Collection of both forms of data can increase reliability of data and allow for a more thorough inspection of decision-making processes. Structured observations were employed to collect data during decision-making to detect unverbalised aspects of reasoning. The combined data-collection techniques were used to collect data on different aspects of decision-making.

To maximise the likelihood of similar decision-making tasks, the decision-making of nurses while planning and managing care of patients post AAA surgery was investigated. The care of patients within the first 24 hours after surgery constituted the decision-making episodes of the study. The TA sessions also all occurred during the first two hours of each participant's shift, to further ensure similarity of conditions for participants.

The study was conducted in two parts, a pilot study that was conducted two months prior to the main study, followed by the main study conducted over a six-month period. The pilot was conducted to trial and refine methods and tools. Both the pilot study and the main study were conducted in an ICU of a regional New South Wales (NSW) hospital. The ICU involved is a 12-bed unit serving a broad geographical area and the nurses in the unit regularly care for AAA repair patients, scheduled one day a week.

5.3.1 Participants

The participants consisted of eight ICU nurses in the study and one nurse in the pilot study. The nurses were recruited into two categories, novice and expert, with four nurses in each category. Sampling was purposive, as the nurses were selected for experience level (see Table 4 for selection criteria).

Table 4: Selection criteria for participants (adapted from Benner, 1984)

Expert	Novice
Registred Nurse (RN)	RN
Critical Care Certificate/Diploma, Certificate, Diploma or Degree in nursing	Degree in nursing
More than three years' Critical Care experience	No more than two years' experience in nursing
More than six months' experience in current unit	New graduate on rotation or direct entry critical care staff or recently commenced in critical care
Currently working at least 30 hours/fortnight	Currently working at least 30 hours/fortnight
Recognised as "senior" in unit with team leader responsibility	Recognised as "junior" in unit
Consider themselves to be experts in monitoring patient haemodynamic status in critical care areas	Consider themselves to be novices in monitoring patient haemodynamic status in critical care areas

5.3.2 Sample size.

The sample size used for the study was eight and was based on sample sizes used in studies of a similar nature. Small sample sizes are not uncommon in studies using TA, as data collection yields a large amount of data for each participant which is then intensively investigated. A detailed account of each participant's decision-making is undertaken and these are then compared. The results are not necessarily generalisable to the population, due to the small sample size and absence of parametric statistical analysis, but can be used to make class predictions to compare the groups by employing descriptive statistics such as frequencies of operators and processes. The data are rich in detail and can illuminate how decision-making of participants is occurring. The method also generates many tasks that are similar for both groups of participants which allows for replication logic, the logic of experiments, whereby repeated cases of similar tasks replicate the data for these tasks.

5.4 Procedure

Prior to the study, the manager of the selected unit was approached, the study discussed and permission sought to conduct the study in the unit. Permission was granted and recruitment sessions were used to enlist participants. The study began with a pilot study, which is discussed below.

5.4.1 Pilot study

The pilot study was designed to refine data-collection methods, the protocol used for structured observation and the interview schedule used for retrospective TA. It was also conducted to examine the proposed data-analysis methods and tools and refine these. An expert nurse volunteered to be in the pilot after the first recruitment session. The pilot session was conducted on an afternoon shift and lasted for two hours. Prior to data collection, the participant was given an exercise to practise TA. The exercise has been used by other researchers such as Aitken (2000), and consisted of asking the participant to TA while working out how many windows there are in her/his house. The exercise proved successful for the purpose of practising TA and this was reported in feedback by the participant. The exercise was consequently used in the main study.

5.4.2 Data-collection tools

The tools used in the study for the structured observation and the interview had been refined after piloting. The tools and the changes are discussed below. The observation schedule is discussed first, then the interview schedule.

5.4.2.a Observation schedule

An observation scheduled described by Bales (Kagan and Evans, 1995) (see Appendix 3) was adapted for this study. The schedule has 12 categories of group interactions and examines the interaction between individuals in a team or group. The tool was adapted by adding a timeline to record over the two hours what was happening. This observation schedule proved to be cumbersome and did not appropriately capture required data. Problems with this tool included:

- Inability to capture adequately participants' body language. At one stage the participant in the pilot looked perplexed; this was recorded on additional notepaper and explored in the interview by asking the participant "You looked perplexed when thinking about …, is this correct and can you explain your thinking and what was worrying you?"

- Some of the data collected by the tool also proved to be redundant, as the same data were recorded in the TA transcripts. For example, the information about the verbal interactions with peers could be heard on the tape and all that was needed on the observation schedule was a note as to who the participant was talking to and at what time.
- The section recording what participants wrote on charts and in notes was also omitted from the final observation tool. Participants were verbalising as they wrote on the charts and in the patient notes, leading to a verbal record of this data.
- The schedule was also modified in order to be easier to use and the final version only had three sections for recording what was happening (see Appendix 4). The three sections related to activities carried out that were not verbalised, whom participants were interacting with and any body language and facial expressions used by the participants.

5.4.2.b Interview schedule

An interview schedule was developed and refined during the pilot and was used to guide questioning during retrospective interview sessions. The pilot TA session was transcribed and three days after the TA session, the original interview schedule (see Appendix 5) was used to interview the participant in the pilot. The interview schedule was subsequently changed by the addition of a question to collect data on the participants' demographics. Questions examining the elements of cues noted, knowledge sources used and role perception were also added (see Appendix 6). The participants were asked what signs and symptoms they noticed and how they knew to look for these. The participants were also asked how they saw their role in caring for patients. This was added, as the pilot participant mentioned on a few occasions her/his role in caring for the patient and how it could impact on care delivered.

The wording of some questions was also changed to make the interview schedule easier to use. For example, the question “Do you think there is a more correct way of doing …” was changed, as the wording implied the way the participants were practising was incorrect. The wording was changed to “Is that what you would normally do in such a situation?”. The question “What other typical interventions are there?” was omitted, as the answer is implied in the amended question “Is that what you would normally do in such a situation?” Some open-ended questions, such as “Tell me about …” were also added to gather information on particular issues that needed to be explored further. This was done to stimulate recall memory on incidents requiring further exploration.

5.4.3 Instruments used in analysis

The analysis in this study involved using the method of PBG (Newell, 1966; Newell and Simon, 1972). This analysis involves three stages or sequential steps to analyse the data, including referring, assertional and script phrase analysis for each participant, as described in Chapter 4. The analysis of these three stages involves developing schedules of concepts for the referring phrase analysis and schedules of operators and processes for the other stages. The concepts and operators used for referring and assertional phrase analysis can be developed either from theory or generated from the data (Ericsson and Simon, 1993). Coding frameworks were developed for the three phases of analysis and are discussed below.

5.4.3.a Schedule for referring phrase analysis

A schedule for use in analysing the transcripts for concepts used by the participants was developed and tested in the pilot. Concepts refer to a nursing concept (for example, breathing, fluid balance, pain, circulation, comfort) that participants were using to make decisions related to patient care. The list of concepts was developed from the literature, particularly in relation to caring for AAA patients, and then refined in relation to the main concepts used for monitoring the haemodynamic status of post-operative AAA patients and those factors impacting on the haemodynamic status of post-operative AAA patients in the pilot study (see Table 5).

Table 5: Concepts used in the study

Concept	Attributes
Airway	Ventilation, suctioning, masks, nasal prongs, sputum
Breathing	Positioning, respirations, oxygen, oxygen saturations, monitoring saturations, arterial blood gases
Circulation	Blood pressure, central venous pressure, limb observations, renal perfusion and assessment of all the above
Pain	Observation, pain scale, physical assessment, medications, medication rate, epidural, dermatones, comfort
Nausea	Medication, assessment
Fluid balance	Intravenous therapy, hydration, output, input, assessment
Elimination	Faecal output, bowel sounds, nasogastric output, drainage
Hygiene	Pressure care, mouth and eye care, hygiene
Mobility	Turning, positioning, getting out of bed
Wound	Dressing, assessment, drainage
Comfort measures	Positioning, touching, communicating
Family	Referral to family members or significant others
Equipment	Monitors, pumps, ventilator

There were some common concepts identified in research examining decision processes in nursing. The common concepts from the studies of Jones (1988) and Greenwood and King (1995) and Greenwood et al. (2000) were pain, respiration, circulation, hydration, urinary output, mobility and elimination. From the literature on monitoring in ICU and on caring for post-operative AAA patients, the concepts involving technological equipment were included as were those involving management of central venous pressure and blood pressure and other aspects of haemodynamic stability. Observing for complications such as those that affect the condition of the limbs was also included, as these may also be related to haemodynamic stability. During analysis of the pilot data, the concepts family and comfort measures were added. These two concepts were considered by the pilot participant as impacting on haemodynamic stability, as they were seen to affect the patient's anxiety and comfort.

5.4.3.b Schedule for assertional phrase analysis

The operators for the study were developed from careful analysis and comparison of operators described in nursing studies to date, and were then refined in the pilot study. The operators are representative of processes commonly described in the information-processing theory. Most of the studies in nursing, examining decision processes, have concentrated on one process only, for example, hypothetico-deductive reasoning, with only a few employing an eclectic approach. Employing an eclectic approach has involved examining decisions for a variety of decision processes such as hypothetico-deductive reasoning, pattern-matching and intuition using either different frameworks in the one study, such as information-processing, to describe hypothetico-deductive reasoning and interpretive theories to describe intuition, or only one framework to describe different processes. This study used the one framework and recognised the existence of more than one process in CDM by nurses namely, hypothetico-deductive reasoning, pattern-matching and intuition, all of which have been identified in terms of the information-processing theory. Some minor processes that can also be explained in terms of the information-processing framework were also included. These processes were if/then procedural rules, automaticity, trial and error and knowing the patient. Operators representing all three CDM processes were used. The original list of operators included the common operators in Table 6, and was generated from a literature review. This list was refined after the pilot and the final list is shown below in Table 7.

The operator, "indicate" was omitted, as it is similar to the operator "interpret". Similarly, the operator "causal" was also omitted, as it closely resembles the operator "rationale". The description of the operator "act" was changed to include what the participants were going to do or what they had already done as well as what they were currently doing. The operator "course" was also added to describe a course of action to be taken which differs from a description of what the participant was actually doing, as it involves an element of planning ahead.

Even though it was suggested by Coderre et al. (2003) that the process of pattern-matching cannot be observed and that transcripts should be analysed for pattern-matching by noting missed steps, it was noted in the pilot study that the participant was verbalising statements indicating this process. For example, the participant in the pilot stated "he coughed if he needed a bit of suctioning, most of those know that if they cough you will come", and "they always are confused on day three so by tomorrow or the next day we should be prepared for a confused patient" indicate that nurses are matching patients to past cases. Prediction was also evident in the pilot, for example, "I knew he would be stressed as patients like him get stressed so I knew he would be stressed". It was predicted that the patient would behave in a certain way by considering him in light of other similar patients that had been cared for.

Table 6: Original 0perators developed for the pilot study

Operator	Description
Plan	collect, study data and charts, identify information, gather cues, read notes and charts
Rationale	explain, give a reason, link by cause
Interpretation	reason, come to an understanding of signs
Diagnose	conclude patient problems
Choose	Select alternative courses of action
Review	go over data
Relate	discover new relationships
Act	description of what doing
Goal	description of what the outcome should be
Description	list facts, identify context
Indicate	inference, predict
Causal	Cause
Evaluation	Judge

The operators "predict" and "match" were therefore added to describe the processes of pattern-matching. Pattern-matching is a process in which past experiences or cases are used to decide how to care for the present patient. This may involve planning, with cues or patient presentation being matched to prior cases, or interpreting or relating information in light of knowledge from prior cases, as in the above examples from the pilot. It also involves the ability to anticipate potential problems, as the tacit knowledge of conditions or illnesses allows a wide range of experiences and a sense of how the patient should normally progress. Knowledge is also available on abnormal reactions and this can be used to anticipate problems and predict an outcome. Prediction is a feature of pattern-matching, as is matching current cases to what is known.

The operators were then further organised in an hierarchical order to reflect the development of higher order thinking and clinical skills. This involved categorising operators following Higuchi and Donald (2002) into the groups as follows:

- “Collect” means to gather all available information
- “Description” refers to the delineation or definition of a situation or thing
- “Selection” is the choosing of information to consider in preference to other
- “Inference” is the act of drawing conclusions from evidence
- “Match” is the matching of current situation to past situations or knowledge or the predicting of care, which is being able to predict what may happen. This category was not used by Higuchi and Donald, (2002)
- “Synthesis” refers to the composition of parts into a whole
- “Verify” is confirmation of accuracy.

Categorisation of operators was undertaken to allow the PBG to reflect an hierarchical order from left to right of the graph. The final list of operators is shown below in Table 7 below.

5.4.3.c Schedule for script phrase analysis

The script phrase analysis involved aggregation of operators to identify processes of cognition. The processes were based on a literature review and/or from inductive examination of scripts. The transcript in the pilot was examined to determine whether examples of processes could be identified from aggregation of operators in the scripts. The main processes identified in the literature review were hypothetico-deductive reasoning, pattern-matching and intuition. Some minor processes also identified are if/then production rules, automaticity, trial and error and knowing the patient (see Table 8). The operators that might be expected as part of the process are outlined in Table 8 below.

Table 7: Final list of operators used in the study

Operator	Description	Category;Higuchi and Donald, (2002)
Plan	study data and charts, gather cues, e.g., "patient's BP is 110/80"	Collect
Describe	describe or list facts, context, objects or people, e.g., "the patient has had a AAA"	Describe
Act	describe what actually doing or what going to do, actions by nurse or what want patient to do e.g. "I am putting up the tridal"	Describe
Review	review data, go over patient data, reconsider data, actions, facts, e.g., "I think the BP was 110/60 before, that's right 110/60".	Select
Goal	describe what want to happen, a desired outcome, e.g., "we want his pain to be down to 2 or 3 by the end of the shift"	Select
Rationale	give reasoning for what doing or how things work, explain, link by cause, e.g., "he has just had some aramine because his blood pressure kept dropping"	Select
Interpret	reason, come to an understanding of signs or symptoms e.g. "he may be a carbon dioxide retainer (interpret) but his carbon dioxide on his gas was only 40–44, (plan) so probably isn't (interpret)"	Inference
Relate	discover new relationships, e.g., "BP is a bit low (interpret), yeah it was after we increased the epidural tridal (relate)"	Inference
Match	match current situation to past situations or current patient to past patients, e.g., "AAAs usually are confused day 2 or 3, most of them really get confused then"	Match
Predict	predict an outcome, e.g., 'he will be extubatable by 4 o'clock."	Match
Choose	choose course of action between different alternatives available, e.g., "we can give him more fluids or we could give him some gel"	Synthesise
Diagnose	Give definitive decision regarding a patient problem; e.g., "the patient is fluid depleted"	Synthesise
Course of action	course of action that will be followed the decision between alternatives has been made and one course of action chosen, e.g., "we will work on getting him pain free by adjusting the epidural rate when we need to."	Synthesise
Evaluation	judgment of status or verification, e.g., "the aramine has worked well".	Verify

Table 8: Processes of decision-making and expected operators

Process	Aspects	Operators
Hypothetico-deductive reasoning	Cues gathered	Plan
	Cues interpreted	Rationale, interpret, relate, review
	Hypothesis generation	Diagnosis, goal, choose
	Cue interpreted	Rationale, interpret, relate, review
	Hypothesis evaluation	Evaluation
	Action/outcome	Choose, course
Pattern recognition	Cues chunked	Plan with cues being matched to prior cases, match
	Arranged and rearranged	Interpret, relate in light of prior cases
	Matched to LTM data	Match, predict
	Evaluation	Evaluate
	Outcome	Course
Intuition	Decision made with little or no conscious awareness	Missed steps, non-verbalised behaviors
	Direct link LTM	straight to actions and solutions

Hypothetico-deductive reasoning can be of two main types, forward reasoning and backward reasoning. Forward reasoning occurs where the nurse collects cues and information and interprets patient status to come to a problem identification or diagnosis. Backward reasoning occurs when a nurse works backward from an identified problem to possible causes. A problem is noticed, then cues collected to try and determine the causes of the problem.

The processes of hypothetico-deductive reasoning with forward reasoning may have operators ordered more or less similar to the list below:

- “plan”
- then “rationale” or “interpret” or “relate” or “review”

- then “diagnosis” or “goal” or “choose”
- then “rationale” or “interpret” or “relate” or “review”
- then “evaluation”
- then “choose” or “course” (see Appendix 19, Table 41 and Graph 3).

The process of hypothetico-deductive reasoning with backward reasoning may have operators ordered more or less similar to the list below:

- “diagnosis” or “describe” (the problem)
- then “plan”
- then “rationale” or “relate” or “review”
- then “interpret”
- then “choose” or “course” (see Appendix 18, Table 40 and Graph 2).

In both forward and backward reasoning, the participant would not match patients to prior cases and would have a process involving:

- collecting information in the form of cues
- reasoning about these cues and
- coming to a conclusion or diagnosis
- and ending with a course of action
- and possibly evaluation.

Pattern-matching involves the nurse comparing the current situation to previously experienced situations, and predicting what may occur next. This comes about from familiarity with previous experience with patients and the building-up and storage of knowledge in the LTM. Due to familiarity with similar past situations, nurses tend to chunk cues and link these early in the process to stored knowledge in the LTM. Hence pattern-matching or pattern recognition may appear to be almost automatic, with many intervening steps of reasoning being missed.

For pattern recognition (pattern-matching), a participant may:

- rearrange data (reorder cues collected)

- match cues to past patient data
- match current patient to previously seen patients or situations
- predict what may happen to a patient or may happen next, using knowledge of past case or patients.

The operators used may consist of:

- “plan”
- “match”
- “predict” (see Appendix 20 Table 42 and Graph 4)

Pattern-matching may involve the gathering of cues using the operator “plan”, but these would not be reasoned about using the operators as in hypothetico-deductive reasoning outlined above but would be matched to a past case or an act almost immediately.

The process of intuition involves a direct link to the LTM and the gathering of cues and the considering of information may not be evident. Intuition may be recognised by:

- non-verbalised behaviours
- missed steps in reasoning
- the moving straight to actions and solutions from perception of information.

Intuition may be hard to distinguish from automaticity described below, which has a similar pattern, and such instances need exploration in interview. It should be noted that not all steps will necessarily be followed in order for all processes.

5.4.3.d Other possible processes

Other processes outlined in the decision-making literature that may possibly be recognised in the study are:

- **If/then statements:** which reflect procedural rules to direct behaviour; these may be present in clinical decision-making. They were identified in problem-solving involving context-free problems, but may also be present in context-dependent problem-solving and decision-making. To identify such processes the scripts were examined for instances of nurses using production rules such as if …, then do …, if …then do ….

b) Automaticity: is a process that may be similar to intuition, but may represent internalisation of routines and procedures rather than knowledge of situations and patient presentations. Automaticity may be identified by noting patterns in transcripts of situations in which participants attended tasks or routines during which intervening reasoning or steps were missed and where they seemed automatically to know what to do. For example, in the pilot study the participant noted during care planning that the patient needed to have a procedure the following day and that the patient had a nasogastric feed running. The participant immediately decided to turn the feed off at 2.00 a.m., six hours before the scheduled procedure, without going through any reasoning steps in between. The procedure was so well known that the reasoning between needing to turn off the feed and working out the actual time was automatic.

c) Trial and error: is a process of trialling interventions until one is found that works. For example, in the pilot the participant tried different positions to make the patient comfortable until one succeeded. This process can be identified by examining the script for similar incidences in which participants are trying out interventions and evaluating them. A possible pattern is the operators "act" and "describe" and "evaluate", followed by more "act" and "evaluate"

d) Knowing the patient: is a process whereby nurses know what to do due to having knowledge of that patient. To identify such processes the script is examined for statements that participants made that indicated such knowledge and that it is directing the subsequent care.

5.5 Main study

The study was conducted after modification of tools for both data collection and analysis from the pilot. Information sessions were provided for all 55 staff on the unit, including full-time, part-time and casual staff. The information sessions were designed to contact as many staff as possible at one time and were held after handover with staff from both the morning and afternoon shifts, two to three times a week over several weeks. The information sessions were short, five to ten minutes. The researcher's contact details and an information letter were handed out during the sessions. An information letter regarding the study (see Appendix 7) was also sent by internal hospital mail to all staff on the unit.

Participation in the study was voluntary and participants completed a consent form (see Appendix 8). Novice and expert members of staff were identified from volunteers, according to the selection criteria, and these participants comprised the study. TA sessions were organised with volunteers according to when a volunteer was on duty and was also allocated to care for a patient within the first 24 hours post AAA surgery. This involved staying in touch with volunteers and ringing the ward regularly to check whether a volunteer would be allocated to care for the appropriate patient. The ward could not guarantee a potential participant would be allocated an AAA patient, as the unit's staffing needs took precedence over the study needs. The researcher attended on any shift when a participant was allocated to an appropriate patient and this involved all three shifts throughout the day or night.

5.5.1 Data collection

The researcher met with participants who had volunteered prior to the data collection commencing and explained the data-collection technique and how participants would be involved. Contact was maintained with participants in order to be able to schedule the sessions. Prior to the beginning of the session, a consent form was given to participants (refer to Appendix 8). The participants were given time to read the form and encouraged to ask questions before being asked to sign the consent form. The consent form covered issues of privacy and confidentiality.

Data collection occurred for the first two hours of a shift for a postoperative AAA patient. This was also within the first 24 hours postoperatively for every patient included in the study. Prior to data collection, participants practised TA with a simple exercise that was tested in the pilot study. Patients and their families were given an explanation of the study procedure and the nurses' use of TA. They were advised they could terminate the

TA at any time if it was intrusive or upsetting. This did not happen in any of the sessions. Participants were also instructed not to verbalise any information that could be distressing to the patient or family. Other staff working in close proximity to the study participant were also told that the TA session was proceeding and they were informed that only information relating to the study participant would be included in the transcripts.

To carry out the observation, the researcher sat in a corner of the room close to the participant but away from the patient and family and recorded on the observation schedule any appropriate information (see Appendix 4 for observation schedule). During structured observation the Hawthorne effect could affect validity and this was addressed by accepting that the nurses' performance at the time of data collection represented optimal practice, and therefore could be interpreted as reflecting the best decision-making practices of which each nurse was capable.

Retrospective interviews were used in conjunction with TA to explore the TA session in further detail, for two main reasons. First, in TA sessions in real-world settings, participants are instructed not to verbalise anything they consider may be harmful for patients but to divulge this in a later interview (Greenwood and King, 1995). Second, TA is a technique to trace cognitive processes; the processes verbalised in TA sessions are those that occur in the short-term memory. To access processes and information in the long-term memory retrospective interviews were conducted (Aitken, 2000). Retrospective interviewing was guided by an interview schedule (see Appendix 6). The interviews were conducted in a quiet room close to the unit at a time that suited the participants.

Notes about the session were recorded in a diary by the researcher immediately after the session and these notes were used to add to the interview questions. Interview sessions were held within three to four days after the TA sessions and the researcher transcribed the TA session in the meantime. This was done to enable the researcher to develop some areas for further exploration with the participants within a close timeframe of the observation session so as the participant could recall the details of the session. The observations, transcribed TA session and notes taken by the researcher were used to guide issues for exploration in the interview session. The interview sessions lasted for 45 minutes to an hour. Transcription of the TA sessions and the interview sessions constituted all verbal data collected. Transcription of the audio tapes was carried out by the researcher, who is familiar with both nursing language and the particular language used in critical care areas. In analysis, however, verbalisations that were not TA, such as social exchanges between participant and others, were excluded, as were social exchanges between participants and patient and family members. Exchanges relating to the main areas of the study, in particular information from others about patient status, care or comfort were included. After data collection and transcription, the data were analysed using a combination of techniques described below.

5.5.2 Data analysis

The data collected by TA were analysed using protocol analysis based on the principles explicated by Newell and Simon (1972), with the generation of PBG. PBG were used to graphically represent the data and to identify concepts, operators, and aspects of tasks, cues and information sources used by each participant. Frequencies of operator usage were calculated for each participant and then for the two groups, novice and expert nurses. Matrices were used to compare operator usage by novice and expert nurses. The information from the PBG was then aggregated and processes for each participant determined. Processes used by expert and novice nurses were then compared. Content analysis was used to further analyse data to answer the research questions and to help understand how expert and novice nurses used the operators and processes. A summary of the overall analysis process can be found in Appendix 9 and Figure 4, and the whole process is detailed below.

5.5.3 Transcription of tapes

The first stage of the analysis was to transcribe the tapes from all sessions (see Appendix 9 for a summary of the analysis process). The transcripts were numbered for each

Figure 4: Summary of analysis using PBG

Step 1 ***Transcription***

1a Verbatim transcription of both concurrent and retrospective transcripts for all participants

1b Highlight sections relating to identified areas of study

1c Segment relevant sections into meaningful phrases, A1 to An

Step 2 ***Construct problem space***

2a Divide identified sections into discrete relevant tasks and describe tasks

2b Describe outcomes of each discrete task

2c Inductively describe categories of task outcomes

2d Classify tasks as either proactive or reactive

2e List cues used in each discrete task

2f Identification and listing of information sources

Step 3 ***Referring phrase analysis***

For each meaningful phrase, identify the concepts that the participant is concentrating on

Step 4 ***Assertional phrase analysis***

Identify operator that facilitates movement of reasoning from each concept to the next

Step 5 ***Graphing PBG***

5a Create a separate graph for each task of the transcripts

5b X axis?identified concepts graphed successively down the graph

5c Y axis – identified operators in order of lower to higher thinking order graphed across the top of the page

5d Vertical line drawn from concept to operator, horizontal line connecting consecutive operators that are the same

Step 6 ***Estimating frequencies***

7a Tally each type of operator for each graph, then for each participant and then for novice and expert

7b Calculate frequencies for each participant for both sessions, then for novice and expert

Step 7 ***Script phrase analysis***

Identification of processes by examination of PBGs for patterns

Step 8 ***Content analysis of scripts***

Use content to expand on usage of processes and operators participant from one to eight, and identified as concurrent or retrospective (Figure 4, Step 1a). There was one concurrent and one retrospective transcript for each participant and each was allocated a letter of the alphabet. The concurrent transcript for the pilot participant became A, the concurrent transcript for participant one became B and the retrospective transcript for participant one became C, and so on.

There are a number of ways to segment the TA protocol for analysis, such as pauses in speech, intonation, contours of speech or complete phrases and sentences (see Appendix 9 for summary). Pauses in speech were indicated on the transcripts, but contours in speech were not recorded in any way. The script was therefore segmented into meaningful phrases as suggested by Newell and Simon (1972). These meaningful phrases were then coded by being allocated the transcript letter and then a number (Figure 4, Step 1c). For example, the pilot transcript was coded from A1–A88, the script of TA session of participant one was coded B1–B 538, and the transcript of the interview of participant one was coded C1–C263 and so on (Figure 4, Step 1c). The participants were not identified in any way other than by participant one, two, three and so on and their transcripts were identified by a letter from A–O. Phrases from scripts were identified by codes such as G23, A243. This was undertaken to ensure anonymity and privacy (Figure 4, Step 1c).

5.5.4 Constructing the problem space

After the phrases were numbered, the transcripts were then read and reread and divided into discrete, relevant tasks to allow analysis on a task-by-task basis (see Appendix 9 for summary). The tasks were numbered task one to task n for each transcript. The segmenting of transcripts into discrete tasks is suggested by Newell (1966), who recommends examining the tasks in order to describe the problem space to be better able to understand the processes. This was undertaken in his study by examining each task and making notations on the transcript and combining this with notations made during the observation in the TA sessions. Newell's study (1966) used notations about tasks to better understand operators and processes but employed no specific method to analyse this type of data. Studies in nursing using TA and PBG have often combined content analysis with PBG to better understand the TA transcripts and the operators and processes in context. This was carried out in the current study to further understand the use of processes and is described later.

The transcripts were divided into discrete tasks relating to the main focus, haemodynamic status and tasks that could impact on it, and these tasks were highlighted (see Appendix 9 for summary) (Figure 4, Step 2a). The discrete tasks included monitoring for parameters of haemodynamic status, such as heart rate, blood pressure, central venous pressure, oxygen saturation and fluid status. It also involved monitoring and management of pain and anxiety, temperature, respiration and potential problems with circulation to the limbs and kidneys as these can impact on haemodynamic status. Information related to haemodynamic imbalances such as renal failure, possible myocardial infarct, restricted flow to the bowel and paralytic ileus and restricted flow to feet with consequent ischaemia, were also included.

Sections of the TA sessions not dealing with the above tasks were excluded from analysis using PBG, as were the questions in the interview that did not specifically cover these areas. The excluded sections were later analysed using content analysis.

The task was initially described briefly and an outcome identified, as suggested by Newell (1966) (Figure 4, Step 2b). For example, the description of task 15 for participant one was “reviewing observations and patient situation as blood pressure down”. The task involved the participant collecting cues and information and reconsidering the meaning of the information, as the patient’s blood pressure had dropped. The outcome for this task was “decided blood pressure low as patient had moved his arm and caused an artifact in the reading” (Figure 4, Step 2b). This was undertaken for all relevant tasks of all the transcripts from the TA sessions for all participants. The description of tasks and the task outcomes were tabulated to allow easy reference (see Appendix 10, Table 33 for an example). These were not compared numerically, as tasks vary in the real world of practice depending on patient and situation and numerical comparisons are not really meaningful. However, description of tasks can show the range and depth for novice and expert nurses. Tasks were enumerated by classifying into categories of outcomes by reviewing the literature and inductively developing the categories from the transcripts (Figure 4, 2c).

The outcomes of tasks were classified into five categories "managing", "assessing/evaluating", "planning", "diagnosing" and "seeking help" and this was added to the transcripts (Figure 4, Step 2c). "Managing" referred to tasks that involved an assessment leading to an outcome that involved an intervention decided on by the participant. "Assessment/evaluation" referred to a task that had an assessment with an evaluative statement about patient condition, but no intervention except the decision that the current status was acceptable. "Planning" referred to an assessment leading to an outcome of a plan of care for the rest of the shift. "Diagnosis" referred to an outcome that involved diagnosing a problem after assessment. "Seeking help" referred to an assessment, with the outcome of asking for help and with no independent decision being taken. The percentages for task outcomes were calculated and tabulated for each participant and then for novice and expert nurses.

The tasks were also classified according to how the participants approached the task, whether they were proactively planning ahead and not reacting to a present problem or reactively considering a problem as it arose (Step 2d). These descriptions were added to each task on the transcript. The two descriptions of task approach, proactive or reactive, were developed inductively from examining the transcripts and from a literature review. Nurses are described as being able to anticipate problems and plan ahead to prevent to problems from arising, and expert practitioners are reportedly more capable of predicting and preventing problems than novice nurses, who are believed to more often address a problem once it has arisen (Hanneman, 1996). Care delivered by expert and novice nurses should reflect this ability, with a possible greater number of tasks that involve planning ahead for expert nurses, as opposed to a greater number of tasks showing reacting to a problem for novice nurses (Hanneman, 1996). The percentage of proactive and reactive tasks were calculated and tabulated for each participant and then aggregated and compared by novice and expert.

Each relevant task on the transcript and interview transcript was then analysed for the cues that the participant noted and these were recorded on the transcript (Step 4, 2e). The definition used to determine what constituted a cue is given in Appendix 2. The variety of cues used for each participant was tabulated and these were then aggregated by novice and expert participants and the number of cues used by both then compared.

Transcripts were also examined to determine how participants were relating cues together and to the concepts identified in the study (Figure 4, Step 2e). This was carried out using content analysis; the results were then tabulated and compared. For example, the cues used by novice and expert participants to assess for patients' pain were examined and how these were related by both novice and expert participants was noted and tabulated.

Each task was then analysed for any possible sources of information used by participants (Step 4, 2f). The information sources were tabulated and presented for all participants as an aggregate. For example, for participant one, task 21, the participant had gained knowledge about the patient from others, namely the patient's carer; this was described as information from others. All the information gathered was summarised and then tabulated for each participant. The table included task, description, outcome, cues, operators used and information sources (see Appendix 10, Table 33 for an example).

5.5.5 Referring phrase analysis: identifying concepts

The tasks were then analysed using the three stages of PBG: the referring phrase analysis, the assertional phrase analysis and the script phrase analysis (Figure 4, Step 3) (see Appendix 9 for a summary).

The referring phrase analysis involved examining the concepts used by the participant with the aid of the schedule developed and tested in the pilot. Development of the schedule is discussed under 5.4.3.a Schedule for referring phrase analysis. This was to capture the vocabulary of concepts being concentrated on (Greenwood et al., 2000). Concepts were recorded next to each meaningful phrase. For example, for task one, participant one the first phrase and its concept are shown below.

B1 need to keep that oxygen on	Respiration

This was carried out for all phrases for each discrete but relevant task of the script that covered the focus of the study, as outlined above. Identification of concepts allows a better understanding of the decision tasks on which the participant is concentrating. This information was used in the content analysis to further understand the operators and processes in context.

5.5.6 Assertional phrase analysis: identifying operators

The assertional phrase analysis involved examining the script for the operators that linked each new state of knowledge or each phrase (Figure 4, Step 4). The schedule of operators developed and refined during the pilot was used for this stage of the analysis (see Methods section, 5.4.3.b). An example is recorded below, taken from the transcript of participant six.

K 155 It's unusual for them to come back so warm	Match
K 156 Generally they come back cold	Match
K 157 And as they warm up they tend to drop their BP	Match
K 158 So I am hoping that his blood pressure will stay stable	Predict

The information generated in this way was then graphed in PBG. This involved a time sequence of the concepts down the page and the operators linking them across the page. These were joined by drawing a line to connect the operators and concepts and a graphic representation resulted for each task considered in the study (see Appendix 11, Graph 1, for an example of PBG).

The frequency of operators for each participant was calculated and tabulated for TA sessions (see Appendix 12 for example), interviews (see Appendix 13 for example) and then for TA sessions and interviews combined (Figure 4, Step 6). The frequency of operators for novice and expert nurses was then calculated and tabulated for TA sessions and interview sessions. The frequency of operators was also calculated manually by combining operators from both the TA sessions and interview sessions. The calculated frequencies for expert nurses for TA sessions, interviews and both together were compared for novice and expert nurses (Figure 4, Step 6). Simple descriptive statistics were used and the computer statistical analysis programme SPSS 11.5 (SPSS, 2002) employed.

5.5.7 Script phrase analysis: Identification of processes

The transcripts were then analysed for processes using script analysis (Figure 4, Step 7). This involved examining each task for any processes using the schedule developed and tested in the pilot (see Section 5.4.3.c Schedule for script phrase analysis) and also examining the graphs for patterns of operators that could indicate processes. The processes used by novice and expert nurses were compared and examples of the different processes tabulated.

5.5.8 Content and thematic analysis of scripts

Content analysis was then used to analyse the transcripts, interview transcripts and observation schedules to help illuminate the use of operators and processes (Figure 4, Step 8 and Appendix 14, Figure 5). A coding framework was developed for this purpose to guide the content analysis. The coding framework had three main categories, namely tasks, cues and information sources. Tasks were examined in relation to: a) how participants proceeded with planning and care delivery, b) whether guidelines were used and how c) how participants saw their role in the tasks carried out for patients. Cues were examined for: a) how they were used by participants, b) how usage of cues impacted on decisions about the delivery of care and c) how this influenced decisions made. Information sources were examined for: a) type of information, b) source of information and c) how this influenced decisions made (see Appendix 15, Table 36 for an example of coding).

The overall process of the content and thematic analysis involved:

- Examining the meaningful phrases from the transcripts for key words and phrases that answered the general aims of the coding framework
- Phrases meeting the general aims of coding framework were highlighted and aggregated under coding framework headings; these were then enumerated.
- Phrases with similar meaning under the coding framework were then clustered and further meaning developed using diary entries taken after observation, notes written during the analysis of the transcript and the observation schedule.
- Themes were generated from key words and phrases in the subcategories by explicating common threads in the key phrases. The themes were enumerated and tabulated.
- The themes generated were presented as aggregated themes for novice or expert nurses
- Data was then quantified by enumerating and tabulating the frequencies of times each theme occurred for novice and expert nurses
- The frequencies of themes used by novice nurses as opposed to expert nurses were then compared
- The interview transcripts also had questions to elicit information on tasks, cues and information sources, and this was similarly analysed
- Diary notes were kept of the process and served as an audit trail of the analysis
- Content analysis also examined the transcripts for further information on operators and processes. The operators and processes were examined in relation to how operators were used, for example whether the operator rationale was given, how the information was used for the rationale obtained. If a process such

as hypothetico-deductive reasoning was detected, what information was used and whether it was forward reasoning or backward reasoning. Identified processes were enumerated for each individual and tabulated.

5.6 Validity and Reliability

5.6.1 Reliability

A number of approaches were taken to increase reliability and validity. To increase reliability, data were collected using both concurrent and retrospective verbal protocols. This is believed to supply different and complementary data to increase reliability and also allows checking of data during the analysis phase. The use of observation as another source of data collection also increases reliability by allowing cross-checking during data analysis (Newell and Simon, 1966; Coderre et al., 2003).

All data were collected by the one researcher and primary analysis was also conducted by the same researcher. This is believed to increase reliability and consistency in studies using PBG analysis (Aitken and Mardegan, 2000). All data collection and transcription were attended by the researcher who is familiar with both the tasks and language used in the study setting. This also increases the reliability and consistency of data collection and analysis (Fonteyn et al., 1993; Aitken and Mardegan, 2000).

To reduce possible bias in data collection from the participants, the retrospective verbal protocol sessions were scheduled as soon as possible, with a maximum of three to four days after the concurrent verbal protocol session. Scheduling the session soon after the TA sessions meant that the participants' recall was more accurate and that they would not just give the researcher what they thought was needed. This was used to attempt to overcome the possible problem of participants reconstructing accounts of what happened rather than reporting cognitive processing (Taylor and Dionne, 2000). To further overcome this potential problem, the questions used during the retrospective recall sessions were not leading questions but remained neutral, and also were designed to stimulate recall of specific instances. For example, participants were asked "Tell me what you were thinking when …". To improve internal reliability, low inference descriptors, such as verbatim accounts, were used to report the results of the content analysis as well as simple descriptions of what occurred during the sessions. The inter-rater reliability for using the schedules was determined by having sections of the transcripts analysed by another nurse familiar with TA using the schedules and calculating for Kappa.

5.6.2 Validity

To counter concerns that simulations lack external validity, the study collected data using TA in the real world of clinical practice. In structured observations the Hawthorne effect could affect construct validity. This was addressed by accepting that the nurses' performance during the data-collection period represented their optimal practice and hence their decision-making was the best they are capable of. A combination of data-collection techniques was employed in the study to further increase the construct validity of the study by ensuring that many aspects were noted and recorded and data were not missed. The use of different data-collection techniques also allowed checking of data obtained by different techniques against each other, thus increasing the construct validity of the data.

5.7 Ethical considerations

Prior to the study, approval was sought from the Ethics Committee of the Area Health Service and University of Technology, Sydney (UTS). The researcher was asked to outline measures to be taken to ensure the patients would not be affected by the TA method of data collection.

The research participants were observed for periods of two hours. This could have been intrusive, so efforts were made by the researcher to limit the effect of this as much as possible. None of the participants verbalised that this was a problem and most reported becoming used to the procedure with little problem. The participants were also asked to participate in interviews with the researcher, which involved them giving up some of their own time. Participants were not paid for their involvement or compensated for time lost. The researcher made efforts to ensure the interview sessions were scheduled at times to suit the participants and all interviews were successfully completed. Participants were not identified during data analysis or during discussion of the results and conclusions. Any quotes used in the research were only used with the permission of participants and names or identifying data were not used. Participants had the right to remove any information that they felt was identifying, inappropriate or damaging. Access to the information collected was restricted to the researcher and the researcher's supervisors. Data were stored in a locked file. The data consisted of tape recordings and transcripts of the recordings on computer discs as well as hard copies. Only the researcher had access to the data and the keys to the filing cabinet. The information collected was used for the research only and not for any other purpose.

All participants were able to withdraw from the research at any time without giving a reason. Informed consent to participate was formally given before research began, and the informed consent was given in writing on a consent form (see Appendix 3).

For the proposed study the following guidelines were used to limit the exposure of patients to potentially detrimental information:

1. An explanation of what was happening was given to both patients and families and the data collection was terminated if this was requested. This did not happen in the study; the patients did not find the data collection intrusive.
2. The nurses were instructed not to verbalise any information they considered could be detrimental to patients and family during TA sessions and asked to discuss such information in the retrospective interview session.
3. Any information from TA and concurrent observation that was considered to identify the staff, patient or family was deleted. The participants and other staff and patients were not identified in transcripts; they were identified by letters and numbers denoting their status, for example, P1 (participant 1), PT1 (patient 1), S1 (senior 10), F1

(family member 1).

5.8 Summary

The study examined the decision-making of nurses for one type of patient using the method of TA with PBG and content analysis to analyse the large amount of data generated. This resulted in a diverse range of results which are presented in the following chapter.

Chapter Six

Results

This Chapter presents the results of the study. The data collected by TA and observation were analysed in a number of ways to build an in-depth, rich description from the small sample to illustrate how a group of nurses reason and decide about tasks while managing similar patients. The demographic characteristics are presented first, then data on the problem space, which includes a description of tasks, cues used and information sources. Data on tasks is presented to build a picture of the task environment and includes task outcome and whether a task was proactive or reactive. Data on cues are presented to examine the incoming data participants were perceiving and includes the frequency of cue usage, and how cues and concepts are linked. The frequency of cue usage is compared for novice and expert nurses. Data on information sources are presented as a composite list of all sources used by participants and illustrates some sources of knowledge being accessed by participants. Data on the operators used by participants are presented next and includes the frequencies of the different operators from TA sessions and from retrospective interview sessions and then from both combined. The frequencies of operators are compared for novice and expert participants. Data on processes are then similarly presented. Finally, the themes generated in the content analysis are presented.

6.1 Characteristics of the sample

The study sample consisted of four novice nurses and four expert nurses; two were male and six were female (see Table 9). The range in years for experience for the expert participants was 10–25 years in ICU and for novice participants eight months to one year in ICU. All four novice participants had a undergraduate degree as their entry to nursing, while three of the expert participants had a degree, two had entered nursing with a degree and one had upgraded qualifications to a degree after entering nursing. The participants ranged in age from 20 to 50, with the four expert participants being over 30, while the novice participants ranged in age from 20 to 35. One of the novice participants had entered ICU directly after graduation and had previously worked as an enrolled nurse. Another novice had a career involving other tertiary qualifications prior to undertaking the nursing degree.

Table 9: Demographic data.

Participant	Sex	Age	Education	Experience
Pilot	Female	40–45	Hospital training, ICU certificate, Midwifery Certificate, Nursing Degree	Mental health, 10 years ICU
1 Novice	Male	30–35	Nursing Degree	2 years nursing, 1 year ICU
2 Expert	Male	40–45	Hospital training, ICU certificate	25 years nursing, 20 years in ICU
3 Expert	Female	30–35	Nursing Degree, ICU certificate,	10 years, most in ICU
4 Novice	Female	25–30	Enrolled Nurse (EN), Nursing Degree	Direct entry ICU, 8 months ICU
5 Novice	Female	20–25	Nursing Degree	2 years, 1 year ICU
6 Expert	Female	40–45	Hospital trained, Nursing Degree Honours, ICU certificate	20 years, mostly ICU
7 Expert	Female	30–35	Nursing Degree, ICU certificate,	10 years nursing, 6 years ICU
8 Novice	Female	20–25	Nursing Degree	1 year nursing, 6 months ICU

6.2 Constructing the problem space; describing and classifying tasks, cues and information sources

Tasks were analysed to construct the problem space for each participant's decision-making incidences and to contextualise decision-making. Tasks were described on the basis of what was occurring and what the outcome was and this was written on the transcripts during analysis. A description of each task for each participant was compiled in a table as the analysis proceeded and included task description and outcomes. The table also included information on cues collected, information sources used and operators, and the tables were used to summarise the information for easy reference during analysis (see Appendix 10, Table 33). Tasks were classified according to the outcome and by segregation into either proactive or reactive task. A summary of the tasks attended by the novice and expert participants was also compiled (see Appendix 16, Table 37). The data from each analysis are presented below.

6.2.1 List of Tasks

The tasks attended to by all participants were examined, then described and listed under novice and expert participant. The list of tasks attended for AAA patients is quite extensive (see Appendix 16, Table 37). Overall the expert participants attended a wider range of tasks, with some differences in tasks for novice and expert participants.
Some of the differences included:

- All the expert participants considered either telling the family the patient's condition or getting someone to tell them when they could come into the ICU to visit the patient or to inform them of the patient's progress.
- Two expert participants extubated their patients, no novice participants extubated patients.
- Expert participants assessed tubes and central lines including type and date but no novice participant did this.
- Expert participants checked blood tests and carried out arterial blood gas analysis (ABGs) on patients.
- Expert participants also used touch to communicate with patients more often than novice participants.

6.2.2 Task outcomes for novice and expert participants

Tasks were analysed for type of outcome using content analysis and the results are presented below. The task outcomes were:

- **Managing-**a task involving an assessment leading to an intervention implemented by participant
- **Assessment/evaluation-**a task involving an assessment leading to an evaluative statement about condition, but no intervention

- **Planning**-a task involving assessment leading to an outcome of a plan of care for the rest of the shift or part of shift
- **Diagnosis**-a task involving assessment leading to diagnosing a problem after consideration of cues and data
- **Seeking help**-a task involving assessment leading to referral to a colleague for help to proceed, with no independent decision being taken

Most of the tasks involved “assessing/evaluating” and “management” of patients and this accounted for 66% of the total (see Table 10). Expert and novice participants had almost equal frequencies of the task outcomes “managing” and “assessing/evaluating”.

Table 10: Frequency of outcomes and ranges for tasks for novice and expert participants

Task outcomes	Overall average frequency (range)	Novice participants average frequency (range)	Expert participants average frequency (range)
Managing	28% (8–48%)	30% (8–45%)	27% (8–48%)
Assessing/evaluating	38% (26–67%)	38% (26–67%)	37% (29–62%)
Planning	16% (0–32%)	9% (0–11%)	23% (0–32%)
Diagnosing	6% (0–15%)	3% (0–8%)	10% (0–15%)
Seeking help	12% (0–55%)	20% (0–55%)	3% (0–5%)

Tasks involving “managing” included:

- assessing respiratory status and implementing deep/breathing and coughing exercises or repositioning patient
- assessing patient’s status and informing families of patient’s condition or giving comfort
- assessing pain or blood pressure and titrating IV solutions
- assessing alertness and respiratory status and changing ventilator settings.

Tasks involving “assessing/evaluation” included:

- assessing for pain using pain scales and recording
- assessing endotracheal tube (ET) tube placement and recording
- assessing limb observations and noting on chart

- assessing dermatones and recording
- assessing and checking equipment by checking monitor parameters and pressure bag readings and recording assessment.

Expert participants had task outcomes involving more “planning” and “diagnosing”, whereas novice participants had more outcomes involving “seeking help”, however, there was one expert participant with no tasks involving “diagnosing” or “planning” and one novice participant with no tasks involving “seeking help”. Examples of “planning” include:

- patient assessment and consequent timing of care episodes to ensure patient comfort
- assessing IV lines and fluids and preparing ahead of time to ensure IV solutions were ready when the current one finished
- assessing patient respiratory status and planning how and when to get the patient out of bed and with what help.

Examples of “diagnosing” included:

- assessing haemodynamic status and diagnosing fluid depletion and then referring to the doctor for fluid replacement.

Examples of tasks involving “seeking help” included:

- assessing patient’s fluid status and asking other nurses about meaning of assessment and what course of action to take
- reviewing ventilator settings and seeking help to understand or reset ventilator settings and asking about the meanings of observations not within the normal range.

6.2.3 Task approach

The type of approach to tasks was classified into two main categories, either proactive or reactive. Proactive tasks involved planning ahead and anticipating what would happen, for example, one participant decided to get the patient out of bed to allow for the patient to breathe better and hence prevent the problem of possible chest infection. Another participant assessed haemodynamic status and decided to review pain status as the patient awakened. This was done as there was the possibility of the patient experiencing pain on awakening, leading to a need for more pain relief which could impact on haemodynamic status. One participant turned the intravenous glycerol trinitrate (IV GTN), down even though there was no change in the patient's BP, as the participant believed that "as patients warm up their BP falls" and the patient was starting to "warm up".

Reactive tasks involved responding to a problem once it had occurred. For example, a participant was told by a patient that s/he were experiencing pain; the participant had not assessed for pain prior to the complaint. Another participant noticed a patient's oxygen saturations were low, the participant then assessed the patient to determine why this was occurring. A participant also reviewed a patient's status by assessing haemodynamic parameters when BP dropped and changed the GTN infusion up and down every time the patient's BP changed. The frequency of each type of task for each participant can be viewed in Appendix 17, Table 38.

Expert participants had a higher frequency of proactive tasks (81%) compared to novice participants (55%) (see Table 11). Expert participants appeared to be anticipating more than novice participants what care would be needed, whereas novice participants were reacting more to problems than expert participants.

Table 11: Frequency and range of approach to tasks for novice and expert participants

Novice/expert	**Reactive tasks** **Average frequency (range)**	**Proactive tasks** **Average frequency (range)**
Novice	45% (23–63%)	55% (43–77%)
Expert	19% (14–36%)	81% (69–86%)

It is worth noting that the average frequency of 55% for novice participants may have been skewed due to one novice who had a higher frequency of proactive tasks than any of the other three. The frequency of proactive tasks for each of the novice participants was 55%, 43%, 44% and 77% (see Table 38, Appendix 17).

6.2.4 Cues used by novice and expert participants

Cues that participants noted during care of patients were examined and recorded for each participant and then tallied and aggregated for expert and novice participants. Cues were also examined in relation to how cues were used together to assess a patient and then tabulated for novice and expert participants.

The range of cues used overall was quite extensive. The number of different cues used by expert participants was 81, while novice participants used 49 different cues, indicating that expert participants used a wider range of cues than did novices (see Tables 12–17). Novice and expert participants used almost the same number and type of cues to assess vital observations and cardiac rhythms, except for rhythm strips, which were used by expert participants but not novice participants (Table 12).

Table 12: Cues used by novice and expert participants: vital observations and cardiac rhythms

Concept	**Cue**	**Novice**	**Expert**
Vital observations	Oxygen saturation	✓	✓
	HR	✓	✓
	BP artline	✓	✓
	BP manual		✓
	Mean arterial pressure (MAP)	✓	✓
	Central venous pressure	✓	✓
	Temperature	✓	✓
	Pulse	✓	
Cardiac rhythms	ECG	✓	✓
	Rhythm strip		✓

The cues used to assess for respiration and ventilation differed for novice and expert participants in that expert participants gathered the additional cues chest movement, air entry, muscle strength, tidal volume and whether the patient had been a smoker or non-smoker (Table 13).

Table 13: Cues used by novice and expert participants; respiration and ventilation

Concept	**Cue**	**Novice**	**Expert**
Respiration	Depth	✓	✓
	Rate	✓	✓
	Chest movement		✓
	Air entry		✓
	Muscle strength		✓
	Tidal volumes		✓
	Smoker/ex-smoker		✓
Ventilation	Apnoea	✓	✓
	Rate	✓	✓
	Patient size	✓	✓
	Spontaneous breathing	✓	✓
	Coughing	✓	✓
	Breathing up	✓	✓
	Biting tube	✓	
	Tidal volume	✓	✓
	Mode	✓	✓
	Minute volume	✓	✓
	Alertness	✓	✓
	Peak airway pressure		✓
	Positive expiratory end pressure (PEEP)		✓
	Oxygen percentage		✓
	Sedation		✓

The only difference in the use of cues for assessing limb status was the use by expert participants of the peripheral vascular disease (PVD) history of patients (Table 14).

Table 14: Cues used by novice and expert participants: limb observations

Concept	**Cue**	**Novice**	**Expert**
Limb observations	Pulses	✓	✓
	Movement	✓	✓
	Warmth	✓	✓
	Swelling	✓	✓
	Capillary return	✓	✓
	Skin colour	✓	✓
	PVD history		✓

Expert participants used more cues to assess the patients for pain than novice participants, including restlessness, gesturing and grimacing, distress, withdrawing when touched, sleeping or not sleeping, tensing muscles, holding the stomach and pointing to where the pain was occurring (Table 15).

Table 15: Cues used by novice and expert participants: pain and pain medication

Concept	Cue	Novice	Expert
Pain	HR	✓	
	BP	✓	
	Patient report	✓	✓
	Pain scale	✓	✓
	Restlessness		✓
	Gesturing. grimacing		✓
	“Crummy”		✓
	Distress		✓
	Withdrawing when touched		✓
	Sleeping		✓
	Tensing muscles		✓
	Holding stomach		✓
	Pointing to area		✓
Epidural and dermatones	Level dermatones	✓	✓
	Temperature	✓	✓
	Epidural rate	✓	✓
	Site leakage		✓
	Oxygen saturation		✓

Expert participants also used more cues than novice participants to assess for fluid balance including output of drains, dry mouth, urine colour, urine specific gravity, patients’ age, central venous pressure and BP (Table 16).

Table 16: Cues used by novice and expert participants: fluid balance

Concept	Cue	Novice	Expert
Fluid balance	IV rate	✓	✓
	Blood transfusions	✓	✓
	Balance in/out	✓	✓
	Urinary output	✓	✓
	Nasogastric output	✓	✓
	Drains output		✓
	Dry mouth		✓
	Urine colour		✓
	Urine concentration	✓	✓
	Millilitres per hour	✓	✓
	Urine specific gravity		✓
	Age		✓
	Central venous pressure		✓
	BP		✓

Expert participants noted more cues to assess wounds than novice participants, including the presence of drains and whether the wound was clean or dirty (Table 17). Expert participants also collected more cues to assess a patient's mental state, including following commands, eye opening and response to vocal stimuli (Table 17). Expert participants also used the cues, weight of patient, exercise patterns and patient appearance in an overall assessment of patients to assess haemodynamic status, whereas novice participants did not use these cues (Table 17).

Table 17: Cues used by novice and expert participants: wound assessment, blood tests, mental state.

Concept	Cue	Novice	Expert
Abdominal assessment	Girth	✓	✓
Wound	Dressing	✓	✓
	Ooze	✓	✓
	Drains		✓
	Clean/dirty		✓
Blood tests	Arterial blood gases	✓	✓
	Blood count	✓	✓
	Electrolytes		✓
Mental state	Pupil size, reaction	✓	
	Sternal rub	✓	
	Following commands		✓
	Eye opening		✓
	Response to vocal		✓
Nausea	Patient report	✓	✓
Other	Weight		✓
	Exercise patterns		✓
	Patient appearance		✓

In addition to expert nurses having a broader range of cues (81 as compared to 49), they also displayed greater relating between cues and concepts, as discussed below.

6.2.5 Relation between cues and concepts for expert and novice participants

Analysis of the transcripts was used to determine how novice and expert participants were relating cues and using them to assess patient status around the main concepts of the study (see Table 18). The concepts examined were those that formed the basis of the analysis, that is, those relating to haemodynamic status (see Table 5, Chapter 5).

Examination of how participants related cues to concepts showed that expert participants related more cues to the concepts than novice participants. Expert participants related heart rate (concept circulation) to possible medications that may slow the rate, possible haemodynamic compromise, and a need to investigate further by attaining rhythm strips

Table 18: Some links made by expert and novice participants between cues and concepts

Novice participant: ***Concept***-Cues	**Expert particpant:** ***Concept***-cues
Circulation- HR-none BP-relate to pain either up or down relate to epidural, down relate to fluid depletion, down relate to CVP Arterial line reading-relate to position of hand in relation to HR relate to trace	***Circulation***- HR-link to medications that both slow and fasten rate relate to need to do rhythm strip Slower rate haemodynamically comprised beta blocked (slow rate) BP-relate to pain, anxiety, stress, temperature, fluid depletion relate to epidural relate to whether patient warm or cold, BP down when cold relate to BP increases as warms up relate to moving patient relate to settled and comfortable relate to blowing graft (high) relate to knocking of the kidneys relate to CVP relate to fluids in theatre, how much lost Arterial line reading-relate to position of hand in relation to heart relate to trace relate to kinking
Pain- Pain rating-relate to pain medication relate to position and activity relate to deep breathing Epidural-relate to BP possibly dropping relate to breathing, depressed relate to temperature, infection relate to position may effect delivery	***Pain***- Pain rating-relate to position relate to pain medication relate to deep breathing Epidural-relate to leaking may not be giving pain relief relate to ncreased temperature possible infection relate to saturations relate to breathing and coughing to prevent pneumonia relate to BP may drop
Fluid balance- Fluid depletion-relate to lose lot of fluids in theatre relate to urinary output relate to loss of potassium	***Fluid balance***- Fluid depletion-relate to type of operation relate to lose lot of fluids in theatre relate to blood loss and bowels relate urinary output relate to clamping to kidneys may lead to lower urinary output and poor renal function relate to BP
Mobility- Positioning-relate to pressure care relate to breathing and prevention of pneumonia relate to positioning for epidural	***Mobility***- Positioning-relate to breathing prevention pneumonia relate to coughing relate to pressure area care
	Overall patient state status-relate to how patient looks relate weight, age, size relate to history of illnesses and diseases relate to prior exercise and patient lifestyle

(see Table 18). Novice participants did not relate heart rate to any other cues (see Table 18). BP (concept circulation) was related by expert participants to ten cues and by novice participants to four cues (see Table 18).

Novice and expert participants related similar cues to the concepts of pain, mobility and fluid depletion, however, expert participants related the clamping of the kidneys during surgery to fluid depletion whereas novice participants did not (Table 18). Expert nurses also used a range of cues to estimate overall patient status, while the novice participants did not use any cues do to this (see Table 18).

6.2.6 Information sources

The transcripts were examined for the sources of information used by each participant. These were tabulated with a wide range of sources of information identified (Table 19).

Table 19: Information sources

Peers, handover
Patient
Family, other carers, e.g., hostel staff
Ward meetings, Communication book
Theoretical knowledge; university lectures, from doing assignments
College of nursing courses, courses such as ICU certificate
Inservices, short hospital courses, packages
Patient notes
Patient charts
Hospital guidelines
Clinical Pathways. Policies
Procedures
Research
Personal; knowing patient
Experience
Doctor preference

Research was mentioned infrequently but was used by one participant, an expert, to ensure a new policy based on research was followed. One expert took the patient's Glucose Monitoring Rate then decided the patient needed insulin, as research had shown that Glucose Monitoring Rate in ICU patients should be kept within normal range. The participant then had to persuade a Resident Medical Officer (RMO) new to the ward that this was the case and eventually called on the ICU registrar to explain the research and need for an insulin infusion, which was eventually ordered. Information sources are discussed in more detail under themes.

6.3 The three stages of PBG

6.3.1 Referring phrase analysis; identifying concepts

Concepts were identified during PBG analysis in the referring phrase of analysis using the schedule developed and reported in Methods (Table 5). The concepts identified refer to nursing concepts; in this study they were specifically related to aspects of care affecting haemodynamic status. The concepts identified using the schedule were written on the transcripts and these were used later in the development of the PBG graphs. Concepts were related to cues collected and have been discussed above.

6.3.2 Assertional phrase analysis; identifying operators

The assertional phrase analysis identified the operators used by participants. An operator is a cognitive thinking strategy that links each new state of knowledge generated as a nurse makes a clinical decision. The operators identified for participants were tabulated and frequencies compared for novice and expert participants. The data on operators were collected using both concurrent TA (as nurses delivered care for a patient) and retrospective TA (as nurses discussed their care in an interview) and the data on operators are presented in three ways. First, the combined frequency of the operators is presented and this involves adding together the frequencies of operators used by all participants in both the concurrent and retrospective sessions. The combined frequency of categories of operators is also presented. Second, the frequency of operators used by all participants for concurrent TA sessions is presented and represents the frequency of operators that the participants were using during actual delivery of patient care. The frequencies of categories of operators are also presented for the concurrent TA session. Last, the frequency of the operators used by all participants during the interview sessions is presented, along with the frequencies of categories of operators and represents the frequency of operators and categories of operators used during recall of the delivery of care to the patient. The operators identified by concurrent and retrospective TA represent the same decision-making episodes that occurred in actual practice but represent different ways of collecting data on these same decision-making episodes.

6.3.2.a Combined frequency of operators for concurrent TA sessions and retrospective interview sessions for all participants (operators overall)

The cognitive operators and categories of operators used for analysis of the transcripts are presented in the Methods section (Table 7). The combined frequencies of the categories of operators (see Table 20), along with the combined frequencies of operators, are presented below (see Table 21).

Table 20: Categories of operators overall

Category: operators	**Frequency**
Collect: plan	13.5%
Describe: describe, act	38.3%
Selection: review, goal, rationale	13.5%
Inference: interpret, relate	14.2%
Match: match, predict	8.4%
Synthesis: choose, course, diagnosis	4.7%
Verification: evaluate	7.4%

Overall the frequency of usage of cognitive operators decreased as the level of higher order thinking skills increased. Participants were using more operators at the lower levels of higher order thinking skills, including “act” and “describe” (both from category description) and “plan” (category collect). “Describe” refers to describing facts, people, context or objects and “act” refers to describing actions that were being carried out or were about to be carried out, whereas “plan” refers to collecting data or cues. Making inferences about the data, which comprised the operators “interpret” and “relate”, was the next most frequent, followed by selecting what information to use and why, which referred to the operators “review”, “goal” and “rationale”. Matching current situations to past situations (operator “match”) and predicting possible outcomes or courses of action (operator “predict”) were next in frequency, followed by “synthesis” or putting information together, which comprised “choose”, “course” and “diagnosis”.

Table 21: Frequency of operators overall

Operator	Frequency, (SD)	Range
Plan	13.5% (8.1)	0.7–27
Describe	20.1% (4.5)	14.8–31
Act	18.2% (7.1)	8–28.8
Review	2.4% (2.8)	0–11
Goal	1.8% (2.5)	0–8.1
Rationale	9.4% (3.1)	2.9–14
Interpret	11.2% (5.1)	5.1–24
Relate	3.0% (2.3)	0.4–9.6
Match	6.1% (7.3)	0–21.4
Predict	2.3% (3.2)	0–9
Choose	1.4% (2.2)	0–6
Diagnose	0.8% (.85)	0–2.5
Course	2.6% (2.2)	0–8.3
Evaluate	7.4% (3.3)	2.5–16.2

The combined frequency of operators was also compared by the groups, novice and expert participants. The results are presented below.

6.3.2.b Combined frequencies for operators compared for novice and expert participants for TA sessions and retrospective interview sessions

The frequencies here represent the combined frequencies of the TA session and interview sessions (see Tables 22 and 23). Novice participants used the operators of the categories “collect” and “describe”, comprising “plan”, “describe” and “act”, more than the expert participants. The novice participants also used the operators of the category “select” ("goal", "review", "rationale") more than expert participants.

Table 22: Combined frequency of operators for novice and expert participants

	Novice participants		Expert participants	
Operator	**Frequency (SD)**	**Range**	**Frequency (SD)**	**Range**
Plan	15.2% (9.1)	0.7–27	11.7% (7.3)	3–20
Describe	21.5% (5.7)	14.8–31	18.7% (2.8)	15.5–23.8
Act	19.3% (8.6)	8–28	17.0% (5.6)	11–28
Review	3.5% (3.7)	0–11	1.2% (0.8)	0–2
Goal	2.7% (3.3)	0–8.1	0.8% (0.5)	0–1.8
Rationale	10.1% (3.2)	2.9–14	9.1% (2.7)	4–12
Interpret	10.9% (6.6)	5.1–24	11.4% (3.5)	7–17.5
Relate	3.2% (3.2)	0.4–9.6	2.9% (1.4)	0.7–4.3
Match	1.4% (0.9)	0–2.5	10.9% (7.9)	2–21.4
Predict	0.5% (0.8)	0–2.2	5.3% (2.8)	1.6–9
Choose	1.7% (2.4)	0–6	1.0% (2.0)	0–5.5
Course	2.83% (2.7)	0.2–8.3	2.4% (1.8)	0–4.8
Diagnose	0.8% (0.8)	0–2.5	0.7% (0.9)	0–2
Evaluate	8.9% (3.7)	4–16.2	6.6% (2.8)	2.5–9

Table 23: Categories of operators for novice and expert participants for combined TA and interview sessions

Category: operators in category	**Frequency Novice**	**Frequency Expert**
Collect: plan	15.2%	11.7%
Describe: describe, act	40.8%	35.8%
Select: review, goal, rationale	16.4%	11.2%
Inference: interpret, relate	14.1%	14.3%
Match: match, predict	1.8%	16.1%
Synthesis: choose, course, diagnose	5.3%	4.2%
Verification: evaluate	8.9%	6.6%

The use of operators in the category "synthesis" was low by both groups, but novice participants used the operators of this category slightly more often than expert participants. The operator "evaluate" is slightly higher in frequency for the novice participants overall than for expert participants. Expert participants had a much higher frequency of the operators of the category “match”, namely “match” and “predict”, than the novice participants.

6.3.2.c Operators for TA sessions for novice and expert participants

The frequency of operators for the concurrent TA sessions, which represents actual decision-making episodes, is calculated by adding the frequencies for all novice participants and then all expert participants (Table 24 and Table 25).

Table 24: Operators for TA sessions for novice and expert participants

	Novice participants		**Expert participants**	
Operator	**Frequency**	**Range**	**Frequency (SD)**	**Range**
Plan	18.2% (3.0)	13.7–20.5	17.2% (3.2)	14–20
Describe	18.7% (4.6)	14.8–25.2	18.3% (1.8)	16–20.2
Act	25.8% (3.6)	21–28.8	20.1% (5.5)	16–28
Review	5.1% (4.2)	1.2–11	1.5% (0.6)	0.6–2
Goal	2.3% (2.9)	0–6.6	1.1% (0.5)	0.7–1.8
Rationale	8.3% (3.6)	2.9–10.4	8.7% (3.6)	4–12
Interpret	8.9% (3.5)	5.8–12.4	9.5% (2.6)	7–12.8
Relate	2.4% (1.8)	0.4–4.6	2.9% (1.6)	0.7–4.3
Match	1.2% (0.6)	0.8–2	5.4% (3.7)	2–10.5
Predict	0.8% (1.0)	0–2.2	3.9% (1.6)	1.6–5
Choose	0.4% (0.3)	0–0.8	0.4% (0.6)	0–1.3
Course	1.3% (0.8)	0.2–2	3.0% (1.1)	2.1–4.5
Diagnose	0.3% (0.2)	0–0.4	0.3% (0.5)	0–1
Evaluate	7.1% (2.1)	4–8.8	7.5% (2.0)	5–9.8

When considering the operators identified in the TA sessions, there were a number of differences between novice and expert participants, including:

- Expert participants had higher frequencies of the operators “match” and “predict”, both of which comprised the category “match” and of the operator “course”. Expert participants had a higher frequency of category “synthesis” and a slightly higher frequency for the category “inference” than novice participants.
- Novice participants identified the operators “plan” “act”, “review” and “goal”

more often than expert participants and had higher frequencies of the categories “selecting”, made up of the operators “review”, “goal” and “rationale”, than expert participants.

- Novice and expert participants identified approximately similar numbers of the operators “describe”, “rationale”, “choose”, “diagnosis”.

Table 25: Categories of operators for novice and expert participants for TA sessions

Category: Operators in category	**Frequency Novice**	**Frequency Expert**
Collect: operator plan	18.2%	17.2%
Describe: describe, act	44.5%	38.5%
Select: review, goal, rationale	15.7%	11.3%
Inference: interpret, relate	11.3%	12.4%
Match: match, predict	2%	9.3%
Synthesis: choose, course, diagnosis	2.0%	3.6%
Evaluate: verify	7.1%	7.5%

The results indicated novice and expert participants described situations to the same extent, but novice participants were performing more actions or expert participants were verbalising these less. Novice participants also reviewed cues, data and information more often and set more goals for themselves than expert participants. Expert participants interpreted information such as cues and data slightly more often than novice participants. This, combined with the result that novice participants used selection (operators “review”, “goal” and “rationale”) more than expert participants, may indicate a greater tendency for novice participants to use rule-based reasoning based more on theoretical knowledge with expert participants tending to use matching to prior cases more often. One novice participant used the operator “choose” by following rules of the unit when it was said “obviously we had better return it if it is under 300, if it is anything over 300 you discard”. Hence rules may have been directing the choice of interventions in this instance.

6.3.2.d Operators for retrospective interview sessions for novice and expert participants

The frequencies of operators for retrospective interview sessions were calculated as well, to determine whether they were the same or different from the TA sessions (see Table 26 for operators and Table 27 for categories of operators). Both the concurrent TA transcripts and retrospective interview transcripts refer to the same decision-making episodes for each participant and this was done to increase reliability of data collection and to add complementary data to allow a more detailed examination of each participant's decision-making episodes.

Table 26: Operators for interview sessions for novice and expert participants

	Novice participants		**Expert participants**	
Operator	**Frequency (SD)**	**Range**	**Frequency (SD)**	**Range**
Plan	10.2% (14)	0.7–27	4.5% (2.2)	3–7
Describe	23.3% (5.1)	21–31	19.3% (4.2)	15.5–23.8
Act	10.7% (2.5)	8–13	12.9% (1.7)	11–14.2
Review	1.4% (1.5)	0–2.9	0.9% (1.0)	0–2
Goal	3.3% (4.2)	0–8.10	0.5% (0.5)	0–1
Rationale	12.5% (2.5)	9.6–14	9.7% (1.1)	8.5–10.7
Interpret	13.6% (9.6)	5.10–24	14% (3.1)	11.5–17.5
Relate	4.2% (4.7)	1–9.6	2.9% (1.5)	1.2–4
Match	1.6% (1.4)	0–2.5	18.1% (5.3)	12–21.4
Predict	0% (0)	0	7.2% (3.1)	3.6–9
Choose	3.3% (3.1)	0–6	1.8% (3.2)	0–5.5
Course	4.8% (3.1)	2.2–8.30	1.8% (2.6)	0–4.8
Diagnose	1.5% (0.8)	0.9–2.5	1.3% (1.2)	0–2
Evaluate	11.4% (4.3)	8–16.2	5.0% (3.0)	2.5–8.4

When considering the operators identified in the retrospective recall sessions (interviews) there were a number of differences between novice and expert participants, including:

- Expert participants had higher frequencies of the operators "match" and "predict" and a slightly higher frequency of the operator "interpret".
- Novice participants had a slightly higher frequency of the operators "plan", "review", "goal" and "rationale" and "verification" in the retrospective recall of the interview session, which is similar to the concurrent session confirming the findings in the concurrent session of novice participants collecting cues and data

and reviewing it more often. Novice participants also again had a higher frequency of the category "selecting" than expert participants (see Table 27).

- Novice and expert participants identified approximately similar numbers of the category "inference", composing "interpret" and "relate" (see Tables 26 and 27).

Table 27: Categories of operators for novice and expert participants for interview sessions

Category: operators in category	**Novice**	**Expert**
Collect: plan	10.2%	4.5%
Describe: describe, act	34.2%	32.2%
Select: review, goal, rationale	17.2%	11.1%
Inference: interpret, relate	16.7%	16.9%
Match: match, predict	1.6%	25.3%
Synthesis: choose, course, diagnose	9.6%	4.9%
Verification: evaluate	11.4%	5.0%

There were some differences in frequencies of operators for the concurrent TA sessions and retrospective interview sessions, but there were also similarities. Some differences are to be expected as retrospective recall taps into the LTM rather than the STM, and using both data-collection techniques allows collection of complementary data. The differences included:

- The frequency for the operators "plan" was lower for retrospective interview sessions than for the TA sessions for both groups of participants (see Tables 26 and 27).
- Both novice and expert participants had a higher frequency for the category "describe" for the retrospective interview session than the concurrent TA sessions, but a lower frequency of the operator "act" for the retrospective interview session than for the concurrent TA session (see Tables 26 and 27).
- In the concurrent TA sessions, novice participants had a lower frequency of the operator "course" and "choose" than in the retrospective interview session but a higher overall frequency than expert participants, due to the higher frequency in the retrospective interview session (Table 26).
- Experts had much higher frequencies of "match" and "predict" in interview

transcripts.

Both novice and expert participants described more details of context and people when recalling what was done, but both recalled fewer actions than they had actually carried out and fewer cues used. The much higher frequency of use of the operators “match” and “predict” for retrospective recall sessions could possibly indicate that there were times in the concurrent TA session when expert participants used matching and predicting but did so automatically, without verbalisation. There may well be times when TA did not identify the participants’ use of these operators.

The higher frequency of the operators “choose” and “course” in retrospective recall interview sessions by novice participants than by expert participants is the reverse of the concurrent TA sessions. When recalling to the researcher, novice participants described more alternative courses of action (operator “course”) than they actually carried out and also described more complete courses of action than they actually implemented.

6.3.2.e Summary

Overall the operators with the highest frequency are those from the two categories “describe” and “collect”. The frequency of usage of operators also decreases as the level of higher order thinking skills increases; the number of operators in the category “synthesis” is least for both groups. Overall novice participants tended to use the operators from the categories “describe” and “collect” more often than expert participants, as well as the operator “review”. Expert participants tended to use the operators of the category “inference”, including “interpret” and “relate”, slightly more often in the TA sessions, although overall the usage of these operators were the same for both novice and expert participants. Expert participants used the operators “match” and “predict” more often than novice participants.

6.4 Script phrase analysis; identifying processes

Processes were examined using PBG script phrase analysis to examine for patterns in graphs indicating possible processes and content analysis to identify themes. This was accomplished using the schedules developed in Table 8 and also by following the description of patterns outlined in Methods, Section 5.4.3.c. In real situations the patterns in PBG graphs may not follow exactly the format as suggested in the Methods Section 5.4.3.c, however, many are similar. Processes were evident from both the graphs and content analysis and these are outlined.

Participants all used more than one type of process, most used a combination of hypothetico-deductive reasoning, pattern-matching, automatic processes (which may have been insight or intuition) and if/then procedural rules, some also used trial and error and knowing the patient (see Appendix 18, Table 36). An eclectic approach was used by all in that participants used different decision-making processes at different times rather than relying on one approach. Expert participants used a range of processes such as hypothetico-deductive reasoning, pattern-matching and if/then processes (see Table 28). Some of the processes used by expert participants may be automatic and not identifiable during concurrent TA but reportable in the retrospective interview session; these types of processes may represent intuition or insight, automaticity or pattern-matching (see Table 28). Novice participants used if/then processes, some hypothetico-deductive reasoning and beginning pattern-matching as well as trial and error and automatic processes (see Table 28).

Table 28: Use of processes by novice and expert participants

	Hypothesis generation	Pattern-matching	Automatic	If/Then	Trial and error
Novice	26.2%	15.8%	5.4%	44.7%	7.9%
Expert	27%	42%	2.2%	28.8%	0%

6.4.1 Identified processes

6.4.1.a Hypothetico-deductive reasoning

The processes of hypothetico-deductive reasoning were identified in participants' transcripts using the schedule presented in Methods (Table 8) and looking for decision tasks that had operators with a similar order to that listed below:

- “plan”
- then “rationale” or “interpret” or “relate” or “review”
- then “diagnosis” or “goal” or “choose”
- then “rationale” or “interpret” or “relate” or “review”
- then “evaluation”
- then “choose” or “course” for forward reasoning.

(see Appendix 19, Table 37 and Graph 1, for examples of patterns representing hypothetico-deductive reasoning, forward reasoning).

For backward reasoning the starting point is:

- “diagnosis” or “describe” (the problem)
- then “plan”
- then “rationale” or “relate” or “review”
- then “interpret”
- then “choose” or “course” (see Appendix 20, Table 38 and Graph 2).

In both forward and backward reasoning, the participant did not match to prior cases or patients, but identified a problem then collected information in the form of cues and reasoned about these cues to come to a conclusion or diagnosis which led to a course of action.

The processes were then enumerated for each participant, and aggregated and compared by the groups, novice and expert participants (see Table 28). Hypothetico-deductive reasoning is used slightly more often by expert than novice participants. Examination of the processes representing hypothetico-deductive reasoning revealed that novice participants more often used backward reasoning in hypothetico-deductive reasoning, whereas expert participants used forward reasoning more often. Some of the hypotheses of novice participants were also unstated.

For example:

One novice was seen to be collecting some of the cues that could lead to a hypothesis such as fluid depletion but did not state a diagnosis, but rather worked back from a low BP to explain it:

"his BP is down (1), systolic about 100, 105 (2), give him fluid (3), brought it up to 115 (4), now it is 126 (5), and I haven't given him any more (6), he is passing urine (7) maybe he hasn't got enough fluids (8) give some more (9) BP is 125 (10)".

Operator: "describe" (1), "plan" (2), "act" (3), "plan" (4), "plan" (5), "act" (6), "plan" (7) (8) "interpret" (9) "act" (10) "plan".

One expert participant reviewed cues about patient's BP. The BP was low, and generated an hypothesis of fluid depletion, then the participant reviewed more cues about pain and fluid status, mainly around CVP, BP, GTN rate, and confirmed a diagnosis of possible fluid depletion.

"check the BP, it's a little bit low (1), could be lost fluids (2), check with the non invasive, still low (3), what's the epidural rate? (4), his mean is around 60, but I'd prefer it close to 70 (5), been looking at his old notes (6), try to work out why heart rate is slow (7), check how much he lost in theatre (8), he has lost a lot of fluid (9), are you in pain (10), wonder if we can turn the epidural down a little (11), BP is a bit low (12), he isn't very warm, BP low (13), Might need a fluid bolus, probably fluid depleted (14), do you mind if I give him 250, normal saline, gelofusion? (15), …. BP picking up with a bit of fluid (16)".

This represents forward reasoning whereby the participant worked from data gathered to a diagnosis. The operators used were "plan" (1), "interpret" (2), "plan" (3), "plan" (4), "plan" (5), "act" (6), "rationale" (7), "act" (8), "interpret" (9), "plan" (10), "act" (11), "rationale" (12), "describe" (13), "diagnose" (14), "choose" (15), "evaluate" (16). The cues were used to confirm a diagnosis and an action taken to give more fluids (see Appendix 20, Table 40 and Graph 2).

6.4.1.b Pattern-matching

Pattern-matching was apparent in participants' reasoning and decision-making, however expert participants used pattern-matching more often than novice participants (see Table 28). See Appendix 21 (Table 39 and Graph 3) for an example of the process. Matching to illness scripts, paradigm cases or exemplars or to previous experience was observed more often for expert than novice participants.

For example, matching from an expert based on previous experience:

"sometimes they can go into shock after surgery, but once they are fluid filled they do a lot better … yeah a lot come back so behind in fluid you are replacing up to 10-11 litres" The participant anticipated fluid depletion and consequently assessed for it. Operators: "predict", "rationale", "match",

"what's his BP because his (1), it's unusual for them to come back so warm (2), generally they come back cold (3), and as they warm up they tend to drop their BP (4), so I am hoping that his BP will stay stable (5), since he is already warm (6), that is not usually the case (7)." Operators: "Plan" (1), "match" (2), "match" (3), "predict" (4), "predict" (5), "relate" (6), "match" (7) (see Appendix 21, Table 41 and Graph 3).

Novice participants tended to remark on cases that are out of the ordinary for them and this could be an example of building of patterns by novice participants or learning by paradigm cases. For example:

One novice participant said, "he came down without one (NG tube), which is quite strange, it's the first AAA I have had without an NG tube, I think it is because he came down extubated, he was extubated when he came to us, we don't get a lot extubated but we get some... when they pulled out his ET tube I think they have taken out his NG tube."

Novice participants also tended to match patients to some extent to the limited experience they have and to start to develop schemas about what to expect. For example:

> One novice participant reasoned about checking emergency equipment. She explained doing this as she had been in a situation in which a patient arrested soon after handover, and the room had not been restocked and there was some important equipment missing. She had learned from this to always check this equipment first thing on a shift.

Some of the matching of expert participants appears to be in the form of illness scripts or schema that they use and many of these are similar between participants. Expert participants were also observed teaching novice participants some of the illness scripts. The language used by participants for some of these schemas is similar. For example:

> Novice participants were told information they needed to care for AAA patients by expert participants. Most novice participants talked about “having to chase fluids as the bowels had been hanging out over the belly”, leading to patients being behind in fluids on arrival back at the ward and “blowing the graft” and “knocking off the kidneys”, leading to a need to keep BP stable and to ensure output is observed carefully. This is discussed further under information sources and “collective knowing the patient”.

6.4.1.c If/then processes

If/then procedural rules were a process used by both expert and novice participants when managing some interventions. Novice participants used if/then processes more often (see Table 28) and appear to have sets of if/then rules. See Appendix 22, Table 40 and Graph 4, for an example of this process. An example of an if/then process was demonstrated by a participant using procedural rules while managing a GTN infusion to control BP, while another participant used them to manage epidural infusions for pain relief. A further example was demonstrated by a participant deciding on cues such as a low BP or a high BP reading from an arterial line. For example, a novice participant said:

"If BP is high or low (1), then check waveform (2), if waveform is alright (3), then check artline is flushing (4), if flushing all right (5), then check that the artline is not kinked (6), if not kinked (7), then check the position of the hand in relation to the heart (8), if this is not the problem, then check against a manual reading (9), if still abnormal then report the reading (10)".

Operators: "plan" (1), "act" (2), "evaluate" (3), "act" (4), "evaluate" (5), "act" (6), "evaluate" (7), "act" (8), "evaluate" (9), "act" (10), "evaluate" (11), "act" (12).

The reasoning here appears to be a kind of backward reasoning from the problem low/high BP to determine the cause following a set of alternative rules. Novice participants appeared to have had such knowledge passed to them from senior staff. This is discussed further under information sources and the passing on of collective knowledge.

6.4.1.d Trial and error

If/then procedural rules were being used by novice participants to manage BP. Trial and error was also used by participants to manage aspects of care. See Appendix 23, Table 41 and Graph 5, for an example of trial and error. Trial and error is a decision-making process in which the decision-maker tries out successive interventions to determine which works best. There is often no set of procedural rules to guide the process, for example, trialing different positions with patients to make them comfortable. An example from the study is:

A novice participant was managing a patient's BP by titration of a GTN infusion. As the patient's BP was fluctuating and very labile, the novice changed the rate of the GTN infusion often to control BP. Every time the BP changed, she changed the infusion rate and turned it on and off in response to the fluctuations in BP.

"I am putting the GTN back on (1), because her mean arterial pressure is 111 (2), they want it below 95 (3), I just put the GTN back on (4), 'cause it went to MAP of 114 (5), … alarms for BP (6), yeah I think she had better have a bit more (7), the BP is still very high (8), so I should be increasing the … her BP is still up though (9), so I will increase the GTN (10), yeah I have increased it (11), because her MAP is 120, so it should be around 90 (12), it is down a bit now (13), put the rate down a bit (14), … her BP has come back up again (15), put it up again (16), I am going to increase that again as her MAP is still like 110 (17), her BP has decreased (18), so I will decrease the tridal (19), never can tell what is going on, might turn it off (20) … then turn it back on if she needs it (21), BP picks up very quickly (22), … yeah it is very labile (23)".

Operators: "act" (1), "rationale" (2), "describe" (3), "act" (4), "rationale" (5), "describe" (6), "choose" (7), "rationale" (8), "act" (9), "act" (10), "act" (11), "rationale" (12), "describe" (13), "act" (14), "plan" (15), "act" (16), "rationale" (17), "rationale" (18) "act" (19), "act" (20), "act" (21), "describe" (22) "interpret" (23).

She described this in the retrospective interview session as trial and error, in which she was trying to get the right balance to manage the patient's BP. However, the participant finally came to recognise the patient's pattern and decided to leave it at a low rate and not change it for a while and this worked. This was also reported by the participant in interview. This coming to know a pattern of a patient is discussed further under themes. During the TA session a senior had actually suggested that she leave the rate as is (see Appendix 23, Table 43 and Graph 5).

6.4.1.e Automatic processes

Automatic processes were also used by some participants during the study. Automaticity, as outlined in the information-processing theory, involves participants carrying out procedures or routines in which they automatically appear to know what to do and miss intervening steps or reasoning; such processes may represent internalised sets of procedural rules. Alternatively this example may have represented an instance of a participant who had stopped verbalising or it may have also represented intuition. For example:

A novice noticed that the patient's saturations were low and immediately put the nasal prongs back on the patient. The action was carried out automatically without the participant verbalising what s/he were doing. When interviewed about this later on the novice outlined how they do this by "noticing saturations are low, then look at the waveform, if this is all right, look at patient, the answer is usually with the patient". This may be an example of automaticity without voicing it at the time, but it is not subconscious, as s/he was aware of what s/he doing at some level and could retrospectively describe what s/he did. The automaticity here is perhaps an internalised routine that was based on a set of procedural rules.

6.4.2 Identified themes.

Themes were delineated from aggregation of common expressions in content and thematic analysis using the coding framework described (see Methods Section, 5.5.8, and Appendix 14, Figure 5 and Appendix 15). The content analysis resulted in the delineation of themes that describe how the participants manage the care of patients while caring for post-surgical AAA ICU patients. The themes were developed in relation to the study questions and cover the areas of tasks, cues, information sources and processes, and are presented in Table 29. These themes were enumerated for novice and expert participants by counting the number of times the novice and expert participants mentioned the themes, and then were tabulated.

Both novice and expert participants had statements concerned with the theme “on my watch” and both groups mentioned this theme relatively frequently. The theme “big issue” was mentioned more often by the novice than the expert participants and may have been more of a concern to this group. Similarly, the theme “seeking help” was mentioned more by novice than expert participants, as was the theme “under control”. Expert participants mentioned the theme “directing care” and “big picture” more often than novice participants, and both groups mentioned “collective knowing the patient”. The themes are presented below and examples given to illustrate their meaning.

Table 29: Themes mentioned by novice and expert participants and number of times mentioned

Theme:	Frequency	Frequency
On my watch	33	26
Under control	12	0
Big issue/get on top of it	51	2
Big picture	0	5
Directing care	2	14
Seeking help from others	12	0
Collective knowing patient	12	8
Maintaining simultaneous con centration	0	12
Prioritising care	0	6

6*.4.2. “On my watch”*

The theme “on my watch” was developed in the category of the coding framework “cues”, in the subcategory, “how do participants use cues” and was relatively frequent for both groups of participants. Statements referring to “watching”, “keeping an eye on the patient”, “keeping safe” and “on my watch” were considered collectively under the theme “on my watch”. Similar statements that made up this theme were statements such as “I am keeping an eye on it” or “just watch it” “just keep an eye out”, as well as “keeping an eye on what s/he is doing. One novice participant reported being told “they said just said to just sit on him and watch or you know just see what he does with that, give him a bolus and just see what he does”.

The theme “on my watch” was used by both novice and expert participants and related to the constant monitoring that was observed to be a feature of all participants’ care. The high overall frequency of the operators “plan” (collecting cues) “act” and “describe”, which involve collecting information about patients, concurs with the common theme “on my watch”, as this was often achieved by participants collecting much data on patient status. This theme indicates that the participants may have seen their role as watching over or keeping patients safe by constant monitoring to detect problems.

A question was added to the interview schedule to explore this issue further and the participants were asked how they saw their role. Many referred to their role as one of monitoring and making sure the patient was stable physically. This was not the only role they discussed in relation to how they saw their role in caring for patients; other roles mentioned covered caring, comfort and advocacy. However, all participants mentioned as part of their role the importance of watching over, monitoring and keeping the patient safe. Examples of statements that reflect how participants saw their role are, “My role is almost like an attentive observer of their systems, for me I like it to be my nursing role is to be real diligent regarding BP, very diligent”, “and you really have to protect safety, so that you have to protect that patient”. One novice participant expressed this as “by the end of the shift I felt like I had kept her alive and didn’t make her any worse so that was a positive to actually finish the shift feeling like I had adequately looked after her”.

6.4.2.b “Big issue”

This theme was identified under the category of the coding framework, “cues”, “how the participants used cues”, and the theme “big issue” was common for novice participants. Frequently used phrases for novice participants were “big issue” as well as “big problem” “focusing on” and “get on top of”, and were collectively considered under the subcategory “big issue”. The novice participants appeared to see some aspects of the patient’s condition as a main focus and concentrated on this with the gathering of cues around this issue. During hand-over to novice participants, other nurses were observed to be instructing the novice nurse that something was a big problem. Statements such as “yeah pain was an issue at handover” were made during the interview by novice participants. The novice participant who made this statement in the retrospective interview collected a lot of data on pain in the concurrent TA session and this was the main problem considered by this participant. The cues on pain collected by this participant were, however, narrow in range; the same type of data were collected repeatedly. The participant repeated statements such as “so ... pain is the big issue”, and “we are trying to get on top of his pain, because pain is the big issue at the moment”. The novice also had goals centering on getting pain under control, “I am trying to get on top of his pain”, “we want it (pain score) to be around two or three out of ten …. that’s where we are heading”. Other novice participants were concentrating on a big issue and collecting a smaller range of cues than expert participants, with cues often being around the one key issue. The lower range of cues for novice participants may reflect a concentration on a “big issue” or a more limited knowledge base. The novice participants also had a greater frequency of the operator “goal”, which may also indicate they were concerned with issues and had goals to help them “get on top of it”.

Often novice participants were directed by a “big issue” or priority that was set by handover or senior nurses directing them. For example:

A novice participant was directed early on to do an ECG, so concentrated on this first. Another novice participant had been handed over that BP was an issue and again there was a lot of collection of cues around BP.

6.4.2.c “Under control”

The theme “under control” was identified under the category of the coding framework, “tasks”, subcategory “how participants proceeded with planning care”. This theme describes how novice participants approached the planning of care for various tasks. On analysis, novice participants’ scripts appeared to read like a story with a step-by-step attendance to tasks. The novice participants in this study did not appear to be able to handle more than one task at a time and appeared to need structure of some kind to help manage care while attending to the various nursing tasks involved. For example:

One novice participant reported: “but I started to try and focus on individual things at a time” while another stated “It was confusing, there were 50 million people in there and they were all saying different things … And trying to focus on what was most important thing …. The novices were confused when there was a lot going on and felt out of control and needed to “get on top of things” by focusing on important issues.

One novice reported: “But it is trying to keep up with everything, like I just didn’t know what was going on with so many people coming in and telling me different things”. This same novice reported in the interview feelings of being out of control at the beginning of her shift but felt that by the end of the shift she finally had things under control, “by the end of the shift I had it under control, but the first three hours it was just all over the place”.

This theme relates to the other frequent theme mentioned by novice participants, “big issue/get on top of it”. Novice nurses may have felt a need to be in control. They often did this by focusing on “big issues” and following a set guide, such as flow chart or critical pathway, something that directed care and helped them get on top of things.
For example:

Novice participants attended vital observation assessments, then pain assessments, then limb observations, following the order outlined on the flow chart. This was often suggested to them by senior staff. One novice participant was advised “just to follow the flow chart to work out what to do, bring your chart in and we will start from there”. They therefore collected cues, operator “plan”, according to the guidelines they were following and the cue collection may only be as extensive as the guide, accounting for the lower frequency of cues for novice participants.

It appeared to be confusing for novice participants to have too many directions from different people, as they may not have developed the ability to handle more than one task at a time and they needed to give each task their full attention, a fact others may not have been aware of.

6.4.2.d "Seeing the big picture"

The theme "seeing the big picture" was identified under the category of the coding framework, "tasks", subcategory, "how participants approached tasks". The theme occurred more often for expert participants than novice participants, and this may be related to hypothetico-deductive reasoning or pattern-matching, possibly both. The overall picture seen by expert participants was often based on a broad range of cues with more linkages, and this could be due to the extensive experience and knowledge they have. For example:

One expert participant was assessing for limb observations and stated "I'm having trouble feeling these pulses, this man has got PVD, don't think he has TEDS as he has got PVD, has he had an endartectomy?" The participant queried vessel disease from a quick assessment of the patient; the participant had not read the notes or had a handover yet on the patient. The assumption of PVD later proved to be correct.

Another expert participant noticed a patient was bradycardic and queried what medications the patient took, and also noticed the patient was tanned and predicted that he would have fewer problems as was he healthy due to exercise. It was later revealed he had been playing golf and swimming to increase fitness after giving up smoking.

Expert participants also had both a broader range of cues and more extensive linkages between cues and concepts. This may lead to more detailed hypotheses compared to novice participants and an ability to "see the big picture". Novice participants' hypotheses appeared more limited. For example:

One novice participant used hypothetico-deductive reasoning to generate a hypothesis about fluid depletion and to disconfirm this using one cue, CVP. "I am going to do a CVP as volume is a big thing with these people, they lose a lot of fluid intraoperatively, we want to replace that (possible diagnosis fluid depletion) … so his CVP was 14, so we know he is well filled, as the normal CVP is around 8 so he is well filled, CVP was 14".

In contrast, the diagnosis of fluid depletion from an expert considered the vital observations of BP, heart rate and temperature, CVP, urine output and fluid input, as well as the fact the patient was receiving an epidural infusion to arrive at a diagnosis of fluid depletion. The hypothesis was based on more complete and far-ranging information and all information was considered at the time to allow the expert to "see the big picture".

6.4.2.e "Seeking help"

The theme "seeking help" was identified in the category of the coding framework "tasks", subcategory "how tasks are approached'. Novice participants were much more likely to ask for help than expert participants, they requested more information from peers and doctors, and needed more guidance than expert participants (see Table 29). However, how this help was delivered was important, as at times it was confusing for novice nurses who were struggling to get their work "under control".

As well as seeking help from others especially those more senior, novice participants were also observed to be deferring decision-making responsibility more often. If help was not at hand this could be concerning for novice participants.
For example:

One novice participant was very concerned about a patient's low BP but could not find a doctor to refer this to. This caused some distress:"I don't want to keep giving him fluids, I don't know where they have gone, I am not sure where they have gone, where has everyone gone, do you know where the doctors are by any chance, has anyone seen the doctors?". In interview the participant said in relation to this: "I was a bit concerned about it, um, yeah, I was noticing it was dropping and I think at the time the doctors weren't around anywhere so I was kind of should I go out and get them or should I just sit on him and watch what he does, I think I was a bit indecisive as to what to do".

6.4.2.f "Directing care"

The theme "directing care" was identified in the coding framework category "tasks", subcategory, "how tasks were approached". This theme was identified for expert participants but not novice participants. The theme "directing care" may have been related to the constraints on the nurses in that they cannot diagnose medical conditions or order care. The very low frequency of the operator "diagnose" correlates with this finding. However, if expert participants could not diagnose and order interventions they often directed care and asked for what they believed should be done. This forms the theme "directing care". The higher frequency of the operators "match" and "predict" indicate that expert participants have experience with treatments and can recognise situations and possibly know what needs to be done and they will use this knowledge to ask for what they believe should be done for the patient or direct others to give the appropriate care. For example:

An expert nurse decided a patient was fluid depleted and asked a doctor to write up fluid boluses "I think I'll just see if I can give him a quick 250 ml bolus, do you mind if I give him a fluid bolus, his BP is just a little bit low. I am assuming with the epidural started up BP is mean 65. If I can just give him a 250 ml bolus that might do the trick".

One expert participant decided that the patient needed an insulin infusion and asked the doctor to write it up. "Probably needs some insulin … find a doctor and start some insulin, any doctors up your way, this chap needs some insulin".

Another described in the interview how she asks doctors for what she wants and her opinion is normally respected and it is written up: "I felt that the patient was under-hydrated therefore I recommended a fluid bolus and my opinion was taken and respected and the fluid bolus was ordered".

Expert participants also often asked medical staff to set parameters they want for the BP and heart rate at which intervention would be required: "so what do you want for the parameters". Novice participants did not do this but expressed concern at not having such guidelines: "they did not really classify, well OK if his BP drops down to here then come and get us or give him a bolus so they weren't really specific with their treatment plans, yeah, which is a bit confusing". The ability to decide on what was needed was probably related to experience and matching and being able to predict appropriate care. Also, expert nurses were very familiar with unit policy and procedure and normal interventions and were comfortable asking for what they believed was necessary.

6.4.2.g "Maintaining simultaneous concentration

The theme "maintaining simultaneous concentration" was identified in the category "tasks", subcategory, "how participants approached and managed tasks". This theme indicated the ability of some participants to be able to refocus on a decision task, after they were distracted from that task without loss of their train of thought. The theme was identified for expert participants but not novice participants. During the analysis of transcripts, the novice participants' transcripts appeared to proceed in a step-by-step manner and it was easy to determine the separate subtasks. In contrast, when analysing the transcripts of expert participants, determining subtasks was harder, as there were times when two or more tasks appeared to be mixed together. When sections of the expert participants' transcripts where two or more tasks appeared mixed together were examined carefully, two separate tasks became apparent, with the participant switching attention from one task to the other and back without losing the train of thought on either of the tasks. Expert participants appeared to be capable of handling more than one task at a time and maintaining coherency in each separate task. Careful examination of the transcripts also showed that expert participants appeared capable of refocusing on a task when distracted from that task, again without a loss of the train of thought on that task. The theme “maintaining simultaneous concentration” was developed to explain this and occurred for expert participants but not novice participants.

Expert participants appeared to work without any obvious guidelines, and despite managing different tasks concurrently and moving between the tasks, they appeared to smoothly co-ordinate care. Examples are listed below:

1. An example involved an expert managing BP “turn the GTN off. Oh MAP is coming up” (someone comes in and asks him if he has got nasal prongs). “He has gone to get some nasal prongs, I might just give him a bit of a bolus, his CVP was only 6”. Even though the participant seems to be switching from one task to another, he is keeping track of where he was up to.

2. In contrast, a novice was fixing an arterial line and the alarms went off. She attended to those and then said “now back to … (pause)”. She had to think about where she had been up to before the interruption by looking at what she had been doing and this took time. This is in contrast to expert participants who can go back to where they were at and do so quickly with no effort.

3. Another expert was setting up and fixing lines as well as setting ventilator settings at the same time and listening to handover from theatre staff, as well as talking to other staff about patient, and giving orders to other staff as to what she wanted done. She said to theatre staff, I got all that, referring to the history they had given her. She then said: “she didn’t actually say she had given him propofol on the way down so I just assumed he was spontaneously breathing …” (she asked theatre staff about further information they have about the patient on his operation while putting on red dots and connecting to patient to monitor)…“so propofol and any other muscle relaxants, that’s good, it should wear off quickly” this was done while also taking a handover on fluids and theatre care.

4. In comparison, a novice participant, also setting up a patient from theatre, was setting up her patient with help and was confused as she found it hard to concentrate on the handover and she didn't follow most of it, especially as she was also trying to concentrate on getting the patient settled.

As expert participants were able to concentrate on more than one task at a time, this may explain the observation that expert nurses used touch with patients in contrast to novice participants who did not. Novice participants may have been concentrating on the task at hand and had been unable to think about using other interventions with their patients.

6.4.2.h "Prioritising care"

The theme "prioritising care" was also identified in the category "tasks", subtask "how do participants approach and manage care". The theme "prioritising care" was identified mainly for expert participants. It was noted that as well as being able to manage more than one task concurrently, the expert participants appeared to prioritise care based more on assessment and patient need and condition. The expert participants appeared to be able to predict what would be needed for the patient from matching to patients seen previously. This enabled the expert participants to be able to deal with the more pressing problems first after a rapid assessment, leaving less important issues until later. In contrast, the novice participants often organised care following the ICU flow chart or AAA pathway and often had difficulty working out which tasks were of higher priority and needed to be attended to first. Results presented in Sections 7.4.2.b and 7.4.2.c also highlight the difficulty the novice participants had in organising care and knowing what to do when.

Expert participants also often decided to cluster tasks at more opportune times. The ability to cluster and prioritise care may have been due to their ability to anticipate care needs or from repeated experience. For example:

One expert asked a patient whether he wanted anything done before she went out to bring the family in and then decided to wash the patient before bringing the family in, while also doing a head-to-toe assessment on the patient.

Expert participants nearly all sent someone out early for the family to come in, whereas novice participants omitted do this**.** Informing the family of the patient's status appeared to be important to expert participants.

6.4.2.i "Collective knowing the patient"

The theme "Collective knowing the patient" was identified in the category of the coding framework "information sources", "where information was obtained from, and how it influenced decisions made". Participants spent time talking to the patient and getting to know her/him and then passed some of this information on to others caring for the patient. This was termed "Collective knowing the patient", as the knowing of the patient came from a few knowledge sources, not just the one source. Some knowledge about the patient came from sources such as peers and carers and this was passed on to help in the care of the patient, while other knowledge came from nurses and was also passed on to others. The knowledge gained from different sources became the patient's story and was repeated from nurse to nurse and used in caring for the patient. For example:

From observation it was noted that one novice participant knew the patient was anxious, but on questioning it was revealed that this was passed on in handover and that it had been checked by ringing the patient's carer.

The novice participant had not gained this knowledge just from the patient but from a range of collective sources. The knowledge was termed "Collective knowing the patient", as it was used by the group to know the patient and not just by one nurse to know and care for that patient.

Another example of "collective knowing the patient" involved:

a patient whose care was observed by the researcher on his arrival back from theatre on the evening shift. The same patient care formed the basis of observation by the researcher the next morning but with a different participant as part of the data-collection process. The first participant caring for the patient, an expert, noticed he had a good tan, he seemed to be doing well and she was wondering about his being fit, hence in a better condition post-operatively. She asked the family about this, and they said he played golf and did exercise a few times a week. This was passed on in handover next morning to the next participant and she used this collective knowledge as well to judge his prognosis and referred to his golf-playing and exercise habits and how it helped him to cope better with the operation.

"Collective knowing the patient" was also evident in some of the common terminology used by participants, such as "blow the graft", "knock off the kidneys" and the information that the novice participants reported they were given about AAA patients. The knowledge that novice participants were given was often similar and often they were given sets of procedurals rules to follow when caring for AAA patients, as well as certain indicators to watch out for. For example:

One novice participant stated: "volume is a big thing with these people"; the senior nurse had instructed him on this. This was also told to other novice nurses and was stated by most of the senior nurses as an issue to watch out for in AAA patients.

Another novice participant was told to watch the BP, as if it is high it can "blow the graft". The terminology reflects transmitted knowledge which was also used by other participants.

Information was passed on regarding cues from expert participants to novice participants. For example:

Novice participants reported being taught the rules. “If a patient’s BP is low, then check a few things first such as a kinked artline, the waveform (trace), do a manual reading to check artline reading is right, check pain and medications and so on”.

The use of “we” in instances where the correct grammatical expression is “I” may also indicate “Collective knowing the patient”. Both groups of participants used “we” instead of “I” and this appeared to be in instances in which the responsibility for decision-making was shared. This may be due to the decisions being more worrying for the nurses, hence a sharing of responsibility or in areas where the decision may be out of the domain of the nurse. “We” often appeared to be used when reasoning about and discussing things such as ventilation, managing BP and pain. This may reflect the fact that these are group decisions, involving peers and doctors. “I” tended to be used correctly for decisions that involved routine tasks that are within the nursing domain, for example, when giving a wash or turning a patient. For example:

“I” was used in tasks that the nurse is usually responsible for “I have tried to put his bed on a slant”,

whereas “we” tended to be used when reasoning about tasks that may not be directly the nurses’ responsibility or may involve group management of the situation, for example:

“I’m going to check his CVP … we want to replace that to make sure we stay on top of it”. “O.K., I’m going to give him another bolus of the epidural, 5 mls per order we gave him some half an hour ago”. “I am going to get the physio up here we don’t want him getting pneumonia”. “Um, his tidal volume is we will up that just a little bit”. “BP is a little low … we really need to address that before I take the tube out”. “I just want to check your level of pain … as it is important that we know your level of pain … we may have to look at your order see if we can give you a bolus from your epidural”.

The last example may denote that the participant saw giving boluses as a joint decision.

However, this task is within the nurse's role and it may have been of concern to the participant and it therefore became a group responsibility. The study does not allow for a full investigation of how and why nurses are using "we" and "I" this way, however, this is an interesting observation and it may indicate a collective knowing and collective responsibility for certain tasks in nursing.

6.4.2.j "Doctor preference"

The theme "doctor preference" was identified in content analysis using the coding framework under the category "information sources". The theme "doctor preferences" was mentioned by expert participants as a source of knowledge for care of the patient but not by novice participants. Different doctors were described as having different preferences and these needed to be followed for their patients. The preferences represented variances on the normal practice of the patient, for example, different doctors had different days when the nasogastric tube was removed or when the heparin was ceased. One expert participant reported: "Dr D will have a nasogastric for three or four days", and further added, when asked by the family how long the patient would have the tube in: "This one can't come out. If I take this out Dr D will shoot me." Another reported: "Um, you know Dr D will have antibiotic treatment, Dr M usually doesn't", while another said, in regard to what information they would give more junior nurses about caring for AAA patients: "I would ask them to find out the surgeon's name because they have different requests especially Dr M, so find out how he likes his BP".

6.5 Reliability

The operators for concurrent TA session and retrospective interview session had some differences as outlined above in Section 6.3.2.e, however, there were also many similarities and this supports the belief that data collection using both concurrent and retrospective TA can increase reliability. The similarities were evident in that the frequencies of operators decreased as the level of higher order thinking skills increased in both the concurrent TA session and the retrospective interview session. In both sessions novice participants also used the operator "review" more often than expert participants, whereas the expert participants used the operators “match” and “predict” more often. The much higher frequency of use of the operators “match and “predict” in the retrospective recall session may indicate that some of the reasoning of the expert participants during the concurrent TA session may have been automatic or perhaps represents intuition. The findings are relatively constant across both data-collection techniques of the same decision-making instances.

Differences were apparent mainly for the operators “plan” and “act”. The frequency of the operators “act and “plan” were lower in the retrospective interview session, and may be due to the retrospective interview session tapping into the LTM rather than the STM, in which recall of all the cues and what participants were doing is less.

Inter-rater reliability was assessed by having another nurse expert in decision-making studies analyse sections of the transcript using the coding frameworks to determine the correlation between the coding of the researcher and the other nurse. Discussion between the researcher and nurse expert after the first attempt to use the coding schedule resulted in the clarification of codes. After clarification of the codes a Kappa of 0.774, $p = 0.05$, 95% confidence interval of 0.5215–0.887 for the coding schedule for concepts was obtained and a Kappa of 0.702, $p = 0.05$, 95% confidence interval of 0.521–0.887 for the coding framework for operators was obtained.

6.6 Summary

The data from the study demonstrate differences in the use of operators and processes by novice and expert participants, as well as differences in how they approach and manage the decision tasks, the depth and range of cues they access and some interesting observations on the information used by both novice and expert participants.

Many of the tasks that participants made decisions about concerned assessment and management of patient care. In the approach to the tasks of the study expert, participants demonstrated a more proactive approach than novice participants, who exhibited a more reactive approach. Expert participants also tended to plan care more often than novice participants, which is reflected by a higher frequency of the operator “course” for expert participants as well as a higher frequency of the approach to tasks involving “planning”. Novice participants tended to seek help more often in their approach to tasks and decision-making than expert participants.

The participants used a wide range of cues to make decisions, but expert participants used twice as many different types of cues than novice participants, even though the novice participants had a higher frequency of the operators “plan” (collect cues). Expert participants also linked more cues and concepts than novice participants. This is reflected in the slightly higher frequency of use of the operators “interpret” and “relate” by expert participants than novice participants.

The operators used by the novice and expert participants showed a higher frequency of operators in the lower levels of the higher order thinking skills than in the higher levels. This included the operators “plan”, “act” and “describe” in the lower levels and the operators “diagnose”, “choose” and “course” (category synthesis) in the higher levels. Novice participants use the operator “plan” (collect cues) and “review” more often than expert participants, whereas expert participants had a slightly higher frequency of the operators “interpret” and “relate”. Expert participants also had higher frequencies of the operators “match” and “predict” than novice participants and all participants used the operators “diagnose”, “course” and “choose” infrequently.

A wide range of information sources was also used by all participants, with expert participants mentioning the theme “doctor preference” in relation to information sources, while novice participants did not. Participants were also noted to be exchanging information about patients and passing on a story about a patient’s care and this may represent “collective knowing of a patient”. Instances of knowledge being passed on from expert participants to novice participants were also noted, and this was often accomplished with sets of procedural rules and common terminology.

Both groups of participants used the process hypothetico-deductive reasoning, however, expert participants tended to use forward reasoning during hypothetico-deductive reasoning whereas novice participants tended to use backward reasoning during hypothetico-deductive reasoning. This concurs with the expert participants using both a proactive and planning approach to tasks more often than novice participants. Expert participants used the process pattern-matching more often than novice participants. Both groups of participants used if/then sets of procedural rules, some of which may have been automatic especially for the expert participants.

The main themes identified in the study were “on my watch”, which was identified for all participants, and referred to the constant monitoring and observation of patients seen to be an important aspect of the role in caring for post-surgical AAA patients. This concurs with the high frequency of the operators “plan”, “act” and “describe”.

The theme “under control” was identified for novice participants but not expert participants. This theme describes feelings of confusion, being overwhelmed, and often not knowing what to do or how to prioritise care. This concurs with novice participants having a mainly reactive approach to decision tasks and often seeking help from others for decision-making. It also supports the other often-mentioned theme by novice participants, “big issue”, whereby an issue handed over to the novice can form the main focus of care. This is often reflected in the narrow range of cues used by novice participants but a concern with collecting the same cues around the central issue or “big issue”.

Expert nurses, on the other hand, often mentioned the theme “big picture” and collected a wider range of cues based on a broader overview of the patient’s condition, with a more proactive approach to decision-making tasks. Expert participants also used the operators “match” and “predict” more often, as well as the process pattern-matching and appear to be able to anticipate what is needed and collect a wider range of cues, which together with better links with concepts, allows planning for and prediction of needed care. Expert participants were also noted to “direct care” to ensure that the care they believe should be implemented actually is. Expert participants also appeared to have the ability to manage more than one task concurrently and to be able to keep track of their reasoning when distracted from a decision-making task. The findings are discussed in relation to the literature in the next Chapter.

Chapter Seven

Discussion and implications

This Chapter considers the meaning of the results of the study, particularly in relation to the literature, and considers the potential impact on nursing practice, education and research. Much of the data corroborates other research in this area and, using the information-processing theory, a picture can be built of expert and novice reasoning and decision-making about the care of AAA post-surgical patients. The theory of information-processing is based on the study of the cognitive behaviour of individuals completing particular tasks and grouped data are not used to test theory but to develop models to describe an individual's cognition (Newell and Simon, 1972). When using information-processing theory emphasis, is put on discovering and describing the mechanisms that are sufficient to perform a cognitive task under study and this is the first step in outlining how individuals perform certain cognitive tasks (Newell and Simon, 1972). The theories developed describe behaviour in a task by describing the manipulation of information down to a level at which a task can be described as a process for performing the task (Newell and Simon, 1972). The data described in this study begin to outline how novice and expert nurses decide on care while monitoring haemodynamic status during the care of post AAA patients and the data allow for the description of mechanisms of cognitive strategies involved in such decisions.

The discussion of the data are presented with some verbatim quotes that allow the reader to judge the fit to their own experience. The findings are discussed in relation to theoretical considerations, particularly of the information-processing theory and the findings of other researchers. The differences and similarities between expert and novice participants are considered. The Chapter examines the findings of each section separately and then considers them as a whole. The demographic data is considered first, then the findings concerning the description of the problem space, namely tasks, cues, and information sources, then the use of operators and processes, and finally the themes generated by content and thematic analysis.

7.1 Demographic data

The study employed a small sample, eight nurses in all. Small samples are the norm in studies using TA; seven nurses participated in the study by Grobe et al. (1991), eight in Aitken's (2000), six in Greenwood et al.'s (2000) and 15 in the study by Simmons, Lanuza, Fonteyn, Hicks and Holm (2003). The current study was similar to all these studies in this respect. However, for each participant there were many decision tasks examined, ranging from 15–29 for individual participants, totalling a relatively large number of decision tasks.

Some of the novice participants in this study had entered the nursing workforce directly into critical care, and the others had only been in nursing for six months to one year before entering ICU. Some new graduates do indeed need to "hit the ground running" and to be relatively knowledgeable on commencement as they enter into specialist areas straight from graduation or not long after. If this trend is becoming more common, then undergraduate education does need to consider and accommodate this (Messmer et al., 2004; Ihlenfeld, 2005).

The education level of all but one expert participant was at least at the level of an undergraduate degree, and the expert participants, in line with the selection protocol, had post-registration qualifications in critical care. The fact that all but one participant had a degree reflects the findings of an Australian study which examined the relation between decision-making by Australian nurses and a number of factors including educational level. The study found that 15% of participants held only a hospital certificate, with the other 85% indicating they had either a post-graduate certificate or diploma or degree in nursing, with 71% indicating they had a university qualification of some sort (Hoffman, Donoghue and Duffield, 2004). Very few Australian nurses, especially in specialist areas, have only a hospital certificate.

Two of the novice participants had previous work experience, one as an enrolled nurse and one in another field requiring advanced studies. This is reflective of the nurses entering the workforce today, with nursing having relatively high numbers of mature-age students with previous work and life experience. There is also a significant cohort of undergraduate nurses in Australia who have previously qualified as an enrolled nurse (Kilstoff and Rochester, 2004). These nurses are bringing a diverse range of work and educational experiences with them into nursing.

7.2 Description of tasks in the study

A description of the decision tasks of the study can help illuminate the reasoning processes of participants and contextualise such processes (Newell, 1966). It has often been acknowledged that decision-making is task-dependent and that understanding tasks is important, however, few studies actually describe the task in detail (Benner, 1984; Tanner et al., 1987; Thompson and Dowding, 2002). Examination of decision-making using simulations can control the task to a certain extent and allow some understanding of the task which comprises the problem space and usually involves tasks centred on patient assessment, planning care, or infrequently, implementation and evaluation of care (Thompson and Dowding, 2002). Using TA in the real world results in complexity in understanding the tasks involved in decision-making and may involve assessment, planning care, implementation and evaluation. Previous studies using TA in the real world examining orthopaedic nurses' decision-making (Greenwood and King, 1997), neonatal nurses' decision-making (Greenwood et al. 2000) and critical care nurses' decision-making (Aitken, 2000; Aitken, 2003; Aitken and Mardegan, 2000) did not describe tasks in depth. Two studies in nursing, one using Naturalistic Decision-making with event sampling and observation (Bucknall, 2000) and one using TA in England (Lamond et al., 1996), described decision tasks as involving the categories intervention, communication, evaluation, inference, description and causality. The current study gives a reasonably detailed description of the problem spaces for the decision tasks of the study and this helps to understand the cognitive processes better in context.

The care of patients in this study involved an extensive and complex list of interrelated tasks concerned with managing the care of post AAA surgical patients, with some differences noted in the tasks attended to by both novice and expert participants. The majority of tasks attended by participants in the study were centred on the monitoring and implementation of interventions. Few tasks involved diagnosis and the choosing of alternative options for treatment. This is not unexpected, as the study examined tasks around monitoring and managing haemodynamic status and aspects of care that could impact on haemodynamic status. However, overall examination of the number of tasks in total in the transcripts showed that assessment and monitoring comprised a large proportion of all tasks. The differences in tasks attended by novice and expert participants are presented first, followed by task outcomes and then the approaches to tasks taken by both novice and expert participants.

Overall, expert participants attended a wider range of tasks than novice participants, and this finding is probably related to a greater knowledge base and more extensive experience. Expert participants also considered family as well during the carrying out of tasks and more often used touch to communicate with patients. This was also found by Harrison and Nixon (2002) and Ellerton and Gregor (2003), who described how expert nurses develop communication and relationships with patients and families, whereas novice nurses defined their work as a set of skills and procedures to be attended, with most lacking the capability for helpful communication with families. This may have occurred in these two studies as the novice nurses were concentrating on their practice and found it difficult to also consider other issues such as the families. Similarly in the current study, despite emphasis placed in most undergraduate programmes on holistic care, novice nurses did not consider the families' needs. This needs further consideration in research and education.

The outcomes of tasks were also different for novice and expert participants. Both groups had higher frequencies for task outcomes assessment and management than other task outcomes; together this accounted for 61.85% of task outcomes. Tasks involving monitoring may be common to critical care nursing. The findings of studies that described the frequency of CCU and ICU work as being centred mainly on monitoring, up to 50% of the time in some studies (Harrison and Nixon, 2002; Adomet and Hicks, 2003; Bucknall, 2003; Wong et al., 2003) are evidence of the importance of monitoring in this area.

Expert participants had a higher frequency for the outcomes “planning” and “diagnosing” than novice participants, however, overall not many task outcomes involved “diagnosis”. Examination of transcripts revealed that at times participants appeared to be using an unstated diagnosis and some decision tasks represented these. Expert participants were noted to have gathered cues and to have combined them in a way that would suggest a diagnosis and these were used in interaction with doctors when discussing care. This is discussed in more detail in the section on themes, “directing care”. Not surprisingly, novice participants had a higher frequency of the outcome “seeking help”, when no decision was made but was deferred to others for advice and help. This deferring of decisions to others may lead to a delay in treatment (Bucknall, 2000) and novice nurses need to be encouraged to seek help early.

Expert participants’ tasks were characterised as involving more “proactive” planning which could prevent problems, whereas those of novice participants were more often “reactive”, occurring after a problem had occurred. This concurs with literature that describes expert nurses as being able to anticipate and predict possible adverse outcomes due to greater experience and domain-specific knowledge. The anticipation of possible problems is believed to be possible, due to greater experience with similar cases as well as greater knowledge of assessment and understanding of physiology and pathology and may occur by pattern-matching (Radwin, 1998; Redden and Wotton, 2001). This anticipation and prevention of problems was described by Prowse and Lyne (2000) as informed vigilance, which could allow rapid detection of problems and “rescuing” of patients postoperatively. Expert nurses are able to forward plan and have automatic routines in place to help in this, and this may help them to “rescue” patients and keep them safe (Taylor, 1997).

However, one novice had a high score for frequency of “proactive” tasks, and analysis of this script showed that this was due to planning according to the flow chart and care plan. The definition of “proactive tasks” was gathering of cues and data to plan ahead and the novice participant with a higher frequency of proactive tasks appeared to be doing this. However, it was not based on an anticipation of problems but rather on standard procedures. This differed from the expert participants who often did not use the flow chart to proactively plan care but instead used their prior knowledge and experience. This accords with other author’s descriptions of the approach novice nurses take to tasks, novice nurses being described as having an unfocused approach dependent on policy and procedures (Hanneman, 1996), and structured by routines such as care plans (Benner et al., 1996).

In summary, novice and expert participants approached tasks differently. The differing approaches had some affects on aspects of decision-making such as the operators and processes used and this is elaborated on throughout the discussion. Many of the decision tasks in the study also involved assessment of patients, and this appears to be a common decision task for nurses. Therefore, understanding any differences in the way novice and expert nurses collect information for assessment is important in nursing.

7.3 Cue usage and cue linkages

Overall, study participants used a very wide range of cues to assess and monitor patients for a variety of concepts related to and impacting on the patient’s haemodynamic status. In clinical practice a very extensive body of knowledge in monitoring and assessing patients exists from which novice nurses need to learn, both from theory and experience. Expert participants in this study used a greater variety of cues, 81 different cues in total compared to 49 different cues for novice participants. This was also found in Taylor’s study (1997) in Australia, where novice nurses were observed to be collecting few cues compared to expert nurses who accessed an extensive range of cues, including such things as facial expressions, age, weight-bearing capacity, seriousness of illness and degree of dependence. The expert nurses in Taylor’s (1997) study incorporated these cues with test results and other information to obtain a total picture of the patient. They also were noted to judge single anomalies in vital signs, such as a low BP, in relation to the whole picture of the patient that they had established. Similarly, in the current study expert participants often employed many cues to explain such things as low or high BP, whereas novice participants did not. It is important that novice nurses learn the extensive cues presenting in clinical practice, as focusing on too few cues may lead to inaccuracies in detecting patient problems (Currey and Botti, 2003). Novice nurses may need more guidance and education to understand the wide range of cues used by expert nurses in the care of patients.

Expert participants also related cues to more concepts and had more linkages between these. For example, expert participants related heart rate to three different concepts, whereas novice participants related it to one. A similar result was obtained in an Australian study examining orthopaedic nurses' clinical reasoning; expert nurses were found to relate items of information together more frequently than did novice nurses (Greenwood and King, 1995).

The better linkages by an expert in a discipline are demonstrated by their superior performance when unexpectedly asked to recall information during a task. In this situation they recall more complete and accurate information than novice nurses in a discipline, due to the way the information has been incorporated into their memory in meaningful patterns that are easier to make sense of and recall (Ericsson, 1996). During cognitive processing, experts in a discipline appear to be capable of generating a complex representation of encountered situations, which aids in recall and is often demonstrated in their relating of information together. Novices in a discipline often have a simpler representation of situations which may hinder recall and may lead to reviewing information more often (Ericsson, 1996).

The explanation from the information-processing theory describes the LTM as being made up of an enormous collection of interrelated nodes which are accessed by either recognition or by way of links that associate nodes to others already accessed (Ericsson and Simon, 1984; Ericsson and Simon, 1993). As expertise is developed in a domain, the nodes in the LTM are capable of storing more meaningful chunks that are accessed more readily by linkages from one node to the next. Hence it is probably more important to understand how expert nurses relate information together than how much and what kind of information they have. There is a need to carry out more comprehensive analysis of cue clusters to be able to identify both critical and pivotal cues being used in practice, as very little research has examined how expert nurses use cues in the real world of practice. Understanding how experts use cue cluster and pivotal cues may help in developing educational materials for undergraduate and novice nurses. There is also a need to understand how expert nurses link cue clusters together to build highly complex systems of relationships between cue categories (Jones, 1988; Redden and Wotton, 2001).

The method here for examining relations between cues and concepts gives some basic information and illustrates that there is a difference between how novice and expert nurses use these. However, a method such as concept mapping, as used in the study by Aitken (2000), could illuminate this better and would be useful in further studies to explicate this further.

7.4 Information sources

A wide range of information sources was mentioned by participants in this study. Research was mentioned infrequently by participants but was used by one participant as a reason for a new policy being implemented during care. This is an important finding in view of the emphasis on evidenced based practice, few of the nurses in this study were using research evidence in their practice. Information sources were examined more fully using content analysis and are discussed under the themes of collectively knowing the patient, doctor preference, experience, use of guidelines and policies and information from others.

7.5 Operators

As outlined in Chapter Two, human cognition can be seen as the processing of information. This involves the transforming of a sequence of internal states successively (Ericsson and Simon, 1993). Information is perceived by an individual and then processed by a number of memories including the sensory memories, STM, and LTM or LT-WMs. Ericsson and Simon (1993) point out that it makes no difference if we assume a single homogeneous memory with different modes of activation or several discrete memory stores referring to the variations of the theory on processing, what matters is that the information-processing can be seen to operate in the same way. While processing the operands, states of knowledge are transformed into a new operand or output by an operator, a strategy used to induce the transformation (Newell, 1966). The operators used are closely adapted to specific retrieval demands of corresponding tasks and differ for different domains. The operators examined in this study were determined by analysis of nursing decision-making literature and refined during the pilot study, and the findings are discussed below. The operators identified for the study were present in all transcripts, indicating that they are relevant to the tasks of the study and probably reasonably reflect thinking strategies used by nurses while caring for patients. The operators “match” and “predict” were developed from the pilot but not used in other nursing studies examining decision-making which employed TA and PBG to identify operators. However, other nursing research would appear to support the use of such operators in studies using TA, as processes resembling pattern-matching have been described in studies using other methodologies (Fonteyn and Cahill, 1998) and the operators were identified for participants in the study. The frequency of the operators varies and this is discussed below.

7.5.1 Operators overall

The outcomes of the analysis on the operators overall will be considered first. The frequency of the operators decreased as the operators increased in the complexity of higher order thinking skills. There was more time spent on the categories of operators “collecting” and “describing”, than on “selecting”. “Inference” was next in frequency, then “synthesis”. This may be due to fact that nurses use more lower level thinking skills or alternatively that any task will have a higher ratio of lower order thinking skills to higher order thinking skills, as more time is spent in gathering information than in the selection and validation of an outcome.

Overall, the operators with the highest frequency were “act” and “describe”. Participants spent much of their time doing routine tasks in which they described facts and events or described actions they were carrying out. According to Newell (1990), when problem-solving an individual searches through a problem space, the search proceeds coherently until something new arises that is not understood and this leads to an effort to resolve the difficulty. Much of the task, however, can be routine, with effort expended whenever a situation arises that the individual does not understand. The care of postoperative AAA patients appears to mirror this, with a high proportion of the operators being concerned with stating actions being carried out and descriptions of what was occurring. Many of these actions and routine tasks are common to nursing and do not present problems for the nurse, for example, bathing, routine observations that are within expected limits, turning a patient. Problem-solving or more complex reasoning occurs when something such as an observation outside expected limits, patient complaints of discomfort, or other anomalies in assessment trigger concern, as they are not immediately understood. It was reported in the study by Bucknall (2003) that nurses were fast and efficient doing familiar tasks but slower and less confident in unusual situations, reflecting the finding of this study that cognitive processing proceeds routinely until an unusual situation requires consideration and solving. The findings of this study also corroborate the findings of studies examining nursing work, that a large percentage of ICU nurses’ time is spent doing more routine work and observations, up to 82% in some studies (Harrison and Nixon, 2002; Wong et al., 2003), with a consequent high frequency of cognitive operators in TA involved with describing situations and actions.

The high frequency of the operator “describe” is similar to the findings of Higuchi and Donald (2002), who also found this operator to have the highest overall frequency in their study of nurses' documentation. Their study was also carried out in the real world of practice but differed from the current study, as it involved retrospective recall in the form of written patient notes. The nurses in the study by Higuchi and Donald (2002) used description frequently to outline patient circumstances and the events that had occurred on the shift; they spent a high proportion of their time listing facts. A similar finding was reported by Lamond et al. (1996) in a study using TA and PBGs, that classified decisions into four types: causal, descriptive, evaluative and inference. Descriptive decisions accounted for 65% of all decisions.

One possible explanation for the large proportion of time spent on routine tasks with consequent operators involving "act" and "describe" is that stress-inducing decisions are often handled by routines. The idea of nurses using routines to relieve stress has been present in nursing since Menzies' (1960) seminal work on the functioning of nursing as a social system as a defence against anxiety. The nursing service was described in Menzies' (1960) study as attempting to spare staff anxiety by limiting the decisions to be made by the use of routine tasks, which were standardised and carried out like rituals. Nursing has attempted to move away from the type of inflexible routine care described by Menzies (1960), and care practices are now expected to be based on evidence and individual care practices. However, Menzies's findings (1960) may still be relevant to the current study, especially in reference to the use of "we" by participants in situations where "I" is grammatically correct. "We" may have been used to share responsibility around for certain problematic decisions, hence giving ownership to the group, not the individual.

The meaning of routine care as used in this study does not necessarily imply the type of inflexible ritual tasks described by Menzies (1960), but routines that an individual builds up from experience or is taught on entering the nursing workforce. Routine, as used in this way, implies familiarity with doing a task and not inflexible ritual practice. Work that is familiar to a nurse would become routine, as indeed it does in other disciplines, however, there still may be attempts by nurses to decrease anxiety through sharing tasks and carrying out comforting familiar routines. The anxiety induced by decision-making has been described and it is believed to negatively impact on care; having familiar routines to manage care may be beneficial (Boychuk Duchsher, 2002). However, care is needed that all nurses remain alert for changes in patient condition to ensure patient safety. The issue of nurses using routines to decrease anxiety will be addressed further in relation to the use of procedural rules and some of the findings from the content analysis.

The finding in this study that nurses use the operator “act” frequently in the performance of tasks in the real world of practice is similar to the findings of Wong and Chung (2002), who also found that in real-life situations many of the actions of nurses are standard interventions and that work is often procedure-driven and not dependent on complex reasoning. The operator “act” was also used in a study examining nurses’ decision-making using simulated patients (Jones, 1989). “Act” was defined as giving care and was found to have a low frequency (Jones, 1989). However, this contrary result is probably due to the use of simulated patients. In such studies nurses are usually set a problem to solve or asked to plan care and much of the routine, taken-for-granted care would not be considered by participants and researchers. Studies in the real world, such as the current study, illuminate routine care and the cognitive operators employed.

In contrast to the finding in this study that nurses are engaged in much reasoning concerning routine, Taylor (1997) concluded from her study that nurses in the 1990s were giving more holistic care than in the past, as routines were rarely mentioned by nurses and only by expert nurses in relation to following surgeons’ orders. Taylor’s (1997) study examined novice nurses (students) and expert nurses (who had entered nursing after completing a tertiary degree) in the clinical area for decision-making about five procedures: showering, taking BP, doing a complex dressing, testing urine and doing a blood glucose test. The data about decision-making during the performance of these tasks were collected by observation followed by interviews. Taylor (1997) does not define what is meant here by routines, but presumably it refers to the following of specific procedures in prescribed order. However, the tasks chosen for Taylor’s (1997) study would presumably be very familiar to experienced nurses and the carrying out of such tasks would often be routine in the sense of being very familiar. Hence the participants in Taylor's (1997) study may not have discussed such routines in interview, leading to a finding of nurses not carrying out many routines. The current study using TA demonstrated that all participants participate in many routine tasks.

The operator "plan", which is the collection of cues, had the next highest frequency. There is an emphasis on assessment, reflected by the relatively high frequency of this operator. This supports the work of Higuchi and Donald (2002), who found the operator "selection", defined as the collecting of cues and information, to be next highest in frequency of the operators used in their study of decision-making in recording of patient notes. The study by Jones (1989) examining decision-making using simulated patients recorded a high frequency for the operator "plan" as well, and it was concluded that obtaining information dominates the nursing diagnosis task.

Whether much of the reasoning of nurses is concerned with diagnosing or management is of interest in relation to the finding of high frequencies of the operators "act", "describe" and "plan" in the current study and the finding of the current study that many tasks involve assessment and management. Much of the American literature on nursing care emphasises the importance of nursing diagnosis. Diagnosis in decision-making is also a prominent feature in medical decision-making. The diagnosis by American nurses refers to diagnosing nursing problems as opposed to medical problems, but similar processes are believed to be used. Research into nurses' decision-making, however, is highlighting that much of nurses' reasoning does not involve diagnosing but management and implementation of treatment plans (Fonteyn and Cahill, 1998). The high proportion of decisions fitting the category "descriptive" in the study by Lamond et al. (1996) led the authors to conclude that much of the concern of nurses is not with diagnosing but with assessment and management. Researchers in nursing have also pointed out that medical decision-making differs from that of nursing (Crow et al., 1995). Medical practitioners are concerned with diagnosing and finding an explanation, while nurses are concerned with providing an accurate picture of a patient's condition and carry out frequent assessment and gathering of cues in order to do this (Crow et al., 1995).

Nurses' cognitive reasoning and decision-making in the real world of practice appear to be concerned with continual assessment and management of patients with lesser emphasis on diagnosing; this has been termed, in relation to ICU nursing, "monitor gazing" (Harrison and Nixon, 2002). The continual assessment of patients may reflect the tasks and roles of nurses and can impact on the cognitive processes used, as these appear to be related to task (Hamm, 1991; Hammond, 1996; Lauri et al., 2001). As much of nursing decision tasks are concerned with assessment and management of patients, many of the cognitive operators used are concerned with gathering cues, describing facts and context and carrying out actions. This is to be expected in ICU, where patients are unstable and require constant monitoring. This would seem to lend support to the idea that one role of nurses in patient care is the surveillance and early detection of patient problems, a role which acts to keep patients safe (Aiken, 2003). This role is believed to be important in much of the everyday routine work of nurses, which tends to be invisible (Spilsbury and Meyer, 2001).

The operators "diagnose" and "choose" had the lowest overall frequencies. According to Benner et al. (1996), no participants in their study discussed diagnosing and they concluded this was not the model used in practice, but that nurses used engaged reasoning. Engaged reasoning involves nurses making decisions on the basis of their involvement with the patient and their ability to recognise patterns in clinical situations. Benner et al. (1996) also suggested that the role of nurses may be more involved with assessing and managing and less with diagnosing and prescribing. This appears to reflect a common conclusion with the current study, as well as those of Lamond et al. (1996) and Fonteyn and Cahill (1998). This feature of decision-making has implications for nursing, especially in education, and this will be discussed further.

The finding that the operator "choose", selecting between alternative courses of action, had a low frequency is supported by Hallett et al. (2000), who found that nurses do not consider a range of options and then choose one, as some literature describes, or in the way some clinical methods imply, but instead seemed to link problems to what is needed to be done. Nurses may spend less time diagnosing and choosing between alternatives than is often suggested in literature on decision-making processes (Hallett et al., 2000). It was further suggested by Watson (1994) that as basic principles have become internalised with experience, expert nurses are able to focus down on particular aspects of a problem and do not consider unproductive alternatives, hence operating at a higher level of reasoning, and much of their reasoning during decision-making may become automatic.

The operator “verify” in the current study had a relative low frequency but had a higher frequency than the operators “diagnose”, “choose” “relate and “interpret”. In the study by Higuchi and Donald (2002), the operator “evaluate” or “verification” had a lower frequency to the current study. The difference in the operator “evaluate” between the current study and that by Higuchi and Donald (2002) is probably due to the fact that the study by Higuchi and Donald (2002) examined written patient notes, which are a form of retrospective verbal recall, as opposed to the concurrent verbal recall used in the current study. In real-world situations, nurses were “evaluating” or “verifying” information and the situation more often. This again reflects the continual assessment and reassessment, with evaluation of patient status being used by participants in the study. An interesting finding reported from a study that examined the psychological needs of ICU patients from the patient perspective is that patients describe feeling safe as a core variable in their psychological needs and the feeling of being safe is often generated by being watched over and closely monitored (Hupcey, 2000). Patients in the study by Hupcey (2000) reported feeling safe, as the nurse “checked on me frequently”. The continual assessment of patients by nurses appears to engender in patients a feeling of safety and this role of nurses may be important. The next section discusses the differences in the use of operators by novice and expert participants.

7.5.2 Differences in usage of operators between novice and expert participants.

The way expert and novice participants used operators varied in frequency. While this was not always great, and statistical significances could not be determined due to the small sample size and dependence of data, the differences may be important to understand how better to educate novice nurses to develop expertise and to support them in the clinical arena. The differences thought to be most important are considered below.

7.3.2.a Operator "plan"

The operator "plan", which was defined as the collection of cues and information in planning care, had a similar frequency of use by novice and expert participants, with novice participants collecting slightly more cues overall. This was apparent in both the concurrent and retrospective protocols. This would appear to indicate that novice participants collect slightly more cues while planning care for real patients. In addition, expert participants used a much more extensive range of cues than did novice participants, although the total number of cues used by expert participants was slightly fewer. The cues used by novice participants were from a narrower range, indicating that novice participants concentrated on a few types of cues in comparison to expert participants who collected slightly fewer cues but had a much wider range, indicating that they concentrated on many more types of cues. In the current study expert participants used a greater range of cues in the real world to anticipate possible problems but only collected what was necessary for the situation. Novice participants, on the other hand, were selecting the same type of cues more frequently but were unaware of other cues that may have helped in assessment of the patient. Over-selection of cues was noted in a study of student nurses' decision-making using simulations and it was noted that the fewer cues the student selected, the more accurate the student was in the case study (Thiele et al., 1991). This may also be true in the real world of practice with participants who select fewer cues in total being more accurate. There is conflicting information from the decision-making literature regarding the collection of cues, some contending that novice nurses select more cues than expert nurses but that they do so in a less directed manner (Benner, 1984, 2001), while others contend that the opposite is true, with novice nurses collecting minimal cues while planning care (Taylor, 1997).

The conclusion that expert nurses collect fewer cues than novice nurses was generally made in relation to studies that used simulated patients or in those that relied mainly on retrospective recall of critical incidences, as opposed to those that examined decision-making in the real world. In some of these simulated studies, cues were presented to the participants, with some cues being relevant and some not, as in the study by Elstein et al. (1978). Other studies gave all or most cues up front (Lamond and Farrell, 1998; Coderre et al., 2003) and this may have led to the finding of over-selection of cues by novice nurses, as they selected all the cues they could and could not discriminate between what was important to the particular case and what was not.

Expert nurses were described in these studies as being able to focus on relevant information to make an accurate decision and are described as being able to do this due to their experience of prior cases which helps them narrow their selection of cues, hence concentrating on the correct ones (Lamond et al., 1996; Reischman and Yarandi, 2002). The above two studies concluded that expert nurses focus only on relevant information, which would appear to be reasonable in case studies where the problem is presented and all information is available. Simulated case studies use problems that are easily identified by an expert nurse and may account for the apparent use of fewer cues in these studies.

Benner's (1984) seminal work on decision-making did not employ case studies but retrospective recall in the form of narratives of critical incidences. Expert nurses were described as only paying attention to certain types of diagnostic cues and ignoring others, which allows a more rapid focusing-down on problems. The expert nurses were described as being able to use less information and to be more accurate. The method of data collection may have influenced the cues reported retrospectively by expert nurses, with the selection during the narrative of only those that stand out as being important and others that may have been gathered at the time being ignored in recall.

The real world of practice differs from simulated case studies in that the patient's condition is dynamic and can change rapidly, especially in critical care. The contrary finding of this study that expert nurses select a wider range of cues than do novice nurses, has been found in some Australian and American studies examining decision-making in the real world. Novices (students) were described as using only a single cue or displaying limited cue acquisition, with frequently only one significant cue being noted and no other cues being sought, while more experienced nurses collected more information (Tanner et al., 1987; Taylor, 1997; Aitken, 2000).

The use of a wider range of cues by expert nurses is reflective of the finding in the current study that expert participants have a more proactive approach to tasks and can anticipate problems, so will collect cues that could possibly help identify problems. They appear to be aware of possible adverse problems and collect a wide range of cues to help detect these problems early.

The explanation for expert participants having a wider range of cues and greater linkages between cues and concepts may be due to the expert participants holding domain-specific LT-WMs. There is evidence from a variety of studies for the existence of domain-specific LT-WMs (Ericsson and Simon, 1993). Research has also shown that through extended practice, individuals can increase performance not by producing increasingly larger chunks in the STM, but by the acquisition of memory skills in LTM and LT-WM (Ericsson and Charness, 1994). This allows for the superior memory of expert decision-makers and their faster processing.

The frequency for "plan" was lower for interview sessions than for the TA sessions. This is probably due to the fact that the interview session is retrospective recall as compared to the concurrent reasoning seen in the TA sessions and, as such, the ongoing constant monitoring that occurs during care is not reported. This adds credence to the argument that collecting data on reasoning by TA concurrently in the real world better represents what is actually occurring in the mind and may help to explain the difference, found in cue usage between expert and novice nurses in studies using simulations and retrospective interview and those that examine decision-making in the real world.

7.5.2.b Operator "review"

Novice participants had a slightly higher frequency of the operator "review" than expert participants and tended to go over the collected data more often. The novice participants also reviewed the cues that they had collected more often than the expert participants. A similar result was described in a study of novice and expert pilots' decision-making about aeronautical weather-related problems (Wiggins and O'Hare, 1995). The more frequent reviewing of cues and data was explained by Wiggins and O'Hare (1995) as being due to novice pilots' limited working memories and consequent limited capacity to manage information. This leads to the loss of information or the overwriting of information with incoming information and requires novice pilots to review or "relook" at information on a regular basis (Wiggins and O'Hare, 1995). Ericsson and Simon (1993) point out that there are different beliefs on what happens to information entering the STM, with some believing that it extinguishes with time and others that it is only lost once replaced with new information. Whatever is the case, novice participants appear to need to review information more frequently. Expert participants, on the other hand have built up many domain-specific LT-WMs from experience and these many working memories are capable of handling much more information without the need to review it (Wiggins and O'Hare, 1995).

7.5.2.c Operators "rationale" and "goal"

Novice participants also had a higher frequency of the operators "rationale" and "goal". They gave more explanations for what they were doing and what was happening and set more goals for care. Examination of the operator "rationale" and its use by novice and expert participants revealed that novice participants tended to use theoretical knowledge as a rationale for their decisions and actions. This probably reflects the fact that they are still integrating their theoretical knowledge with ongoing experience and reason about cues and information using what they have learned during their undergraduate years. The use of the thinking strategy “providing explanations” was frequently found in the study by Fonteyn and Cahill (1998) of student nurses’ thinking, and was described as offering reasons for actions, beliefs, or remarks. In the few examples given to illustrate this strategy by Fonteyn and Cahill (1998), the student nurses in the study appeared to be using theoretical knowledge, however, as this was not a conclusion drawn by the researcher it may not be accurate. The description by Fonteyn and Cahill (1998) of “providing explanations” is very similar to the operator “rationale” described in the current study, and this operator, as in the study of Fonteyn and Cahill (1998) probably helped the novice nurses to clarify assessments and interventions and help them reason about what to do. Novice nurses often lack the extensive experiential knowledge of expert nurses and need a framework to reason about patient care, and theoretical knowledge would appear to provide this. They may feel, however, that this base of theoretical knowledge is not always adequate to help them in delivering clinical care, as they often sought help from more senior staff when reasoning about care, as evidenced by the greater frequency of the theme “seeking help” for novice participants.

Novice participants had a higher overall frequency of the operators making up the category “selecting”, that is, “review”, “goal” and “rationale”. Novice participants’ reasoning strategies had more operators concerned with considering what information to use in clinical situations. In contrast, expert participants had a slightly higher frequency of the operators “interpret” and “relate”, which made up the category “inference” and had more operators concerned with the interpretation or inference of information. The frequency of the operators “relate” and “interpret” are discussed below.

7.5.2.d Operators “interpret” and “relate”

Expert participants in the study used the operator “relate” slightly more often than novice participants. This may not be a large enough difference from which to draw inferences but is supported by the greater number of links expert participants made between cues and concepts. The expert participants appeared to relate cues and concepts more often and could relate cues together in more meaningful ways. The thinking strategy “forming relationships" was identified in the study by Fonteyn and Cahill (1998) for nursing students but the study, although reporting this strategy for student nurses, did not make any comparisons to other groups, such as expert nurses. It is interesting to note that one of the quotes from this study, "I'm starting to see a connection here. Every one of my coronary artery bypass graft patients were heavy smokers for a long period of time", appears to illustrate how novice nurses learn from experience to link certain types of information together. Over time these linkages may build up into pictures or stories that nurses have about patients, which help them identify cues that are important.

The finding that expert participants used the operator "relate" to link cues and information together reflects the findings of others that the greater performance of expert nurses is not due to how much information is stored in the memory, but to how such information is related together (Wiggins and O'Hare, 1995). In a study of medical students and medical experts and their reasoning processes, it was found that students could often recall more facts given, but that medical experts were better at recalling the important pieces of information and how they fitted together (Ericsson and Charness, 1994). This clustering of information was also given as a feature of expert reasoning in nursing (Taylor, 1997), and the possible explanation for this ability was greater inter-linkages built up by expert nurses between cues and data in the LTM (Jones, 1989). This allowed nurses to be able to quickly recognise a wide range of possibilities, due to the highly complex system of relationships they have built up between cues (Jones, 1989). The clustering of cues was also pivotal to accurate clinical problem-solving and a lack of knowledge leads to the reliance on too few cues and inaccurate problem identification (Redden and Wotton, 2001). Building up of the linkages may be primarily due to experience, and prior care with similar patients has been shown to be the distinguishing feature in quality nursing assessments, rather than educational experience (Prescott, Dennis and Jacox, 1987).

Novice participants used the operator "relate" slightly less often and one novice did not relate any of the cues she gathered or make any connections. This novice observed that the patient's BP was low, the patient also had a noradrenalin infusion in progress, however, the novice made no decision, the BP was just recorded and with no further consideration as to why it might be low or whether it was related to the infusion. The same novice assessed the patient's pedal pulses, the assessment differed from that done previously by another nurse and was commented on, however, again no consideration was given to the difference in her assessment and the previous assessment and no reason sought as to why this was the case. The novice appeared to be observing and recording the observations with no linkages made between the observations and the patient's status.

7.5.2.e Operators "match" and "predict"

Expert participants in the study used the operators "match" and "predict" more often than novice participants. Expert participants tended to use matching when describing care for a patient or when anticipating care and predicted patient status and outcomes, often based on what they knew from experience. The anticipation by expert nurses of future events has been described in various fields, including medicine and nursing (Ericsson and Charness, 1994; Higgs and Jones, 1995) and was called by Lamond et al. (1996) "future think". This was described as the ability of expert nurses to generate outward perceptual appearances which they expect to see and is due to pattern-matching.

The ability of expert nurses to "match" and "predict" and carry out pattern-matching allows not only the prediction and prevention of possible problems but also allows for faster, more efficient reasoning. This is believed to occur by the building-up of productions in the LT-WM from experience into a large repertoire of prior instances that lead to the development of well-developed models of a domain (Anderson, 1982; Wiggins and O'Hare, 1995; Coderre et al., 2003).

In the interview transcripts, the greater usage of the operators, "match" and "predict" was even more pronounced. Expert participants may have been matching and predicting without vocalising in the concurrent session. It was suggested by Coderre et al. (2003) that most of the pattern-matching used by expert performers occurs automatically, and this may have been happening in some situations, as the frequency of pattern-matching was higher for the retrospective recall than concurrent.

There were some examples of novice participants beginning to build patterns and paradigm cases and beginning to match and predict as well, based on their limited experience. The recognition of patterns by novice nurses was also identified by Fonteyn and Cahill (1998), and was described as identifying characteristic pieces of information that fit together. An example of this recognition of patterns was given in Fontyen and Cahill's study as: "Atrial fibrillation is often seen in post cardiac surgery patients and is also associated with congestive heart failure, so I was almost expecting it." The student here appeared to base the prediction on theoretical knowledge and this was also often the case in the present study. However, there were also examples of novice participants beginning to build patterns from paradigm cases as above and also from knowledge transmitted by expert participants. This transmission of common knowledge about patterns of illness and patient responses is discussed in more detail under information sources and appeared to be one way in which nurses build up patterns.

The more limited usage of the operators "match" and "predict", combined with the result that novice participants used selection more than expert participants, may indicate a greater tendency for novice participants to use rule-based reasoning based on more theoretical knowledge, with expert participants tending to use matching to prior cases more often.

7.5.2.f Operators "choose" and "diagnosis"

The frequency of the operators "choose and "diagnosis" was low and similar for both novice and expert participants. There were, however, some qualitative differences in the ways expert and novice participants used the operator "choose". One novice used the operator "choose" by following the rules of the unit. The patient's nasogastric tube was aspirated and the novice stated "obviously we had better return it (aspirate), if it is under 300, if it is anything over 300 you discard". The intervention was based on choosing between two alternatives dictated by rules of unit policy. In contrast, expert participants used “choose” based more on alternatives known from experience. For example, an expert participant noticed her patient’s BP was low and considered two alternatives, lowering the rate of the infusion for pain or asking for more fluids to be written up. Information on both of these alternatives was considered. Novice participants were described in an American study as employing assessments based on policy, procedure and orders from others, similar to some of the decision-making of novice nurses in this study (Hanneman, 1996). Despite being taught during undergraduate studies to choose between alternative interventions in care planning, in the real world of practice, novice participants were choosing infrequently and were often basing choices on ward policies. This may need further attention in undergraduate education programmes to develop novice nurses’ confidence in deciding on care, based on their knowledge of the patient and the situation rather than just following a guideline.

7.5.2.g Operator “course”

Expert participants used “course” (course of action) more often than novice participants, possibly indicating that they planned overall care more often and had a better overview of what should be done. This is supported by the finding that they had a higher frequency of the type of task, “proactive”, which was the anticipating of events and intervening beforehand.

The operator “course” was used more in retrospective recall by novice than by expert participants. This is the reverse of the concurrent sessions, in which expert participants used “course” more often. This is interesting and may reflect social bias in the interview. The novice participants may have believed that while describing in retrospective recall the care they implemented, the researcher was expecting them to give courses of action that had been employed. Students are often taught care planning during their undergraduate courses, with the outcome being a course of action. In the real world of practice they often did not have an overall plan of action as described in interviews. Similarly, the operator “choose” (choosing between alternative interventions), often involved in care planning exercises, was used more by novice participants in the retrospective recall than the concurrent sessions.

7.5.2.h Operator "evaluate"

This operator had almost the same frequency of use by expert and novice participants in the concurrent TA session but a higher frequency by novice participants in the retrospective session. Expert and novice participants are using ongoing evaluation during care delivery and are constantly evaluating changes in patient condition and any intervention performed for the patient, such as pain relief, changes in titrated drugs and fluids given. Operators similar to "evaluate" used in the current study were employed by Lamond et al. (1996) and Higuchi and Donald (2002), however, neither compared novice to expert nurses for this operator. Interestingly, a study by Bucknall (2000) using event sampling described 51% of ICU nurses' decision-making involving evaluating patient status, however, the definition of evaluation in the study involved all tasks evaluating patient status, which included monitoring and collecting information, as opposed to the definition of the operator employed in the current study. Bucknall's (2000) study also found no difference between novice and expert nurses on evaluative decisions during actual care. Evaluative decisions, according to Bucknall (2000), are important in nursing to ensure patient safety and often go unnoticed by others. Continuing evaluation of patient status is an important aspect of care and novice nurses need to be helped to widen their knowledge of cues and cue linkages to ensure their understanding during evaluation is adequate and that important aspects of the patient status are not missed.

7.5.3 Summary of the use of operators

In summary, expert participants used the operator "plan" (collect cues and information) less often than novice participants, however, they had a larger repertoire of cues and information and more extensive linkages between cues and concepts. Expert participants also used the operator "relate" and the category "inference" slightly more often and had more linkages between cues and concepts, which indicates that one important difference between expert and novice nurses may be the ability to understand incoming data at a deeper level. Novice participants collected more cues in total and reviewed information more often, however, they used a much more limited range of cues than expert participants and related them together less often. Novice participants also spent more time on cognitive tasks involved with understanding what data means, those in the category “select”. Expert participants used the operators “match” and “predict” more often than novice participants. The use of “match” and “predict” has not been demonstrated in previous studies examining nursing decision-making. The differences between novice and expert participants need consideration in nursing practice and education. Novice nurses may need more support with an understanding of how to make decisions. Those supporting novice nurses also need to understand how novice nurses make decisions to assist them in developing the skills needed to better make decisions. Education focusing on the range of cues used in particular clinical areas and how these cues are related together to build a picture of overall patient status may help to develop decision-making skills in novice nurses. It is also important to uncover how and why expert participants relate the broad range of cues they use together, to be able to use this information in designing further education. This may be particularly important during development of assessment skills and may vary for different clinical areas.

The use of real-life situations is valuable for examining the cognitive operators and processes used by practitioners, as results from studies employing simulated case studies differ from those conducted in the real world. This is particularly noticeable in relation to the use of cues by both novice and expert participants. Expert participants in the current study, practising in the real world, collected fewer overall cues than novice participants but a much wider range of cues, which is contradictory to results from simulations wherein expert nurses select quickly only the most relevant cues. This may be due to a number of factors, such as expert nurses being able in simulated situations to easily recognise and identify the important information of a problem and then collect such information. In the real world of practice, expert nurses may match the current patient to their knowledge of patterns of impending problems, with a consequent collection of a wider range of information. A hallmark of the expert may be the awareness of potential problems and of a wide range of cues that indicate such problems and the more extensive relations between cues and concepts.

7.6 Decision-making processes

In contrast to studies using an eclectic approach, this study employed one framework, the information-processing theory, to identify different types of processes used by novice and expert nurses and identified a range of processes used by both groups. The use of a range of processes may be due to differences in culture, education and everyday workplace practices, as well as social and ward culture (Lauri et al., 2001; Redden and Wooton, 2001). It may also be related to the fact that cognitive processes are influenced by the task being undertaken, with cognition varying with task requirements and context (Hammond, 1996; Lauri et al., 2001).

In contrast to some studies that emphasise only one type of process for expert participants and another for novice participants, this study found that in the real world of practice, both novice and expert participants used a variety of processes during clinical reasoning and decision-making. The current study also identified a process discussed in the nursing decision-making literature but previously not identified in any nursing studies: if/then procedural rules. All participants used hypothetico-deductive reasoning and pattern-matching, as well as if/then procedural rules and most also used knowing the patient. Expert participants used slightly more hypothetico-deductive reasoning than novice participants, with the tendency to use more forward reasoning. Novice participants were more likely to use backward reasoning in hypothetico-deductive reasoning. Expert participants used pattern-matching more often than novice participants, while novice participants used if/then procedural rules more often than expert participants. The differences in the frequency of the use of the processes by both groups are discussed below.

7.6.1. Hypothetico-deductive reasoning

Expert participants used hypothetico-deductive reasoning more often than novice participants in the current study. Hypotheses generated in the study by expert participants were well developed, with expert participants linking many cues to generate a hypothesis. The hypotheses of novice participants in comparison were less detailed. This reflects the finding of Taylor (1997) that novice nurses use fewer cues to generate hypotheses which are less complex, while expert nurses linked more cues and information together to give more detailed hypothesis (see Section 7.4.1.a for examples that illustrate this point).

In the current study, most of the participants collected cues and information to confirm cues rather than to disconfirm cues. This finding is in contrast to studies that have found that expert nurses activate hypotheses early in decision-making and then systematically gather cues and information to rule an hypothesis in or out (Westfall, Tanner, Putzier and Padrick, 1986). The finding in the current study is however, supported by Aitken (2003), who could not find any evidence in her examination of ICU nurses' decision-making of expert nurses deactivating hypotheses during decision-making. The finding that expert nurses activate hypotheses early in decision-making is more typical of studies examining decision-making using simulated case studies and, as with the discrepancy in cue collection between simulations and the real world, is probably due to the current study being conducted in the real world. In the real world of practice, rather than generating a hypothesis early and then confirming or disconfirming it, the nurse collects cues and information and then generates a hypothesis after consideration of a range of information and the linkages between this information.

Expert participants in this study were more likely to use forward reasoning during hypothetico-deductive reasoning and novice participants to use backward reasoning. This concurs with findings from studies in nursing and other disciplines. While solving physics problems, novice decision-makers were described by Simon and Simon (Noyes, 1995) as using a "means ends" analysis which involved working backward from the goal, while nursing students were found to use backward chaining in hypothetico-deductive reasoning more (Jones, 1989; Wong and Chung, 2002). In nursing it has been demonstrated that expert nurses are more likely to use forward reasoning, as they can predict what may happen and collect information towards this goal (Lamond et al., 1996). The greater use of backward reasoning in hypothetico-deductive reasoning reflects the greater use of reactive tasks by novice participants, whereby the novice nurse identifies a problem often from the patient report or from routine observations, then reasons backward to develop a hypothesis to explain the problem. In contrast, expert participants had a higher percentage of proactive tasks, whereby they collected a wider range of cues and information and used this to form hypotheses by working forward; the expert participants appeared to be able to anticipate problems and collect information to determine whether this was the case.

The operators typically used during hypothetico-deductive reasoning were “plan”, “interpret” and “relate”, “diagnosis”, “choose”, “course” and “evaluate”. Although, not all operators were used every time during hypothetico-deductive reasoning, they did always occur in the order outlined in Methods Section 6.4.3.c.

Both novice and expert participants were observed using pattern-matching, if/then procedural rules and intuition or automaticity.

7.6.2 Pattern-matching

The operators “predict” and “match” allowed the identification of the process “pattern-matching”. This process was apparent in most of the participants reasoning and decision-making, however, it was used more often by expert than novice participants. Expert participants appeared to be matching to illness scripts or paradigm cases and also to be passing this onto novice participants. This was also noted by Burman et al. (2002), who described pattern recognition or matching by nurses as the looking for patterns that fit with previous cases that the nurse had seen and the use of pivotal pieces of information that would lead to a more in-depth investigation. Cognitive schemas or illness scripts are mental linkages of what certain cases look like and present cases are compared to these (Burman et al., 2002).

In contrast to the pattern-matching of expert participants, novice participants remarked on cases that stood out for them and this appeared to show the beginning of a building of patterns. Pattern-matching by nursing students was described in a study of cognition as involving the identification of characteristic pieces of data that fit together to begin to build pictures of cases (Fonteyn and Cahill, 1998). Expert and novice participants can describe how they learnt from past experiences and novice participants can also describe how expert nurses helped them consider and learn from experience (King and Clarke, 2002). There were instances of learning in the study and transmission of knowledge from expert to novice participants.

Pattern recognition or pattern-matching has been described as holistic, whereby the practitioner does not separate the pattern into its separate features, hence the practitioner is unable to describe the individual aspects of the pattern (Dreyfus and Dreyfus, 1986; Radwin, 1998). It has also been described as not lending itself to recording during TA, leading to an inability to identify the process of pattern-matching in clinical practice (Coderre et al., 2003). However, in the current study, recording of pattern-matching was achieved, participants did verbalise the patterns to which they were matching information and cues (see Section 7.4.1.b, for examples). The examination of TA transcripts does allow for some of the patterns that nurses are using to be identified.

The frequency of the operators “predict” and “match”, however, was greater for the retrospective protocols than for the concurrent protocols, suggesting that there was also some pattern-matching by participants, especially expert participants, that was not verbalised at the time. In interview sessions when asked about these incidences many of the participants could describe how they matched or predicted care and many processes were not truly subconscious. Time, however, limited exploration of all cases of recalled matching and it cannot be stated without reservation that all cases of pattern-matching do not occur at the subconscious level; some may occur this way.

Some pattern-matching may occur automatically, whether this is the same as intuition or not is debatable. The similarity of intuition to pattern-matching is evident and it may be that a similar process is being described. Some authors appear to describe both processes similarly. The experiencing of a "gut feeling" as in intuition is described by Rolfe (1997) as "chunking" and is the process whereby larger and larger units of cognition come to be seen holistically as a single thought or action. This definition appears to combine aspects of the definition of intuition from both the interpretive approaches and information-processing theory.

Pattern-matching is believed to occur due to the building-up in the LTM or LT-WMS of chunks (familiar patterns) and chunking can be seen as learning from past experience, whereby the results of solving a problem are remembered in such a way that allows them to be accessed to solve similar problems (Ericsson and Simon, 1984; Newell, 1990).

7.6.3 If/then procedural rules

If/then reasoning has been described for simple, context-free problems, such as crypto-arithmetic problems, but it has not generally been recognised as a process in CDM in nursing and medicine (Newell, 1966; Newell and Simon, 1972; Newell, 1990), although it has been described theoretically in nursing (Crow et al., 1995; Lauri et al., 2001; Wong and Chung, 2002). This process may not have been previously mentioned in nursing research due to the method of data collection. Most research examining clinical decision-making has used simulations or retrospective interviews or observation without direct recording of reasoning.

If/then production rules are a type of reasoning whereby abstract rules of inference are used and these consist of qualitative statements about the structure of phenomena (Newell and Simon, 1972). They may consist of rules such as if a patient has post-operative pain, then give morphine 10 mg (Noyes, 1995). Sets of procedural rules are built up by experience and act to eliminate lengthy retrieval of information (Anderson, 1995). If/then reasoning appears to be a way to pass on procedural knowledge by giving sets of alternative actions that are used to rule out different causes for a problem. For example, a senior nurse, when asked what information she would pass on to a junior nurse in the current study, described such things as the rules to follow if the BP reading is out of the ordinary. If the BP is low or high, then check the waveform, then check position of the arterial line, then check whether the arterial line is kinked or not, then check against a manual reading. Novice participants also described being given these rules when beginning in ICU, so that they would not just react every time the BP reading on the monitor was high or low. Novice participants appear to want these sorts of rules, as they feel out of control if they have no set guidelines.

Alogarithms, similar to if/then procedural rules, can be used for decision-making, and these are similar to the if/then rules identified in the current study (Thompson and Dowding, 2002). The use of if/then rule based-reasoning was also outlined by Benner (2001) as a type of analytical reasoning used mainly by novice nurses. Novice participants in this study did use if/then procedural rules more often than expert participants, but the expert participants also used this type of reasoning. Novice nurses have also been described as reasoning during decision-making, guided by rules from theory (Benner, 2001), however, there was evidence in the current study of rules being transmitted to novice participants by expert participants. Expert nurses may also internalise procedural rules with experience which then become automatic, leading to the seeming use of automatic processes (Taylor, 1997; Ericsson and Simon, 1993).

7.6.4 Intuitive processes/automatic processes

There were some instances identified in transcripts in which participants noted an observation and this was immediately followed by an action, or where steps appeared to be missing during tasks. This may represent intuition or automaticity. Intuition, as defined in the information-processing theory, would indicate an automatic process, whereby reasoning becomes automatic with continued practice. It is direct perception and it follows rules or laws and hence is observable and measurable (Effken, 2001). Automaticity is a cognitive process that some authors see as a transition from an alogarithm, multi-step memory retrieval to single-step memory retrieval (Moors and De

Houwer, 2006). The immediate steps in a task are carried out without being interpreted or considered and this develops from practice as stimuli in the form of cues, triggering sufficient memory retrieval of information that was associated with the cue in a former presentation (Ericsson and Simon, 1993; Moors and De Houwer, 2006). Automatic processes may occur so rapidly that the decision-maker may not be aware of them at the time and this has led to some authors describing automatic processes as subconscious. However, automatic processes can be detailed later during retrospective interview and decision-makers have outlined how they moved from the observation to the action in decision-making tasks (Ericsson and Simon, 1993). The use of automatic processes by expert nurses was also reported for a group of Australian nurses (Taylor, 1997) and may be similar to processes in this study designated as automatic.

The definition in the interpretative framework of intuition describes it as an immediate grasp of a situation, with reports of a "gut feeling", and that something is not right and this is occurring subconsciously in the sense that the expert cannot outline her/his thinking or reasoning, s/he just knows what to do, due to recognition of very subtle changes in the patient condition (King and Clarke, 2002). Intuition in interpretive studies has been reported as being associated with feelings of unease by nurses about the patient condition and a feeling that something was wrong (King and Clarke, 2002; Effken, 2001).

In the current study, no participants stated that they knew what to do because of a "gut feeling", nor did any discuss a feeling of something being wrong and acting on this. Most of the reasoning was traceable and explainable by the participants, except as mentioned above for some cases of matching mentioned in retrospective recall and some instances involving missed steps. Participants were asked about such incidences in retrospective recall and could outline what they were thinking at the time. Most of the processes were not outside the participants' consciousness. Two studies in Australia examining decision-making also found little talk of "gut feelings" or intuition. In the study by Aitken (2000), only one participant mentioned a "gut feeling" and this participant, although classified as an expert nurse, was the only participant who did not display the conceptual links expected of an expert nurse. In the study by Redden and Wotton (2001), participants had a good knowledge of pathology and how things worked and did not mention intuition as a “gut feeling”. Expert participants in the current study also displayed much more extensive gathering of information about the patient condition and were aware of many indicators of patient status. Changes in patient status were verbalised and more apparent for expert than novice participants. Novice nurses in the study also displayed some instances of automatic processes or intuition. Intuition has been described in interpretive studies as involving a sense of salience (Ruth-Sahd and Hendy, 2005).

A sense of salience about the patient’s condition may actually be perception of subtle changes in condition and that perception may be based in information-processing (Effken, 2001). The questioning used by some researchers such as King and Clarke (2002), who asked participants to describe how expertise develops and to describe intuitive awareness, may actually lead to participants reporting intuition in this way. In the current study, participants were not asked to describe how they think but were asked to think aloud and this may account for the differences. The current study examined everyday care and not critical incidences as outlined by Benner (2001), so comment on such incidences can not really be made from the results of the current study. The use of intuition may also be culturally determined; if groups of nurses believe that is how an expert practises they may be more willing to report reasoning in such a way. Another process identified for most participants was knowing the patient.

7.6.5 Knowing the patient

Most participants also used knowing the patient as source of information on which to base decisions and influence decisions made. Knowing the patient is described as a process for decision-making by some authors (Benner et al., 1996; Radwin, 1998). However, in the context of information-processing, it is probably more useful to consider it as a source of information used by nurses while caring for patients. Knowing the patient and collective knowing of patients will be discussed under information sources used by participants in the study.

Content analysis was used to further analyse data to help the enrich understanding of cognitive operators and processes. The themes developed are discussed below.

7.7 Themes generated from content analysis

Content analysis led to the development of themes that described how participants managed care, what information sources they used and how they conceived of the tasks they were implementing during the care of the post-surgical patient. The themes can help illuminate some of the operators and processes used by the novice and expert participants.

7.7.1 "On my watch"

This theme was mentioned frequently by both novice and expert participants, more so by the novice participants than the expert participants. It was noted in a study by King and Clarke (2002) that beginning nurses "kept an eye" on patients and this involved rechecking vital signs and clinical observations. The current study found that expert nurses also often mentioned "keeping an eye on the patient". The high frequency of the operator "plan" (collect cues) and "review" overall concurs with this theme and points to a general concern with watching the patient and keeping her/him safe. This is probably related to how the nurses saw their role in managing post-operative patients in the ICU. It has been suggested that how nurses see their role impacts on how they carry out tasks (Thompson and Sutton, 1985) and indirectly the cognitive operators they use (Ericsson, 1996). The interview question regarding how the participants saw their role corroborates this, as most participants described their role as monitoring, and making sure the patient was physiologically stable.

The theme "on my watch" also concurs with the finding that most tasks involved patient assessment and evaluation**,** which is a common concern for nurses when managing post-operative patients (Killen, Kleinbeck, Golar, Schuchardt and Uebele, 1997). Whether this applies in other nursing situations, and the tasks associated with the situations, remains to be determined. Junnola, Eriksson, Salantera and Lauri's (2000) work would seem to suggest that nurses from different nursing specialties approach data collection and problem definition in decision-making differently, however others have stated that managing and assessing patients were the main responsibilities of nurses (Lamond et al., 1996; O'Neill, Dluhy, Fortier and Michel, 2004). The watching-over of patients by nurses is an invisible but important aspect of care (Schmidt, 2003) and the differences in the way that expert and novice nurses use the operator "plan" in this task needs consideration to ensure that novice nurses are noticing cues and acting on these or, if not, that this aspect of care is considered by others.

7.7.2 "Big issue"

This theme was common for novice participants but not expert participants. The concern with a big issue appeared to direct to some extent how novice participants carried out care, and the novice participants were often using a big issue that had been handed on to them at the beginning of the shift. The theme "big issue" may be related to the narrower range of cues used by novice participants. Handing over to novice participants that something was a major concern for the patient, such as pain, may have narrowed the focus of the novice participants' reasoning. The novice nurses also had a higher frequency of the operator "goal", which may also suggest that they were focusing on major issues and trying to solve these, with possible detriment to other patient concerns.

Novice participants appear to have a need to focus on one or two main issues because, lacking experience, they have limited domain-specific knowledge and productions in the LT-WM, and this does not allow them to focus simultaneously on more than one task. This focus on one or two main issues is related to the feeling of many novice participants of confusion and being out of control, which was another theme more frequently mentioned by novice nurses than expert participants. Novice nurses, according to Taylor (1997), are often confused about what to do and they find this very stressful and in some CCUs the way groups work together may increase these feelings (Currey et al., 2003). These feelings of confusion and the stress it induces can lead to novice nurses focusing on survival and intense concentration on skills and what to do (Arbon, 2004). This can lead to a more intense focus on one or two patient problems and the pre-encounter data that the novice nurse is exposed to can direct what issues become important (Hanneman, 1996; Taylor, 1997). Limited focus on one or two problems may be directed by forceful features of a shift report (Lamond, 2000). The tendency of novice nurses to focus on a narrow range of problems, especially following a handover with forceful features that directs their attention to a few problems, needs to be considered by others and handover needs to incorporate a wider range of problems and information. Taylor (2002) also found that novice nurses find it hard to absorb information at handover, and this may lead to them being more open to focusing on big issues. Greater attention is needed to not direct them too narrowly in care.

7.7.3 "Under control"

Novice participants reported this theme more often than expert participants. It was characterised by feelings of being out of control and trying to get things under control. This theme is related to the other frequently mentioned theme for novice participants of the big issue, which may be one way for novice participants to feel in control by concentrating on one main issue at a time. The clinical environment can be very confusing for novice nurses, as there are often many competing demands on their time and concentration and hence a need for them to establish control over the environment. This feeling of being thrown in at the deep end is something we have all felt and most will try to exert some control to manage this. Setting goals may help novice nurses feel in control, as may making the field of concentration narrower. The reliance on expert nurses is also a way of reducing confusion and feelings of being out of control (Taylor, 1997). The use of if/then sets of procedural rules passed onto the novice nurses by the expert nurses probably reflects the novice nurses' reliance on expert nurses. Following sets of rules for procedures probably also helps to lessen feelings of confusion and not being in control of the situation.

The focus of novice nurses on technical tasks and following routines and care plans such as flow charts (Hanneman, 1996; Radwin, 1998) occurred in the current study and also reflects novice nurses' need to establish control over their work. Greenwood et al. (2000)

state that following a care routine reduces stress, as it tells nurses when and what to do. This concurs with Benner's (2001) report that novice nurses use rule-based reasoning based on theory and that routines help to structure work. If novice nurses need to structure care in this manner, then there is a need to ensure that the routines, sets of procedural rules and care plans are based on the best available evidence and reflect the best of expert practice. There may also be a need to teach novice nurses how to pay attention to handover information and how to determine what is relevant and important by modelling how expert nurses do this. Expert nurses are familiar with handing over information and know what to pay attention to and focus on (Hardy et al., 2002). Expert nurses may need to be reminded that novice nurses often do not have this ability.

7.7.4 "Seeking help"

Not surprisingly, novice participants are much more likely to seek help from others for decision-making than expert participants. The theme "seeking help" was more common for novice participants. This is related to novice participants feeling out of control and lacking knowledge and experience. The feeling of being out of control leads to them asking more senior nurses for help, as does their lack of experience and knowledge of ward policies and procedures in the clinical setting. The novice nurses' dissociative practice leads to a dependence on policies and advice from others (Hanneman, 1996), and mentoring and supervision may be needed to ensure that the care delivered is safe.

7.7.5 "Big picture"

This theme was more common for expert than novice participants. The ability of expert participants to see the big picture has been reported by Burman et al. (2002) and would appear to be a feature of expert practice. Expert participants had collected a broader range of cues and linked these together more often. This is probably due to more experience and more domain-specific knowledge. The ability to see a big picture was probably related to the development of more extensive hypotheses seen in expert participants, reasoning and the greater usage of pattern-matching also seen in expert reasoning in this study. The ability of expert nurses to incorporate all information about a patient into a total picture, to see the big picture, also distinguishes expert from novice nurses (Taylor, 1997). The slightly more frequent use of the operator "relate" and the greater links between cues and concepts by expert participants is probably reflective of this ability, and novice participants may need to be taught how to relate cues together to develop this skill.

7.7.6 "Maintaining simultaneous concentration/managing simultaneous tasks"

Expert participants appeared not to follow any set order and to move from cues to concepts and back to other cues and issues while managing care. The expert participants also tended to prioritise early, and appeared capable of attending concurrently to more than one task. For example, one expert participant was setting up a ventilator, IV lines and monitors, while at the same time taking handover and reasoning about priorities of care. All these tasks were handled concurrently and, when interrupted, the expert participant could go right back to where she was up to before the distraction. The information-processing theory and in particular Newell's (1990) work, described in "The Unified Theory of Cognition", proposes the existence of LT-WMs that are domain-specific. Access to the LT-WM requires sufficient retrieval cues in attention (Ericsson and Kintsch, 1995). Expert decision-makers need to have knowledge of cues, which have been acquired after much practice in a domain, and these can act rapidly to retrieve information in the LT-WM. The greater usage of a wide range of cues by expert participants in the current study and the ability of expert participants to handle multiple tasks fits in the description of expertise in the information-processing theory. The ability of expert nurses to be able to deal simultaneously with multiple aspects of the management of patients was also noted by Aitken (2000) and Benner et al. (1996). Benner et al. (1996) use these features of expert performance to argue that expertise and intuition cannot be due to faster application of principles and rules of thumbs. They argued the information-processing theory cannot account for rapid and simultaneous processing, due to the limitations of the STM and the four to seven chunks that can be handled at one time. However, the existence of domain-specific LT-WM may explain such rapid and simultaneous processing.

7.7.7 "Prioritising care"

As well as being able to manage more than one task at a time, expert participants also appear to prioritise care and know what tasks are most important. Expert nurses do this rapidly, often while concentrating on another task. For example, when receiving a patient back from theatre, an expert participant noticed the patient was not "breathing up" and that the patient's BP was low and these two issues were handled first, while at the same time the expert participant was taking a handover and directing others in making the patient comfortable. This is in contrast to the novice participants' ability to concentrate only on one task at a time and their difficulty in deciding which task to attend to first. A novice participant who had received a patient back from theatre was confused and needed help from a more senior nurse to manage care. In interview, the novice participant reported being confused and not knowing what to do first. The novice participant also reported not being able to remember most of the handover as she was busy setting up the patient under direction from the more experienced nurse. Expert participants also cluster care to suit the patient and to make work easier. The ability of expert nurses to prioritise care was also noted by Aitken (2000) and is probably due to their ability to predict and to match to prior cases. This allows them to have internalised routines and to be able to anticipate what to pay attention to and what is most important.

7.7.8 "Directing care"

It was noted that there was very little diagnosing by participants in the study and this may be due to diagnosing mainly belonging to the medical domain (Lamond et al., 1996). However, if expert nurses can not diagnose and order interventions, they may be willing to direct care and ask for what they believe should be done. Expert nurses in the study were observed doing this, as were the nurses in ICU in an Australian study (Bucknall and Thomas, 1997). The higher autonomy afforded ICU nurses in Australia was said to explain this (Bucknall and Thomas, 1997). A study of expertise in England further described expert nurses as having an extended role involving recommending care options to doctors (Conway, 1998). Suggesting interventions is often done tactfully, so as not to offend doctors, and at other times the nurse shapes the information given to the doctor to lead to the diagnosis they are considering and to obtain the outcome they want. Directing doctors is not necessarily about power but about ensuring the correct treatment for a patient is put in place (Benner et al., 1996). Nurses have reported saying “we suggest things, and I think people listen” (Prescott et al., 1987). The directing of doctors in the current study may be related to the higher use of the operators “predict” and “match” by expert participants. Due to a large body of prior knowledge that can be accessed to decide on care and knowledge of what interventions are normally used, the expert nurse may be more confident in suggesting care to doctors.

7.7.9. Information sources

7.7.9.a Collective knowing the patient

Knowing the patient has been described in nursing research examining decision-making as a process that nurses use to manage care (Benner et al., 1996; Radwin, 1998). It is variously described but involves nurses coming to know patient patterns and responses and being able to base care on this. According to Benner et al. (1996), knowing the patient is a feature of expert practice, however, in the current study novice participants also had the ability to come to know patient patterns.

Many of the studies that have described knowing the patient have used interviewing and retrospective recall and have not observed care directly. Direct observation of care in the current study, coupled with examination of the verbatim protocols, has led to the development of the theme “collective knowing the patient”, which describes coming to know the patient from a variety of sources in a collective fashion. Knowledge about a patient was built up from the nurse caring for the patient, peers, carers, family and others to build the patient’s story which was passed on from nurse to nurse and used to help decide on care. Other studies using interview, may well have had such collective, knowing but as only individual nurses were interviewed, this passing on of the patient story may not have been noted. Collective knowing may be a feature of Australian nursing, especially in ICUs, as continuity of care with the same nurse caring for the patient is not a common practice. Passing on personal knowledge about the patient to supplement the knowledge of physiological status helps the next nurse to have a fuller picture of the patient. This collective knowing is described by Benner et al. (1996) as sustained vigilance, requiring co-operation amongst nurses. Co-operation allows the pooling of knowledge and can help counter the helplessness found in critical situations (Benner et al., 1996; Hallett et al., 2000). Pooled knowledge is believed to help nurses to care for patients.

Collective knowledge of the patient or pooled knowledge was also evident in some of the terminology used by participants when discussing patients and their condition. Terms such as “blowing the graft” and “knock off the kidneys” were common, and novice participants reported being taught this. Expert nurses translate clinical information so that it can be understood by others and use word pictures to help in this (Conway, 1998). This was noted in the current study and this knowledge became common knowledge for nurses in this unit.

The use of “we” in instances in which the correct grammatical expression is “I” may also indicate collective knowing. It may also indicate shared responsibility for decisions that are more threatening. Pooling of knowledge and referring to “we” may be a way to diffuse responsibility as suggested by Benner et al. (1996). A more in-depth examination of this is needed, perhaps using discourse analysis to determine the meanings and values of the nurses.

The transmission of collective knowledge to novice nurses needs to be accomplished in a way that ensures that the transmission of knowledge does not overwhelm them, hence leading to them feeling out of control and confused. The knowledge transmitted also needs to be accurate and appropriate. Novice nurses may not be able to focus on a lot of information at once, in some situations nurses may need to transmit less information but ensure the most important information is handed on. This may lead to novice nurses managing care more effectively. At the same time, care is needed to ensure that what is handed on by other nurses does not focus novice nurses too much on one issue, a big issue, to the detriment of other issues.

7.7.9.b Doctor preference

A doctor's preference for care routines was mentioned by expert participants but not by novice participants as a source of information for care. This finding was also reported by Taylor (1997), who explained that expert nurses mentioned following surgeons' orders as being the only time they mentioned routines. Expert nurses become familiar with the routines of a unit as well as the normal care prescribed by doctors whose patients they regularly care for and use this knowledge in care planning. Novice nurses have not had time to learn the care routines of particular doctors and do not use this as a source of information. However novice nurses usually are prompted by others as to what is needed for particular doctors, and may learn in this way.

7.8 Issues in data collection: concurrent and retrospective TA

Examining decision-making using both concurrent and retrospective TA is useful, as there were many similarities between the operators and processes identified in the study, as well as a few differences indicating that as well as considerable overlap between the data generated with each method, the different methods also generated some differences in data. The extensive overlap of data from both retrospective recall and concurrent TA increased the reliability and validity of the study, as in each data-collection method the same incidences were talked about and many of the processes and operators matched, with a few differences, described as follows.

Retrospective recall may distort certain operators and processes, such as the under-reporting of "plan" in retrospective recall, and this may be an example of generalisation of information in retrospective recall. The over-reporting of the operator "goal" by novice nurses may represent a retrospective bias in retrospective recall, as the novice nurses may have believed that they needed to demonstrate to the researcher a goal-driven care plan for the patient. Concurrent TA may miss some of the operators being used, such as "match". This may occur due to some unheeded traces of thinking not being verbalised. Using both concurrent and retrospective TA together increases the depth of data collection and allows for these anomalies to be examined more fully.

Observation was also useful to detect information in the transcripts that was not always readily available in TA. For example, the transcripts did not always have information on such aspects as handover and the importance of certain issues or the facial expressions and body language of participants. Observation was also helpful to fill in gaps such as the order of work and whether or not participants were using a chart to guide work.

The use of TA in the real-world setting did not have the problems suggested by others, such as disturbing patients and families. No patient or family member asked for the TA session to be stopped. As well, all the participants continued working while verbalising through TA and the TA session did not interfere greatly with the flow of work. Both novice and expert participants reported that the technique was relatively easy to use and that after the first few minutes they did not feel embarrassed about speaking their thoughts aloud. The researcher also found the transcription of tapes relatively easy, due to experience in the area and a good working knowledge of the language used and the care tasks, routines and environment.

7.9 Implications

7.9.1 Nursing practice

The surveillance and monitoring role in nursing which is believed to keep patients safe is important (Benner et al., 1996). If novice nurses are not noting as many cues as they should or could, they may not be as effective in this role as more senior nurses. There may be a need for close monitoring of novice nurses' practice, and mentors would ideally be placed to undertake this role. The development of descriptions of tasks and cues used may also help novice nurses to practise safely, and elucidation of cues used by expert nurses could be used to form guides for others to use in practice (Currey and Botti, 2003). The teaching of patient safety behaviours to nursing students is also needed, and care needs to be delivered ensuring vigilance by all (Ebright, Kooken, Moody and Al-Ishaq, 2006)

On any given day, care provided in ICUs is different depending on the experience level of nurses, and several studies have supported the use of nurse-implemented protocols over traditional practice in the guidance of care (Curley, 2002). Protocols and flow charts may be useful in assisting novice nurses in the delivery of care but are not often used by expert nurses who have learnt the rules of the protocols. However, it is important to ensure that sets of rules used in such guides to care are based on best-practice evidence. Guides for care developed by expert nurses in an area can be very useful, especially for novice nurses and one such guide was developed by Currey and Aitken (2005) for acute care nurses. As novice nurses may also be influenced by forceful features of a handover and concentrate on too few issues in patient care, the structuring of handover to impart a range of information may help alleviate this problem. Modelling the types of information necessary in handover to novice nurses would also help to ensure that they develop skills in assimilating handover information to better assess and plan care for patients. Novice nurses often feel confused and may feel they have a lack of control over clinical situations. Teaching novice nurses more tactics to manage care such as timing and prioritising may help them cope better with some aspects of care and decision-making. This is often difficult to do in non-clinical situations but may need addressing in the novice nurses' first few weeks of practice. There may also be a need to explain to expert nurses that they need to give clear simple directions, one at a time and from one person at a time, to ensure that novice nurses are better able to cope with the confusion of clinical work. Getting expert nurses to think out loud during instructional incidences to demonstrate how they think may help novice nurses to manage the confusing and conflicting demands of clinical practice. Teaching expert nurses about how novice nurses reason may make expert nurses more aware of how best to impart information to novice nurses.

The use of current patient case studies that model expert decision-making may help novice nurses to develop decision-making skills. Case presentations and case discussions at ward level with expert and novice nurses involved may also help in the transmission of knowledge (Radwin, 1998; Piele 2004), as may mentoring by expert nurses (Taylor, 2002). The mentoring, however, needs to be carefully undertaken, as it can impact on the novice nurses' ability to problem solve and poor mentoring and role modelling can further confuse a novice nurse (Taylor, 1997).

In line with the findings of the current study that found a difference between the way expert and novice nurses reason and make decisions, other studies in nursing have shown a practitioner-student gap in relation to critical care nursing (Endacott, Scholes, Freeman and Cooper, 2003; Meyer and Xu, 2005), especially in how both groups reason, and programmes have been developed to try to redress this deficiency (Endacott et al., 2003; Ballard and Trowbridge, 2004; Gross and Anderson, 2004; Meyer and Xu, 2005). Most of the programmes are designed to help novice or student nurses to learn to reason like an expert and have various approaches from shadowing an expert to special courses. Other approaches to help novice nurses develop reasoning and decision-making skills have involved the development of computer programmes.

Expert systems in nursing involving computer programmes were suggested by Jones (1988) and have recently been developed as a pilot project in the United States of America. Nursing computer decision support programmes, such as the N-CODES project (O'Neill et al., 2004; O'Neill, Dluhy and Chin, 2005), use rule-based decision-making and decision alogarthims for novice nurses to enhance decision-making. The N-CODES project enhances decision-making for novice nurses by having a point of care system delivering clinical knowledge via a hand-held computer. This is an advantage as many paper protocols are not readily available at the patient bedside. These computerised decision support systems are believed to help novice nurses to learn and to better understand decision-making in the clinical area and are particularly centred on focused assessments, anticipating deleterious client reactions and initiating appropriate interventions early (O'Neill et al., 2004). These aspects of CDM are all reflective of the expert practitioner and are frontline responsibilities of nurses (O'Neill et al., 2004). The information is stored as data rules using if/then statements, and is based on the best available evidence. Use of such computer support systems may prove to be very useful as a support for novice nurses. Little of the decision-making research concentrates on identifying the if/then decision rules used by expert nurses and research is needed to extend this field of study.

As well as expert systems to improve novice nurses' CDM skills, simulation technology can be employed (Medley and Horne, 2005). Simulation technology can be used to present real-life clinical situations with equipment reflecting many of the aspects of the real-world, including auditory and visual data, and can be programmed to present students with a variety of real-life situations, allowing them to practise and develop decision-making skills in a safe environment. As well as the development of decision-making skills, the knowledge used by expert nurses is important.

Many researchers in decision-making have called for explication of the domain-specific knowledge that expert nurses use in practice. Reischman and Yarandi (2002) suggest that domain-specific knowledge lies mainly in the procedural memory, and accessing the knowledge may be the possible key to understanding the pattern-matching of expert nurses. Conversely, examining the patterns used by expert nurses in decision-making may illuminate the expert nurses' domain-specific knowledge. The method used in the current study has proven successful in illuminating some of these patterns and may be a useful tool to further uncover expert knowledge.

7.9.2 Education

Decision-making is a learned skill and can be taught, and decision-making skills are generally transferable (Thiele et al., 1991). Therefore developing ways to teach decision-making skills to nursing students and ensuring they can transfer these skills to the clinical area is important. PBL undergraduate nursing programmes often present learning materials as case studies. Case studies used in PBL programmes should model changing situations as they occur in real life to develop nursing students' decision-making skills to the full. The case studies used could also present situations to students over the course of the undergraduate degree that mirror the development of complex thinking skills from lower to higher order thinking skills as the student progresses. Increasing case complexity over the years of a course may also enable the development of decision-making skills in novice nurses (Botti and Reeve, 2003). To enable the development of case studies in this way, the cognitive operators and processes used by expert nurses need to be examined further for a range of clinical situations to ensure fidelity in case studies.

The development of case studies that actually model how expert nurses manage a problem such as haemodynamic instability may also be useful in teaching students, as they will allow students to begin to understand how others reason. This would allow for students and novice nurses to experience how expert nurses use decision-making processes such as intuition or pattern-matching to make decisions and what makes the decision-making of expert nurses different. Identifying the meanings that expert nurses give to patterns of illness during decision-making may enable the novice nurses to better understand expert decision-making (Haggerty Nuttall, 2000). The decision strategies used by expert nurses could be incorporated into nursing programmes in a number of ways, including through the use of videos that show expert decision-makers reasoning about cases, and by having expert decision-makers model their reasoning to students who are on clinical placement. The use of CD-ROM/Web hybrid programmes as in Project L.I.V.E. is also useful in modelling expert decision behaviour to students (Kamin, O'Sullivan, Deterding and Younger, 2003). The incorporation of video clips of real patients into the CD-ROMs enhances and hones assessment skills by exposing students to visual and auditory data. The CD-ROMs could be used in conjunction with web-based asynchronous discussion to further develop decision skills (Sankar and Raju, 2001; Kamin et al., 2003). As well as modelling expert nurses' decision-making behaviors, it is also important to teach reasoning processes as part of PBL packages (Taylor, 1997).

Teaching reasoning processes to students can increase awareness of the different decision-making processes. To teach reasoning processes during education, an approach needs to be taken to expose student nurses to different decision-making and problem-solving strategies. Teaching just one generic problem-solving strategy needs to be avoided and teaching other strategies such as pattern-matching implemented (Burman et al., 2002). Teaching nurses to reflect on thinking skills may also improve their decision-making and cognitive skills, and keeping logs or diaries is a good way of ensuring this occurs (Higuchi and Donald, 2002). Keeping logs can help develop cognitive skills using metacognition, and this was used by Fonteyn and Cahill (1998) as an alternative to teaching nursing students with the use of written care plans. Peer learning with reflection and praxis can also increase learning and can be implemented by having expert nurses coach novice nurses in practice settings and helping them to reflect on practice as it occurs (Eisen, 2001). As well as teaching novice nurses' decision processes, more needs to be done to teach them about cue usage in assessment.

Novice nurses appear to have less knowledge of important cues needed for competent practice and spend less time on relating and interpreting cues and concepts. Novice nurses cannot assimilate all the knowledge of a clinical area before commencing practice, however, learning about the processes of decision-making and how to use these may improve their skills and knowledge over time as they continue to learn in the clinical environment. Cue linkage and recognition can also be taught, and efforts to ensure this occurs also need to be implemented (Thiele et al., 1991; Baxter and Rideout, 2006). One way that this could be accomplished is by modelling how expert nurses assess patients, what cues they use and how the cues are used in conjunction to build an overall picture of the patient status (Botti and Reeve, 2003). Concept-mapping in care planning is believed to be useful in the development of the ability to perceive information, interpret and relate cues and develop further how information relates together and to better understand interventions and problems (Mueller and Johnston, 2002; Hsu, 2004; Clayton, 2006). Concept-mapping has been described as being suited to PBL programmes and promotes a deeper understanding of patient situations (Hsu, 2004). Concept maps link concepts, hierarchies and information, and lines are drawn between concepts, creating a link denoting relationship. Concept maps as care plans in clinical planning are believed to offer advantages over traditional linear care planning, in that they better reflect the way nurses think in the real world (Mueller and Johnston, 2002).

7.9.3 Future research

More research is needed to determine such important aspects of CDM, as the common knowledge held by expert nurses about aspects of care, such as interpretation of monitoring parameters, and how these are linked together to give a picture of the patient status. This information can be used to develop further computer support systems for novice nurses, and methods that illuminate thinking processes in the real world of practice are invaluable to this end. The use of operators and processes by novice and expert nurses in varying clinical situations important to the assessment of patients also needs to be examined further, to develop a better picture of how novice and expert nurses reason over a wider range of situations and assess patients in these situations.

Research also needs to examine decision tasks in detail in other areas to determine whether the decision-making in these areas is similar to or different from the decision-making of the current study, and to develop knowledge of the types of information used by expert nurses that can be used to teach novice nurses and to develop algorithms or case studies.

Research is also needed to examine further how expert nurses use cues and cue clusters and how they develop illness scripts from these about patient status. Understanding how nurses use if/then rules in clinical practice can further extend knowledge of different decision situations and enable the further development of algorithms that can be accessed by student and novice nurses.

7.10 Strengths and limitations

This study involved a small number of participants and examined decision-making around one type of nursing task in ICU. Thus generalising to other types of nursing tasks may be inappropriate. The study was also carried out in one nursing unit only, and may only represent the decision-making practices of nurses in that unit. However, the study examined many decision instances for each participant and gives an in-depth account of individual decision-making. The similarities and differences uncovered in the study may be representative of nursing decision-making across monitoring tasks.

The study was implemented in the real world of practice and this introduced more variability in decision situations than would be apparent in studies using simulations. However, the use of the real world of practice did allow examination of decision-making as it actually occurs and the identification of some differences in process and operators between real-world studies and simulated studies.

The study was carried out by one investigator and this may limit the results, however, there was a pilot study undertaken prior to the study and this helped refine methods and allowed consideration of issues which may have otherwise been overlooked. The data were also analysed by the main researcher, which may limit the reliability of the study. Another researcher well versed in the methodology of TA analysed sections of the transcripts, and inter-rater reliability was determined by Kappa calculations to ensure reliability of analysis.

The methodology used in the study did not always allow for conclusions to be definitely made about instances when participants stopped verbalising. In such instances it was difficult to determine whether the participants were using intuitive or automatic decision processes or had simply stopped thinking and were therefore verbalising. Observation did help identify some of these incidences, but some may well have been missed.

A further limitation of the study was the inability to examine some aspects in detail. The examination of sources of knowledge could be examined in more detail but the constraints of the study did not allow for this.

Strengths of the study included two phases of data collection, concurrent and retrospective TA, which increased the depth and completeness of information collected, enhancing validity and reliability. The concurrent TA sessions enhanced data collection by reducing bias in recall. The retrospective interviews enhanced the data collection process by allowing the researcher to fill in gaps in the concurrent TA protocol. Observation by the researcher during the concurrent TA session also enhanced the data collection, allowing the recording of unverbalised data. A further strength of the study was the inclusion of both novice and expert nurses in the study, which allowed comparisons of the decision-making process of these two groups.

In summary, the current study was conducted in the real world of practice and examined the cognitive operators and processes of decision-making for novice and expert nurses using the methods of TA. Many of the decision tasks of the study involved assessment and monitoring of patients, tasks which involve a high frequency of the operators "plan" (collect cues), "act" and "describe". In contrast to some earlier nursing studies, it was found that novice participants collected more cues than expert participants, but were focusing on a much narrower range of cues than the expert participants. Expert nurses also had a more extensive knowledge of cues and how they related together than novice nurses. Expert participants used the cognitive operators "match" and "predict" more often than novice participants. There were also differences noted in decision processes for both groups such as for hypotheses generation. The differences in the usage of cognitive operators and decisions processes noted for novice and expert participants have implications for nursing education and practice as well implications for future research.

Chapter Eight
Conclusion

The ICU environment is characterised by high acuity patients and is often fast-paced and noisy, with many interruptions to nursing care. Studies have shown that despite this, nursing care in ICUs has ensured better patient outcomes in terms of decreasing mortality and morbidity. Better decision-making by educated nurses has been suggested as the main reason for the improvement. Ensuring all nursing decision-making is of the highest quality is important in this area, especially in relation to the growing numbers of newly graduated nurses entering ICUs earlier in their careers. However, little is known of the actual decision-making processes used by expert and novice nurses in ICUs and a better understanding of such processes is essential for the education of nurses entering this area of practice. This study was implemented to examine the decision processes of both novice and expert nurses in ICUs.

The information-processing theory and the method of TA were chosen for this study after consideration of a range of approaches for studying decision-making. Methods such as those from phenomenology, ethnography and grounded theory give good descriptions of decision-making but do not outline how it actually proceeds and give few guidelines for educators to improve decision-making. NDM is useful for explicating contextual variables in decision-making but also does not allow the tracing of actual decision processes. Decision analysis, on the other hand, prescribes ideal decision-making, not decision-making as it actually occurs. In contrast, the methods associated with the theory of information-processing, such as TA, allow tracing of actual decisions. TA was implemented in this study and allowed the cognitive operators and processes of decision-making to be identified during decision-making in the real world of practice and proved to be an efficient method for detecting nurses' actual decision-making processes. In contrast to authors who suggested that using TA in the real world of practice would present ethical and procedural problems, the participants in the study reported no such problems with the methodology. Using TA in the real world of practice allowed for clarification of some conflicting findings from previous studies, including cue usage and the identification of differences in aspects of decision-making by novice and expert nurses.

The study described aspects that are integral to decision-making in the theory of information-processing, namely decision tasks, cue usage, sources of information and cognitive operators and processes. Expert and novice nurses were included in the study, as were decisions made while monitoring patient haemodynamic status for patients post AAA surgery, an area of practice for which research has shown that nurses making sound decisions can ensure better patient outcomes. The study examined whether there were any differences between novice and expert nurses for all of the above.

Decision tasks were described in the study and many of the tasks of the study involved assessment and monitoring of patients. This concurs with studies that have described nurses' work as comprising almost half the time, observing and monitoring patients and is an important nursing role that deserves attention in undergraduate courses. Ensuring all nurses have good assessment skills is important. The theme identified in this study of "on my watch" concurs with this; all participants described aspects of their nursing role in ICU as watching over and observing patients. Tasks centred on assessment and monitoring involved high frequencies of the cognitive operators "plan" (collect cues), "act" and "describe" which in the study were assigned to lower order thinking skills. Overall, lower order thinking skills had a much higher frequency than higher order thinking skills, again reflecting that much of the participants' decision-making was involved in collecting information and carrying out tasks.

There was a lower frequency of higher order thinking skills, such as "diagnosis" and "choose", by both groups while deciding on care in the tasks of the study. Many of the decision tasks involved assessing and monitoring patient care, not diagnosing and choosing alternative courses of action. This needs to be considered when preparing nurses for this area, as emphasis in education is often on care planning and diagnosing problems and less often on the assessment of patient problems. There is a need to ensure nurses have good assessment skills in the area studied in this research. However other areas of nursing such as nurse triaging in Emergency Care may have decisions with high levels of diagnosing Gertz and Bucknall (2007), and understanding and developing different decision-making skills in nurses is important.

There were differences noted between novice and expert participants for the operators “plan”, “describe” and “act” in the study. In contrast to some earlier nursing studies it was found that in the real world of practice, novice nurses exhibited a greater frequency of the operator “plan” (collect cues) than expert nurses, however, experts collected twice as many different types of cues than novice nurses. Novices were collecting more of the same cue over and over, whereas expert nurses were much more aware of which cues were important, as well as being cognisant of more indicators of patient status than the novice nurses. This is in contrast to studies using simulations, in which it was stated that experts select fewer cues but are more selective in cue usage. In the real world of practice the expert nurses were more selective in cue usage but had a much greater of range of cues that they considered important, and collected these. The expert nurses also collected cues together into meaningful clusters of patterns more often and this, combined with their knowledge of patterns of illness, allowed them to predict what may happen and plan care to prevent problems. The expert participants in the study attended to tasks more proactively and tended to see a bigger picture around the patient. One important defining characteristic of expert nursing may be the way in which expert nurses link cues and information together to assess patient status and the wide range of meaningful cues they are aware of.

In contrast, novice participants in the study had limited knowledge of cues and patterns of illness and carried out tasks more reactively where they put interventions in place after a problem had arisen; their care was characterised less by forward planning to prevent problems. Novice participants also exhibited less extensive relating of cues and a slightly lower frequency of the operator “relate”. If, as Hanneman (1996) points out, expert practice results in different outcomes from novice practice, with expert nurses acting to prevent patient complications through vigilant monitoring and the early application of interventions aimed at improving outcomes, then the more limited cue range and relating of cues by novice nurses is an issue that should be considered and addressed. Education of novice nurses to help them come to understand this important aspect of practice is important. Alternatively, mentoring and supervision may be necessary as they develop these skills in practice to ensure the delivery of safe and adequate patient care.

Expert nurses were also shown to be able to concurrently manage multiple decision tasks effectively, whereas novice nurses were not doing this. Expert nurses also had the ability to prioritise and cluster care, whereas novice nurses were more likely to follow a set of guiding rules. In this study the expert participants displayed aspects of expertise described in the information-processing theory, namely the ability to resume without loss of train of thought a decision task once distracted and the ability to reason simultaneously about more than one decision task. This has not been previously demonstrated using TA in nursing decision-making research. This may be another important difference between novice and expert nurses. Expert nurses need to understand that novice nurses concentrate in an orderly manner on one task at a time to prevent overloading novices with information and causing them confusion. Mentoring of novice nurses may be more effective if delivered by nurses who are closer in experience level, perhaps one or two years ahead as they better understand how novices reason during decision-making. However, the tailoring of information by nurses into sets of if/then rules that was also uncovered in the study may be an important form of transmission of knowledge for novice nurses and further research needs to be instigated to examine such procedural rules.

Expert participants also appeared to be more adaptable and responsive, whereas novice participants were more likely to feel confused and out of control and needed to handle tasks sequentially and one at a time, and hence may need support in managing care. The tendency of novice nurses to focus on an issue and collect information relating mainly to this issue also needs to be addressed, as the narrow focus may prevent them from properly assessing patients.

The differences in the processes noted for novice and expert participants have implications for nursing education and practice as well. Expert participants were more likely to use forward reasoning in hypothetico-deductive reasoning and to gather information to come to a hypothesis, possibly as they could anticipate problems and were collecting information to detect problems. In contrast, novice participants were more likely to use backward reasoning during hypothetico-deductive reasoning, whereby they formed a hypothesis after identifying a problem, then gathered information to support it. Both groups of participants used confirming cues for a hypothesis more often than disconfirming cues. Expert participants did not activate hypotheses early, but rather they gathered sufficient information to develop a hypothesis. This may be due to the current studying being executed in the real world of practice, whereas many earlier studies used simulations. This also needs further consideration in nursing education and research.

The current study also employed two cognitive operators not previously used in nursing decision-making research to investigate decision-making processes, “match” and “predict”. In contrast to Coderre et al. (2003), who stated that pattern-matching cannot be identified as a process in TA, this study did identify incidences of participants using the operators indicative of pattern-matching, “match” and “predict”. The methodology in this study was adequate for demonstrating this important decision process. The expert participants in the current study used the operators “match” and “predict” more often than the novice participants. This process was, however, not restricted to expert nurses, the methodology also demonstrated that novice nurses were beginning to develop patterns as well. The theme “collective knowing of patients” also illuminates how novice participants develop patterns of patients to some extent by the passing on of knowledge common to the unit by more senior nurses. Further research is needed to develop knowledge of how this occurs and the use of alogarithms to deliver care may be useful for novice nurses.

A process discussed in the nursing decision-making literature, but not previously identified in nursing decision-making studies, was described in the current study. This was the process of if/then procedural rules, and the process was employed by both novice and expert participants in decision-making in the study. Some of these procedural rules become internalised and lead to automaticity, and this process was also identified in the current study. If/then procedural rules appear to be a mechanism whereby rules for managing clinical situations are passed on by more experienced nurses to less experienced nurses. Understanding more of these procedural rules is useful in uncovering knowledge in practice.

In contrast to studies that describe knowing the patient by individual nurses, the method used here allowed actual reasoning to be observed in the clinical environment and demonstrated collective knowing of the patient when knowledge of individual patients was shared between nurses to build a patient's story. This story was handed over and care needs to be taken that information is correct and that novice nurses are not swayed by this story while caring for patients, to the detriment of patient assessment.

Many of the themes developed during content analysis in the current study support the findings using PBG and help to understand how the cognitive operators and decision processes differ for novice and expert participants. The theme "keeping an eye on" was identified for all participants and concurs with the high frequency of the operators "plan" (collect cues) and the high percentage of tasks involving assessment of patients. The themes "under control" and "seeking help" which were apparent for novice participants reflect their concern with a "big issue" and the tendency to collect many cues but often with a focus on a limited number of cues centred on a few main issues. The theme "big picture" noted for expert participants concurs with the expert participants' slightly higher use of the operators "relate" and "interpret" and the higher frequency of a proactive approach to tasks by expert participants. The differences between novice and expert participants have implications for nursing practice, education and research.

The findings in the present study point to a further need in education and mentoring to model how experts use cues and cue patterns to anticipate and prevent possible problems.

There is also a need for methods such as concept-mapping to develop an understanding of linkages between patient data and also for more emphasis on cue and concept recognition and interpretation. This is borne out by Baxter and Rideout (2006), who found that students in decision-making often know there is a problem but do not often know what information to collect or how to interpret the information, so they often do not know what to do. Students' theoretical knowledge needs to be broadened so they know how to collect and interpret relevant data and keep patients safe.

In summary, decision-making in this setting was examined for cognitive operators and decision processes used by novice and expert nurses, and other aspects of decision-making, such as type of decision task involved, cues and data gathered and information sources employed. Many commonalities between experts and novices were identified, although a few differences have also been noted in this study, which either contradict previous research or have not been previously demonstrated in nursing research in this area.

As identified by a small number of previous researchers, the methodology used in the study was successfully implemented and ethical and procedural problems were not experienced. The study provided new insights into clinical decision-making by using a combination of approaches, namely concurrent and retrospective TA as well as observation. This approach allowed for contextualizing of the decisions made in a number of ways and allowed an expanded examination of decision-making. It also allowed for the examination of the decision process of pattern-matching, contrary to previous research which stated that it was not possible to detect this process in the real world of practice.

The approach used in this study also made possible detailed descriptions of the problem space of the decision tasks and this allowed a richer description of decisions than has previously been possible using TA alone to examine nursing decision-making. From the examination of the problem space and the decision tasks involved it was determined that both expert and novice nurses in the study spent more time on assessing and managing patients than on diagnosing problems. This aspect of the nurse's role at least in the area of the study may be more important than diagnosing and needs more emphasis in education. Emphasis on developing the assessment skills of undergraduate nurses and novice nurses may be helpful to develop assessment skills in this area. Differences in decision process were also apparent in this study with both expert and novice nurses using a range of processes in contrast to some studies that have reported one decision process only. A decision-making process using if/then procedural rules was apparent in this study but has not been described previously in other nursing decision-making studies. Nurses in the study also did not describe intuition as "gut feeling" and most decisions of expert participants were traceable which is contradictory to some studies pointing out the salient nature of expert nurses' decision-making. In contrast to other nursing studies the participants also used "collective knowledge" of patients as well as individually knowing the patient. Approaches in teaching decision-making may need to be eclectic and involve a range of different decision processes including hypothetetico-deductive reasoning, pattern-matching, intuition and if/then procedural rules as well as concentrating on the important aspect of assessing and linking patient information.

There were also important differences between novice and expert nurses identified in this study. Differences in the way expert nurses used cues in the real-world of practice as compared to simulated case studies were apparent in the study. Contrary to some studies, expert nurses in this study were using a more extensive range of cues than novice nurses and not concentrating on a few pivotal cues as has been reported in simulated studies. Expert nurses also had greater linkages between knowledge and this aspect may be as important as the actual knowledge base they have. Expert nurses also used a more proactive approach to decision making than novice nurses, working to prevent problems before they arise. Expert nurses may be "rescuing patients" as they know what types of problems to anticipate, and this may be a very important aspect of expert nursing. The surveillance and monitoring role of nurses which is believed to keep patients safe has implications if novice nurses are not collecting as many cues as expert nurses and not using these cues effectively. The expert nurses also demonstrated the ability in this study to concurrently manage more than one decision task and to be able to focus simultaneously on more than one decision situation which novice nurses could not do. Although referred to in previous nursing studies this has not been clearly demonstrated as it was in the current study. This has implications for experienced nurses working with novice nurses in that they understand that novice nurses may need to concentrate on one situation at a time and can be easily overwhelmed or confused with information.

There were also differences between novice and expert nurses in the decision processes they used. Expert nurses in the study used more forward reasoning in decision-making than novice nurses which correlated with their anticipation of problems and collection of a range of cues to detect problems. Expert nurses also used the process pattern matching more often than novice nurses. The process of pattern-matching has the cognitive operators “match” and “predict” and these have not been identified in previous studies in nursing.

The differences between novice and expert nurses in decision-making and the new findings from this study have implications for nursing practice, education and research to ensure optimal patient care and ways to incorporate the findings into education and practice need to be developed.

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Appendix

Appendix 1: Abbreviations used in the thesis

AAA	Abdominal aortic aneurysm
ACT	Adaptive control of thought
BP	Blood pressure
CAPS	Capacity-constrained collaborative activation-based production system
CCU	Critical Care Unit
CDM	Clinical decision-making
CVP	Central venous pressure
ECG	Electrocardiogram
EN	Enrolled Nurse
EPIC	Not an acronym but an exemplar of architectural approach to cognition
ET	Endotracheal tube
GTN	Glyceral Trinitrate
HR	Heart rate
ICU	Intensive care unit
IV	Intravenous fluid
LTM	Long-term memory
LT-WM	Long-term working memories
MAP	Mean arterial pressure
NDM	Naturalistic decision making
NSW	New South Wales
PBG	Problem behaviour graph
PBL	Problem-based learning
PEEP	Positive expiratory end pressure
PMP	Patient management problem
PVD	Peripheral vascular disease
RMO	Resident Medical Officer
RN	Registered Nurse
STM	Short-term memory

Soar	Not an acronym but an exemplar of architectural approach to cognition
SPSS	Statistical database (name not an anacronym)
ST-WM	Short-term working memories
TA	Think aloud
USA	United States of America
VPA	Verbal protocol analysis
VPs	Verbal protocols
UTS	University of Technology, Sydney

Appendix 2: Definitions used in the study

The following operational definitions were used to guide the study.

Decision-making: decision-making is the processing of information received in the form of cues or data to produce a decision outcome. Stored knowledge is used during the processing and the processing occurs as the decision-maker moves from one knowledge state to the next by operators.

Expert Critical Care Nurse: possesses a large body of knowledge and procedural skill, formal education in an area of practice, recognised by others for expertise, represents more than experience in length of years.

Novice Critical Care Nurse: beginner, lacks speed and accuracy and efficiency of expert, considered beginner by others.

Cues: information or data that is collected about patient and considered in reasoning about care and management of patient, collection of patient observations from various sources such as monitoring, patient report, report from family and peers.

Tasks: separate incidences of care of patient involving management, observation, routine interventions, comfort measures.

Information source: any source that the participants used to access information and knowledge about patient or patient care.

Operators: cognitive thinking strategies that link each new state of knowledge during clinical reasoning for decision-making.

Processes: the cognitive strategies that are used during reasoning and decision-making about a nursing task, are aggregates of cognitive operators.

Appendix 3: Observation schedule used in pilot (adapted from Observation Protocol Bales (1950) in Kagan and Evans, (1995).

Interactions				
Non-verbal communication	Intonation			
	Emotion			
	Body language			
	Other			
	Comments			
Social emotional	Agrees/disagrees			
	Shows antagonism			
	Defends/asserts self			
	Withdraws			
	Passive acceptance/rejection			
	Understands			
	Concurs			
	Complies			
	Expresses/wishes/fee lings			
	Other			
	Comments			
Task relations	Repeats			
	Clarifies			
	Confirms			
	Evaluates			
	Opinion given			
	Suggestion given			
	Ask information			
	Ask opinion			
	Ask suggestion			
	Ask confirm			
	Ask evaluation			
	Ask evaluation			
	Ask analysis			
	Other			
	Comments			
Who with	Team leader			
	Other nurse			
	Medical practitioner			
	Allied health			
	Other			
Time				

Appendix 4: Observation schedule employed in main study

Non-verbal					
Who involved					
Description of Activity					
Time					

Appendix 5: Interview schedule used for pilot study

- What guidelines would you give other nurses for managing…..situation?
- Tell me how you came to know these guidelines?
- I noticed that you did ... tell me about it?
- Is this what you had expected to do for the patient? Tell me why or why not?
- Do you think there is a more correct way of doing….?
- What other typical interventions are there?
- Is this what you had expected to do for the patient? Tell me about why or why not.
- I noticed you discussed …with…..Tell me about it.
- Did the discussion go as you intended? Tell me about it.

Appendix 6: Interview schedule used for the main study

Demographics: a) approximate age
b) education
c) experience
d) positions held in nursing

1. What information about this patient influenced how you cared for this patient?
2. Where did you get this information from?
3. Tell me about your main sources of information for managing … situation?
4. What guidelines would you give other nurses for managing … situation?
5. Is that would you normally do in such a situation?
6. Are you aware of any research that may help you know how to manage … situation?
7. What would you change if you were talking to an inexperienced nurse? Expert nurse?
8. Is this what you would normally do in such a situation?
9. What signs or symptoms were you noticing when you were … (above situation). What other signs and symptoms would have been useful? What may have not been useful. Why?
10. I noticed that you discussed … with. Tell me about it.
11. I noticed that you did … for the patient. What else could you have done? Tell me about not doing …
12. I noticed you looked … (emotional state, e.g., perplexed, frustrated). Is this correct? If so can you tell me about it?
13. How do you see the nurses' role in caring for these type of patients?

Instances from the transcript were also used to explore issues more fully, for example, if the nurse had been worried about the patient's blood pressure this was used as a prompt to explore her/his thinking about it more fully.

Appendix 7: Information letter to potential participants

An examination of the decision-making by expert and novice nurses, while monitoring patient haemodynamic status and contributing to patient management for post Abdominal Aortic Aneurysm surgery in the clinical setting.

The purpose of this letter is to introduce myself and to outline a research project I wish to conduct in your unit. I would also like to invite you to participate in this research.

I am a Doctoral student from UTS and have an interest in clinical education, and nurse clinical decision-making. My supervisors are Professor Christine Duffield and Dr Leanne Aitken.

I am asking for volunteers to participate in this research project. Your involvement would entail being observed on one occasion for a period of two hours during routine care for a post-operative aortic aneurysm patient. During the observation period I will be noting down activities you are carrying out as you monitor your patient's haemodynamic status and contribute to the care required. You will also be asked to Think Aloud (TA), which involves verbalising your thoughts as you manage your patient's nursing care. A practice session beforehand will be organised to help in doing this. Your thinking aloud will be tape-recorded during the session. You will also be asked to attend a one-hour interview session after the TA/observation session. This session will be held in a quiet room away from your unit, will involve giving up an hour of your own time and will remain confidential.

The project proposes to examine the types of thinking processes used during decision-making by nurses while monitoring patient haemodynamic status for post Abdominal Aortic Aneurism surgery in the clinical setting. The focus of the research is on the way nurses think while managing patients' blood pressure and any other information will not be included in the research. You will not be identified in the research and only the researcher will have access to the data. It is hoped that the result of this research will be translated into educational initiatives to further enhance decision-making for nurses.

Participation in this research project is entirely voluntary and you can withdraw any time from the research without giving a reason. I am available to answer any questions you may have; my contact details are listed below. I will also be holding some short informal information sessions in your ward to answer queries and to explain the project, if you cannot attend a sessions and would like to talk to me personally I will make a time to come and see you.

Your participation is greatly valued.

If you would like to participate please contact Kerry Hoffman on

phone 43 20 2855
e-mail Kerry.Hoffman@newcastle.edu.au

My supervisors' contact details are:
Professor Christine Duffield phone; 0295145729, e-mail Christine.Duffield@uts.edu.au
Dr Leanne Aitken, phone; 0299266051, e-mail Leanne.Aitken@uts.edu.au

Yours sincerely

Kerry Hoffman

This research project has been approved by the UTS Ethics Committee, contact person, Research Officer, 951441279 and the Gifford Hospital Ethics Committee, contact person, Margaret McMillan, extn 3070.

Appendix 8: Consent form

UNIVERSITY OF TECHNOLOGY, SYDNEY, CONSENT FORM - STUDENT RESEARCH

I ____________________________ agree to participate in the research project *An examination of the processes used by expert and novice nurses to make decisions while monitoring and contributing to the care of patients being monitored for heamodynamic status post Abdominal Aortic Aneurysm surgery in the clinical setting* being conducted by Kerry Hoffman, student number; phone of the University of Technology, Sydney, for the purpose of her Doctoral Degree.

I understand that the purpose of this study is to examine the processes used by nurses to make decisions regarding the management of patient BP (blood pressure) in the clinical setting.

I understand that my participation in this research will involve TA (thinking aloud) while managing patient care, for approximately two hours on one occasion and that the thinking aloud will be tape-recorded. I also understand that I will be observed while managing patient care for activities. I also understand that I will be interviewed for approximately one hour regarding the thinking aloud session. I understand that the interview session will involve one hour of my own time and the TA and observation will occur during my normal work hours.

I am aware that I can contact Kerry Hoffman or her supervisor Christine Duffield (Phone: 02 95145792) and Leanne Aitken (phone: if I have any concerns about the research. I also understand that I am free to withdraw my participation from this research project at any time I wish and without giving a reason.

I agree that Kerry Hoffman has answered all my questions fully and clearly.

I agree that the research data gathered from this project may be published in a form that does not identify me in any way.

____ ____/____/____

Signed by

____ ____/____/____

Witnessed by

NOTE:

This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer, Ms Susanna Davis (ph: 02 - 9514 1279, Susanna.Davis@uts.edu.au). Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix 9: Summary of analysis process

- Each transcript was numbered participant one, two etc. and a letter assigned to each. Transcript transcribed verbatim.
- Each transcript was also identified as the concurrent transcript (TA session of practice) or the retrospective transcript (interview). Pilot participant was assigned letter A, participant one concurrent transcript was assigned B, participant one retrospective transcript was assigned C, participant two concurrent D and so on.
- The transcript was read and re-read to allow familiarisation.
- Sections that are not applicable to the aim of the main study were highlighted.
- Applicable sections included;
    - Those relating to haemodynamic status, such as BP, circulation, fluid balance.

      Influencing factors on haemodynamic status, such as pain, anxiety, respiratory function, fever, some medications.
    - Those things that are related to haemodynamic imbalances such as renal failure, possible myocardial infarct, restricted flow to the bowel and paralytic ileus, restricted flow to feet and ischaemic feet, possible low levels of oxygen due to respiratory problems and the effect on haemodynamic status.
- The relevant sections were segmented into meaningful phrases; each phrase is a state of knowledge.
- Each meaningful phrase was numbered from B1 to Bn for participant one concurrent transcript, C1–Cn for participant one retrospective transcript and so on.

<u>Construct the problem space; describe the subtasks that make up the transcript</u>

- The transcript was segmented into discrete tasks such as "patient pain what was done", "saturations down what was done". Each task was numbered.
- The outcome of each the task was outlined, for example, "assessed pain level,

pain medication increased", "put nasal prongs back on patient".

- The cues in the task were listed, for example, BP, HR, CVP, output, patient report of pain.

Referring phrase analysis; identify the concepts the participant is concentrating on.

- For each numbered phrase, the concept the participants is thinking about was identified.

Assertional phrase analysis; identify the operators

- The operator that moved the reasoning from one knowledge state to the next was identified. This was done by examining each numbered phrase in relation to the next numbered phrase and identifying from the predetermined list of operators which operator moved the reasoning from the first phrase to the next.

  For example, A10 BP is 90/50 (operator–plan)

  A11 BP is a bit low (operator–interpret)

  A12 I think the BP was 110/60 before, yeah 110/60 that's right (operator–review)

The PBG were then graphed

- Each task for each participant was graphed separately. The tasks were graphed in order for the concurrent transcript for each participant then for the retrospective transcript for each participant.
- Each graph was numbered to correspond with the participant number and task number and a description of the task recorded on the bottom of the graph.
- X axis–the identified concept of each successive phrase was recorded down the graph in sequential order.
- Y axis–the operators in order of lower thinking order skills to higher order thinking order skills were recorded across the top of the graph.
- A line was drawn from the concept of each phrase to the operator identified for that phrase and the number of the phrase entered at that point. Phrases with the

same concept were linked in the graph.

For example:

	Plan	Act	Describe
Airway________A1			
Breathing____________________________A3			
Airway________________A3			

The graph shows the sequential reasoning of the participant in the problem space, the task, and indicates the order of concepts that were attended during the task as well as the operators for each phrase.

Script phrase analysis;

Involved careful examination of the transcripts to determine patterns of operators that indicate known processes, and careful examination of the graphs to determine patterns in the graphs that indicate processes using schedule developed in Method Section 5.4.3.c.

For example, hypothetico–deductive reasoning;

From transcript; Cues gathered–operator “plan”, then interpreted–operator “interpret”, “relate”, “review”, hypothetico-deductive reasoning–operator “diagnosis”, plan of care operator–“act”, or “course”, and possibly verification–operator “evaluation” (not all steps were necessarily followed in sequential order).

Pattern-matching;

Operators “predict” and “match”

Estimating frequencies

- The number of each type of operator was recorded on each graph “Plan” = n, “act” = n, “describe” = n.
- For each participant the number of each operator for each task of the

concurrent transcript was summed. These were then summed for all tasks of the concurrent transcript and percentages calculated for each participant.

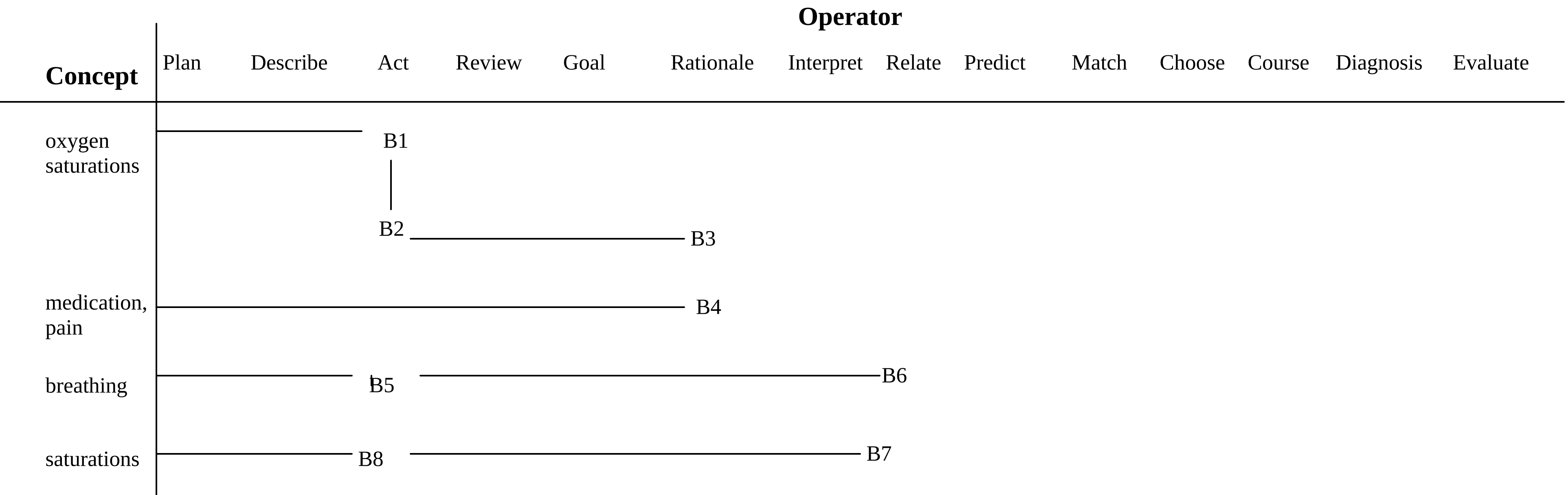
- This was then done for each participant's retrospective transcript.
- The operators for the novice participants were then summed for the concurrent transcripts and percentages calculated, similarly for the expert participants. These were then compared.
- The operators for the novice participants were then summed for the retrospective transcripts and percentages calculated, similarly for the expert participants and again compared.
- The operators for the concurrent and retrospective transcript were also summed overall for all participants and percentages calculated.

Appendix 10: Example of description of tasks used in the analysis

Table 30: Tasks, participant 1, beginning of shift, patient 12 hours post-operative.

Task	Description	Outcome	Cues	Knowledge source	Operators
1	Getting patient to keep mask on, oxygen saturations down	Mask kept on, saturations up	Oxygen saturation, Respiration Patient observation IV rate	Procedural Patient observations	A4 R2 Rl2
2	Patient nauseated, Assessing limb observations	Decided to get order for maxalon	Patient report Limb observations	Patient Experiential Theoretical Procedural	A4 P5 D4 R3 E3
3	Patient in pain	Assessed pain level, responded to patient complaint	Patient report HR, BP, Saturations Output Patient observations	Patient	P3 A4 G4 R3 I3 E4
4	Patient in pain, assessed epidural and pain assessed again	Changed rate of epidural checked dermatones	Patient report BP, HR, Dermatones	Pain report by patient Procedural	D2 A5 G5 R1 Pr1
5	Problem patient nauseated, organised medication and administration	Maxalon prescribed and administrated	Patient report Medication order	Patient Charts Procedural Theoretical Experiental	D4 A2 Rv2 G2 Pr1 Ch2 E1
6	Reviewing observations and assessments	Satisfied patient stable, established goal get on top of pain	Pulses, swollen feet Warm feet Movement toes Colour feet Capillary return Pain assessment	Pathway Charts Patient Procedural	A8 P6 D1 Rv2 G2 R3 e3
7	Assessing why patient has not got a nasogastric tube	Established that was acceptable for patient not to have nasogastric even though this is normal procedure	Nasogastric tube ET tube Size stomach	Patient notes Procedural Experiental	P1 D9 A5 R4 Rl1 E4
8	Assessing wound	Decided dressing needed to be attended that shift	Wound dressing Ooze from wound	Experiental Procedural	P2 G1
9	Blood pressure down, reviewed assessment and blood pressure management	Decided patient blood pressure down due to his pain	BP, Volume output, Pain Hydration	Patient obsevations	A2 P1 D1 Rv7 G1 R2 I1 Rl2 Di1 E1
10	Dermatone levels to low, reviewing epidural and orders	Decided to test dermatones again	Dermatones	Patient observations	D2 A4 R1 I1
11	Patient in pain, checked dermatones again	Decided pain improving goal to get on top of pain	Dermatones	Procedural	P2 A4 Rv2 R1 Pr1 E2 G3
12	Doing routine observations and giving charted medications	Medications given observations recorded		Charts	P2 D1 A4 R2
13	Saturations down assessing why	Decided due to nasal prongs not being on correctly prongs back in	Monitor observations Saturations HR, BP, Pain	Patient report	P6 A2 G1 E1

Task	Description	Outcome	Cues	Knowledge source	Operators
14	Assessing patient				P9 A2 D2 Rv1 R3 Rl1 G1
15	Patient blood pressure down, reviewing observations and situation	Decided a reading artifact due to patient moving	BP, monitor alarms HR, Saturations		P7 D4 R1 I1 E1
16	Considering fluid status, did CVP	Decided patient may be fluid depleted (hypothesis)	Urinary output, CVP	Procedural Theoretical	P7 D3 A9 G1 R4 Pr1 E2 I4
17	Patient blood pressure up, assessing blood pressure	Decided due to position of artline	Alarms, BP, artline position	Procedural Theoretical	P2 D3 A2 G2 R3 I3
18	Reassessing patient pain	Pain down due to epidural rate being increased	Pain scale, Temperature	Procedural Experiental Theoretical	P4 D4 A6 R2 G4 I1 E3
19	Assessing patient status and planning care developing plan of care to help patient breathing and respiratory function	Decided to get patient out of bed to improve his breathing	Alarms, BP, Patient moving, Nasal prongs	Experiental Theoretical	C2 P2 D2 A2 G1 R2 Rl1 Pr1
20	Reassessing pain control	Continue current course of action and increase rate of epidural	Pain scale, Dermatones, Medication rate	Procedural	P4 D3 A4 Rv1 I2 E2
21	Reviewing information regarding patient anxiety, patient anxious	Decided patient anxiety not new but has been present for long time		Information from carer Charts Personal	D2 A1 I2 Rv3
22	Reassessing pain and epidural	Changed patient position to try and get boluses to work	Pain scale, Epidural rate	Experiental	P4 D2 A3 Rv2 G1 R1 I1 Pr1 E1
23	Assessing limb observations	Satisfied observations acceptable	Limb obs, Artline, Alarms	Procedural Experiental	P7 D1 A3 R3 I4 E1
24	Patient restless, assessed restlessness and reviewed	Decided to give TLC and to calm patient	Monitor alarms, Patient condition	Personal Prior experience	D2 A3 R3 I3 E3
25	Assessing patient status	Satisfied with status	Monitor pulse, BP, HR, CVP, Saturations, urinary output	Theoretical Experiental Procedural	P6 D6 A4 Rv1 Rl2 e3
26	Patient complaint of pain reassessing pain	Decided to give another bolus, increased rate of epidural infusion	Pain scale, Monitor	Patient report	P2 D1 A2 C2 E1
27	Assessing patient status, planning care	Satisfied with status, decided to get patient up			P1 D3 A4 R3 M5 Pr2 C2 E3
28	Patient complaint of pain assessing pain and deciding what to do	Increase rate of epidural	Pain scale, Patient behaviour	Patient report Procedural Prior experience	P5 D2 G1 R2 I1 Pr2 C3 E1
29	Reviewing patient status, and comparing to other patients has cared for	Decided patient not confused	Mental status	Past experience	D4 M4 E1



PBG for novice participant during TA session
Task attended too: responding to low Sa02's trying to get patient to keep mask on. Outcome; put mask back on patient, SaO2 back up
Cues used; oxygen saturations, respirations, patient observation, observation of technical equipment

Appendix 12: Examples of analysis of operators in TA transcript

Table 31: Participant 1, transcript TA

Operator	Percentage	Category	Percentage
Plan	19.5	collect	19.5
Describe	14.8	description	35.8
Act	21		
Review	4.6		
Goal	6.6	selection	21.6
Rationale	10.4		
Interpret	6		
		inference	7.7
Relate	1.7		
Match	2	inference	4.2
Predict	2.2		
Choose	0.4		
Course	2	synthesis	2.6
Diagnose	0.2		
Evaluate	8	verification	8

Appendix 13: Example of analysis of interview transcript

Table 32: Participant 1, transcript interview

Operator	**Percentage**	**Category**	**Percentage**
Plan	27	Collect	27
Describe	21	Describe	29
Act	8		
Review	1.2		
Goal	1.9	Select	17.1
Rationale	14		
Interpret	5.1	Inference	7
Relate	1.9		
Match	2.5	Match	2.5
Predict	0		
Choose	0		
Course	8.3	Synthesis	10.8
Diagnose	2.5		
Evaluate	8	Verification	8

Appendix 14

Figure 5: Flow chart for content analysis of data

1. Raw data coded using key words/key phrases that answered general aims of the study E.g., into tasks, cues or information sources.

↓

2. Coded data aggregated under coding framework subheadings. E.g. how do participants proceed with tasks?

↓

3. Phrases with similar meaning under the coding framework were then clustered and further meaning developed.

↓

4. Themes generated from key words and phrases.

↓

5. Themes were enumerated and tabulated.

↓

6. Themes generated were presented as aggregated themes for novice or expert.

Appendix 15

Table 33: Examples of categories and subcategories in content analysis from transcripts and interviews

Tasks	**Cues**	**Information sources**
Subcategory one: How do participants proceed with task? "can you write me up some maxalon". "probably needs some insulin, find a doctor and start some insulin". Participants observed asking doctors for the treatment they wanted. Theme: Directing care.	**Subcategory one: how cues used?** "We are going to keep an eye on her to make sure she is safe." High percentage of operators involved collecting cues and constant monitoring was feature of tasks as noted in diary. Theme: keeping an eye on.	**Subcategory one: how came to know?** Learning by experience; experiental. "I have learned to look out for things that can happen". "When you read it in a book it doesn't sink in but if it happens you remember and learn to look out for it".
Subcategory two: Guidelines used Using a guide: "we get these care plan pathway so if you are not sure of what you are doing you just go by it". Novices observed to use guidelines and pathway whereas expert nurses often did not.	**Subcategory two: how impacted on care delivery** Big issue: "Pain was a big issue". "There were very big indicators of how she was going".	**Subcategory two: how knew about patient** Collective knowing: From observation and transcript, same information was repeated about patient by two different nurses caring for patient on successive shifts, both stated he had a good tan so must exercise and plays golf.

Appendix 16

Table 34: Tasks for novice and expert participants, overall list of what attended

Novice participants Task listed (number of participants who carried out task)	**Expert participants** Task listed (number of participants who carried out task)
	MRSA swabs (1)
	Notified family of condition (4)
	Mental state assessment (2)
Deep breathing/coughing (1)	Deep/breathing coughing (1)
Positioning patient as per protocol (1)	Positioning patient, comfort, pain relief, aid in breathing (2)
Timing care according to flow charts etc (2) being helped by others (2)	Timing cares around patient and clustering care (2) Preparing ahead of time in case IV etc run out (2)
Asked for help to set ventilator (2)	Setting ventilator settings according to patient response (2)
Limb observations (4) one decided against using Doppler even though pulse faint (1)	Limb observations (4) used Doppler for faint pulse Checked other pulses as well popliteal and femoral (1)
Titrating GTN (1)	Titrating GTN (2)
Titrating epidural (4)	Titrating epidural (4)
Dermatone (4)	Dermatones 4
	Extubated patient 2
	Rhythm strips attended 1
Checked pressure bags (1)	Settings of monitors checked and set to patient, checked pressure bags 2
	Assessment size type placement and date inserted of ET central lines and canulas, Is it secure (2)
ECG (1)	
Changing and sorting lines (1) directed by senior (1)	Changed and sorted lines (2)
Wound assessment (1)	Wound assessment (2)
Anchored artline (2) directed by senior (2)	Anchored artline (2)
Blood pressure artline checked trace (2)	Blood pressure artline, checked trace and manual attended as well (2)
	Glucose monitroing rate (1)
Abdominal girth (1)	Abdominal assessment (2)
Pain assessment (4)	Pain assessment (4)
	Checked blood test results (2) Take post op bloods ABG (2)
Bair hugger for cold patient (1)	
	Establishing contact with patient by touch (2)
	Organise X-Ray to check placement central lines etc (2)
ET tube-placement (1)	ET tube- placement, size, type (2)
	Type of central line,Type of canula, Date inserted (2)
Mouth care (2)	Mouth care (2)
Giving comfort; using touch (2)	Giving comfort: using touch (3)
Not all equipment ready; unsure of what needed and order of setting up a patient back from theatre, needed direction (2)	Prepared room had all equipment needed out (could anticipate what would need (3)

Appendix 17: Frequency of task type for each participant

Table 35: Frequency of task type for each participant

Participants	**TA transcript**	
	Reactive	**Proactive**
Participant N	45%	55%
Participant E	26.5%	69.5%
Participant E	18.5%	81.5%
Participant N	57%	43%
Participant N	56%	44%
Participant E	13.6	86.4%
Participant E	16%	84%
Participant N	23%	77%

N= novice

E= expert

Appendix 18

Table 36: Processes used by each participant

Particip-ant	Hypothetic-deductive	Pattern-matching	Automatic	If/then	Trial and error	Others
One	4	2	2	2		Knowing patient collectively Backward and forward reasoning
Two	3	4		4		
Three	4	6		5		
Four	1	2		7	2	Knowing patient
Five	4	1		7	1	Backward reasoning
Six	3	6	1	3		Knowing patient
Seven	2	3		1		Knowing patient
Eight	1	1		1		

Appendix 19

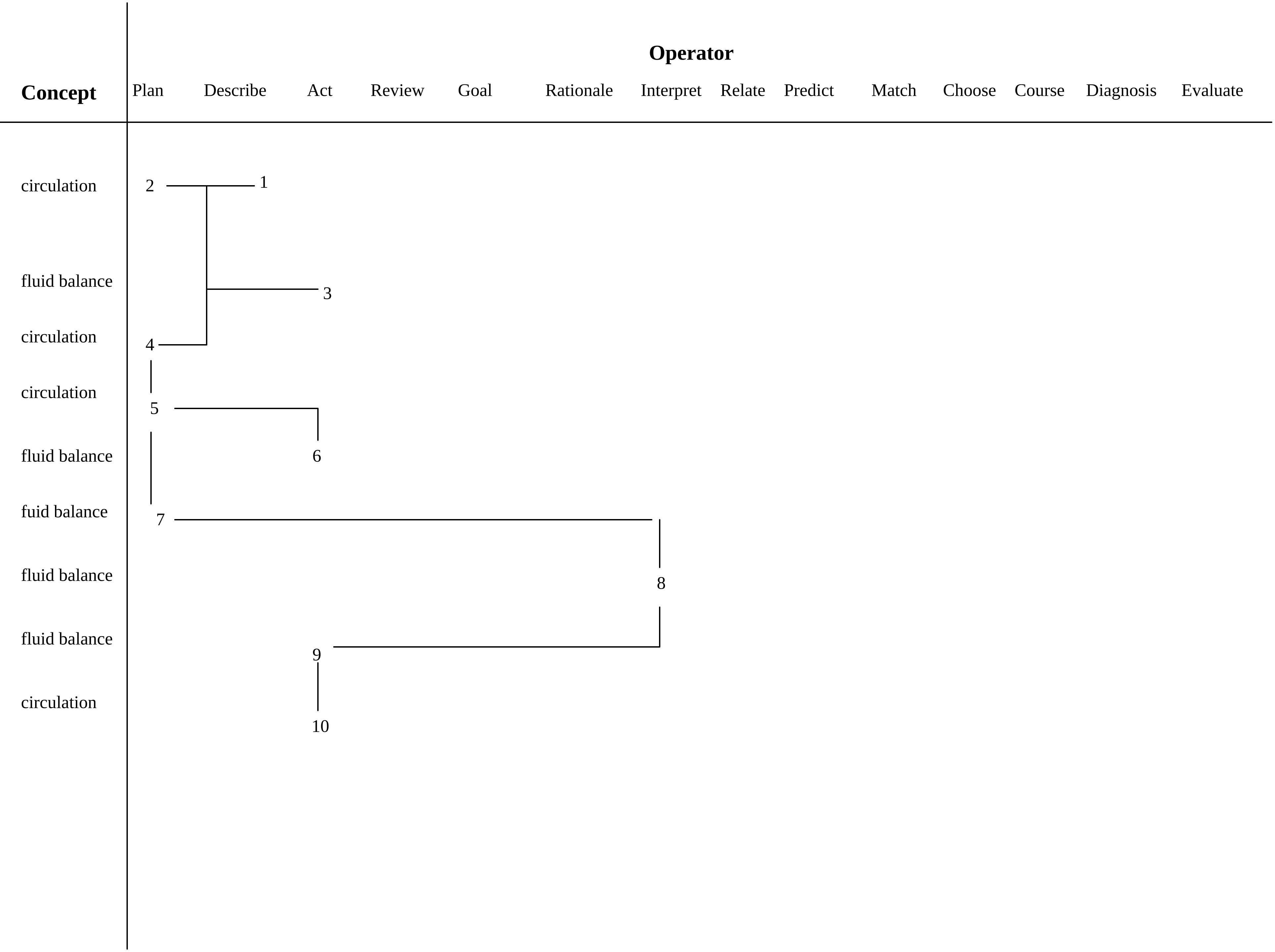
Table 37: Example of concepts and operators for hypothetico-deductive reasoning, backward reasoning

Phrase	Concept	Operator
his BP is down	circulation	“describe”
systolic about 100, 105	circulation	“plan”
give him fluid	fluid balance	“act”
brought it up to 115	circulation	“plan”
now it is 126	circulation	“plan”
and I haven’t given him any more	fluid balance	“act”
he is passing urine	fluid balance	“plan”
maybe he hasn’t got enough fluids	fluid balance	“interpret”
give some more	fluid balance	“act”
BP is 125	circulation	“plan”

Appendix 20

Table 38: Example of phrases, concepts and operators for hypothetico-deductive reasoning, forward reasoning

Phrase	Concept	Operator
check the BP, it's a little bit low	circulation	"plan"
could be lost fluids	fluid balance	"interpret"
check with the non invasive, still low	circulation	"plan"
what's the epidural rate?	pain	"plan"
his mean is around 60, but I'd prefer it close to 70	circulation	"plan"
been looking at his old notes	circulation	"act"
try to work out why heart rate is slow	circulation	"rationale"
check how much he lost in theatre	fluid balance	"act"
he has lost a lot of fluid	fluid balance	"interpret",
are you in pain	pain	"plan"
wonder if we can turn the epidural down a little	pain	"act"
BP is a bit low	circulation	"rationale"
he isn't very warm, BP low	circulation	"describe"
might need a fluid bolus, probably fluid depleted	fluid balance	"diagnose"
do you mind if I give him 250, normal saline or gelofusion?	fluid balance	"choose".
… BP picking up with a bit of fluid",	circulation	"evaluate"

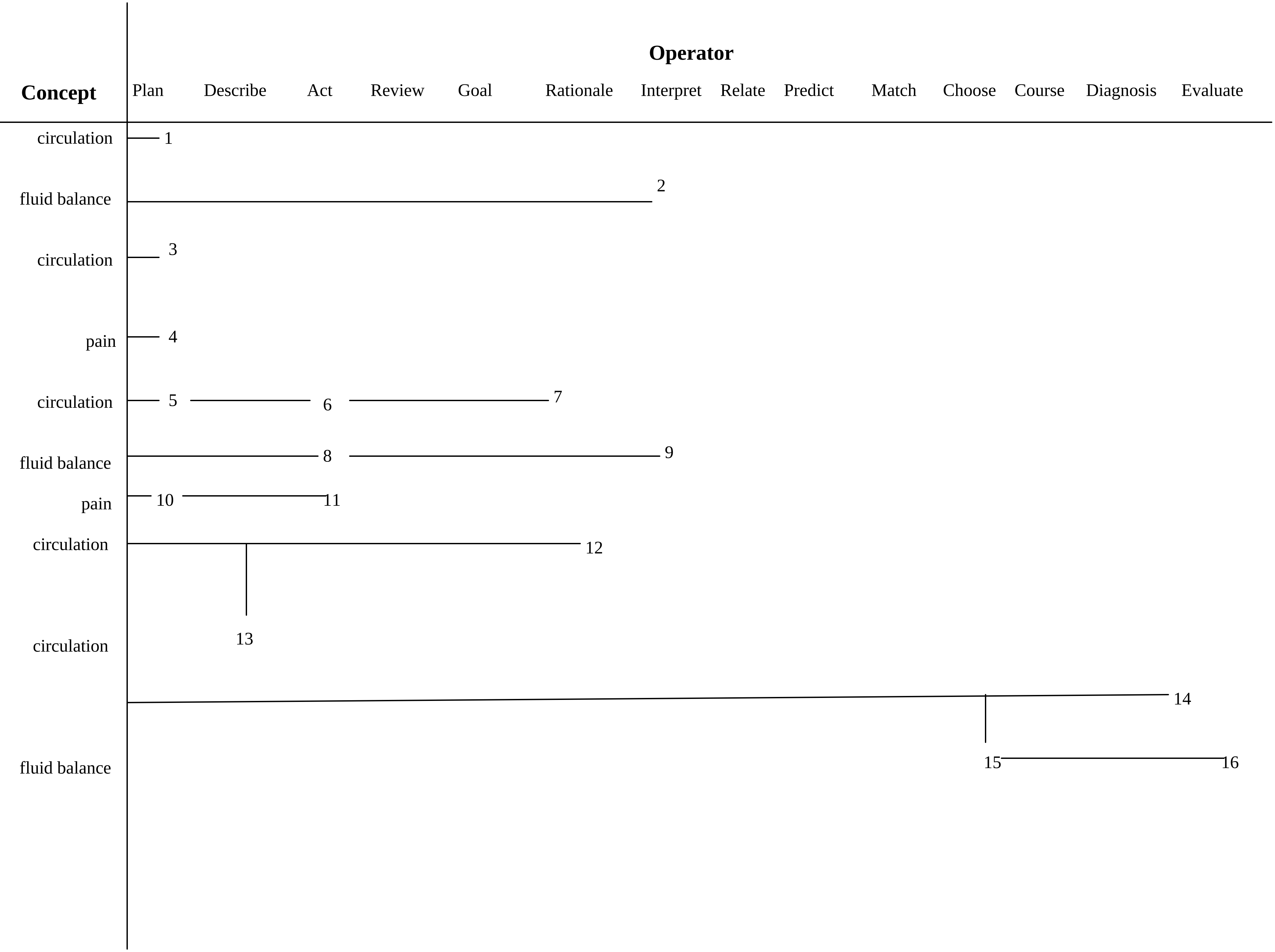


Graph 2: Hypothetico-deductive reasoning, backward reasoning

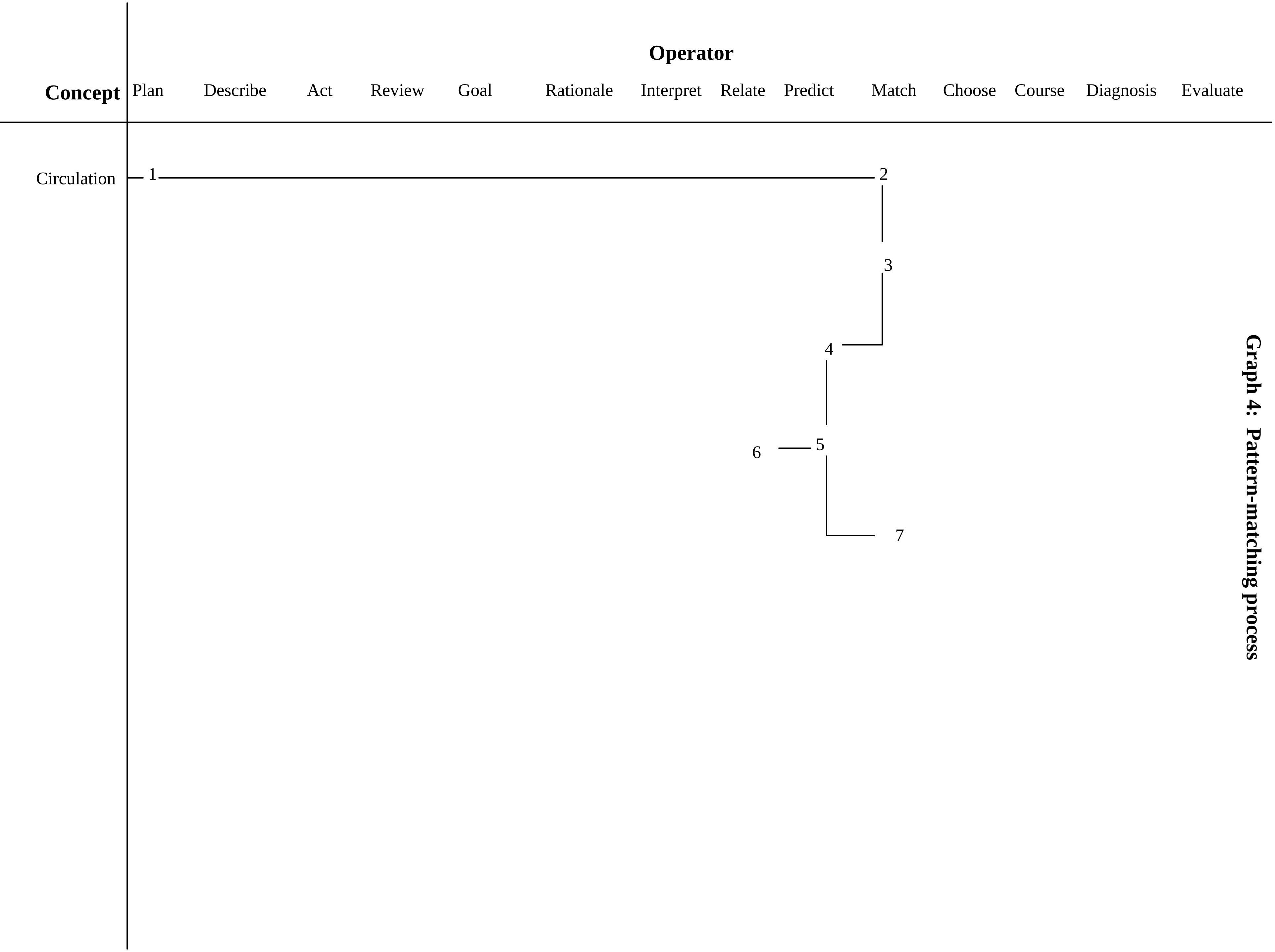
Appendix 21

Table 39: Example of phrases, concepts and operators for pattern-matching

Phrase	Concept	Operator
what’s his blood pressure because his	circulation	“plan”
its unusual for them to come back so warm	circulation	“match”
generally they come back cold	circulation	“match”
and as they warm up they tend to drop their blood pressure	circulation	“predict”
so I am hoping that his blood pressure will stay stable	circulation	“Predict”
since he is already warm	circulation	“relate”
that is not usually the case	circulation	“match”



Graph 3: Hypothestico-deductive reasoning, forward reasoning



Graph 4: Pattern-matching process

Appendix 22

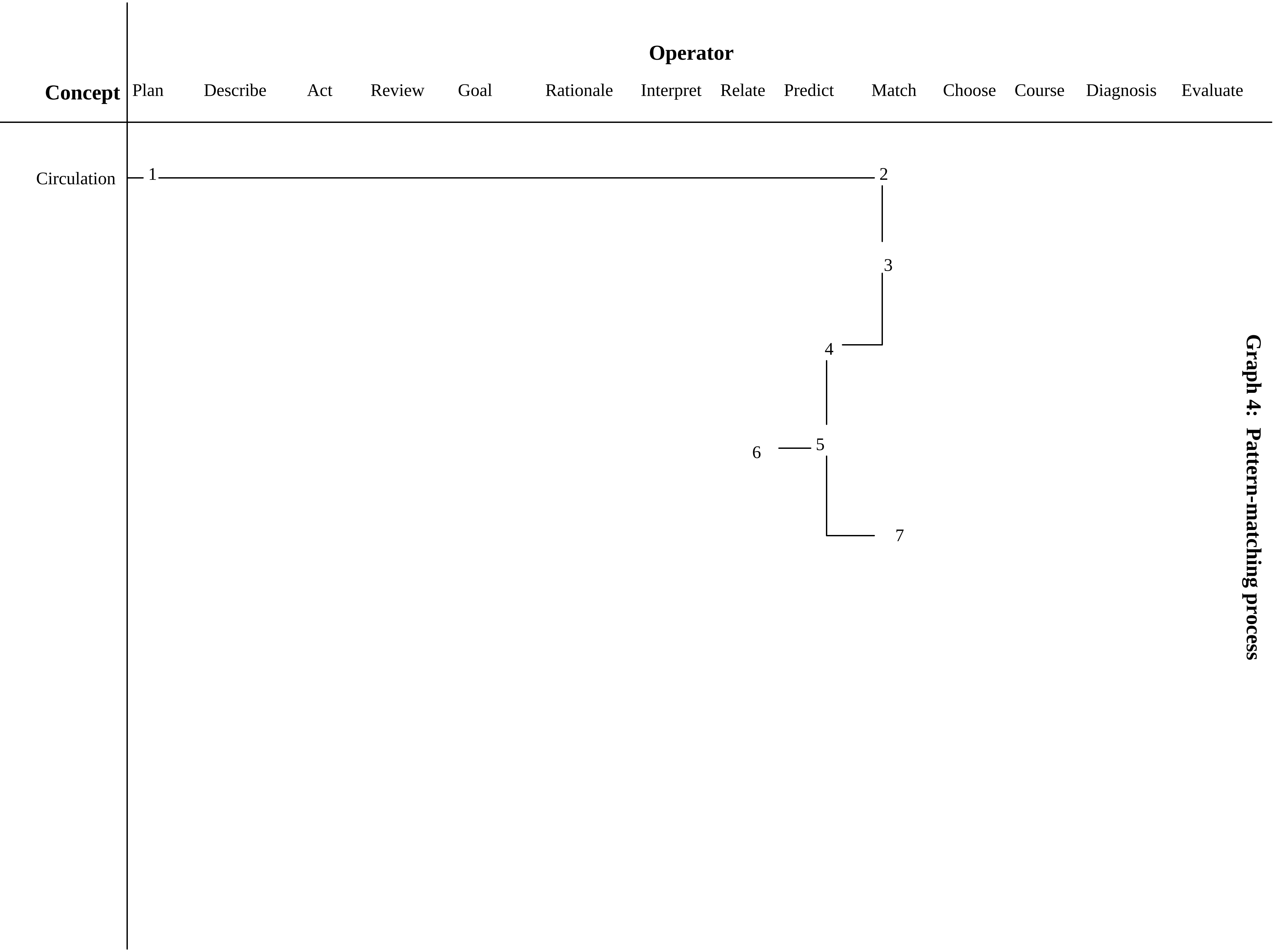
Table 40: Example of phrases, concepts and operators for if/then process

Phrase	Concept	Operators
if BP is high or low	circulation	“plan”
then check waveform	circulation	“act”
if waveform is all right	circulation	“evaluate”
then check artline is flushing	circulation	“act”
if flushing all right	circulation	“evaluate”
then check that the artline is not kinked	circulation	“act”
if not kinked	circulation	“evaluate”
then check the position of the hand in relation to the heart	circulation	“act”
if this is not the problem,	circulation	“evaluate”
then check against a manual reading	circulation	“act”
if still abnormal	circulation	“evaluate”
then report the reading	circulation	“act”

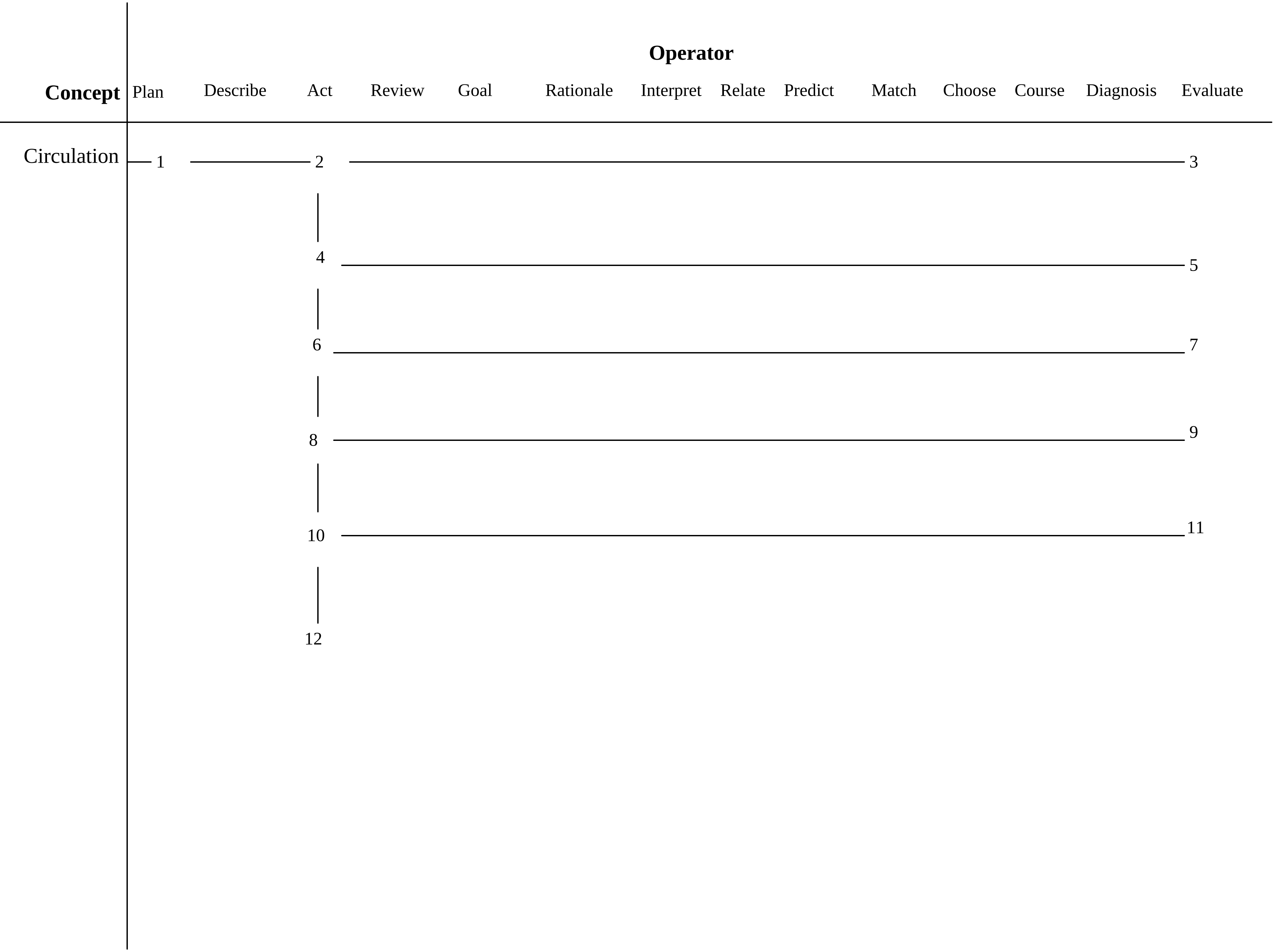
Appendix 23

Table 41: Example of phrases, concepts and operators for trial-and-error process

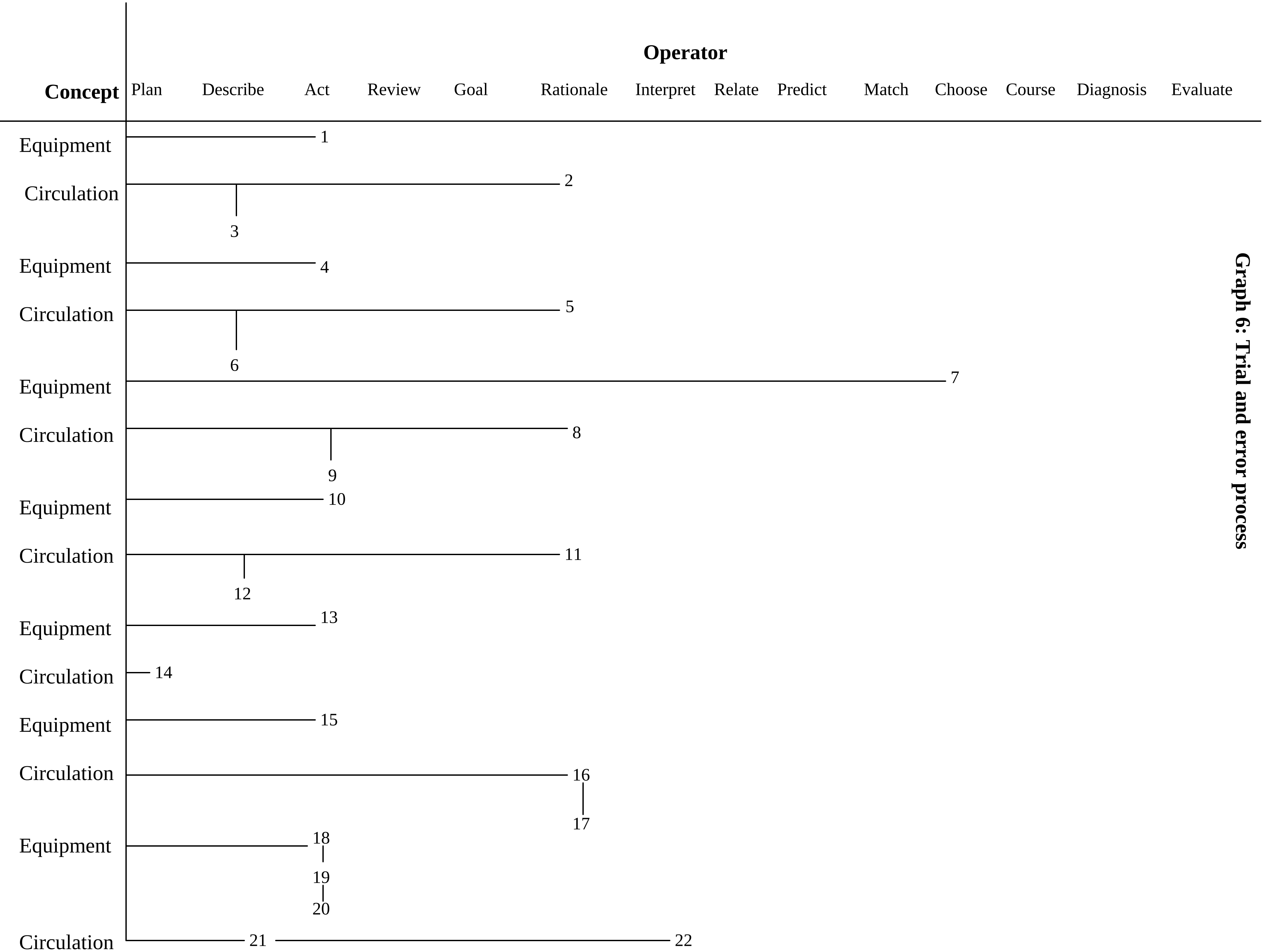
Phrase	Concept	Operators
I am putting the GTN back on	Equipment	“act”
because her mean arterial pressure is 111	Circulation	“rationale”
they want it below 95	Circulation	“describe”
I just put the GTN back on	Equipment	“act”
cause it went to MAP of 114	Circulation	“rationale”
alarms for BP	Circulation	“describe”
yeah, I think she had better have a bit more	Equipment	“choose”
the BP is still very high	circulation	“rationale”
so I should be increasing the … her BP is still up though	circulation	“act”
so I will increase the GTN	equipment	“act”
yeah, I have increased it	equipment	“act”
because her MAP is 120, so it should be around 90	circulation	“rationale”
It is down a bit now	circulation	“describe”
put the rate down a bit	equipment	“act”
her BP has come back up again	circulation	“plan”
put it up again	equipment	“act”
I am going to increase that again as her MAP is still like 110	circulation	“rationale”
her BP has decreased	circulation	“rationale”
so I will decrease the tridal	equipment	“act”
never can tell what is going on, might turn it off …	equipment	“act”
then turn it back on if she needs it	equipment	“act”
BP picks up very quickly	circulation	“describe”
yeah, it is very labile	circulation	“interpret”



Graph 4: Pattern-matching process



Graph 5: If/then process



Graph 6: Trial and error process