Fall 2009

Problem Definition and Hypothesis Generation by Recent Family Nurse Practitioner Graduates

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PROBLEM DEFINITION AND HYPOTHESIS GENERATION BY RECENT FAMILY NURSE PRACTITIONER GRADUATES

A Dissertation

Submitted to the School of Nursing

Duquesne University

In partial fulfillment of the requirements for

the degree of Doctor of Philosophy

By

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December 2009

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ABSTRACT

PROBLEM DEFINITION AND HYPOTHESIS GENERATION

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Dissertation supervised by Linda Goodfellow, PhD, RN

Little is known about the effect of problem definition on hypothesis-generation accuracy in recent family nurse practitioner (FNP) graduates. The hypotheticodeductive-reasoning model served as the theoretical framework for the study. An alternating-treatment single-subject experimental design was used to examine the effects of problem definition on 8 recent FNP graduates' ability to generate hypotheses to diagnose patient problems. Diagnostic-reasoning software provided web-delivered simulated-patient scenarios that described patient problems that were either ill defined or well defined. The independent variable was problem definition (ill-defined versus well-defined problems). The dependent variables were accuracy of the final diagnosis, the total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses plausible, time from initial login to final diagnosis, and confidence in the final diagnosis. Analysis consisted of visual inspection of graphs and nonparametric tests for each of the dependent variables. Expected differences in accuracy between ill-defined and well-defined problems were not found. However, there were significant differences in time (p = .02) and confidence (p = .01) for diagnosing ill-defined and well-defined problems. One conclusion was that problem definition is a function of the individual problem solver's experience. Hypotheticodeductive reasoning was not used by most problem solvers; instead pattern matching was observed in recent FNPs' diagnosis of patient problems. Future studies should address individual perceptions of problem definition. Programs that educate FNPs should evaluate students' understanding of the hypotheticodeductive reasoning model and individualize learning experiences to promote clinical decision-making.

DEDICATION

This dissertation is dedicated to my family. They provided support, encouragement, and love throughout this very long process. My husband Carlos has been supportive of my educational aspirations since the BSN and encouraged me to value hard work and perseverance. My son, Carlos Augusto, has shown me how to overcome things that are perceived as impossible. My son, Juan Enrique, has shown me the benefits of being stubborn and staying on task (or writing to the prompt). My dad, Rex D. Griffith, supported me in my education and provided me the opportunity to study nursing. He showed me how hard work can pay off.

I also dedicate this work to two of the greatest nurses on this earth. Their support has been invaluable in so many ways. Dr. Gretchen Schumacher has helped me to overcome self-doubt and filled me with encouraging words. She has been by my side for the entire doctoral journey, and has constantly supported and encouraged me. Beth Sturzebecher has provided me with continuous encouragement and support since nursing school. I am blessed to have such wonderful friends.

Lastly, I dedicate this work to my dear beloved mother, Patricia A. Griffith. She passed away suddenly from an ill-defined problem while I was analyzing my data. I know that she would be proud of me. She instilled in me a sense of perfection in my work. She was also very giving of her time and talents. I aspire to infuse those qualities into my nursing practice and pass them on to my children.

ACKNOWLEDGMENTS

I would like to acknowledge the entire Doctoral faculty at Duquesne University. They provided me with a solid foundation to begin to investigate clinical decision-making in nursing. Specifically, I want to express gratitude to my entire dissertation committee. Foremost, Dr. Linda Goodfellow, as chair, provided leadership and support; she guided me through the entire process from start to finish. She provided me with superb guidance while allowing me to reach out to simultaneously investigate the phenomena of clinical decision making and educational techniques. Dr. Joan Lockhart provided expertise in methodology and educational research and is a superb editor. Dr. Joyce Penrose introduced me to the topic of clinical decision making when I was her student many years ago. Since then we have coauthored numerous articles and grants to investigate clinical decision making. She served as a content expert in nurse practitioner decision making and has been a long-term mentor. Dr. James Moore has provided invaluable statistical expertise. I appreciate the time each of you devoted to critiquing my work more than you will ever know.

A special thank-you is extended to Dr. Hurley Myers of DxR Development Group. He graciously provided the well and ill-defined scenarios used in the study. In addition he shared his expertise related to the diagnostic reasoning software.

The support of my coworkers and students is truly appreciated. They have been patient and kind as I have worked through this process. Additionally, I would like to extend a heartfelt thanks to the participants in the study. Without their participation, there could not have been a study.

I would also like to thank Slippery Rock University for providing funding opportunities for the preliminary work. This funding made it possible to start this study.

This study was partially funded by the Epsilon Phi Chapter of Sigma Theta Tau International. This study was also partially funded by the Eta Chapter of Sigma Theta Tau International. These research awards were a tremendous help in offsetting the expenses of the project and were invaluable in its completion.

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Statement of the Problem

Introduction

Advanced practice nurses (APNs) are nurses who have educational preparation that exceeds what is required for practice as a registered nurse (RN; Snyder & Yen, 1995). APNs include four types of specialized nurses. Those groups are: clinical nurse specialists, certified nurse-midwives, nurse anesthetists, and nurse practitioners (NP). The advanced practice subset of nurses known as NPs can be further subdivided into several specialty groups. Family nurse practitioners (FNPs) make up one of the largest groups.

FNPs are RNs with advanced academic and clinical experience. This experience, along with additional state licensure and national certification, enables them to diagnose and manage most common and many chronic illnesses across the lifespan either independently or as part of a healthcare team. The role of the FNP as a care provider has continually evolved since the 1960s.

According to Diers (1985), one of the defining characteristics of advanced nursing practice, of which the FNP is a subset, is the decision-making role. Sheehy and McCarthy (1998) added that one of the distinguishing elements of the FNP, as well as all NPs, is autonomy in decision making. Clinical decision making is a complex process that requires nurses to discriminate and synthesize information and then select actions judged to be the best from an array of choices (White, Nativio, Kobert, & Engberg, 1992). The current literature suggests that the clinical decision-making process is complex and that no single process or variable is responsible for clinical decisions. In addition, there is evidence to suggest that many processes are involved, based on individual attributes, relevant experience, and the nature of the problem (Facione, Facione, & Sanchez, 1994; Tanner, Padrick, Westfall, & Putzier, 1987). There is a need to have a better understanding of the thinking processes used by recent FNP graduates.

Purpose

The purpose of this study was to explore the impact of problem definition on the accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that are plausible, time from initial login to final diagnosis as generated by the recent FNP graduate, and confidence in the final diagnosis. The independent variable was problem definition (ill-defined versus well-defined problems). The dependent variables were the accuracy of the final diagnosis, the total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

Problem Statement

Little is known about how clinical problem types impact diagnostic hypothesis generation and accuracy, one of the steps in making clinical decisions. FNPs are trained to serve in primary-care settings, which are usually the patient's first contact with the healthcare system. Patient complaints seen in primary care are often ill-defined patient problems, with varying degrees of severity, and can range from very common to very rare (Sheehy & McCarthy, 1998). Therefore, clinical decision making potentially impacts the safety and quality of life of patients. In this way, it becomes a matter of concern not only for FNPs and their clients, but also for society at large because, at one time or another, most individuals face health-related problems. Because efficient decision makers can improve the safety and quality of life of their clients, more needs to be known about how clinicians make decisions.

Background

Although studies have examined problem definition and decision making in other domains such as medicine, psychology, physical therapy, and occupational and speech therapy, (Cervero, 1988; Elstein, Shulman, & Sprafka, 1978; Frederickson, 1984; Kassirer, 1983), few studies have examined these processes among nurses. One exception is Hauber's (1987) cross-sectional study that examined the effects of knowledge, experience, and problem definition on hypothesis generation in a group of 100 baccalaureate nursing students. The author found no evidence that increased knowledge and experience increased the number and accuracy of diagnostic hypotheses generated. There was, however, a significant difference in hypothesis generation related to problem definition. In addition, Hauber found that the greatest number of appropriate hypotheses were generated when the situation presented was of moderate complexity. Hauber predicted that as problem definition moved along the continuum from well defined to ill defined, the number of hypotheses generated would decrease. Using ANOVA for repeated measures with problem definition as an independent variable and problem complexity as the dependent variable, Hauber found no significant differences ($F = 1.76$, $df = 2, 194$, $p > .1$). Noteworthy is the fact that in Hauber's study, both the novice and the expert structured knowledge in a similar fashion. This may indicate that the way concepts are learned influences the way the information about problems is classified (Broderick & Ammentorp, 1979). Glaser (1984) stated that thinking and reasoning abilities are attained by students when those skills are taught as part of the process of acquiring and structuring knowledge. To prepare better decision makers, cognitive information should be blended with acquisition of knowledge and skills. It is important to specifically examine the variables involved in the decision-making process, such as how a problem is defined.

A second study of RNs was conducted by Lewis (1992) who examined the extent to which participants could rate the complexity of decision-making nursing tasks. This information was used to validate a model of cognitive task complexity under the premise that it is important to understand how task complexity contributes to the decision-making process. The educational implications are that educators should use tasks of less complexity and build on them as they teach decision making. To date, no studies have been found that examine problem definition as a variable in NP or FNP decision making.

To make good clinical decisions, accuracy in the generation of diagnostic hypotheses is crucial. Few studies have addressed accuracy in clinical judgment. Additionally, studies of clinical problem solving have been criticized for not considering the complexity of the clinical problem at hand (Hennen, 1984). These relationships need to be better understood if we are to improve nursing education and ultimately the care provided by nurse practitioners.

Significance of the Study

This study worked to address a gap in the literature about how FNPs make clinical decisions when problem structure is either well defined or ill defined. According to

Broderick and Ammentorp (1979), when information is initially learned in the knowledge domain, the learner tends to retain the internal structure of that knowledge. More information is needed about how FNPs approach well-defined and ill-defined problems so that we can prepare accurate and effective decision makers. This information is critical for training FNPs for clinical problem roles that involve caring for patients across the lifespan who present with a variety of problems that vary from well defined to ill defined.

This study may inspire nursing faculty to revisit teaching methods about decision making. As more is learned about how FNPs make decisions, changes in current curricula can be made that will better prepare FNPs to make accurate decisions and ultimately provide better care. Current research offers little evidence for best teaching methods to assist with the vagaries of ill-defined patient problems. Since so many of the patient problems encountered in primary care are ill defined and treatment depends on an accurate diagnosis, understanding of the processes underlying decision making needs to be better understood.

Nature of the Study

The study examined the effects that problem definition has on experienced nurses who are recent FNP graduates. Diagnostic-reasoning software (DxR; Myers, 2007) provided web-delivered simulated patient scenarios that included patient problems that were either ill defined or well defined. Using the hypotheticodeductive-reasoning method (White et al., 1992) as a framework source to guide this study, the total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that are plausible, accuracy of the final diagnosis, and time from initial login to final diagnosis were measured. The independent variable was problem definition (ill-defined versus well-defined problems). The dependent variables were accuracy of the final diagnosis, the total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that are plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

Research Questions

The research questions that guided this study in the context of well-defined and ill-defined problems are as follows:

1. How does problem definition affect the *accuracy* of final diagnosis?
2. How does problem definition affect the *number* of diagnostic hypotheses generated?
3. How does problem definition affect the *plausibility* of diagnostic hypotheses generated?
4. How does problem definition affect the *time* elapsed from initial login to final diagnosis?
5. How does problem definition affect the *confidence* in the final diagnosis?

Assumptions

The following are the assumptions upon which this study was based.

1. Subjects will follow the instructions given to them and be able to generate diagnostic hypotheses.

2. The scenarios used in the study will accurately depict well-defined or ill-defined patient problems.

Limitations

The following are the limitations of the study.

1. A nonrandom convenience sample was used and thus, the results of this study will not be generalizable to FNPs from other programs.
2. Caring for computer-simulated patients may not be representative of the actual patient encounter in a natural setting.
3. A limitation of the DxR program (Myers, 2007) is that it may give recent FNP graduates cues in obtaining information from drop-down menus with a natural-language interface. Cueing the recent FNP graduate may interfere with the understanding of their process of analysis (Sands, 2001).
4. Computer-simulated problems may not be generalizable to predict performance on real-life patient problems.

Definitions

The following terms are used in this study:

Clinical decision making. "The process nurses use to gather patient information, evaluate the information and make a judgment that results in the provision of patient care" (White et al., 1992, p. 153). In this study clinical decision making was operationalized as the diagnostic hypotheses that FNPs make in response to computerized patient scenarios.

Diagnostic hypothesis. A summary of the physical, mental, social, and personal conditions affecting the patient's health, possibly in the form of an actual diagnosis or a symptom or sign that cannot be clustered with other bits of data (Swartz, 2002). A hypothesis is a conjecture about a diagnosis in response to a computer scenario of a patient problem. In this study the diagnostic hypothesis was any hypothesis that was generated by the subjects in the study.

Diagnostic accuracy. Accuracy of diagnostic hypothesis was determined by whether the diagnosis appeared on the list generated by the case author and expert FNPs.

Diagnostic confidence. The degree to which the subjects are certain of their final diagnosis.

Plausibility of diagnosis. Plausibility is determined by whether the participant's hypothesis is consistent with the consensus of expert FNPs.

Problem definition. Those characteristics associated with patient complaints or presenting symptoms that have a bearing on the diagnosis or management of health and illness and can be characterized as either well-defined or ill-defined problems (Hammond, 1978).

Ill-defined problems. Those problems that (a) are more complex and have less definite criteria for determining when the problem has been solved, (b) do not provide all of the information necessary to solve the problem, and (c) have no procedure that guarantees a correct solution. Ill-defined problems require more reliance on the resources of long-term memory. Two DxR scenarios chosen by expert FNPs were used as ill-defined problems in this study.

Well-defined problems. Those problems that are clearly formulated, and have known algorithms and criteria available for testing the correctness of the solutions. Two DxR scenarios chosen by expert FNPs were used as well-defined problems in this study.

Recent family nurse practitioner graduates (FNP graduates). Graduates from a single FNP program in Northwestern Pennsylvania who have completed all requirements for graduation and graduated no longer than 9 months prior to data collection.

Time elapsed. The time in minutes from initial login to final diagnosis using the DxR software program. The software has the capability to log the time for each user.

Theoretical Framework

The hypotheticodeductive-reasoning model provided the theoretical framework for this study. This model has its origins in medicine (Barrows & Feltovich, 1987; Elstein et al., 1978; Feltovich & Barrows, 1984; Gale, 1982) and has been slightly modified for use by FNPs (White et al., 1992). Stage 1 is early hypothesis generation. Stage 2 is clinical inquiry. Stage 3 corresponds to working hypotheses (diagnostic hypothesis generation). Stage 4 is the final diagnosis. The White et al. model characterizes how reasoning occurs from cue acquisition, when first encountering patient data, to the generation of hypotheses. This is followed by cue interpretation and hypothesis testing in an iterative process through further inquiry. Both inductive and deductive reasoning are used to move back and forth from hypothesis generation to hypothesis testing. The outcome of the process is the final diagnosis or concluding hypothesis. While actual practice depends upon the clinician's ability to develop interventions based on the diagnosis, this study only examined the concluding hypothesis, also known as the final diagnosis.

Summary

To educate efficient and safe FNP decision makers, more information is needed about their ability to solve clinical problems. One step in this discovery process is the investigation of the effects of problem definition on hypothesis generation by recent FNP graduates. In addition, accuracy is crucial in the decision-making process. Additional studies are needed to examine the relationship of problem definition and accuracy of diagnosis. This study provided insight and added to the body of knowledge about how FNPs address complex problems and generate hypotheses in a clinical setting.

Chapter 2

Review of the Literature

Introduction

The purpose of this study is to explore the impact of problem definition on the quantity of hypotheses generated and the accuracy of these hypotheses, as well as the time elapsed from initial login to final diagnosis by recent Family Nurse Practitioner (FNP) graduates. Literature in the disciplines of nursing and medicine from the past 3 decades are reviewed. The following sections present the theoretical framework that underpins this study, a review of the literature that provides the rationale for the study of problem definition, and a review of relevant literature related to hypothesis generation in clinical decision making.

The literature review begins with an introduction to the concept of the advanced-practice nurses (APNs) and places the FNP in this context. The remainder of the chapter describes the theoretical framework of the study. Clinical decision making is the hallmark of advanced-nursing practice (Diers, 1985). A historical overview examines the literature from cognitive psychology and information processing. This leads to the application of that information to the hypotheticodeductive model. Next, problem definition comparing ill-defined and well-defined clinical problems will be reviewed. Because the early studies of clinical decision making were done primarily with physicians, a historical overview begins with a review of those studies. Studies with nurses and nurse practitioners will be reviewed next. This chapter concludes with a discussion of computer simulations and more specifically, Diagnostic Reasoning Software (DxR; Chauncey Group International, 2007).

Advanced Practice Nurses

"The advanced practice nurse is a nurse who has educational preparation beyond that required to become a registered nurse" (Snyder & Yen, 1995, p. 3). The American Nurses Association (ANA; 1992) defined advanced clinical practice to include a graduate degree in nursing, comprehensive assessments, and a high level of autonomy. Further, the APN has expert skill in diagnosis and making clinical decisions. The role of the APN grew from the need to provide quality care for patients when there was an increased need for primary care, concurrent with an increase in physician specialization, and hence, an increased need for primary-care providers. APNs include clinical nurse specialists, certified nurse-midwives, nurse anesthetists, and nurse practitioners (NPs). The advanced-practice subset of nurses known as NPs can be further subdivided into several specialty groups. Eighty-eight percent of master's graduates in nursing programs were NPs representing the majority of all master's graduates (Bednash & Berlin, 2000). FNPs make up one of the subsets of NPs.

Nurse Practitioners

NPs are registered nurses (RNs) who have graduate-level nursing preparation as a NP at the master's or doctoral level. NPs perform comprehensive assessments and promote health and the prevention of illness and injury. According to the ANA (2004) these advanced practice RNs diagnose; develop differential diagnoses; order, conduct, supervise, and interpret diagnostic and laboratory tests; and prescribe pharmacologic and nonpharmacologic treatments in the direct management of acute and chronic illness and disease. NPs provide health and medical care in primary, acute, and long-term care settings. NPs may specialize in areas such as family, geriatric, pediatric, primary, or acute care. NPs practice autonomously and in collaboration with other healthcare professionals to treat and manage patients' health programs, and serve in various settings as researchers, consultants, and patient advocates for individuals, families, groups, and communities.

A study by the United States Congressional Office of Technology Assessment concluded that care by NPs is as good or better than care provided by medical doctors and more effective (Snyder & Yen, 1995). This report served as a springboard for the expansion of the NP in the advanced-practice role. Additionally, this report specifically served to make educators of NPs examine how nurses are educated for this new role including the important decision-making function. A meta-analysis by Horrocks, Anderson, and Salisbury (2002) reviewed 11 randomized controlled trials and 23 prospective observational studies that examined the role of the NP as first point of contact and as a physician substitute in the management of patients with acute illness. They found that assessments of the quality of care and short-term health outcomes are virtually equal between doctors and nurse practitioners. In addition, patient satisfaction is at least equivalent for nurse practitioners as for physicians (Horrocks et al.). The present study focused on FNPs, a type of NP in the category of APN.

When nurses enter an NP program, they bring a wide variety of experiences from life and from clinical work. "No matter what the background and experience level, though, none of them have the experience of autonomous, independent clinical decision making" (Agruss & Marfell, 2000, p. 32). Typically NP students are skilled nurses who are returning to school to move into a different aspect of nursing by specializing their skill set, and they struggle with the role change (Agruss & Marfell, 2000). Additionally, Steiner and Burman (2000) reported that the student entering a NP program is typically an expert nurse who quickly becomes a novice in the NP role. Brown and Olshansky (1998) generated a model from a longitudinal study of 35 newly graduated primary care NPs during their first year of practice. This work documented the struggle of new NPs, who described feeling uncomfortable in the role as well as feeling as if they took a "step backward in expertise" (p. 55). These studies serve to document the similarities of experienced nurses who suddenly became neophytes as they specialized their education into an advanced role. Brown and Olshansky surmised that a root cause of the discomfort was the lack of experience in autonomous, independent clinical decision making.

Family Nurse Practitioners

FNPs are poised to diagnose and manage most common and many chronic illnesses across the lifespan, either independently or as part of a healthcare team (Snyder & Yen, 1995). As of March 2000, there were over 100,000 NPs in the United States (Smith, 2006). It is estimated that FNPs are expected to care for about 80% of the presenting problems that enter primary care. The way that FNPs provide care and receive training is frequently compared to that of physicians. In order to become an FNP, the RN must have at least 1 year of nursing experience and a bachelor's degree in nursing. The nursing experience can vary among numerous specialty settings. Students take an average of 2 to 4 years to complete the FNP curriculum and a large majority of students engage in part-time study (Snyder & Yen, 1995). This is contrasted with standard medical education across the United States wherein students enter medical school with a bachelor degree and matriculate through the program as a group, generally as full-time students. Medical school is a 4-year program of study followed by extensive full-time clinical rotations at least 2 years in length. The entrance requirements and experiences are very different for both groups; yet the expectation to provide safe, cost-effective care for 80% of scenarios that enter primary care is the same.

Because they are on the front lines and their training is comparatively less than physicians, it is important to train FNPs to have good decision-making skills. Efficient training is imperative to ensure that FNPs learn to make good clinical decisions and use the little time they have in training to enhance their abilities. Because there is no single best way to approach teaching and learning, it is important for the teacher to be sensitive to the unique characteristics of the learner (Bastable, 2003). Teaching a particular method or formula to use in making decisions is one approach to structuring the learning experience. To structure learning experiences, more knowledge is needed about how the beginning FNP makes clinical decisions.

Clinical decision making is important because patient care has become more complex and arduous, necessitating accuracy in reasoning skills to maintain or improve patients' health status. Errors in clinical decision making can cause potentially deadly mistakes. To that end, knowledge about decision making is important for nursing faculty teaching in an NP program because education based on inappropriate clinical decision-making models can result in graduates who are ill prepared to make accurate clinical decisions in practice (Fonteyn & Fisher, 1995).

Clinical Decision Making in Diagnosing Patient Problems

The purpose of this section is to clarify the importance of making clinical decisions in the FNP role as it relates to diagnosing patient problems. Clinical decision making will be defined and factors related to clinical decision making such as content knowledge, decision-making process, and the importance of experience will be described. Even though clinical decision making is one of the most critical skills of the FNP, it is the least documented (Lauri et al., 2001). Research on clinical decision making focuses on content and process issues and reveals that decision making is context specific, and that a decision-making process can be taught.

White et al. (1992) defined clinical decision making as, "the process nurses use to gather information, evaluate it, and make a judgment that results in the provision of patient care" (p. 153). In the clinical decision-making process, the FNP gathers data from the patient, generates a hypothesis as to the etiology of the complaint, interprets cues to arrive at a final diagnosis, then evaluates that hypothesis for goodness of fit. This process occurs as a continuous, purposeful theory- and knowledge-based process of assessment, analysis, strategic planning, and intentional follow-up. Because the role of the FNP is multifaceted, the scope of decision making is similarly complex. "The decision-making process incorporates health promotion, disease prevention, risk reduction, management of functional health needs, subjective concerns, program planning, and for some, biomedical diagnostics and disease management" (White et al., 1992, p. 79). Clinical decision making "is a dynamic thinking process that is hypothesis-driven and targeted toward the selection of an hypothesis that best explains clinical evidence" (Szaflarski, 2000, p. 87).

Noteworthy is the fact that this concept of clinical decision making is described in the literature under a number of different terms, in addition to the term clinical decision making used here. The following terms are also used to describe the same concept: diagnostic reasoning, clinical reasoning, clinical judgment, diagnostic problem solving, and clinical inference. This study uses the term clinical decision making (Sox, Blatt, Higgins, & Marion, 1988; White & Risco, 2000).

Because FNPs are often the first person in direct contact with patients in the primary-care setting, they have many opportunities to apply their knowledge to meet patients' needs. As a result, often the FNP's interpretation of data and events determines subsequent action. As more nurses enter the advanced-practice role as FNPs, it is important to have a better understanding of the clinical decision-making process. Clinical decision making is essential to the future of professional nursing practice (Tschikota, 1993). Qualified nurses should be able to use decision-making skills to provide safe and effective nursing care (Paul, 1995).

Clinical decision making is a highly complex phenomenon and is a critical skill for the FNP to master (Lauri et al., 2001). Clinical decision making is related to education and/or clinical experience, has been investigated from the standpoint of the content knowledge decision-making process, and is practiced with various levels of expertise. Content knowledge is an important part of clinical decision making, providing the scientific basis for decisions. Process-oriented studies have examined the decision maker's performance. When a decision maker is faced with uncertainty or an insufficiency of facts necessary to make a decision, engaging a process to make effective decisions is a useful strategy. The premise is that by teaching students a process that can be used to make decisions, such as the hypotheticodeductive method, FNPs can maximize their ability to make efficient and safe choices (Higgs & Jones, 2000). Research in the health sciences (Schmidt, Norman, & Boshuizen, 1990; White et al., 1992) concluded that clinical decision making is not a skill that can be developed independent from relevant professional knowledge and clinical skills. Research (Boshuizen & Schmidt, 1992; Norman, 1990; White et al., 1992) also suggests that knowledge acquisition and clinical decision making go together as expertise is gained. Expert and novice knowledge structures differ in many ways and have been described repeatedly in the literature (Barrows & Pickell, 1991; Benner & Tanner, 1987; Elstein et al., 1978). Experts perform better and are assumed to have better skills than novices (Barrows & Pickell, 1991; Benner & Tanner, 1987; Elstein et al., 1978).

The quality of clinical decision making depends heavily on the knowledge base of the decision maker (Szaflarski, 2000). Having an organized knowledge base in a specific domain is imperative in the decision-making process (Grant & Marsden, 1987; Lipman & Deatrick, 1997; Norman, 1988). The deeper and broader the nurse's knowledge base, the wider the range of cues they discover and use during the deliberation phase of the decision-making process (Moore, 1996).

Clinical reasoning is also highly context dependent. The client's health concern(s), the specific health setting, the care provider's disciplinary background and level of experience, the client's unique personal context, and elements of the wider healthcare environment (Higgs & Jones, 2000) determine the context in which clinical reasoning occurs. Research attending to context-specific factors (e.g., Benner, Hooper–Kyriakidis, & Stannard, 1999) reports that clinical reasoning is complex, interpretive, and personalized: "A good clinician is always interpreting the present clinical situation in terms of the immediate past condition of the patient" (Benner et al., 1999, p. 10). The expert clinician attends to the direction of change in the client's condition and interprets ambiguous and unfolding client information as it becomes available.

There is an important relationship between content knowledge and the decision-making process. A clinician who has extensive experience with certain patient problems can easily recall the most effective hypotheses and diagnoses, as well as the inquiry strategy used to arrive at a given conclusion. With relatively comprehensive content, the process will be rapid and automatic. However, one needs to apply a clinically scientific method to a patient's problems to generate an appropriate hypothesis. Sound clinical decision-making skills using well-considered hypotheses will take the clinician far, even when short on facts. Medical students who were specifically taught reasoning strategies were able to improve their diagnostic accuracy. In a review of studies in philosophy, psychology, and neuroscience Norman (2000) reported that medical students who participated in diagnostic-reasoning exercises generated fewer misdiagnoses and became expert diagnosticians more quickly.

There is a strong argument in the literature that clinical decision making can be learned. In addition, experienced clinicians, mentors, and teachers can assist novices and peers to improve their ability to make sound clinical decisions (Offerdy, 1998; Tanner, 1993; Tanner et al., 1987; White et al., 1992). In addition, clinical decision making in human contexts is more unpredictable and multifaceted than those in the physical sciences. This makes decision making in human problems both complex and challenging.

It has been demonstrated repeatedly that content and process are interrelated (Tanner et al., 1987; White et al., 1992). Several common or core features of clinical reasoning across health disciplines have been identified in the research (Higgs & Jones, 2000). First, clinical decision making and clinical knowledge are interdependent. At one time, medical analysts thought that clinical reasoning and clinical knowledge could be learned independently (Patel & Kaufman, 2000). Many educational programs attempted to deal with the rapidly escalating volume of biomedical information by emphasizing the development of problem-solving skills and devoting less time to content. Research has shown, however, that the development of expertise in clinical reasoning requires considerable depth and organization of domain-specific clinical knowledge (Boshuizen & Schmidt, 1992). Growth in clinical expertise is accompanied by increasing depth and complexity of knowledge structures (Higgs & Jones, 2000).

To increase diagnostic accuracy, FNPs need experience in the role. Many studies (Barrows & Bennett, 1972; Benner, 1984; Benner & Tanner, 1987; Benner, Tanner, & Chelsea, 1996; Burman, Stephans, Jansa, & Steiner, 2002; Carper, 1999; del Bueno, 1990; Silva, 1999) compared expert and novice decision making. Studies with simulated patient situations have been used to distinguish the processes used by novice and expert nurses (Patel & Groen, 1991; Tanner et al., 1987; White et. al, 1992). In an observational study in a naturalistic setting (Intensive Care), nurses considered to be expert have extensive clinical experience in the field and are recognized by their peers as having outstanding clinical decision-making skills (Benner, 1984). In contrast, novice nurses have difficulty discriminating between important and unnecessary data in the clinical setting (Benner). It has been determined that as nursing experience increases, the use of heuristics or scaffolding of knowledge occurs. This is the basis for the argument to simultaneously teach knowledge along with the process of decision making, increasing the ability of the nurse to be an efficient decision maker. It is not known at what point in the nurses' clinical experience the use of these more efficient strategies is most productive. First, novices need to be shown a framework in which to use the hypotheticodeductive method.

The Roots of Clinical Decision Making in Cognitive Psychology

Several approaches have been used to study clinical decision making in nursing. This investigation of clinical decision making derives from information processing (A. Newell & Simon, 1972), which involves the cognitive ability to organize data, facts, or knowledge. Information-processing theory can be used to describe problem-solving behavior as an interaction between a problem solver and a problem task (Corcoran, 1986c; A. Newell & Simon, 1972; Simon, 1979). Tanner (1983) stated that information-processing theory is an attempt to explain diagnostic problem solving in terms of more basic elementary processes and operations. Information-processing theory is of primary importance in this study.

Information processing derives primarily from the cognitive sciences and focuses on memory capacity. In this theory, decision makers are viewed as information-processing systems operating in complex environments. Knowledge is sorted into either short-term or long-term memory (Miller, 1956; A. Newell & Simon, 1972; Simon, 1974). A major assumption of this theory is that there are limits to the human capacity for rational thought (Corcoran, 1986a). Despite the essentially infinite capacity of long-term memory, short-term memory is limited. There is evidence that the capacity of short-term memory is seven, plus or minus two, *chunks*. A chunk is any organization of information that has previously become familiar (Corcoran, 1986b; A. Newell & Simon, 1972). Memory capacity is expanded by chunking or clustering complex information into recognizable patterns, weighing alternative options, and searching for pathways to solutions (Elstein, 1976; A. Newell & Simon, 1972). Information is accessed from long-term memory and cue assessment, then transformed into units that can be cognitively manipulated in short-term memory.

Research using this model was originally directed toward understanding the hypotheticodeductive process used in deriving medical diagnoses (Elstein et al., 1978), a process of generating hypotheses to explain data, then searching for additional data to support the hypotheses. In clinical practice, information-processing models are regarded as consisting of the following analytic components: acquiring cues (data gathering), generating a hypothesis, interpreting cues, further cue acquisition (gathering data, generating a hypothesis, interpreting cues), acquiring further cues, deciding the problem, formulating possible solutions, repeating cue interpretation, and evaluating each hypothesis (Elstein et al., 1978).

Cognitive learning theories, including the information-processing viewpoint, also stress the importance of characteristics of the learner. Information processing is a cognitive perspective that emphasizes thinking processes: thought, reasoning, the way information is encountered and stored, and memory functioning (Bigge & Shermis, 1992; Gagne, 1980; Sternberg, 1991, 1996). The work of A. Newell and Simon (1972) focused mainly on human thinking and information processing. The human system is considered to have many parts, or subsystems, such as sensory, memory, effectors, and arousal subsystems. Individual differences are also considered as each person differs systematically, genetically, and experientially. The performance of the problem solver as it relates to human performance in solving problems was studied. The resultant theory describes how humans process tasks. The decision maker needs to understand the structure of the task and the problem to be solved for efficient decision making to occur.

When decision makers use an information-processing framework, they follow a stepwise process (Elstein, Shulman, & Sprafka, 1990; Tanner et al., 1987). When presented with patient problems, the decision maker formulates initial hypotheses based on the patient’s condition. Additional information is accessed, considered, discarded, or reevaluated as the process continues. The initial hypotheses guide further acquisition of data to confirm, refine, or reject the hypothesis. The accuracy of clinical decisions is associated with gathering accurate and relevant data and accurately interpreting it (Tanner at. al., 1987). Experience, knowledge, intuition, task complexity, and the degree of risk involved are all essential aspects of information processing.

Along with the rise of cognitive psychology, research into clinical decision making adopted a cognitive focus with an emphasis on understanding the nature of clinical decision making (A. Newell & Simon, 1972) and on the development of clinical decision-making expertise (Corcoran, 1986b, A. Newell & Simon, 1972). This cognitive-psychology approach to clinical-reasoning research led to information processing, simulation, decision theory (A. Newell & Simon, 1972), and categorization studies (Elstein et al., 1978). The research conducted by A. Newell and Simon focused mainly on human thinking and information processing. Their book details discussions on chess, symbolic logic, and algebra-like puzzles. Human performance in problem solving is analyzed, including the task environment and problem space. Using think-aloud protocols, Elstein et al. (1978) conducted a detailed descriptive analysis of the reasoning of a group of experienced internists as they performed on a variety of clinical problems that varied in complexity. The investigators found that physicians engaged in clinical decision making commonly used the strategy of generating and testing hypothetical solutions to the problem. In each of these approaches, use of knowledge derived from the clinical knowledge base of the individual was an important factor, as well as the active processing of received data in enabling interpretation and solution of the clinical problem.

Hypotheticodeductive Method: Theoretical Framework of the Study

The hypotheticodeductive approach is a form of clinical decision making that has generated a great deal of interest and research. It involves the generation of hypotheses based on clinical data and knowledge, and testing of these hypotheses through further inquiry. In this method, data collection and decision making are driven by specific hypotheses derived early in patient evaluation (Offerdy, 1998). This approach appeared in the medical literature as a model to interpret and explain the process in the late 1970s (Barrows & Feltovic, 1987; Elstein et al., 1978; Kassirer & Gorry, 1978) and was further described in the 1980s (Barrows & Tamblyn, 1980; Feltovich & Barrows, 1984; Gale, 1982; McGaghie, 1980). Additionally, it appeared in the nursing literature as diagnostic reasoning in the 1980s (Padrick, Tanner, Putzier, & Westfall, 1987). Later, Offerdy described how NPs in Great Britain used this model.

The hypotheticodeductive approach emphasizes the early development of diagnostic and etiologic hypotheses based on the patient's complaint. Additionally, this model stresses the use of hypotheses that have been generated to structure the acquisition of data (Elstein et al., 1978; White et al., 1992). Cutler (1998) described this approach to decision making as the most commonly used and effective method of solving clinical problems.

Students of decision making are taught to deal with uncertainty, yet it is seldom mastered. Deductive reasoning is helpful when faced with unfamiliar situations (Sox et al., 1988). There are several stages of the hypotheticodeductive approach used in patient-care decision making. The clinician starts with basic information from the patient, known as the chief complaint. The decision maker then generates specific hypotheses that might account for the complaint. Using additional clinical data and knowledge, the hypotheses are tested through further inquiry. The four steps are (a) acquire cues, (b) generate a hypothesis, (c) interpret the cues, and (d) evaluate the hypothesis. Elstein et al. (1978) found that diagnostic problems are solved by a process of generating a limited number of hypotheses or problem formulations early in the examination, followed by hypothesis evaluation and testing.

Most descriptions of APN clinical decision making begins with something that is similar to an expanded nursing-process model, integrating elements of hypotheticodeductive reasoning (Smith, 2006). White et al. (1992) adapted the Carnevali (1984) model of clinical decision making for nurse practitioners. This hypotheticodeductive-reasoning model provides the theoretical framework for this study. As shown in Figure 1, Stage 1 is early hypothesis generation, Stage 2 is clinical inquiry, Stage 3 corresponds to working hypotheses (diagnostic hypothesis generation), and Stage 4 is the final diagnosis. White's model characterized how reasoning occurs from cue acquisition, when first encountering patient data, to the generation of hypotheses. This is followed by cue interpretation and hypothesis testing in an iterative process through further inquiry. Both inductive and deductive reasoning are used to move back and forth from hypothesis generation to hypothesis testing. The outcome of the process is the final diagnosis or concluding hypothesis. While actual practice depends on the clinician's ability to develop interventions based on the diagnosis, this study only examined the concluding hypothesis, also known as the final diagnosis.

The information-processing system converts problems without solutions into problems with a set of hypothetical solutions that are progressively evaluated until a diagnosis is reached (Hauber, 1987). This description may seem to oversimplify the process, especially as it attempts to describe what occurs when clinicians are faced with complex, ill-defined problems. The hypotheticodeductive model, as it is used to characterize the way clinicians reason is comprehensive from the induction of the chief complaint to the final diagnosis. However, its focus is limited to specific cognitive activities and does not consider characteristics of the problem to be solved. Consequently, this may alter the clinical decision-making process.

Hypotheses Generation: The First Step in the Hypotheticodeductive Method

The purpose of this section is to link the hypotheticodeductive method to the generation of a diagnostic hypothesis. This is important because hypothesis generation is one of the initial stages in the clinical decision-making process and results in diagnosis of a clinical state, disorder, syndrome, or disease (Szaflarski, 2000). Clinical decision making is a process of testing hypotheses wherein solutions to difficult diagnostic problems are found by generating a limited number of hypotheses early in the diagnostic process and then using them to guide further data collection (Elstein & Schwarz, 2002).

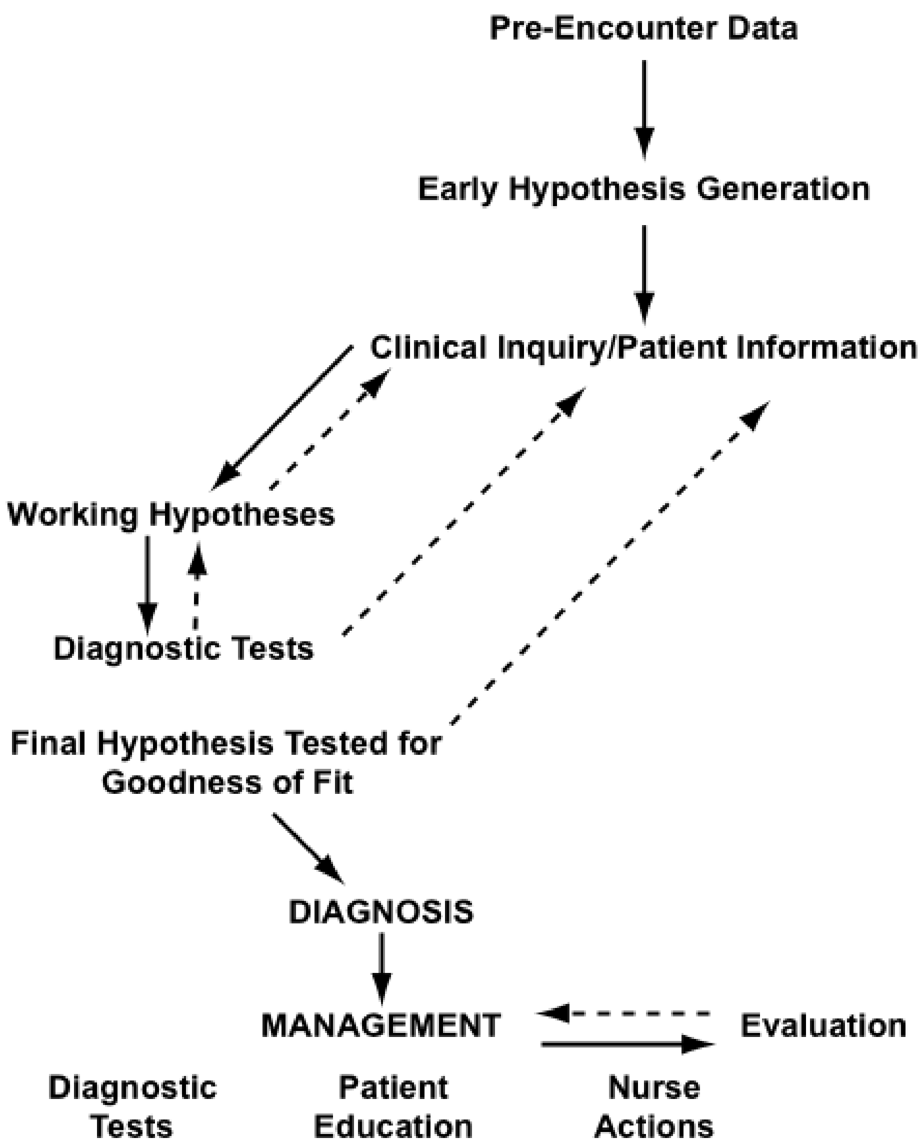

Figure 1. Clinical decision making used by nurses (broken arrows represent need to return to previous step).
Adapted from "Content and Process in Clinical Decision-Making by Nurse Practitioners," by J. E. White, D. G. Nativio, S. N. Kobert, and S. J. Engberg, 1992, *Image, 24*, pp. 153–156. Copyright 1992 by J. E. White, D. G. Nativio, S. N. Kobert, and S. J. Engberg. Adapted with permission.

The initial hypotheses that occur to expert clinicians are determined by the content of the initial data presented. The hypotheses are a product of each person's experience and education and may vary from one person to another (Barrows & Pickell, 1991; Carnevali & Thomas, 1993; Flagler & Mitchell, 2000; Fonteyn, 1991).

Hypotheses serve as a collection of indexing keys for problem-solving. Using hypotheses, the clinician transforms the ill-structured problem presented by the patient into a finite number of tentative, well-structured possible solutions to be investigated. Through the inquiry, the clinician attempts to examine the appropriateness of each of these hypotheses by obtaining more information from the patient. "Hypotheses do not fall into clean, tidy categories" (Barrows & Pickell, 1991, p. 52). Hypotheses are idiosyncratic labels for a personal collection of facts and concepts—a label for memory's filing and access.

Hypothesis generation is a creative process involving brainstorming to come up with a good set of hypotheses. In contrast, inquiry strategy is a deductive, linear process requiring one to pick discriminating questions, examinations, or tests to rank the hypotheses. It is believed that these skills can be developed early by the way one learns and applies new information. A clinician who acquires new information while struggling with a patient problem, and applies information to the problem in the context of the hypotheticodeductive method will ensure future recall. By learning an approach to decision making and consistently applying that to patient problems, the clinician becomes more efficient, effective, and expeditious as a decision maker. This is one of the hallmarks of an expert decision maker (Barrows & Pickell, 1991).

One difference between an average and an excellent practitioner is the speed and focus used to arrive at the correct diagnostic hypothesis and the ability to initiate appropriate treatment that is cost-effective (Eddy, 1996). Training programs for FNPs aim to teach APNs to accurately and expeditiously arrive at diagnostic hypotheses.

The Role of Problem Definition in Hypothesis Generation

The purpose of this section is to link the hypotheticodeductive model to hypothesis generation and problem definition. Problem definition challenges the clinical decision-making process. Multiple diseases or conditions represent an ever-growing diagnostic challenge. The multiplicity may stem from diseases or conditions that have multisystem effects or from multiple independent disorders (Szaflarski, 2000).

An information-processing approach describes problem solving as a process of identifying and developing problem definition. Problems may vary along a continuum of well defined to ill defined and have objective as well as subjective elements of structure. To manage the limited capacity of working memory, individuals engage in a structuring process to solve problems, identifying problem definition where it is present and developing problem definition where it is lacking (Voss & Post, 1988).

Information available at the beginning of a patient encounter is usually insufficient to arrive at any kind of diagnostic conclusion. Before the patient's problem can be defined well enough to allow for treatment decisions, additional information is needed. Research has demonstrated that experts do not approach the problem in the same way. Yet, the approaches generally yield the same diagnostic conclusions, although based on different clusters of information about the patient (Barrows & Pickell, 1991;

Kassirer & Kopelman, 1991). The consensus is that to assist FNPs to learn to make good decisions despite uncertainty, it is necessary to teach a method for dealing with medical uncertainties (Barrows & Pickell, 1991; Kassirer & Kopelman, 1991; Thompson & Dowding, 2002).

Ambiguity and conflicting or inadequate information is common in patient problems. Yet these qualities—inadequate information at the outset, lack of guidelines for problem solution, and lack of assurance that the problem has been solved—are not totally unique to patient problems but are characteristics of ill-structured problems encountered in most professions (Barrows & Pickell, 1991). Barrows and Pickell outlined strategies to cope with ill-structured patient problems. If information is insufficient to define or diagnose at the onset, then a variety of possible diagnoses or hypotheses suggested by the available data must be considered prior to determining where additional information is required for problem solution. Barrows and Pickell described an inquiry strategy that is efficient and hypothesis driven that involves an iterative process wherein data is gathered, then synthesized and used to reevaluate the problem at hand.

Over the last 2 decades, findings from a variety of formal studies of physicians have provided a consistent model of the clinician's problem-solving process. The model developed from these studies is a logical one to cope with any ill-structured problem (Barrows & Pickell, 1991): (a) initial patient information is (b) synthesized into the patient problem; (c) the clinician creates hypotheses about the possible causes for this problem, which serve as a guide for (d) the inquiry strategy. In other words, hypothesis generation leads to the inquiry strategy and data analysis. This is followed by problem synthesis, which in turn leads to diagnostic and treatment decision making. This process outlines the way a good decision maker thinks, whether consciously or not. This process is often performed so quickly and reflexively that the skilled decision maker is unaware of it. Despite the opinions on the conscious effort required to solve a clinical problem, studies (Bordage & Zacks, 1984; Elstein et al., 1978) show that most physicians employ the hypotheticodeductive method, even in situations where the diagnosis may seem obvious (Barrows & Pickell, 1991).

NPs make decisions using large amounts of data that are elicited in the nurse–patient encounter. These encounters often include complex social situations and take into account the health condition of the client. The data collected are then categorized into meaningful patterns. This type of decision making can vary on a continuum from straightforward to high complexity. In addition, the level of patient health can also vary from very low to very high. There may also be a wide range of variability in the amount and quality of evidence-based health information available on which the clinician can base decisions.

Well-Structured Versus Ill-Structured Problems

Problem-solving domains vary in the degree of structure that is present in the problem content and solution. Problem content in different domains was described by Voss and Post (1988) along a continuum from well-structured to ill-structured problems. Problems with objectively well-structured content are defined as those with few open constraints and a clear goal state. The problem-solving process used to resolve these problems entails identifying this structure and matching a solution to the problem.

Problems with ill-structured content are those with many open constraints and a vague goal state. The problem-solving process entails developing a problem structure, which serves to create a series of well-structured problems that may then be solved (Simon, 1973; Voss & Post, 1988).

Problem solutions in different problem domains were described by Voss and Post (1988) along a similar continuum of structure. Objective, well-structured solutions are those that meet objective standards for a correct solution and in which there is consensus in a community of problem solvers regarding the outcome of the problem solution (i.e., solutions to mathematics and physics problems). The goal of problem-solving is to identify the correct procedure to obtain the solution, which may be checked against an objective standard for correctness.

Other problems have ill-structured solutions. Objective, ill-structured solutions are those for which there is no absolute standard for a correct solution, in which there is no singular way of being right, and in which there is no consensus regarding the outcome of problem solution (i.e., solutions to social-science problems). These solutions vary across individuals because variation is possible in how individuals narrow the constraints of the problem. In the scenario of this type of problem solution, the goal of the problem solver is to develop a relatively correct solution, which is judged according to criteria such as utility and coherence of argument, as well as according to the pragmatic judgment of peers who think it will “work” (Voss & Post, 1988).

Problem-solving research (A. Newell & Simon, 1972; Simon, 1973; Voss & Post, 1988) has usually focused on how an ill-structured problem situation is defined and structured (as by generating a set of diagnostic hypotheses). Psychological decision research (Kassirer & Kopelman, 1991) typically looks at factors affecting diagnosis or treatment choice in well-defined, tightly controlled problems. A common theme in both approaches is that the ability of humans to access previously acquired information is limited. Nevertheless, the problem-solving paradigm has concentrated on identifying the strategies of experts in a field with the aim of facilitating the acquisition for these learners.

Problem-solving is dependent on the problem solver's knowledge base. The ability of the clinician to solve a clinical problem is based on what the clinician knows about the problem to be solved. Expertise can vary widely across different scenarios (Higgs & Jones, 2000). Differences between clinicians are to be found more in their understanding of the problem and their problem representations than in the reasoning strategies employed (Elstein et al., 1978). Thus, it makes more sense to talk about reasons for success and failure in a particular scenario than about generic traits or strategies of expert diagnosticians.

In medicine, the finding of scenario specificity has challenged the hypotheticodeductive model as an adequate account of the process of clinical reasoning (Higgs & Jones, 2000). Both successful and unsuccessful diagnosticians employed a hypothesis-testing strategy. Diagnostic accuracy depended more on mastery of the content in a domain than on the strategy employed. By the mid-1980s, the view of diagnostic reasoning as complex and systematic generation and testing of hypotheses has been criticized. Not all scenarios seen by an experienced clinician appear to require hypotheticodeductive reasoning (Davidoff, 1998). Norman, Trott, Brooks, and Smith (1994) found that experienced physicians use a hypotheticodeductive strategy with difficult scenarios only, a view supported by Davidoff. Difficult scenarios need systematic hypothesis generation and testing. Whether a problem is easy or difficult depends in part on the knowledge and experience of the clinician who is trying to solve it (Higgs & Jones, 2000).

For novices, most situations will initially be problems that are not solvable by routine methods, and generating a small set of hypotheses is a useful procedural guideline (Higgs & Jones, 2000). Professional judgment and decision making in the ambiguous or uncertain situations of healthcare is an inexact science (Kennedy, 1987) that requires reflective practice and excellent skills in clinical reasoning (Cervero, 1988; Schon, 1983).

The context in which clinical reasoning occurs plays an important role in the process of clinical reasoning, both in terms of the parties who are involved in the reasoning process and in terms of the many environmental factors that need to be considered. The context of clinical reasoning comprises a number of elements, including the unique client's clinical problem. Clinical problems can be "confusing and contradictory, characterized by imperfect, inconsistent, or even inaccurate information" (Kassirer & Kopelman, 1991, p. vii).

Clinical Decision Making in Advanced Practice Nurses

A small number of studies have been performed focusing specifically on the clinical decision making of APNs using patient simulations. Tanner et al. (1987) studied the cognitive strategies of diagnostic reasoning by practicing nurses (n = 15) and junior and senior nursing students (n = 28) using simulated-patient situations. The data were verbal responses to three videotaped vignettes. Results indicated that the diagnostic-reasoning process used by the nurses and nursing students paralleled the same general decision-making model described in studies of physicians. Not only did the subjects activate diagnostic hypotheses early in the encounter, they systematically gathered additional data from the patient encounter to further refine the hypotheses. Using a separate one-way analysis of variance, there was no statistically significant difference among the nursing students or experienced nurses with regard to the number of hypotheses generated. In their sample it was determined that even beginning students had sufficient knowledge to generate plausible hypotheses in the scenarios. The researchers reported that the information-processing theory used as the theoretical framework for the study provided little assistance in explaining the lack of differences between the groups with regard to knowledge relevant to the task. Further examination of the process of hypothesis generation related to the complexity of the patient problem is needed.

White et al. (1992) also used the information-processing model to study clinical decision making in NPs. Their study was conducted using simulated patients on the computer. Their sample included a mixture of 27 FNPs and obstetrical/gynecological NPs. The FNPs were divided into two groups consisting of those with more than 2 years of experience (n = 11) and those with less than 2 years experience (n = 10). The remainder (n = 6) were obstetrical/gynecological NPs. By reviewing logs of the participants' processes used in caring for the patient, two investigators concluded that all the NPs, both novice and experienced, used a hypotheticodeductive model to solve patient problems. They found that the hypotheticodeductive decision-making process was more likely to result in the correct diagnosis when used by the obstetrical/gynecological NP. Conversely, in descriptive analysis, they found that FNPs with fewer than 2 years experience tended to widely sample the data rather than focus the assessment on the investigation of the hypothesis.

Another study done by Sands (2001) used 20 entry-level NPs. Sands' study was also conducted using simulated patients presented with DxR. This software leads the participant to use the hypotheticodeductive method as they work on the scenario. The purpose of Sands' study was to examine the factors shaping the diagnostic-reasoning process of entry-level NPs who were recent graduates from a master's degree program. The hypothesized relationship between years of previous RN experience and DxR scores was supported (Sands, 2001). NPs with 5 or more years of previous RN experience ($n = 50$) were found to have greater diagnostic-reasoning scores (DxR; $t = 2.19$, $p = .03$) than entry-level NPs ($n = 20$). Diagnostic reasoning was significantly correlated with months of experience ($r = .25$, $p = .04$). Noteworthy is the fact that this study used subjects from five different universities in Central and Southern California. In addition, the students were graduates of a variety of different specialty tracks including family, adult, gerontological, pediatric, and acute care. The respondents were given a patient complaint or problem from a typical primary-care setting where a young female patient complains of fatigue. The resulting final diagnosis was pregnancy. The study is limited in the fact that it does not report the degree to which geriatric, acute care, and pediatric specialists encounter this type of complaint in their practice setting or to what degree the content was presented in the educational program.

Ritter (2003) examined the diagnostic reasoning of 10 expert NPs. The purpose of the study was to examine whether the information-processing model, the hermeneutic model, or a combination of the two models best describes expert NPs. According to Ritter, most NP programs use the information-processing model, a theory based on the fundamental premise that human reasoning consists of a combination of characteristics of the human problem solver and the task environment. On the other hand, hermeneutics theory is based more on the notion that meaning is subjective and embedded in the context. That is to say that experts can understand many subtleties of a situation and interpret cues and meanings from situations accurately. The study used content analysis of think-aloud processes obtained during patient encounters. Results indicated that NPs use the information-processing model 55% of the time and the hermeneutical model 45% of the time. Overall, specific steps of either information processing or hermeneutics accounted for 99% of participants' think-aloud responses. In information processing, gathering information accounted for 32% of responses. In hermeneutics, educated skill accounted for 25% of the responses. It was determined that the information-processing approach was used to initiate decision making. Hermeneutics were then used for cue acquisition, thereby bringing structure to the clinical problem and determining what information was salient.

In a study by Cioffi and Markham (1997), 30 midwives were given simulated patient assessments of low and high complexity. The sample consisted of volunteers who had various levels of experience. A think-aloud approach showed that there were problem-solving differences depending on scenario complexity. It was determined that memory for particular conditions affected decisions. As scenario complexity increased, the midwives depended on the rules of probability to solve the problem at hand.

In summary, these five studies all addressed important issues about decision making in APNs with varying levels of experience using patient simulations. They examined hypothesis generation as well as differences among problem solvers. Only one study (Cioffi & Markham, 1997) examined the characteristics of the problem, using an in-subjects design, aggregating group data related to decision making. To date, no studies have looked at FNP approaches to clinical decision making when the characteristics of the problem vary in complexity.

The Use of Computer Simulation in the Study of Clinical Decision Making

To study clinical decisions in a naturalistic setting, computer-simulated patients have been used. Simulations allow all students to have the same experiences in a standardized presentation and manner with a core group of disorders that are commonly seen in practice (Kohlmeier, Althouse, Stritter, & Zeisel, 2000) To improve one's decision-making abilities it is necessary to both practice the hypotheticodeductive method as well as experience the nuances of the clinical encounter. Some experts report that one of the limitations of computer simulation is that it is artificial (White & Risco, 2000).

Bryce and colleagues found that students perceived the DxR patient simulation to offer a highly valued interaction (Bryce, King, Graebner, & Myers, 1996, 1997, 1998). Although they felt that the program could not replace real-patient contact, they felt that it should be used as an adjunct to real-patient encounters. The authors listed several advantages of simulated-patient scenarios:

1. Scenarios give greater exposure to patient problems;

2. Scenarios allow follow through on a patient from beginning to diagnosis, not always possible on real patients;
3. Scenarios are always available whereas real patients are not;
4. Students can reference information and discuss with peers when working with simulated patients;
5. The pace of caring for a simulated scenario allows for increased time to process decisions;
6. Simulated scenarios are not fraught with stress because mistakes do not have severe consequences for the patient; and
7. Scenarios do not involve risks to the patient so interventions can be investigated with minimal risk.

Computerized patients allow students to develop clinical reasoning skills at a deep level before having to deal with the complexity and unpredictability of the real world. Their use reduces the variability and lack of control in an actual clinical setting. The main reason to use simulated patients is to control the learning environment. Other advantages include ethics and safety, economy, and reproducibility (Higgs & Jones, 2000).

Gaps in the Literature

The present study addressed several gaps in the literature. There has been little research on hypothesis generation as it relates to the problem definition. Additionally, little is known about how graduate FNPs use a generated hypothesis list to arrive at a diagnostic conclusion. No studies were found that linked the total number of hypotheses generated to the likelihood of a correct diagnosis. The proposed study adds to the knowledge base about decision making by examining the total number of hypotheses generated for both well-defined and ill-defined problems. For instance, if the problem is well defined or straight forward, does the FNP have a higher degree of accuracy in making a correct diagnosis if they identify fewer diagnostic hypotheses? Or, alternatively, are these decision-making factors so individualized that despite controlling for the educational program and curriculum completed to become an FNP and the entry requirements, there is no relationship between number and accuracy of diagnostic hypotheses generated? In contrast, when presented with a very complex patient problem, it is not known if FNPs have a higher degree of accuracy when they hypothesize more diagnostic possibilities. The healthcare environment functions on a schedule that is time conscious. Yet, no studies have been found that link time from initial encounter to diagnosis. Further, there are no available studies linking FNPs to diagnostic time and accuracy.

Summary

The purpose of this chapter was to review the relevant literature that informs the study of problem definition and its relationship to hypothesis generation and accuracy in entry-level FNPs. In addition to providing a general overview of the literature on clinical decision making and problem definition, the chapter highlighted the literature on computer simulations and diagnostic-reasoning software.

Clinical decision making is central to clinical practice. In teaching an entry-level FNP how to make clinical decisions, it is important to take into consideration their clinical knowledge base. The varying knowledge level of each RN who attends a FNP program is augmented as additional complex information is gained through the curriculum. The hypotheticodeductive-reasoning process involves the generation of diagnostic hypotheses based on clinical information about a patient. The hypotheses are then further tested through the use of both the inductive and deductive processes by gathering additional patient information. The final outcome of the process is the diagnosis statement or concluding hypothesis. While actual practice depends on the clinician's ability to make interventions based on the diagnosis, this study only examined the point up to the concluding hypothesis, known as the final diagnostic statement.

As demonstrated by this review of clinical decision making, the hypotheticodeductive method, and problem definition, researchers to date have not focused on the entry-level FNP's ability to make clinical decisions. The effect of problem definition and its relationship to hypothesis generation and accuracy in the student FNP has not been addressed in the literature.

Chapter 3

METHODOLOGY

Introduction

Little is known about problem definition as it relates to the decision making of recent family nurse practitioner (FNP) graduates. To expand the knowledge base on problem definition and decision making, this study explored the impact of problem definition on accuracy of final diagnosis, on number of hypotheses generated, on plausibility of these hypotheses, on time from login to final diagnosis, and on confidence in the final diagnosis in recent FNP graduates. This chapter describes the methods used to answer the research questions of the study. This chapter includes a description of the research design, setting, sample, DxR, measures obtained from DxR that will be used in the study, variables in the study, the procedures for data collection, protection of human subjects, and data analysis.

Research Design

An alternating-treatments single-subject experimental design was used in this study (Barlow & Hersen, 1984; Brink & Wood, 1998; Gay, Mills, & Airasian, 2005; R. Newell, 1992). The single-subject study is more robust if it is replicated with more than a single subject. The more the results are replicated on additional single subjects, the more confidence there is in the results (Gay et al., 2005). In single-subject research, as in group research, each replication provides additional information about the external validity of the results. This study had eight replications.

From the perspective of group research, rather than single-subject research, the design was also viewed as a within-subject experimental design with *N* being the same as the number of single-subject replications. In both single-subject and within-group designs, the subjects serve as their own controls. This research followed single-subject methodology and procedure. Data analysis is graphical subject by subject as well as inferential with the subjects combined into one group.

Setting and Sample

Subjects were recent graduates of a single National League for Nursing accredited FNP program in northwestern Pennsylvania. The program is part of a three-university consortium, located in a primarily rural setting. The target population was recent FNP graduates who met the sample criteria and consent to participate in the study. The criteria consisted of (a) completion of all clinical courses in the curriculum, and (b) experience working with the DxR. The FNP curriculum consists of five clinical courses and seven theory courses. The curriculum is consistent with the guidelines published by the National Organization of Nurse Practitioner Faculties and includes 600 hours of supervised clinical practice in the community. The DxR software is used as a teaching tool in several of the clinical courses. Subjects were excluded if they had not taken all of the clinical courses in this curriculum at this particular school.

Because variables such as educational background, nursing experience, and content of an educational curriculum may influence the decision making of recent FNP graduates, study subjects were targeted and drawn from a nonprobability, convenience sample from the same academic program, had the same coursework, and completed program requirements. Eight recent FNP graduates met the criteria for participation in the study and all were invited to participate. In the context of single-subject research, the sample size was thus 1, with the number of replications being the number who consented to participate in the study. There were eight replications.

Measures

A demographic tool adapted from Sands (2001) was used to collect data to describe the sample. These data included age, gender, race, and the type of initial nursing-preparation program. The tool also yielded information about years of experience and the type of experience as a registered nurse (RN) before starting the FNP program (see Appendix A). These demographic data were used to describe each subject and, in some cases, explain differences in individual performance.

The measures used to address the research questions of the study were obtained from DxR to provide Web-delivered simulated-patient scenarios. DxR is a complete patient-simulation package (Myers & Dorsey, 1994). Four patient scenarios were used in this study. Each subject was presented with the patient's chief complaint and medical history and chose questions to ask the patient from a list of 250 interview questions. Before proceeding to the physical exam, the subject was prompted to make hypotheses as to the possible cause of the problem and to rank them in order of probability. Next, the subject performed the computer-based physical examination on the patient. This involved the subjects being presented photographs of the patient including close views of specific body regions. Buttons and pull-down menus represented the 375 available physical-examination procedures. The subject could click a button to select an examination tool, such as an ophthalmoscope, reflex hammer, or sphygmomanometer. The cursor on the computer screen changed to an image of the examination tool over the patient's body and the subject could click the mouse to see the findings. Findings are presented as text, pictures, sound, or video, whichever format is appropriate to the examination. At any point, the subject was able to revise the list of hypotheses. After the physical examination, the subject moved to laboratory tests and chose from a list of 450 possible tests. Next, the subject made a final diagnosis, indicating level of confidence in the diagnosis. For purposes of this study, the scenario was complete at this point. The program automatically created a unique record for each subject that could be used to review the subject's performance. Each scenario took approximately 30–60 minutes. The subjects were allowed as much time as they needed to complete each scenario.

The only published validity and reliability data on the DxR instrument were published by Sands (2001). Sands conducted a review of the literature to support the content validity of the scenario used in her study. Using 70 nurse practitioners (NPs) from varying specialty areas as well as varying levels of experience, Sands also tested reliability of the DxR using an equivalence approach by administering a traditional paper and pencil multiple-choice instrument designed by the researcher and correlating the scores with the overall clinical-decision reasoning scale provided by the DxR program ($r = .77$, $p = .02$). This reliability score is generally considered an acceptable level of reliability.

Variables

Demographic data were collected to describe the sample. Information on age, race, gender and type of initial RN preparation were collected. The amount and type of RN experience was also collected. This information is used to describe each subject. Additionally, these data are used to explain differences in individual performance.

Independent variable. The independent variable for this study was problem definition. It was delivered in the form of patient scenarios from the DxR software program. The subject was exposed to alternate treatments in the form of four patient scenarios. Two scenarios reflected well-defined patient problems while the other two reflected ill-defined patient problems. The presentation of the scenarios was alternated to control the sequence of scenarios. For the four scenarios there were eight sequences of treatments presented. Subjects were randomly assigned to one of the sequences shown in Table 1.

Table 1

Orders of Presentation of Well-defined and Ill-defined Patient Scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Sequence 1	W_a	I_a	W_b	I_b
Sequence 2	W_a	I_a	I_b	W_b
Sequence 3	I_a	I_b	W_a	W_b
Sequence 4	I_a	W_b	I_b	W_a
Sequence 5	I_a	W_a	W_b	I_b
Sequence 6	I_a	W_a	I_b	W_b
Sequence 7	W_a	W_b	I_a	I_b
Sequence 8	I_b	I_a	W_b	W_a

Note. W_a and W_b represent the two well-defined scenarios; I_a and I_b represent the two ill-defined scenarios.

Individual consultation with Dr. Hurley Myers of DxR Corporation resulted in the choice of the patient DxR scenarios (personal communication April 15, 2005). Three well-defined and three ill-defined patient scenarios were chosen from the catalog of available scenarios because they commonly occur in primary care and were considered appropriate for the recent FNP graduate. To select the four scenarios for the study, two experienced FNP faculty members whose specialization is family practice and who were familiar with the DxR evaluated the six patient scenarios (see Appendix B) independently. The faculty members were given the definition of a well-defined problem and an ill-defined problem and asked to place each scenario into either the well-defined category or the ill-defined category. They then were asked to evaluate its content and appropriateness for a recent FNP graduate and to determine if the patient complaints and problems presented in the scenarios commonly occur in primary care and in the scope of practice of the FNP.

After categorizing the patient scenarios and rating their appropriateness, the FNP faculty raters viewed a list of hypotheses generated by the scenario author (see Appendix B). To generate a sense of validity of the hypothesis list, the following questions were asked: Is each hypothesis on this list a plausible hypothesis for this patient scenario? What other hypotheses might be plausible? The researcher then reviewed the results of the two independent evaluators and selected two of the well-defined and two of the ill-defined scenarios upon which the evaluators agreed. The ratings of the plausibility of the hypotheses were used to generate a final list of hypotheses. The final list of hypotheses was used in this study to evaluate the accuracy of the recent FNP graduate's final diagnosis on each scenario.

Dependent variables. With presentation and response to the four patient scenarios, each subject had five measures related to their diagnosis of the patient. These five measures were the dependent variables:

Accuracy of the final diagnosis;

Total number of diagnostic hypotheses generated;

Percent of the diagnostic hypotheses plausible;

Time from initial login to final diagnosis; and.

Confidence in the final diagnosis.

The number of diagnostic hypotheses refers to the total number of hypotheses that were generated by the subject. The percent of diagnostic hypotheses that were plausible was calculated by comparing (a) the number of diagnostic hypotheses generated by the subject that were included on the list of plausible hypotheses generated by the expert FNP faculty to (b) the total number of hypotheses generated. Accuracy of the final diagnosis was determined by whether it appeared on the list generated by the expert FNP faculty. Confidence was the degree of certainty in the final diagnosis as self-reported by the subject. Time was computed by the DxR program in minutes and seconds from initial login to the subject's confirmation of the final diagnosis. The patterns of responses on the dependent variables related to problem definition (whether the scenario was well defined or ill defined) are reported in Chapter 4.

Procedures for Data Collection

Nonprobability convenience sampling was used to solicit participation in this study. The data were collected from recent FNP graduates of a National League for

Nursing Accrediting Commission accredited FNP program in northwestern Pennsylvania. The program is part of a three-university consortium, located in a primarily rural setting. The target population was FNPs that met the sample criteria and consented to participate in the study. Eligible subjects were identified and selected as follows: The inclusion criteria were reviewed with the FNP program director to assist with identification of all recent FNP graduates. There were 9 recent FNP graduates from the 2007 class and there were 20 students working to complete the requirements for graduation in the 2008 class. Once identified, a letter was mailed to all potential subjects, briefly describing the purpose of the study and inviting them to participate (see Appendix C). Second and third mailings were conducted to solicit as many FNP recent graduates as possible. A return postage-paid envelope addressed to the investigator was included for the subject to return the signed consent. Eight FNP recent graduates responded. Each subject was then contacted with the scheduled time and date to complete the DxR scenarios. Each subject was appointed a time to meet at a computer-equipped classroom on the university's campus to complete the four scenarios.

At the appointed time the researcher provided written instructions (see Appendix D) to the subject about how to proceed. The instructions included the demographic data form (see Appendix A) and indicated that the subject would be presented with four scenarios via the DxR and instructed to work through the patient scenarios up to and including making the final diagnosis. The instructions included information about taking a break between scenario presentations and what to do when finished with the last presentation. The investigator remained in the quiet setting of the computer lab while the subject worked through the DxR cases in order to answer any questions about the software and to ensure that no outside resources were used. No time limits were imposed; subjects were allowed as much time as they needed to complete the DxR scenarios. Upon completion, the investigator thanked the subjects. A check for $100 was mailed to the subjects as a token of appreciation for their time and any inconvenience they may have had in participating in the study. Subjects also were asked to complete travel reimbursement forms. Travel reimbursement was at the federal rate of 58.5 cents per mile.

The data was recorded using the DxR program as the subject worked through each of the four patient simulations. These data were transferred to an Excel spreadsheet as well as to SPSS for analysis. The demographic data form was marked with an identifier known only to the investigator and linked to the data obtained from the DxR program.

Procedures for Protection of Human Subjects

The researcher was approved on an expedited basis from both the Duquesne University Institutional Review Board and the research site's Institutional Review Board (see Appendix E). Participation was voluntary and there were no consequences for nonparticipation. A copy of the consent form is provided in Appendix F. The benefit–risk ratio was assessed for this study, indicating minimal risk and important benefits. No individual was identified by name or demographic information and individual results remain confidential. Subjects were offered a summary of the study once it is completed. Benefits of the study include the opportunity for subjects to care for four computer-simulated patients, and dissemination of findings to the larger healthcare audience.

Compensation for completion of the study included reimbursement for travel mileage to the testing center at the federal rate of 58.5 cents per mile and $100 as a token of appreciation for their time and any inconvenience such as travel time and loss of work. Subjects received written feedback about the scenarios, the hypotheses, and final diagnoses. All data were kept confidential and coded with only the researcher, research advisor, and committee members having access to the code book. The master list of the subjects will be shredded at the end of the research study. Consent forms are kept in a separate locked file in the researcher's home and also will be destroyed at the completion of the study.

Procedures for Data Analysis

Primary analysis in a single-subject design involves presentation of data for each subject. To address the research questions, data for each subject is presented in the chapter that follows for accuracy of final diagnosis, number of diagnostic hypotheses generated, plausibility of hypotheses generated, time elapsed, and confidence in the final diagnosis.

Demographic description of the sample. The overall group is described in respect to the eight demographic questions (see Appendix A). Means, standard deviations, and ranges are reported for age (Question 1) and experience (Question 7) because they are continuous variables. The remaining demographic variables are categorical and are described using frequencies and percentages. While the overall description of the group was informative, the primary use of the demographics was to describe individual subjects and to help interpret their results. For example, participants who have a strong background in a certain specialty area may have performed differently from others when presented with the same scenario. That is to say, a patient problem that has been identified as ill defined for most may actually be viewed as a well-defined problem by a participant with years of nursing experience in a specialty area.

Data scoring. The DxR contained the subjects' responses to the two ill-defined and the two well-defined patient-problem scenarios. The data associated with the five dependent variables is extracted from the DxR: total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that are plausible, accuracy of the final diagnosis, confidence in the final diagnosis, and time from initial login to final diagnosis. These data and the demographic information were entered into Excel and transferred into SPSS for the subsequent graphing and statistical analyses.

Graphical analysis. Data analysis in single-subject research design generally involves visual inspection and analysis of graphic representation of results (Barlow & Hersen, 1984; Gay et al., 2005; Todman & Dugard, 2001). Visual analysis can be used to examine two overall aspects of the data. The first is the level (performance of the independent variable) and the second is the trend (the changes or patterns in the data path; Richards, Taylor, Ramasamy, & Richards, 1999).

The independent variable in this study is problem definition, presented under two conditions, the well-defined and ill-defined DxR scenarios. The dependent variables are the total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that are plausible, accuracy of the final diagnosis, confidence in the final diagnosis, and time from initial login to final diagnosis. For each subject, five graphs are presented in the next chapter, one for each of the dependent variables. In these graphs the horizontal axis indicates how the subject responded to the well-defined scenarios and the ill-defined scenarios. The vertical axis shows the dependent variable of interest. Figure 2 is a hypothetical example of such a graph.

If the study was limited to just the one subject, this result would not be very useful or informative other than to suggest that there may be an association between ill-defined and well-defined patient presentation problems and correct diagnosis. However, if independent replications show similar patterns, the evidence becomes stronger with each replication and strengthens the validity of the results. On the other hand, if the visual patterns are erratic from subject to subject under the two conditions, there will be less confidence that well-defined and ill-defined patient problems result in differences in FNP diagnoses.

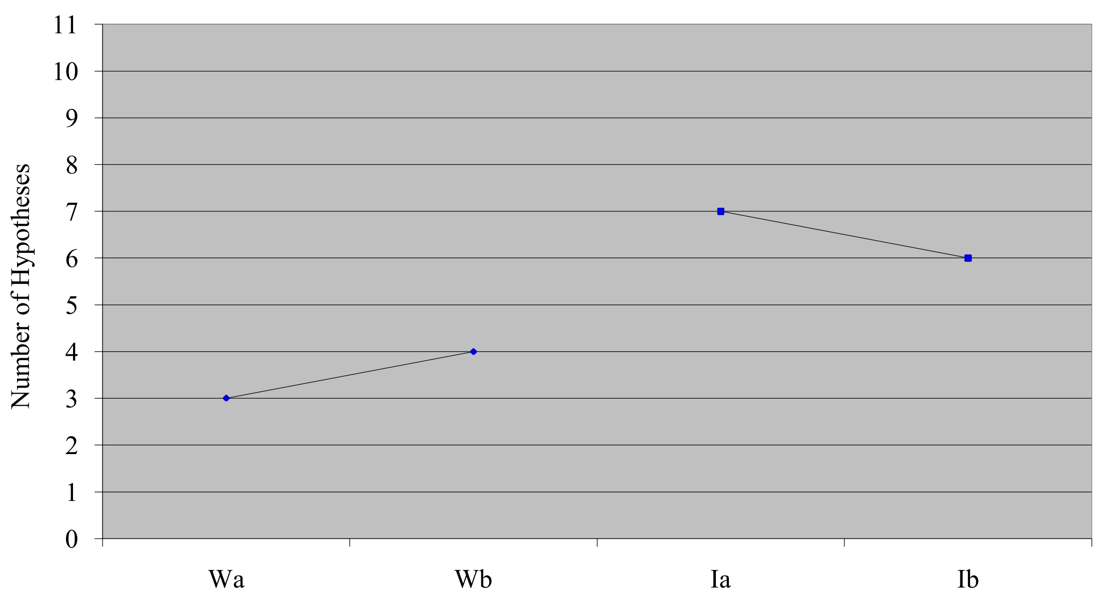

Figure 2. Total number of hypotheses generated under each scenario for a hypothetical subject.

Statistical analysis. Visual graphical analysis was supplemented by statistical analysis. From a statistical perspective this research was considered as a single factor repeated measures design. As described earlier, each subject was measured four times on each of the five dependent variables—two times associated with the well-defined scenarios and two times associated with the ill-defined scenarios. Typically, if the sample size is large enough the statistic employed is a parametric repeated measures analysis of variance. However, when sample size is small, as is the case here, the Friedman nonparametric test for repeated measures is more appropriate. The Friedman test compares ranks rather than means. Thus, five separate Friedman analyses were conducted – one on each of the dependent variables. The results are presented in the next chapter.

Summary.

Chapter 3 presented the research design, the setting and sample, measures, and variables used in the study, and outlined the procedures for data collection, protection for human subjects, and the plan for the data analysis. Chapter 4 will provide the results of the data analysis both graphically and statistically.

Chapter 4

Analysis of the Data

This study investigated the effects of problem definition on the accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that are plausible, time from initial login to final diagnosis, and confidence in the final diagnosis as generated by the recent family nurse practitioner (FNP) graduate. Consistent with the single-subject design, this chapter is organized by a presentation of the results for each subject along with a graphical presentation of those results. This is followed by a brief summary of the group results. Statistical analyses for the group included five separate Friedman analyses—one for each of the dependent variables.

The scenarios that were selected after the expert faculty review included two well-defined scenarios and two ill-defined scenarios. The first well-defined scenario, W_a, was a scenario about Mr. Jackson, an 18-year-old male complaining of recent onset of abdominal pain. His final diagnosis was acute appendicitis. The second well-defined scenario, W_b, was a scenario about Mrs. Swenson, a 52-year-old female complaining of back pain. Her final diagnosis was a vertebral compression fracture. The first ill-defined scenario, I_a, described Mrs. Gantner, an 86-year-old female complaining of memory loss. Her final diagnosis was degenerative dementia of the Alzheimer type. The second ill-defined scenario, I_b, was about Mr. Pilsner, a 76-year-old male complaining of bloating. His final diagnosis was abdominal aortic aneurysm. Complete information regarding all of these scenarios including the list of plausible hypotheses can be found in Appendix B.

The DxR software provided an overview statistics screen that allowed a visual inspection of each subject's clinical problem-solving processes. It was provided as a color-coded timeline of each subject's actions while working through the DxR scenarios. An observation of each subject's diagnostic process was used to supplement the data analysis. The next section will review the results of the 8 subjects for each of the dependent variables in the study as well as relevant demographic data that may help to interpret these results.

Graphical Analysis

Subject 1. Subject 1 was a 40-year-old White female. Her original nursing education was as a diploma nurse and she had over 12 years of nursing experience. She worked in the Intensive Care Unit (ICU) and had held that position for 5 years. In addition she had 10 years of Emergency Department (ED) experience. She also had some experience in pediatrics, surgical areas, recovery room, and the cardiac-catheterization laboratory. The diagnostic-reasoning software records the process that subjects follow as they work through the scenario (See Appendix G for an example from Subject 1). This includes both the sequence of the investigation of the patient complaint as well as the specific questions, physical-examination procedures, and laboratory tests that were ordered. An observation of this subject's decision-making process showed that her process in working through the scenarios was consistent through all four scenarios. She elicited the history of the present illness (HPI); then examined the patient, then ordered laboratory work. She did not appear to use an iterative hypothesis-generation approach in any of the scenarios.

Subject 1 received her scenarios in the following order: W_a (abdominal pain), I_a (memory loss), W_b (back pain), and I_b (bloating). Figure 3 shows the data for this subject. The independent variable was problem definition (ill-defined versus well-defined problems). There is a separate plot for each of the dependent variables: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

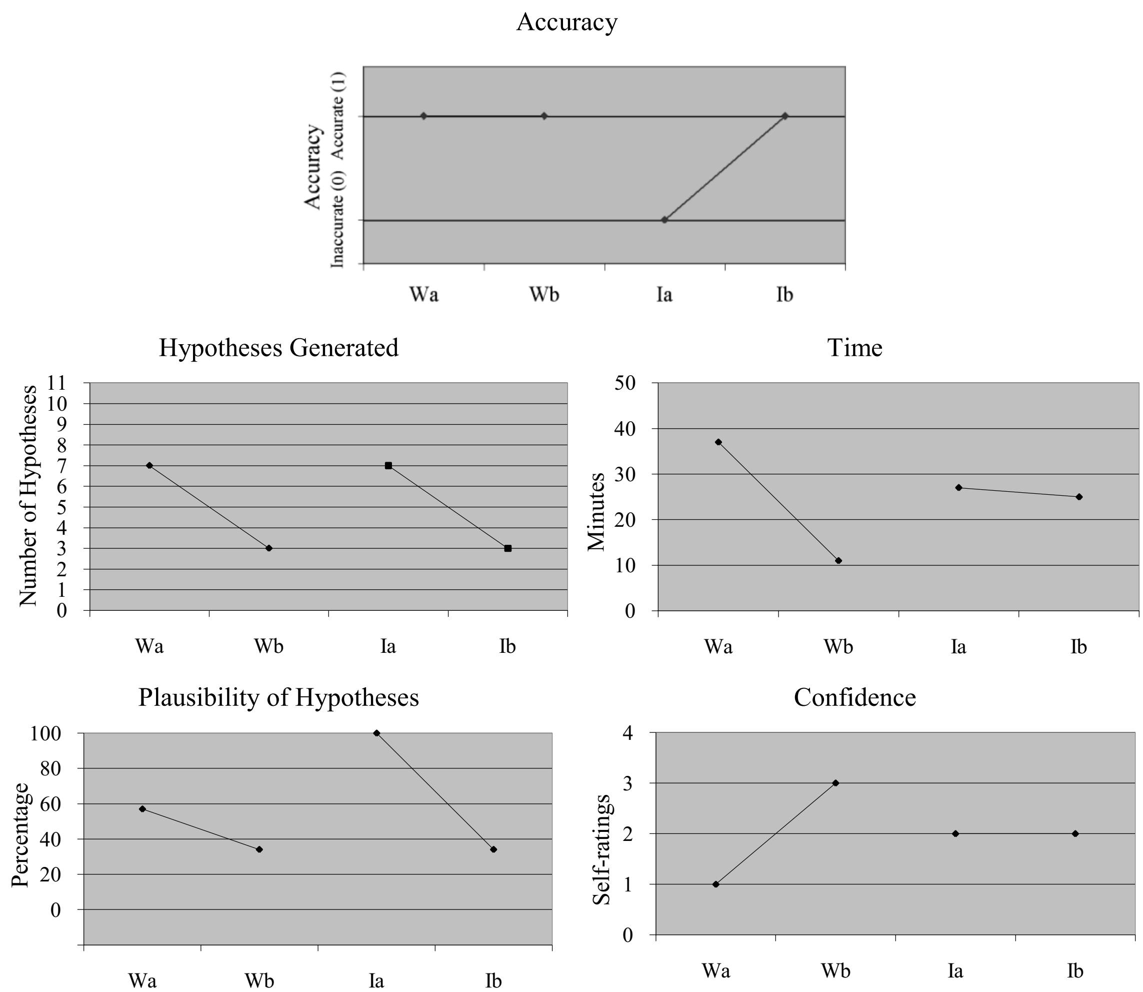

Figure 3. Data for Subject 1 on accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in three of the four scenarios. She misdiagnosed the I_a scenario although she generated seven hypotheses that were all plausible.

Number of diagnostic hypotheses generated. For the W_a scenario she generated seven hypotheses; seven hypotheses for Scenario I_a ; three for W_b; and three for I_b .

Plausibility of diagnostic hypotheses generated. For the W_a scenario four of the seven hypotheses that were generated were on the list of plausible hypotheses created by the experts. For the I_a scenario, all seven hypotheses generated were on the plausible list. For the W_b scenario, one of the three hypotheses generated was plausible, and for the I_b scenario one of the three hypotheses was listed as plausible.

Time elapsed from initial login to final diagnosis. The W_a scenario took the subject 37 minutes to diagnose correctly. The I_a scenario took 27 minutes and was the only scenario where the subject was incorrect in the final diagnosis. The W_b scenario took 11 minutes from initial login to final diagnosis. The I_b scenario took 25 minutes.

Confidence in the final diagnosis. This subject was somewhat confident in making the final diagnosis on the W_a scenario. She was confident in making the diagnosis for the I_a, very confident in diagnosing the W_b scenario, and confident in diagnosing the I_b scenario.

Summary. In summary, Subject 1 accurately diagnosed three of the four scenarios. She misdiagnosed the ill-defined scenario, I_a, the memory-loss complaint of an outpatient elderly female, probably not a type of complaint that was commonly encountered in this subject's work experience. This scenario does not commonly occur as a presenting complaint in the ICU and only occasionally occurs in the ED. She was very confident in diagnosing the W_b scenario about back pain, accurately diagnosing the problem in 11 minutes with three hypotheses. She was least confident in diagnosing the abdominal pain complaint, W_a. She listed seven hypotheses, of which four were plausible, and took 37 minutes to diagnose the scenario. This subject was confident in making the diagnosis for the I_a and I_b scenarios, taking 27 and 25 minutes respectively. Observing the relationships between the dependent variables, it appears that as diagnostic confidence increased, the amount of time from initial login to final diagnosis decreased.

There did not seem to be a strong relationship between problem definition and the number and plausibility of diagnostic hypotheses. However, based on an observational analysis of this subject's performance on the W_a scenario, compared with the other scenarios, it appears that this scenario was more difficult for her. Even though she was accurate in making the diagnosis, she used more time, generated more hypotheses, and had a decreased level of confidence with the W_a scenario. Problem definition did not seem to relate to confidence in the final diagnosis. She reported that she was confident in the scenario that she misdiagnosed and somewhat confident to very confident in the scenarios that she diagnosed correctly. Problem definition also did not seem to have a relationship to the amount of time spent making the diagnosis.

This subject had 12 years of nursing experience with the majority of it in the ED. Thus one might assume that she had ample experience as a nurse with patients whose complaint was acute abdominal pain as in the patient in the W_a scenario. Yet she had considerable difficulty as evidenced in the amount of time spent on the scenario as well as with the confidence she reported with the abdominal-pain diagnosis. The misdiagnosis of the I_a scenario might be due to the supposition that in her work experiences in the ED and ICU, she did not come in contact with patients who complained of memory loss. However, the concept of memory loss was covered in detail in the FNP curriculum.

This subject did not appear to use an iterative hypothesis-generation approach in any of the scenarios. In each scenario she elicited the HPI, examined the patient, and then ordered laboratory work. However, when the W_a scenario was presented, she generated more hypotheses, took more time, and had a lower confidence level.

Subject 2. Subject 2 was a 38-year-old White female. Her original nursing education was as an associate degree nurse and she had over 14 years of nursing experience. She held national certification in infection control and had worked in the infection-control area for 7 years. She worked in nursing administration and had held this position for 3 years. In addition she reported that she had 9 years of medical/surgical nursing experience. Observation of her diagnostic process showed that she investigated the HPI, then the past medical history, review of systems (ROS), and then went to examine the patient. After the examination, she ordered laboratory tests. There was no noted iterative process in decision making. She used the same process in all four scenarios.

Subject 2 received her scenarios in the following order: W_a (abdominal pain), I_a (memory loss), I_b (bloating), and W_b (back pain). Figure 4 shows the data for this subject. The independent variable was problem definition (ill-defined versus well-defined problems). Each dependent variable is shown in a separate plot: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

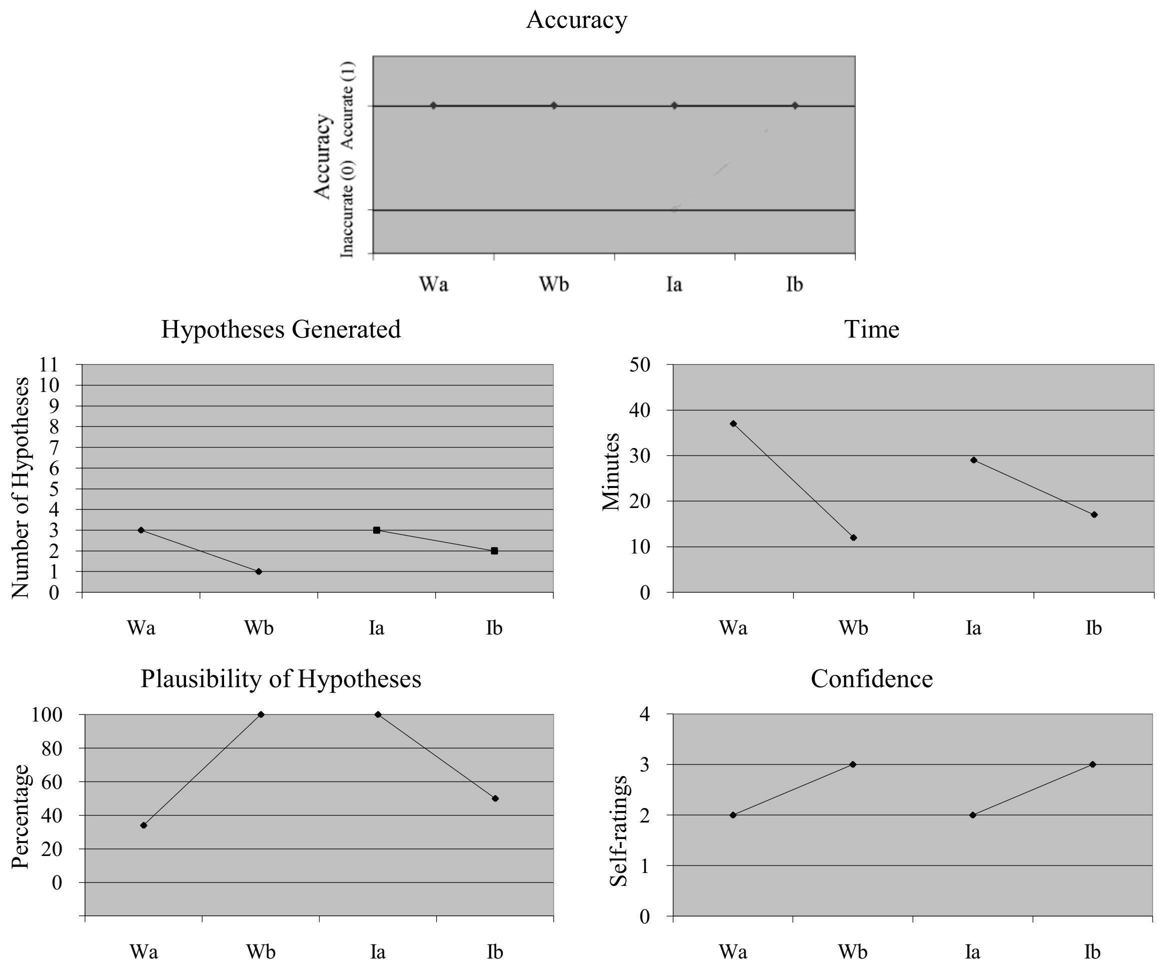

Figure 4. Data for Subject 2 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in all four scenarios.

Number of diagnostic hypotheses generated. For the W_a scenario the subject generated three hypotheses; three for the I_a scenario; two for I_b; and one for the W_b scenario.

Plausibility of diagnostic hypotheses generated. For the W_a scenario one of the three hypotheses generated was on the list of plausible hypotheses created by the experts; for the I_a scenario, all three were designated as plausible; for I_b, one of the two hypotheses generated was plausible; and for the W_b the sole hypothesis that was generated was plausible.

Time elapsed from initial login to final diagnosis. The W_a scenario took the subject 37 minutes to diagnose correctly. The I_a scenario took 29 minutes, the I_b scenario 17 minutes, and the W_b scenario 12 minutes from initial login to final diagnosis.

Confidence in the final diagnosis. This subject was confident in making the diagnosis for the W_a and I_a scenarios. She was very confident in diagnosing the I_b and W_b scenarios.

Summary. In summary, Subject 2 accurately diagnosed all four scenarios. She had a substantial amount of nursing experience prior to entering the FNP program, and was also a nurse administrator. She was very confident with the back-pain scenario, W_b. She correctly made the diagnosis in 12 minutes with just one hypothesis. She was also very confident with the ill-defined abdominal-aortic-aneurysm scenario, I_b, and made the diagnosis in 17 minutes with two hypotheses. She was confident in her diagnosis in the other two scenarios. The relationship between the dependent variables appeared to support the observation that as diagnostic confidence increased the amount of time from initial login to final diagnosis decreased. There did not seem to be a strong relationship between problem definition and the number and plausibility of diagnostic hypotheses. Additionally, problem definition did not seem to have a relationship to the amount of time spent making the diagnosis. However, observation of the time to diagnosis and the rating of confidence led to the observation that scenarios W_a and I_a were more difficult for this subject to diagnose.

This subject did not appear to use an iterative hypothesis-generation approach in any of the scenarios. In each scenario she elicited the HPI, past medical history, ROS, examined the patient, and then ordered laboratory work. Although there was very little variability in the total number of hypotheses generated and the accuracy of the final diagnosis, some observations can be made. When the W_a and I_a scenarios were presented, she generated a few more hypotheses, took more time, and had a lower confidence level.

Subject 3. Subject 3 was a 52-year-old White female. Her original nursing education was as a diploma nurse and she had over 29 years of nursing experience. She also held a degree in occupational education. She worked in an administrative position for 7 years. She listed a varied nursing background that included ED ambulatory care, medical nursing, obstetrics, postpartum, and nursery experience. She also reported recovery room and flight nursing experience. Observation of her diagnostic process showed that she investigated the HPI and then went to examine the patient. After the examination, she ordered laboratory tests. There was no noted iterative process in the decision making, regardless of problem type. She used the same process in all four scenarios.

Subject 3 received her scenarios in the following order: I_a (memory loss), I_b (bloating), W_a (abdominal pain), and W_b (back pain). Figure 5 shows the data for this subject. The independent variable described ill-defined versus well-defined problems. The accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis are each shown in a separate plot.

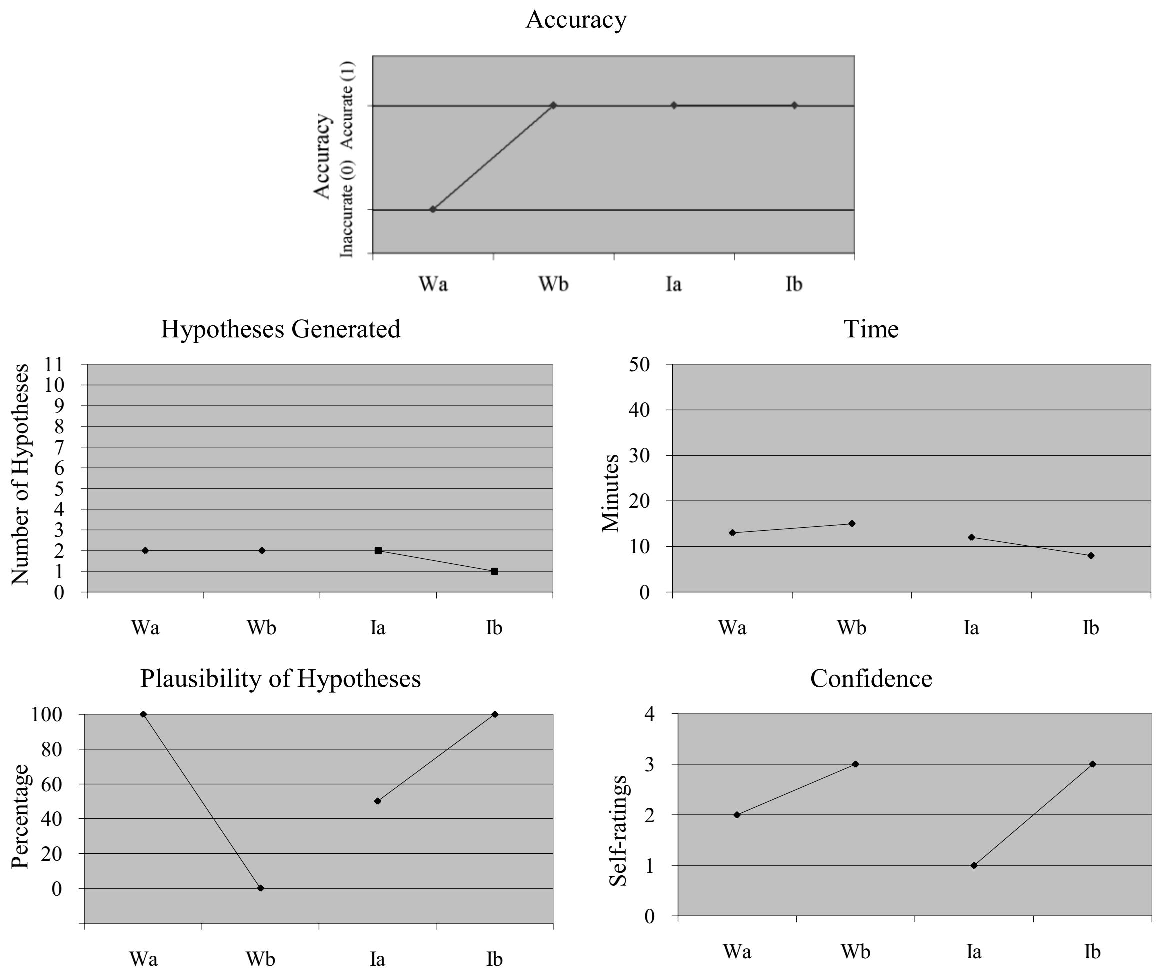

Figure 5. Data for Subject 3 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in three of the four scenarios. She misdiagnosed the W_a scenario although the correct diagnosis (acute appendicitis) was on her list of hypotheses. It is supposed that she made an error in reporting the symptom "presents with a 5-hour history of burning in right lower quadrant" rather than actual diagnosis in her final analysis.

Number of diagnostic hypotheses generated. Overall, Subject 3 did not generate very many hypotheses. For the I_a scenario she generated two hypotheses. On her next scenario, the I_b scenario, she only generated one hypothesis. For the W_a scenario she generated two hypotheses and on the W_b scenario she also generated two hypotheses.

Plausibility of diagnostic hypotheses generated. For the I_a scenario one of the two hypotheses that were generated was on the list of plausible hypotheses created by the experts. For the I_b scenario, she generated just one hypothesis and it was on the plausible list. For the W_a scenario, both of the two hypotheses generated were plausible. For the W_b scenario neither of the two hypotheses was listed as plausible.

Time elapsed from initial login to final diagnosis. The I_a scenario took 12 minutes to diagnose correctly, I_b took 8 minutes, the W_a scenario took 13 minutes (the scenario with the incorrect final diagnosis), and W_b scenario took 15 minutes from initial login to final diagnosis.

Confidence in the final diagnosis. This subject was somewhat confident in making the I_a scenario diagnosis. She was very confident in diagnosing the I_b scenario. She reported that she was confident in making the final diagnosis on the W_a scenario even though she misdiagnosed it. She was very confident in diagnosing the W_b scenario.

Summary. In summary, Subject 3 accurately diagnosed three of four scenarios. She misdiagnosed the W_a scenario, the abdominal-pain complaint. Her vast nursing experience, which included ED experience, should have given her an opportunity to care for a patient with a similar complaint on more than one occasion. For this subject, there does not seem to be a strong relationship between problem definition and the number and plausibility of diagnostic hypotheses. Nor does not there appear to be a relationship between problem definition and confidence in the final diagnosis. She was confident in the diagnosis that she missed and ranged from somewhat confident to very confident in the scenarios that she diagnosed correctly. Problem definition also did not seem to have a relationship to the amount of time spent making the diagnosis. There was very little variation in the time she spent on each scenario.

This subject had 29 years of nursing experience with the majority of it in an administrative position. Her other experiences included the ED. Thus, one might assume that she had ample experience as a nurse with patients whose complaint was acute abdominal pain such as the patient in the W_a scenario. The concept of acute abdominal pain was covered in detail in the FNP curriculum. The misdiagnosis of the W_a scenario might be due to the supposition that she made an error, listing it as her final diagnosis.

This subject did not appear to use an iterative hypothesis-generation approach. In each scenario, she elicited the HPI, examined the patient, and ordered laboratory work, indicating she did not use the hypotheticodeductive decision-making method as she worked through the scenarios.

Subject 4. Subject 4 was a 32-year-old White male. His original nursing education was as a diploma nurse and he had 10 years of nursing experience. He had worked in the emergency room for the previous 8 years. In addition, he also listed ICU and Cardiac Care Unit (CCU) nursing experience. An observation of his decision-making process revealed that in each scenario he investigated the HPI and then examined the patient, then ordered laboratory work. There was no observed iterative process in decision making in the scenarios that he correctly diagnosed. However, in the scenario he misdiagnosed, he appeared to use an iterative process between examination and HPI.

Subject 4 received his scenarios in the following order: I_a (memory loss), W_b (back pain), I_b (bloating), and W_a (abdominal pain). Figure 6 shows the data for this subject. The independent variable pitted ill-defined against well-defined problems. There is a separate plot for each of the dependent variables: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

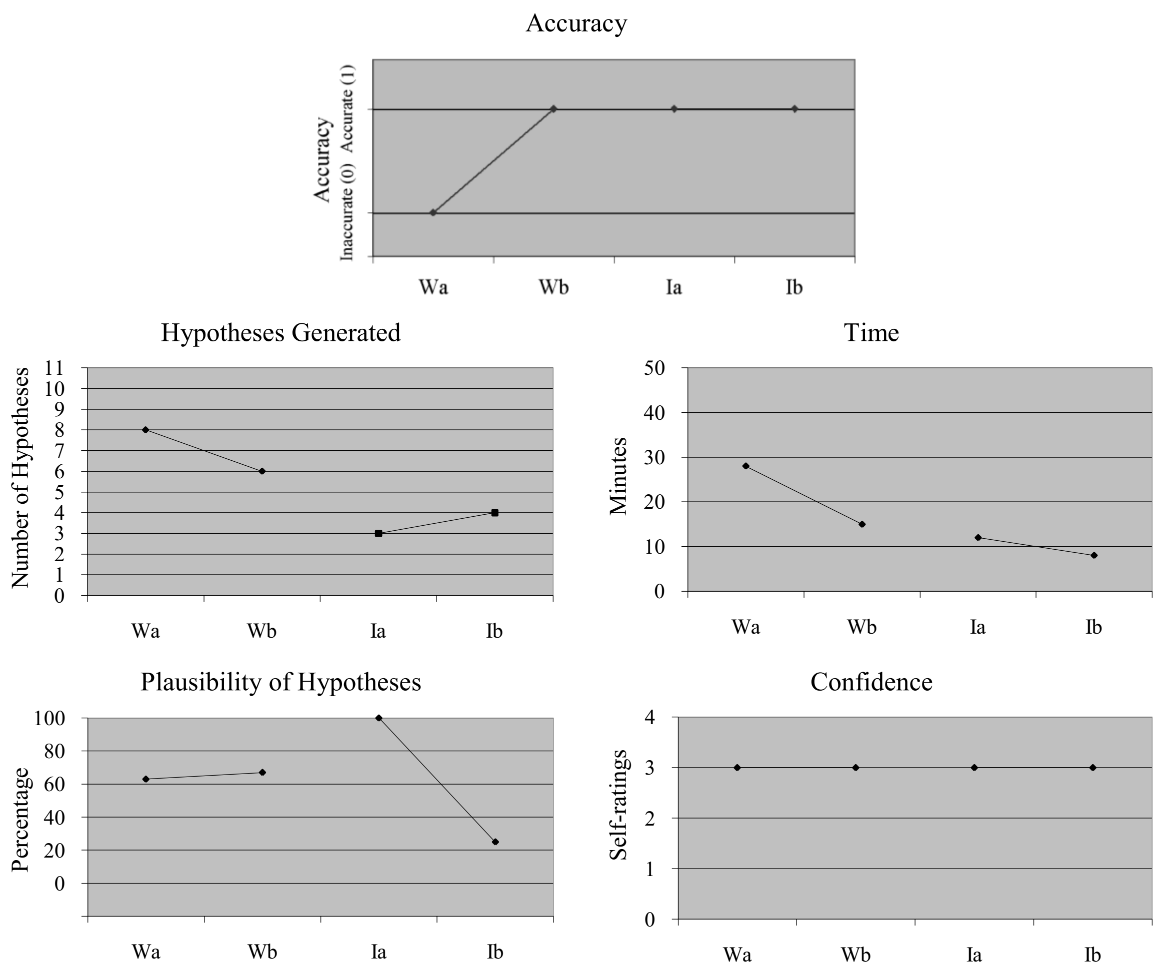

Figure 6. Data for Subject 4 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in three of the four scenarios. He misdiagnosed the W_a scenario although he generated five plausible hypotheses.

Number of diagnostic hypotheses generated. For the I_a scenario he generated three hypotheses, six for the W_b, four for I_b, and eight for the W_a scenario.

Plausibility of diagnostic hypotheses generated. For the I_a scenario all three of his hypotheses were on the list of plausible hypotheses created by the experts. For the W_b scenario, four of the six hypotheses that were generated were on the plausible list. For the I_b scenario, one of the four hypotheses generated was plausible. For the W_a scenario five of the eight hypotheses were plausible.

Time elapsed from initial login to final diagnosis. The I_a scenario took the subject 12 minutes to diagnose correctly; W_b took 15 minutes; I_b took 8 minutes from initial login to final diagnosis; and the W_a scenario took 28 minutes and was the scenario where the subject was incorrect in the final diagnosis.

Confidence in the final diagnosis. This subject noted that he was very confident in his diagnoses for all of the scenarios presented, even though he misdiagnosed the W_a scenario.

Summary. In summary, Subject 4 accurately diagnosed three of four scenarios. The scenario that he misdiagnosed was the acute abdominal-pain patient in the W_a scenario. He reported that he was very confident in diagnosing all of the scenarios, and therefore confidence ratings do not appear to be a good measure of difficulty in diagnosis for this particular subject. There may be a relationship between problem definition and the number of diagnostic hypotheses. In this instance, there were more hypotheses generated in the well-defined scenarios.

This subject had 10 years of nursing experience, most of it in the ED where the abdominal-pain complaint is very common. One might assume that he had ample experience as a nurse caring for patients whose complaint was acute abdominal pain such as the patient in the W_a scenario. Even though he reported that he was very confident in the final diagnosis, it was incorrect. In fact he failed to identify that this was a surgical abdomen. He spent more time working the scenario and generated more hypotheses than in the other scenarios, appearing to use a more iterative process. This may indicate that the diagnosis was more difficult for him than his confidence rating indicated.

Subject 5. A 42-year-old White female, Subject 5 received her original nursing education as an associate degree nurse, and reported that she held a degree in metrology. She had 4 years of nursing experience and was employed in a medical/surgical position. She also listed some long-term care experience. An observation of this subject's decision-making process showed that in three of the scenarios (W_b, I_a, and I_b) she investigated the HPI, and then examined the patient and ordered laboratory tests. There was no noted iterative process in the decision-making process used in these scenarios. She correctly diagnosed the back-pain scenario (W_b) and the bloating scenario (I_b). She misdiagnosed the memory-loss scenario (I_a) using the straightforward process. However, she used a different process in the other scenario, the abdominal-pain scenario, (W_a). In this scenario, she went through the HPI to the examination, then back to the HPI and ROS, then back to the examination in an iterative way. She misdiagnosed the memory-loss scenario (I_a).

Subject 5 received her scenarios in the following order: I_a (memory loss), W_a (abdominal pain), W_b (back pain), and I_b (bloating). Figure 7 shows the data for this subject. The independent variable was problem definition (ill-defined versus well-defined problems). Each separate plot illustrates a dependent variable: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

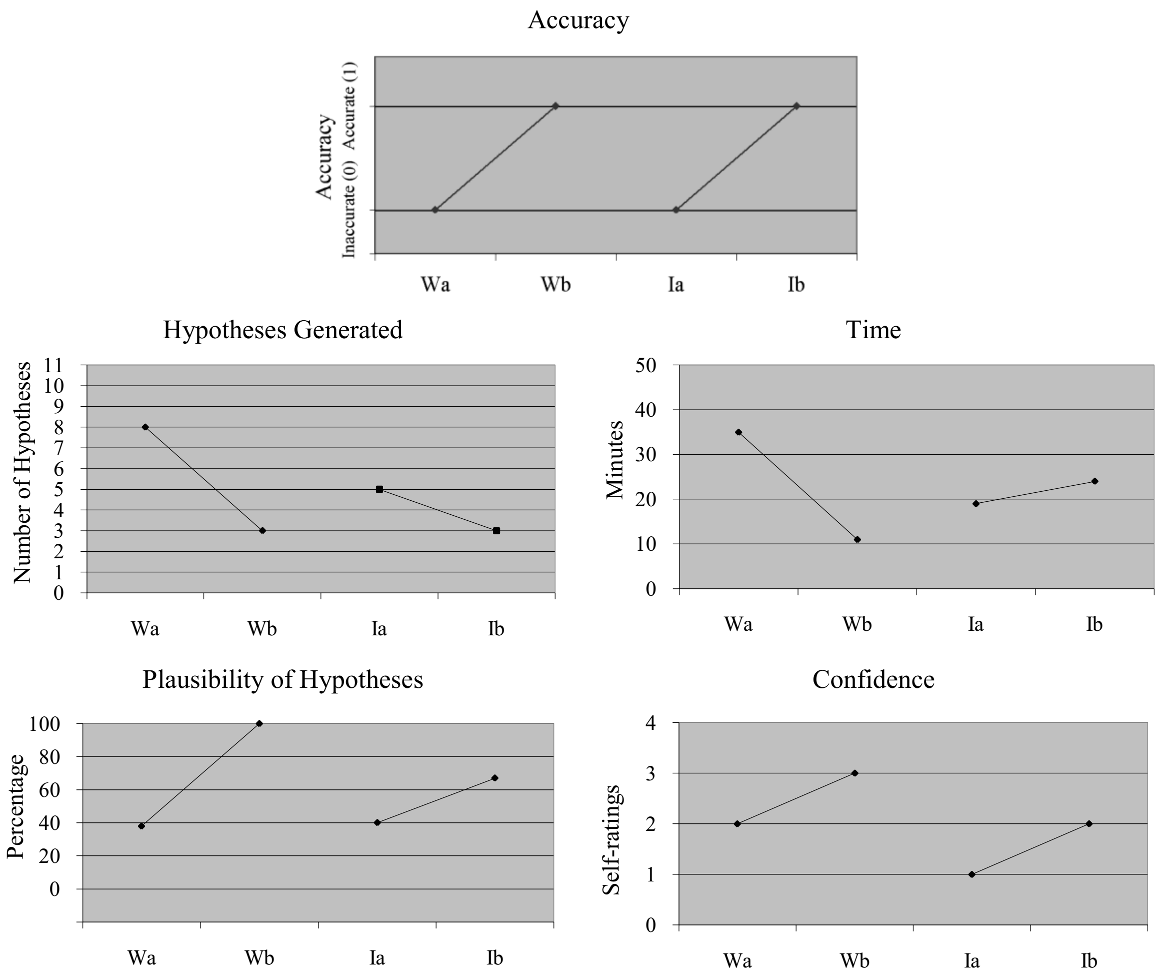

Figure 7. Data for Subject 5 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in two of the four scenarios, I_b and W_b. She misdiagnosed the I_a scenario, the memory-loss scenario, although she generated five hypotheses of which two were plausible. She also misdiagnosed the W_a scenario, the abdominal-pain scenario, although she had the correct diagnosis on her list of hypotheses.

Number of diagnostic hypotheses generated. For the I_a scenario she generated five hypotheses, for W_a eight, for the W_b scenario three, and for the I_b scenario three hypotheses.

Plausibility of diagnostic hypotheses generated. For the I_a scenario two of the five hypotheses that were generated were on the list of plausible hypotheses created by the experts; for W_a, three of the eight were on the plausible list, for the W_b scenario, all three hypotheses generated were plausible, and for I_b two of the three hypotheses were considered to be plausible.

Time elapsed from initial login to final diagnosis. The I_a scenario took the subject 19 minutes from initial login to final diagnosis and she misdiagnosed it. The W_a scenario took 35 minutes; it was the second scenario she misdiagnosed. The W_b scenario took 11 minutes from initial login to final diagnosis. The I_b scenario took 24 minutes.

Confidence in the final diagnosis. This subject was somewhat confident in making the diagnosis for the I_a scenario. She was confident in the W_a scenario as well as the I_b scenario. She was very confident in diagnosing the W_b scenario.

Summary. In summary, Subject 5 accurately diagnosed two of four scenarios. She was very confident in diagnosing the well-defined back pain (W_b), accurately diagnosing the problem in 11 minutes with three hypotheses. She was least confident in diagnosing the Alzheimer's-dementia scenario (I_a). She listed five hypotheses, of which two were plausible, and took 19 minutes to arrive at a final diagnosis for that scenario. This subject was confident in making the diagnosis for the W_a and I_b scenarios and took

35 and 24 minutes respectively. For this subject, as diagnostic confidence increased, the amount of time from initial login to final diagnosis did not decrease. There did not seem to be a strong relationship between problem definition and the number and plausibility of diagnostic hypotheses.

This subject did not appear to use an iterative hypothesis-generation approach in two of the scenarios. In the back-pain scenario (W_b) she made an accurate diagnosis, and was also accurate in the bloating scenario (I_b). In those scenarios she elicited the HPI, examined the patient, and then ordered laboratory work. She used a different process on the other two scenarios. There is evidence that the hypotheticodeductive method was employed when the abdominal-pain (W_a) and memory-loss scenarios (I_a) were presented. In these instances she used a more iterative approach, generated more hypotheses, took more time, and reported a lower confidence level. In addition she misdiagnosed these two scenarios. This may be attributed to her relative lack of extensive and varied nursing experiences.

Subject 6. Subject 6 was a 36-year-old White female, originally a diploma nurse with more than 10 years of nursing experience. She held a national certification with a nursing case-management specialty and worked in nursing administration for 3 years. The rest of her nursing background was quite varied and included ED, ICU, and oncology. She reported that most of her experience was in geriatrics in a nursing home as a staff nurse, case manager, and Director of Nursing. Her diagnostic process was similar for all four scenarios. An observation of her decision-making process showed that she investigated the HPI and then went to examine the patient. After the examination, she ordered laboratory tests. There was no noted iterative process used in decision making even though she generated many hypotheses in each scenario.

Subject 6 received her scenarios in the following order: I_a (memory loss), W_a (abdominal pain), I_b (bloating), and W_b (back pain). Figure 8 shows the data for this subject. Ill-defined versus well-defined problems composed the independent variable. The accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis are illustrated in separate plots.

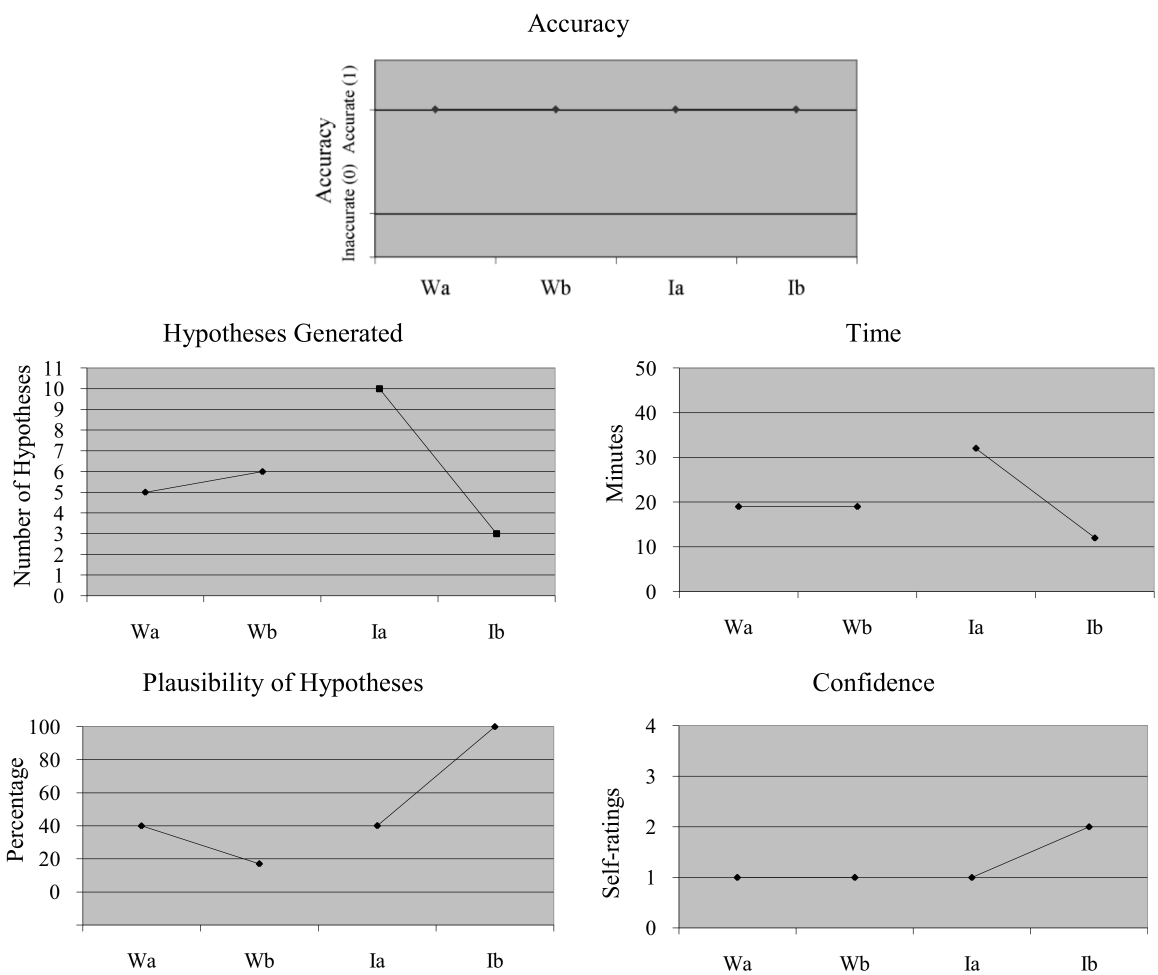

Figure 8. Data for Subject 6 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in all four scenarios.

Number of diagnostic hypotheses generated. For the I_a scenario she generated 10 hypotheses, for the W_a scenario 5 hypotheses, for I_b 3, and for W_b 6.

Plausibility of diagnostic hypotheses generated. For the I_a scenario, 4 of the 10 hypotheses that were generated were on the list of plausible hypotheses created by the experts. For the W_a scenario, 2 of the 5 hypotheses that were on the plausible list. All 3 hypotheses generated for the I_b scenario were plausible, as was 1 of the 6 hypotheses for W_b.

Time elapsed from initial login to final diagnosis. The I_a scenario took the subject 32 minutes to diagnose correctly, while the W_a scenario took 19 minutes to make the final diagnosis. The I_b scenario took 12 minutes from initial login to final diagnosis and the W_b scenario took 19 minutes.

Confidence in the final diagnosis. This subject was somewhat confident in making the diagnosis for the I_a, W_a, and W_b scenarios. She was confident in diagnosing the I_b scenario, the abdominal-aneurysm scenario.

Summary. In summary, Subject 6 accurately diagnosed all four of the scenarios. She was confident in diagnosing the bloating complaint (I_b), diagnosing it in 12 minutes with three hypotheses. She reported that she was somewhat confident in diagnosing all of the other scenarios. On the Alzheimer's-dementia scenario (I_a), she listed 10 hypotheses, of which 4 were plausible, and took 32 minutes to diagnose the scenario. This subject was also somewhat confident in making the diagnosis for the abdominal-pain (W_a) and back-pain (W_b) scenarios. She took 19 minutes to arrive at a diagnosis for each of those scenarios. It appears that as diagnostic confidence increased, the amount of time from initial login to final diagnosis decreased. There did not seem to be any relationship between problem definition and the number and plausibility of diagnostic hypotheses.

This subject has experience in a wide area of nursing arenas. She has held both staff and administrative positions. Even though she reports that most of her experience is in geriatrics in a long-term-care setting, it seems that she had the most uncertainty with the memory-loss scenario (I_a) in the geriatric client. This evaluation is made on the basis of time and degree of confidence rating.

This subject did not use an iterative hypothesis-generation approach in any of the scenarios. In each scenario, she elicited the HPI, examined the patient, and then ordered laboratory work. There is some evidence that the hypotheticodeductive method was employed to a small degree when the memory-loss (I_a) scenario was presented. In this instance, she generated more hypotheses, took more time, and had a lower confidence level.

Subject 7. Subject 7 was a 41-year-old White female who began as a diploma-prepared nurse who later earned the bachelor's degree in nursing and also had a degree in business administration/marketing. She had 10 years of nursing experience. She was employed in a CCU position, but also had ICU experience, medical-floor experience, and experience in a nursing home. An observation of her decision-making process showed that she investigated the HPI, then investigated the ROS, and then examined the patient. After the examination, she ordered laboratory tests. There was no noted iterative process in decision making. She used the same process in all four scenarios.

Subject 7 received her scenarios in the following order: W_a (abdominal pain), W_b (back pain), I_a (memory loss), and I_b (bloating). Figure 9 shows the data for this subject. The independent variable was ill-defined versus well-defined problems. There is a separate plot for each of the dependent variables: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

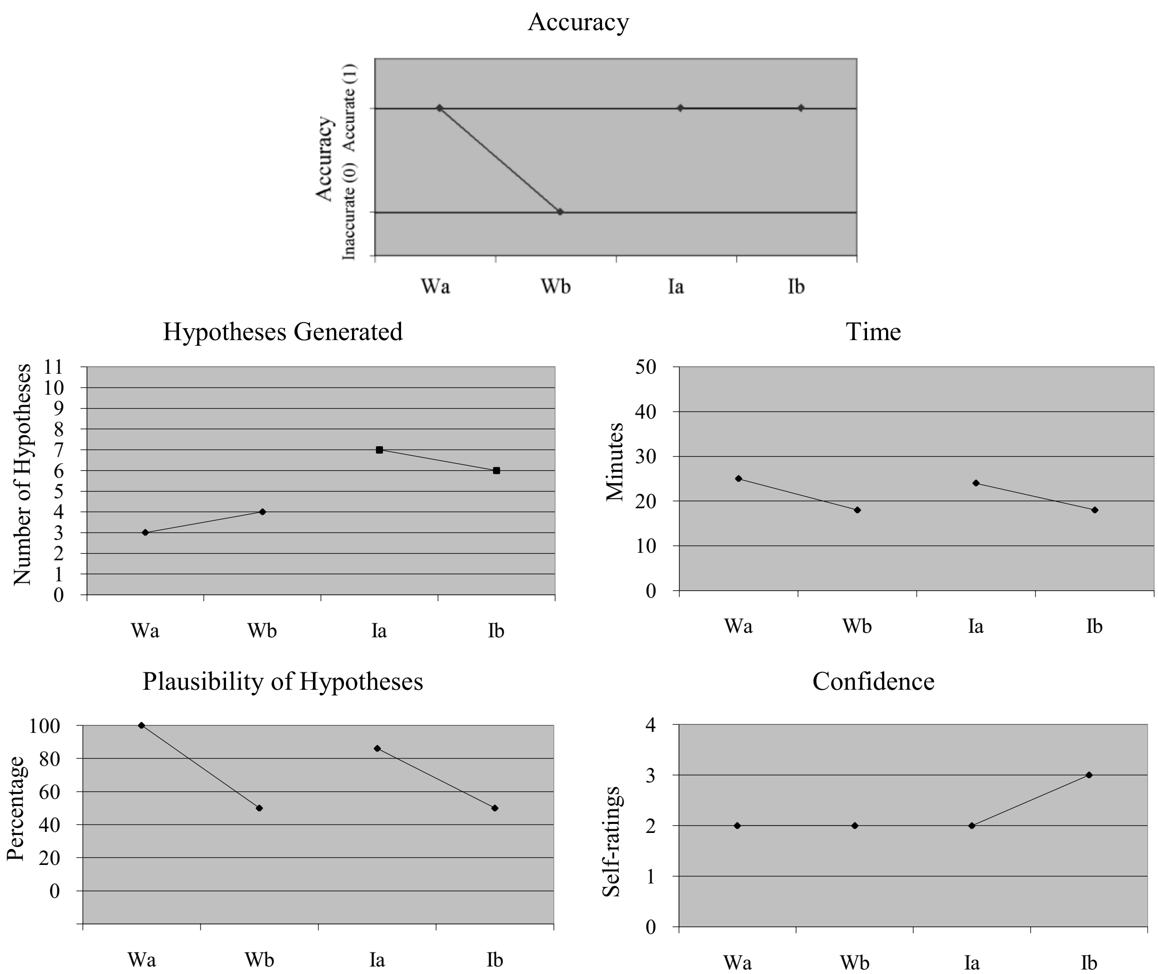

Figure 9. Data for Subject 7 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Accuracy of final diagnosis. This subject was accurate in three of the four scenarios. She misdiagnosed the back-pain (W_b) scenario, even though she generated four hypotheses, two of which were plausible and one of which was the correct diagnosis.

Number of diagnostic hypotheses generated. For the W_a scenario Subject 7 generated three hypotheses. For the W_b scenario she generated four, for the I_a scenario seven hypotheses, and for I_b six. Overall, she generated more hypotheses for the ill-defined scenarios.

Plausibility of diagnostic hypotheses generated. For the W_a scenario all three of the generated hypotheses were on the list of plausible hypotheses created by the experts. For the W_b scenario, two of the four hypotheses that were generated were on the plausible list. For the I_a scenario, six of the seven hypotheses generated were plausible. For the I_b scenario three of the six hypotheses were listed as plausible.

Time elapsed from initial login to final diagnosis. The W_a scenario took the subject 25 minutes to diagnose correctly. The W_b scenario took 18 minutes and was the scenario where the subject was incorrect in the final diagnosis. The I_a scenario took 24 minutes from initial login to final diagnosis, and the I_b scenario took just 18 minutes.

Confidence in the final diagnosis. This subject was confident in making the diagnosis for the W_a, W_b, and I_a scenarios. She was very confident in diagnosing the I_b scenario (abdominal aneurysm).

Summary. In summary, Subject 7 accurately diagnosed three of four scenarios. She was very confident in diagnosing the ill-defined abdominal aneurysm (I_b). She accurately diagnosed the problem in 18 minutes with six hypotheses. She was confident in diagnosing the remaining scenarios. For the abdominal pain (W_a), she listed three hypotheses, of which all were plausible, and took 25 minutes to diagnose the scenario. This subject was also confident in making the diagnosis for the W_a and I_a scenarios, taking 18 and 24 minutes respectively. For the well-defined scenarios, the time from initial login to final diagnosis relates to the level of confidence; however there is little variation in time and confidence level, and thus there is no clear pattern with the ill-defined scenarios. There did not seem to be a strong relationship between problem definition and the number and plausibility of diagnostic hypotheses. However, she has many years of diverse nursing experience including ICU, CCU, long-term care, and administration. It is not known to what degree this nursing experience influenced her decision making. It is suspected that she did not encounter the back-pain complaint in those settings as frequently as the other complaints and perhaps this might explain her misdiagnosis of this scenario.

This subject did not use an iterative hypothesis-generation approach in any of the scenarios. In each scenario she elicited the HPI, ROS, examined the patient, and then ordered laboratory work. There are no clear patterns emerging from the graphs of this subject's performance on the scenarios. There was little variation in time and confidence on the scenarios.

She correctly diagnosed three scenarios. The diagnosis that she missed (W_b), the back-pain scenario, was on her list of hypotheses. She also noted that she was confident in the back-pain scenario.

Subject 8. Subject 8 was a 34-year-old White male bachelor's of science in nursing prepared nurse who was certified in gerontology and reported over 11 years of nursing experience. He was working in a CCU position that he had held for 7 years. His background also included ICU and the medical floor. An observation of this subject's decision-making process showed that in three of the four scenarios he investigated the HPI, then ROS, and then examined the patient. After the examination, he ordered laboratory tests. There was no noted iterative process in any of decision making. The abdominal-pain scenario that was misdiagnosed (W_a) is included in this group. In the bloating scenario (I_b) he used a different diagnostic strategy. He went from the HPI to PE and did not investigate any of the ROS.

Subject 8 received his scenarios in the following order: bloating (I_b), memory loss (I_a), back pain (W_b), and abdominal pain (W_a). Figure 10 shows the data for this subject. The independent variable, ill-defined versus well-defined problems, defined the problem. There is a separate plot for each of the dependent variables: accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percentage of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis.

Accuracy of final diagnosis. This subject was accurate in three of the four scenarios. He misdiagnosed the W_a scenario although he generated five hypotheses of which three were plausible.

Number of diagnostic hypotheses generated. For each scenario Subject 8 generated five hypotheses.

Plausibility of diagnostic hypotheses generated. For the I_b scenario three of the five hypotheses that were generated were on the list of plausible hypotheses created by the experts. For the I_a scenario, four of the five were plausible. For the W_b scenario, two of the five hypotheses generated were plausible, and for the W_a scenario three of the five hypotheses were listed as plausible.

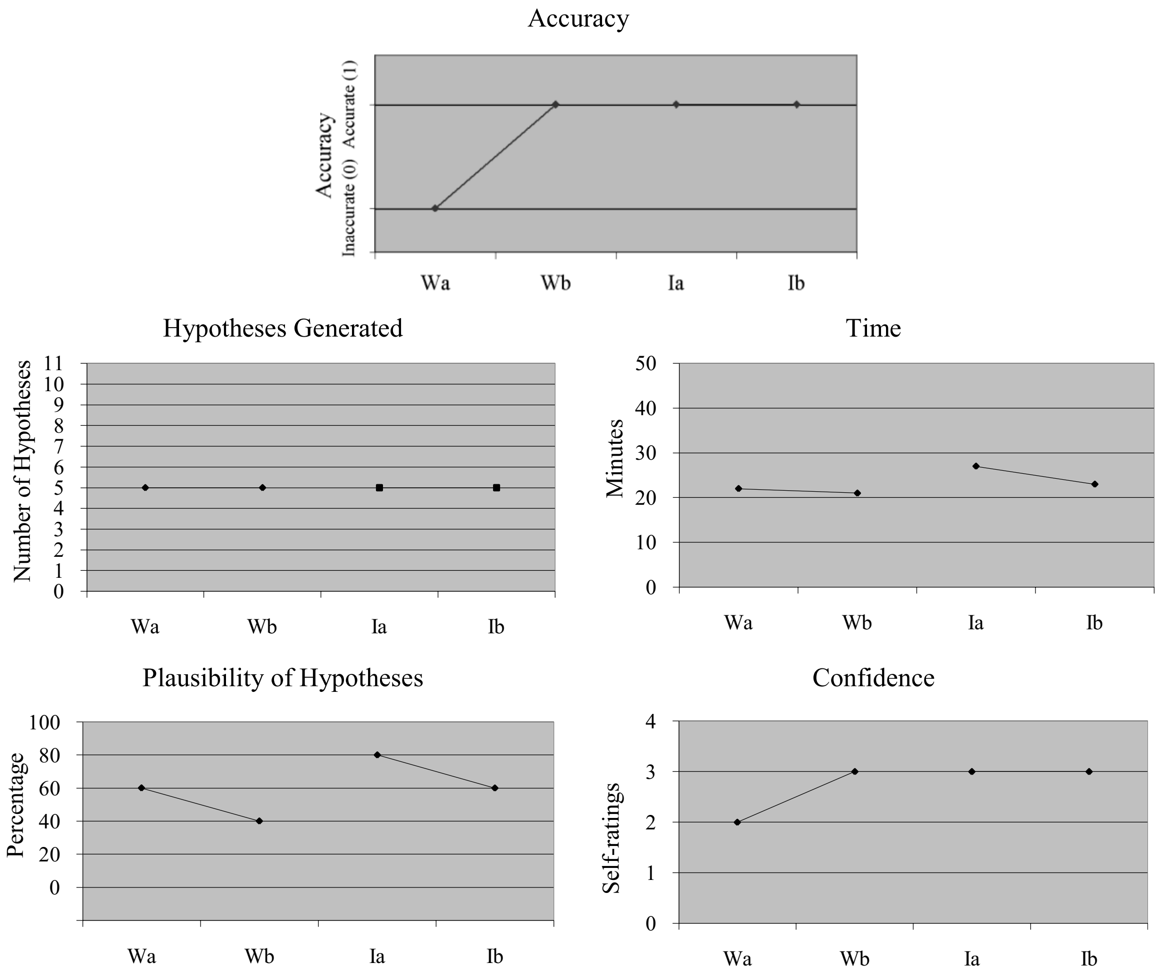

Figure 10. Data for Subject 8 accuracy, number of hypotheses generated, plausibility, time, and confidence as a function of problem definition.

Time elapsed from initial login to final diagnosis. The I_b scenario took the subject 23 minutes to diagnose correctly. The I_a scenario took 27 minutes. The W_b scenario took 21 minutes from initial login to final diagnosis. The W_a scenario took 22 minutes and was the scenario where the subject was incorrect in the final diagnosis.

Confidence in the final diagnosis. This subject was very confident in making the diagnosis for the I_b, I_a, and W_b scenarios. He was confident in the diagnosis of the acute appendicitis (W_a) although he misdiagnosed the scenario.

Summary. In summary, Subject 8 accurately diagnosed three of the four scenarios. He reported that he was very confident in diagnosing all of the scenarios he diagnosed correctly. In the scenario he misdiagnosed (W_a) he listed that he was confident in his diagnosis. In the acute-appendicitis scenario, he listed three plausible hypotheses and took 22 minutes to make a diagnosis. Even though he was inaccurate in the final diagnosis, it was on his plausible list of diagnoses. In the scenario that he misdiagnosed his confidence was lower. There did not seem to be a relationship between the amount of time from initial login to final diagnosis and any of the other variables. There did not seem to be a relationship between problem definition and the number and plausibility of diagnostic hypotheses.

This subject had 11 years of nursing experience in a variety of areas. Of particular interest is the fact that he was certified in gerontology. This may explain why he generated the highest percentage of plausible hypotheses for the ill-defined memory loss geriatric scenario (I_a). However, his practice probably has been limited in the number of acute abdominal-pain scenarios he has encountered. This could account for his lowered confidence level and misdiagnosis on the scenario. He did have appendicitis on the list of diagnostic hypotheses, but failed to recognize that this was a surgical abdomen.

This subject did not use an iterative hypothesis-generation approach in any of the scenarios. In three scenarios, he elicited the HPI and ROS, examined the patient, and then ordered laboratory work. There was another decision-making process that was noted. For example, on the I_b scenario, the data-gathering phase was truncated by the subject. He reported a high degree of confidence in making the diagnosis. There was little variation in time across the scenarios, and no variability in the number of hypotheses generated. He generated the greatest percentage of plausible hypotheses in the memory-loss (I_a) scenario. The subject's extensive geriatric experience could account for the confidence and accuracy in this diagnosis.

This section reported the results in graphical and narrative form for the 8 single subjects. The following section will present the statistical analysis when the subjects are grouped to look for the effects of problem definition on accuracy of final diagnosis, number of hypotheses generated, plausibility of hypotheses, time from login to diagnosis, and confidence in the final diagnosis.

Statistical Analysis

In single-subject research the primary method of analysis is graphical. However, as the number of single subjects increase, group statistics can also be informative. Statistical procedures are available based on a small sample size. As such, the data for the 8 subjects were treated as group data and statistical procedures were applied to supplement the single-subject reports.

Data Entry and Screening

The subject-by-subject demographics and complete DxR responses were collected and entered into Excel for the 8 subjects. The data were then screened for entry errors. Several errors were found and corrected. The Excel file was then converted to SPSS for the statistical analyses, whereas the Excel file was used for the individual subject graphs shown in the next section.

Demographics. Table 2 presents a description of the overall group on several demographics. All 8 of the subjects were Caucasians and ranged in age from 32 to 52 with a mean age of about 40 years.

Six of the subjects were female. Of the subjects' initial education in nursing, one had a baccalaureate degree in nursing, 5 had diplomas in nursing, and 2 had associate degrees in nursing. Three also had a degree in a non-nursing field. Three reported that they are nationally certified in a nursing specialty. The majority of the subjects, 6, have between 10 and 14 years of nursing experience. One subject had greater than 20 years of nursing experience. One other subject reported 2 years of full-time experience.

Table 2

Subject Demographics (N = 8)

Demographic	*n*	*M*	*SD*	Range
Age	8	40	6.16	32–52
Gender				
Female	6			
Male	2			
RN program				
Associate Degree Nurse	2			
Diploma	5			
Bachelor's Degree in Nursing	1			
Degree in non-nursing field				
Yes	3			
No	5			
National certification specialty				
Yes	3			
No	5			
RN (Years full time)				
< 10	1			
10–14	6			
> 14	1			

Note. Percents are not shown because the *n* is most meaningful when the number of subjects is small.

Nonparametric analysis. Each subject was presented with four patient diagnostic scenarios. Unknown to the subject, the scenarios had been preclassified as being either well-defined or ill-defined patient problems. The research questions queried if there would be differences on five dependent variables associated with well- and ill-defined scenarios. The five variables were accuracy of diagnosis, number of diagnostic hypotheses, percentage of the hypotheses that were plausible, time taken to reach a diagnosis, and confidence in the diagnosis.

From a statistical perspective the research can be considered as a single-factor repeated-measures design. Typically, if the sample size were large enough, the statistic employed will be a parametric repeated-measures analysis of variance. However, when sample size is small, as is the case here, the Friedman nonparametric test for repeated measures is more appropriate. The Friedman test (Siegel & Castellan, 1988) compares ranks rather than means.

Five separate Friedman analyses were conducted—one on each of the dependent variables. Table 3 provides the results for the five analyses. The results are provided in one table rather than five separate tables because the same scenarios are represented for each of the five dependent variables. For ease of observation and interpretation the scenarios are arranged from high to low by rank for each of the variables.

First, an overall orientation to the table may be useful. The means (*M*) are shown, although they are not used for the Friedman test. The next column shows the rankings by scenario. It may be seen that the means and ranks follow the same patterns with respect to high through low. This is expected because the raw data do not change.

Table 3

*Friedman Repeated Measures Summaries for the Effects of Well- and Ill-Defined Scenarios for Five Dependent Variables (*N *= 8)*

Variable	M	Mean Rank	$\chi^2(3)$	Exact *p*
Accuracy			5.53	.19
I_b	1.00	2.94		
W_b	0.88	2.69		
I_a	0.75	2.44		
W_a	0.50	1.94		
Hypotheses			6.68	.08
I_a	5.25	3.06		
W_a	5.12	2.94		
W_b	3.75	2.19		
I_b	3.38	1.81		
Plausible			3.12	.39
I_a	74.50	3.12		
W_a	61.50	2.44		
I_b	60.75	2.38		
W_b	51.00	2.06		
Time			9.27	.02
W_a	27.00	3.44		
I_a	22.75	2.88		
I_b	16.88	1.81		
W_b	15.25	1.88		
Confidence			11.43	.01
I_b	2.62	3.19		
W_b	2.62	3.06		
I_a	1.88	1.94		
W_a	1.88	1.81		

Note. W_a and W_b represent the two well-defined scenarios; I_a and I_b represent the two ill-defined scenarios.

The Chi-square distribution is used to determine probability levels for the Friedman test and is analogous to the *F*-ratio used in analysis of variance. The next column shows the probability level for the chi-square. Software is now available (the SPSS add-on module) that allows for exact probability levels, whereas the usual probability level provided is an estimate. An estimated level is very reliable when the sample size is large and all assumptions are met. The Friedman test makes no assumptions about the data and exact tests are more reliable when the sample size is small.

No statistical hypotheses or probability levels were established beforehand for this research. This was because the research was exploratory as an initial study using the DxR in the manner described earlier. However, of the five variables it was anticipated that, by definition, the subjects would show greater accuracy on the well-defined scenarios than on the ill-defined scenarios. No expectations were made for the other four dependent variables. As a point of reference, if the conventional .05 level is used there were differences for time (p = .02) and confidence (p = .01). In addition, the number of diagnostic hypotheses generated approached statistical significance (p = .08). No statistical difference was shown for accuracy (p = .19) or plausibility (p = .39).

Putting statistical differences aside, it is informative and useful to follow the two well-defined scenarios through the five dependent variables. First, the W_a scenario ranked last in respect to accuracy (4 of the 8 subjects were accurate). W_a also took the most time and the subjects were least confident in their diagnoses, although W_a did rank second in the number of hypotheses generated and percentage of plausible hypotheses. Accuracy for W_b, as anticipated, was good and ranked second (7 of the 8 subjects were accurate on this scenario). Although W_b had the smallest percentage of plausible hypotheses, it took the least amount of time and ranked second in confidence.

It is also interesting to track the ill-defined scenarios through the dependent variables. Unanticipated, I_b ranked first in accuracy (all 8 subjects were accurate). I_b also generated the least number of hypotheses with next to lowest rank in percentage of plausible hypotheses. It ranked first in confidence and ranked second to last in time. I_a ranked third in accuracy, first in the number of hypotheses generated, and first in the percentage of plausible hypotheses.

In summary, the quantitative results reveal important and useful findings. Taken as a whole the results indicate that the well- and ill-defined scenarios did not have the effects anticipated in accuracy of diagnosis. Plausible explanations for this are discussed in the next chapter. The patterns of the rankings associated with the other four dependent variables will provide beginning baselines for continuing research.

Chapter 5

Discussion

Introduction

This chapter presents a discussion of the findings and relates the conclusions to the literature. The major objectives of this study were to explore the impact of problem definition on the accuracy of the final diagnosis, total number of diagnostic hypotheses generated, percent of the diagnostic hypotheses that were plausible, time from initial login to final diagnosis, and confidence in the final diagnosis as generated by the recent FNP graduate. The design of the study was an alternating-treatments single-subject experimental design. This final chapter presents an interpretation of the results in relation to the purpose of this study. Additionally, linkage to theory, limitations of the study, recommendations for future research, applications to education, and applications to practice will be addressed. The results of this study support and extend previous research on clinical decision making in nursing.

Theoretical Framework of the Study

The hypotheticodeductive method was the theoretical framework used in this study. It involves the generation of hypotheses based on clinical data and knowledge, and testing of these hypotheses through further inquiry. In this method, data collection and decision making are driven by specific hypotheses derived early in patient evaluation (Offerdy, 1998). This decision-making approach emphasizes the early development of diagnostic and etiologic hypotheses based on the patient's complaint. Additionally, this model stresses the use of hypotheses that have been generated to structure the acquisition of data (Elstein et al., 1978; White et al., 1992). Cutler (1998) described this approach to decision making as the most commonly used and effective method of solving clinical problems.

Several studies have examined how nurse practitioners use the decision-making process to analyze patients' chief complaints (Ellis, 1997, Tanner et al., 1987, White et al., 1992). These studies reported that subjects used hypotheticodeductive reasoning to arrive at diagnoses. The present study also hypothesized that FNP recent graduates would solve clinical problems by using the hypotheticodeductive method, using iterative hypotheses testing to identify and develop problem structure. It was also hypothesized that problem definition (ill-defined versus well-defined problems) would affect the total number of diagnostic hypotheses generated. It was assumed that an ill-defined problem would cause the problem solver to have an increased degree of uncertainty in the decision-making process. No direction was placed on the prediction that problem definition would affect the total number of hypotheses generated because it was unclear if uncertainty about the diagnosis would increase or decrease that number. It was hypothesized that as problem complexity increased, the hypotheticodeductive-reasoning process would be used by more subjects.

In this study, the clinical decision-making process used by each subject as they worked through the scenarios was observed using the DxR software program. Data indicate that the subjects used a consistent problem-solving process to evaluate the simulated patients. Largely, the process can be described as gathering and interpreting data while generating relatively few hypotheses. Subjects in this study did not work back and forth in an iterative fashion as seen in the hypotheticodeductive model. In fact, there were just two scenarios of 32 total scenarios reviewed by 8 recent FNP graduates in which an iterative process was used. Interestingly, two subjects used it on the same case (W_a) and they were both inaccurate in their diagnosis. Therefore, it cannot be assumed that students who are taught a hypotheticodeductive-reasoning method in a classroom setting necessarily apply it in the clinical arena. Expert decision makers may rely on pattern matching, however novices must be trained in hypotheticodeductive methods to generate clinical hypotheses.

Despite the finding that the hypotheticodeductive-reasoning method was not evident, it was observed that most subjects used a consistent process to evaluate scenarios. Subjects seemed to follow a pattern-matching style of decision making. This pattern-recognition method, described in several studies (Benner et al., 1996; Mandin, Jones, Woloschuk, & Harasym, 1997; Ritter, 2003), entails nurses using various short cuts or heuristics to simplify decision making. Pattern matching does not usually employ hypothesis testing or a specific search strategy. Instead, information is "clustered" into a few key pieces that facilitate a pattern of data that is recognized by the problem solver. Pattern recognition is a conscious process whereby the nurses contemplate patient scenarios and classify them based on their similarity to previous scenarios they have encountered (Offerdy, 1998; Mandin et al., 1997).

Based on the literature review, it was hypothesized that there would be more variation in the use of the hypotheticodeductive method as problem definition moved across the continuum from well defined to ill defined because it was expected that recent FNP graduates would not be familiar with the more ill-defined problems. This pattern was not observed in this sample. This may be because subjects perceived the scenarios differently than the researcher categorized them, or had previous experiences with scenarios here classified as ill defined. Another explanation may be that faculty assume students understand and apply hypotheticodeductive reasoning when in fact they may not, and curricula may not reinforce or measure understanding of this form of clinical reasoning.

In conclusion, while it was presumed that recent FNP graduates were using the clinical reasoning method they were taught (the hypotheticodeductive method), it was clear that another process, pattern matching, was also used by recent FNP graduates. Further inquiry regarding this finding is warranted in additional settings and circumstances, including other educational programs and with larger sample sizes.

Problem Definition

For the purpose of this study, *well-defined* problems were problems that were clearly formulated and have known algorithms and criteria available for testing the correctness of the solutions. *Ill-defined* problems were those problems that are (a) more complex and have less definite criteria for determining when the problem has been solved, (b) do not provide all of the information necessary to solve the problem, and (c) have no procedure that guarantees a correct solution. The results in this study may indicate that FNP recent graduates did not identify well-defined and ill-defined scenarios in the same way as the experts who classified them as ill defined and well defined. One way to determine whether recent FNP graduates perceived a problem as well defined is whether they were accurate, more confident, and took less time.

The scenarios that were selected after the expert-faculty review included two well-defined scenarios and two ill-defined scenarios. The first well-defined scenario, W_a, was a scenario about Mr. Jackson, an 18-year-old male complaining of recent onset of abdominal pain. His final diagnosis was acute appendicitis. The second well-defined scenario, W_b, was a scenario about Mrs. Swenson, a 52-year-old female complaining of back pain. Her final diagnosis was a vertebral compression fracture. The first ill-defined scenario, I_a, described Mrs. Gantner, an 86-year-old female complaining of memory loss. Her final diagnosis was degenerative dementia of the Alzheimer type. The second ill-defined scenario, I_b, was about Mr. Pilsner, a 76-year-old male complaining of bloating. His final diagnosis was abdominal aortic aneurysm.

The W_a scenario, while categorized as a well-defined scenario by faculty, did not fit this definition for the recent graduates. Half of the subjects inaccurately diagnosed this scenario and took longest to complete it. The FNP recent graduates also reported that they were the least confident in making the final diagnosis in this case.

In contrast, the I_b scenario, while categorized as an ill-defined scenario by the faculty, did not fit this definition for the recent graduates. This scenario was the only one that all subjects accurately diagnosed. They were also very confident in their diagnosis and took less time than the scenarios with which they struggled. The other two scenarios, W_b and I_a, were perceived and classified in the same way by the recent FNP graduates and the faculty experts who classified the scenarios. W_b was diagnosed accurately by all but one subject. That subject was the recent graduate who had the least RN experience prior to entering the program. The W_b scenario took the least time and subjects were very confident in their diagnosis. The subjects also generated relatively few hypotheses for this scenario. The I_a scenario was misdiagnosed by 2 of 8 subjects; they reported less confidence, took more time, and generated the greatest number of hypotheses of any of the scenarios.

One conclusion of the study is that the definition of a problem is a function of the individual problem solver and their prior experience. This study used the opinion of experts to classify the scenarios; however, the subjects' performance did not support the expert classification. The ability of the clinician to solve a problem is based on what the clinician knows about the problem (Higgs & Jones, 2000). Recent FNP graduates bring a wide variety of nursing experiences to FNP education and those experiences may affect reasoning. Recent FNP graduates appeared to have a different knowledge base than the expert FNP faculty, and, in some cases, problem definition varied even among the recent FNP graduates. This finding is important to note because little research has been done on problem definition and hypothesis generation. This preliminary work will lay the foundation for further studies to explore problem definition in decisions made by FNPs.

Hypothesis Generation in Clinical Decision Making

As reported in Chapter 4, the total number of hypotheses generated approached statistical significance. The subjects in this study were consistent, with little variation in the number of hypotheses generated for each problem type. Of interest regarding the number of hypotheses generated, it has been found that diagnostic problems are solved by a process of generating a limited number of hypotheses or problem formulations early in the examination, followed by hypothesis evaluation and testing (Elstein et al., 1978). The number of hypotheses entertained is reported to be constrained by working memory

(Thomas, Dougherty, Sprenger, & Harbison, 2008). As noted in Information Processing Theory (A. Newell & Simon, 1972), humans have a long-term memory that is virtually infinite in capacity. However the short-term memory, or working memory, is limited to 7 +/- 2 *chunks* of information. While no direction was assumed between problem definition and number of hypotheses generated, the results of this study support the assertion in the literature that individuals work with a limited number of hypotheses in their short-term memory. Thomas et al. (2008) also found that the number of hypotheses that problem solvers can actively entertain at any point is constrained by not only cognitive limitations, but also by the characteristics of the problem to be solved. It is unclear from this study if the characteristics of the problem to be solved (ill defined or well defined) had an effect on the number of hypotheses generated because the subjects' individual perceptions of the problem characteristics were not assessed. However the two scenarios with the highest accuracy rate generated a mean number of hypotheses of 3.38 and 3.75 whereas the two scenarios with the lowest accuracy rate generated a mean of 5.25 and 5.12 hypotheses. These means seem to indicate that the problem solvers generated more hypotheses when the problem was more difficult for them. Based on the analysis of the data and the literature reviewed for this study, it could be recommended to further explore this concept in future studies.

The two scenarios that had the lowest accuracy rates had mean numbers of hypotheses that corresponded to the limits of working memory; however, it should be noted that the percentages of plausible hypotheses were reasonably high (75% and 62%). The two scenarios that had the highest accuracy rates had mean number of hypotheses below the number that would be expected of working-memory limitations. The subjects in this study generated small numbers of hypotheses for each scenario, and therefore, did not tax their limits for short-term memory capacity.

Accuracy, Time, and Confidence in Decision Making

There was no statistical difference shown for problem definition in relationship to accuracy. Despite lack of statistical significance, the highest ranked scenario in relationship to accuracy was a complaint considered ill defined by expert reviewers. By definition it was anticipated that the subjects would show greater accuracy in the well-defined scenarios rather than the ill-defined scenarios. While W_a was perceived by expert reviewers to be a well-defined complaint, it ranked lowest for accuracy (4 of the 8 subjects were accurate). These results again support the explanation that problem definition is in “the eye of the beholder.” In essence, each individual problem solver defines problem complexity on an individual basis.

Taken together, time and confidence may be best indicators of how difficult or ill defined a problem was considered to be by subjects in this study. For the most part, as time increased, confidence decreased. For example Subject 1 took longest on scenarios W_a and I_a and reported being somewhat confident on W_a and confident on I_a while on other scenarios that took less time, Subject 1 reported feeling confident and very confident. Subject 2 took the longest time on W_a and I_a, reporting both as confident whereas the other two scenarios took less time and Subject 2 reported feeling very confident about the analysis. Subject 7 took the longest time on W_a and I_a and reported confidence in the diagnosis. Less time was taken for the other two scenarios and Subject 7 reported being confident and very confident about the analysis. One of the reasons for this observed phenomenon may be that hypothesis generation is a product of each person's experience and education (Fonteyn, 1991; Higgs & Jones, 2000; Tanner et al., 1987; White et al., 1992). The literature reports that one difference between an average practitioner and an excellent practitioner is the speed at which they arrive at a correct diagnosis (Eddy, 1996).

Summary of Individual Subject Results Based on Professional Experiences

Individual results in this study are supported by the literature: decision making is dependent on context and based on experience. Further, decision making is put into a personal context as the decision maker formulates decisions. Content knowledge is an important part of this personal context and varies by each individual decision maker. The quality of a clinical decision depends heavily on the knowledge base of the decision maker (Szaflarski, 2000). In essence, if an individual has never encountered a certain disease process or learned about it, the assumption can be made that a diagnosis will be less accurate.

Subject 1 was accurate in three of the four scenarios. In the scenario that the subject misdiagnosed, memory loss, the practitioner was still confident in the diagnosis. Subject 1 may have missed this diagnosis due to the fact that the majority of the subject's professional experience came from the Emergency Department (ED), where there is little exposure to clients with memory loss as a chief complaint. Subject 7 was inaccurate on one scenario, back pain. Because this subject worked in the ICU and CCU it is presumed that this nurse had little exposure to clients with a chief complaint of back pain. Subject 8 was inaccurate in diagnosing the abdominal-pain scenario and was also less confident in this diagnosis. Subject 8 had little documented nursing experience working with clients whose chief complaint was abdominal pain. In contrast, Subject 6 was accurate on all of the scenarios, yet took more time on one of the ill-defined scenarios, memory loss. Most of this subject's work experience was in geriatrics, with ample exposure to clients with memory loss as a chief complaint. Perhaps this nurse spent more time on this scenario because of the subject's advanced content knowledge, thus identifying more cues or pertinent positive and negative information to assess and follow. Subject 3 was accurate in three of the four scenarios, but misdiagnosed the abdominal pain. This RN had 29 years of experience as a nurse in varied settings including ambulatory care and medical surgical supporting the resulting accuracy. However, this nurse had the least amount of experience in settings where abdominal pain is the presenting complaint.

In this study, RNs with a wide and varied degree of experience prior to entering the same FNP program demonstrated the ability to make quick, accurate decisions. Moore (1996) stated that the deeper and broader the nurse's knowledge base, the wider the range of cues they discover and use during the deliberation phase of the decision-making process. The impact of the relationship between content knowledge and the decision-making process has been well documented in the literature and was supported in this study (Barrows & Pickell, 1991; Carnevali & Thomas, 1993; Flagler & Mitchell, 2000; Fonteyn, 1991; Tanner et al. 1987; White et al., 1992).

The importance of the single-subject design to elicit these findings is emphasized. It is important to examine the performance of each individual rather than assessing group decision making. This allows researchers to make connections between individual experience and decision-making performance, to define problems based on individual experience, and to understand how experience constrains hypothesis generation.

Limitations of the Study

The scenarios selected after the expert faculty review included two well-defined scenarios and two ill-defined scenarios. Performance of recent graduate FNPs did not confirm this classification. This discrepancy in perception of problem definition limits interpretation of the results of this study. Ways of overcoming this limitation include having each subject rate or categorize the problem as ill defined or well defined during the process and performing an analysis based on their definitions.

This study was not performed under the pressure of a time constraint as it would be in an actual practice setting. Thus, subjects were not pressured to make decisions without ample time to consider all alternatives. However, actual practice settings require decision makers to be time efficient and make decisions under the pressure of a time limit. Thus, the artificial environment in this study limits the ability to apply the results to an actual practice setting. This study was performed in a laboratory simulation. Thus the results may not transfer to the actual practice setting. Replication of the study in a more naturalistic setting may strengthen the findings.

Recommendations for Future Research

Even though this study did not reveal many significant differences in the independent variable (problem definition) as it relates to the dependent variables (accuracy of the final diagnosis, number and plausibility of hypotheses generated, time elapsed from initial login to final diagnosis, and confidence in the final diagnosis), it has served to lay the groundwork for future studies. Some of that groundwork is related to the identification of well-defined and ill-defined scenarios. Because it was readily apparent in this study that problem definition was closely related to each subject's past experiences and contextual knowledge of the subject, each subject framed the problems presented in the various scenarios differently. Future studies examining the effects of problem definition and problem solving will need to examine the perception of problem definition for each individual subject. This study used expert faculty to classify the scenarios as either ill defined or well defined before presentation to the subject. A future study might ask each subject to classify the problem. For example, student or recent-graduate input rather than expert input might better delineate the way these scenarios are perceived by subjects with a particular level of expertise. In addition, the subjects could also validate or identify the level of problem definition (ill vs. well) on completion of the scenario. Perhaps problem definition is in "the eye of the beholder" and based more on an individual subject's experience and knowledge base. Problem definition may also be better delineated when the number of scenarios is increased.

Decision making is a complicated process that is not well understood, and because it is not observable, it is difficult to measure. Decision making is often rapid and may occur on a subconscious level (Benner, 1984; Benner & Tanner, 1987). Despite measurement difficulties, future work is imperative to refine strategies of measurement and improve understanding of clinical decision-making processes to potentially improve patient outcomes. Simulation studies that include "speak-aloud" techniques may enrich insight into individual decision-making processes as subjects report their steps and reasoning as they perform. Standardized simulation approaches could continue to be recommended because they also give insight into the individual decision-making process. Simulation software such as DxR Clinician has the capability of reporting individual's steps in their investigative approach to the chief complaint. Additionally, simulation approaches offer the ability to replicate without potential individual variances that may occur with use of standardized live patients.

To enhance the knowledge of clinical decision making, future research endeavors should include both single-subject and group designs. While the single-subject design captures individual decision making, replication with larger numbers of subjects can allow for inferences about decision making. Measuring clinical decision making longitudinally as a subject matriculates through an academic program, moving from RN to NP, allows further investigation of the individual development of the phenomena. The ability to establish baseline data regarding decision making and application of an educational intervention focusing on hypotheticodeductive reasoning would expand the approach to investigation of clinical decision making and improve the validity of results.

Recommendations for FNP Education

As health care continues to evolve, the decision-making responsibilities of the FNP will continue to expand (Hravnak et al., 1998). As a result, faculty is challenged to implement instructional approaches that will promote effective learning. The hypotheticodeductive-reasoning model is the basis for clinical decision making for the FNP (Chase, 2004; Cutler, 1998). The model facilitates the teaching of a "way of thinking" and a standard approach to clinical problem solving and can be used to strengthen certain decision-making skills. Because the subjects in this study demonstrated a pattern-matching type of decision making (inductive) versus the iterative thinking (deductive) characteristic of the hypotheticodeductive model, careful attention and evaluation should be given to the integration of the hypotheticodeductive-reasoning model in FNP curricula (Chase, 2004). Evaluation of students' understanding and application of the model at different points throughout a curriculum allows faculty to provide individualized learning experiences to enhance knowledge where gaps occur.

As clinicians become more comfortable and efficient in diagnosing commonly occurring problems that are well defined, such as appendicitis and back pain, they can scaffold their knowledge to improve their diagnosis of ill-defined problems such as abdominal aneurysms that may occur less commonly. On graduation, the FNP is expected to care for 80% of the conditions they encounter in a primary-care-practice setting accurately, cost effectively, and in a timely manner, with large volumes of patients. In this study, the well defined W_a problem was misdiagnosed by 3 of the 8 subjects. The occurrence of appendicitis in primary care is somewhat common and could be potentially fatal if misdiagnosed or undetected. An instructional process that focuses on the most common chief complaints encountered in clinical practice would be prudent to prepare the FNP for safe practice in the reality of today's practice environment.

In this study, the one subject with the least nursing experience prior to entry into the FNP program was least accurate in making final diagnoses after completion of the same curriculum as the more experienced nurses. It is not possible to generalize from a single subject, however, it does merit exploration into the professional work experience of nurses admitted to FNP programs.

Health-policy implications for this study relate to curriculum development. National standards for FNP education should be monitored for consistency to evidence-based educational methods and practices. Studies such as this one should be used to inform national standards as they relate to FNP curricular guidelines.

Recommendations for Practice

The main recommendation from this study is for education and future research about individual problem solving. Because NPs are in the practice domain and this study revolves around preparing students for entry into practice, these findings amplify the need for a focus on self-analysis of decision making that can translate into integration of new graduates in the practice setting. Mentors in practice settings can help prepare these new providers by giving them a list of the top 10 or 20 most common diagnoses seen in that practice. Meetings or discussion could be held reviewing ill-defined patient presentations in the practice setting.

Professional learning does not occur in a vacuum, but occurs in a context (Clark, 2001). The preceptor, in addition to ongoing patient-care responsibilities, provides the context for onsite clinical instructions for students. This relationship between the student and preceptor serves to facilitate growth in the profession. Because preceptors assist in the preparation of quality care providers, the preceptor is the key to linking classroom learning with application of that knowledge in the clinical arena (Risco, 2004). This study reinforces the need for quality NP preceptors who are aware of the hypotheticodeductive-reasoning method and have the capability of helping student apply it in the clinical setting.

Conclusion

Clinical decision making is essential to clinical nursing practice, yet research into the cognitive processes underlying clinical decision making is limited. The purpose of this study was to explore the impact of problem definition on the accuracy of the final diagnosis, total number of hypotheses generated, percent of the diagnostic hypotheses that are plausible, time from initial logon to final diagnosis, and confidence in the final diagnosis. Using an alternating-treatments single-subject design, this study used diagnostic-reasoning software as a means to provide web-delivered simulated-patient scenarios that describe patient problems that are either ill defined or well defined. The independent variable was problem definition (ill-defined versus well-defined problems). Analysis consisted of visual inspection of graphs and randomization tests for each of the five dependent variables for each single subject, to seek differences between diagnoses of ill-defined and well-defined problems.

This study has contributed additional knowledge to the decision-making literature on recent FNP graduates, but more research is needed. Clinical decision making is one of the hallmarks of clinical practice of the FNP and further investigation of the phenomenon beyond this study is warranted. As clinical decision-making behaviors of entry-level FNPs are better understood, effective instructional techniques and curricular enhancements will be valuable in expanding the efficiency with which FNPs are taught, and commensurately, their skill set as they enter practice.

Little is known about the effect of problem definition on hypothesis-generation accuracy in FNPs. The hypotheticodeductive-reasoning model served as the theoretical framework for the study. The study examined the effects of problem definition on 8 FNP recent graduates' ability to generate hypotheses of patient problems. Expected differences in accuracy between ill-defined and well-defined problems were not found. However, there were significant differences in time and confidence for diagnosing ill-defined and well-defined problems. It was concluded that problem definition is a function of the individual problem solver's experience. This conclusion is well documented in the literature and further refinement of this phenomenon should be included in future studies. Hypotheticodeductive reasoning was not used by most problem solvers; instead pattern matching was observed in recent FNPs diagnosis of patient problems. Future studies should address each problem solver's individual perceptions of problem definition. Programs that educate FNPs should evaluate students' understanding of the hypotheticodeductive-reasoning model and individualize learning experiences to promote accurate clinical decision-making.

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Appendices

Appendix A

Demographic Questionnaire

Please complete the following questions.

1. Age _______ years

2. Indicate your gender
   - ☐ male
   - ☐ female

3. Indicate your ethnic background
   - ☐ American Indian or Alaska Native
   - ☐ Asian
   - ☐ Black or African American
   - ☐ Hispanic or Latino
   - ☐ Native Hawaiian or Other Pacific Islander
   - ☐ White
   - ☐ Other

4. Indicate the first program you completed that prepared you to take the RN licensure exam.
   - ☐ ADN
   - ☐ Diploma
   - ☐ BSN

5. Do you have a degree in a non-nursing field? If yes please specify your degree.
   - ☐ yes
   - ☐ no

   If yes please specify your degree____

6. Do you hold national certification in any nursing specialty? If yes please specify your certification.
   - ☐ yes
   - ☐ no

   If yes please specify your certification______________________________________

7. Indicate your amount of work experience as an RN before you entered the FNP program (full time is considered 32 hours or more per week)

___________ years full time

___________ years part time

8. Indicate the clinical area where you have gained most of your experience as an RN, what year you last worked in this area on a regular basis, and how many years you have worked in this area.

If your experience is varied, please indicate the number of years next to each setting.

ICU	_____years	Last year worked________
CCU	_____years	Last year worked________
surgical ICU	_____years	Last year worked________
neonatal ICU	_____years	Last year worked________
pediatric ICU	_____years	Last year worked________
emergency room	_____years	Last year worked________
ambulatory care	_____years	Last year worked________
medical floor	_____years	Last year worked________
surgical floor	_____years	Last year worked________
pediatric floor	_____years	Last year worked________
labor/delivery	_____years	Last year worked________
post partum	_____years	Last year worked________
nursery	_____years	Last year worked________
operating room	_____years	Last year worked________
recovery room	_____years	Last year worked________
administration	_____years	Last year worked________
community health	_____years	Last year worked________
public health	_____years	Last year worked________
education	_____years	Last year worked________
psychiatry	_____years	Last year worked________
other	_____years	Last year worked________

please specify) ____

Appendix B

DxR Scenario Evaluation Form

Directions— You are being asked to evaluate 6 Diagnostic Reasoning (DxR) scenarios and to formulate a list of hypotheses for each case. Please make the list as complete as you can. You may include hypotheses that have a low likelihood of becoming the final diagnosis. After working through each DxR scenario, determine whether it represents an ill-defined or well- defined patient problem. Place each scenario into one category and indicate the category by placing a check mark in the appropriate column in table B1. Use the following definitions to categorize each scenario:

Ill-defined problems are those problems that (a) are more complex and have less definite criteria for determining when the problem has been solved, (b) do not provide all of the information necessary to solve the problem, and (c) have no procedure that guarantees a correct solution. Ill structured problems require more reliance on the resources of long-term memory.

Well-defined problems are those problems that are clearly formulated and have known algorithms and criteria available for testing the correctness of the solutions.

Table B1

List of Six Scenarios

	Ill defined	Well defined
DxR Scenario 1 - Mr. Corelli		
DxR Scenario 2 – Mrs. Ganter		
DxR Scenario 3 – Mr. Jackson		
DxR Scenario 4 – Mr. Pilsner		
DxR Scenario 5 – Mr. Sprague		
DxR Scenario 6 – Mrs. Swenson		

Please indicate if the patient's chief complaint and the final diagnosis of the problems presented are chief complaints and problems that commonly occur in primary care. Please also indicate if you think they are within the scope of practice of the FNP recent graduate.

Table B2

Patient Problem Presentation

	Does this chief complaint commonly occur in primary care?	Does this problem commonly occur in primary care?	Is this chief complaint within the scope of practice for a recent FNP graduate?	Is this problem within the scope of practice for a FNP?
DxR Scenario 1—Mr. Corelli				
DxR Scenario 2—Mrs. Ganter				
DxR Scenario 3—Mr. Jackson				
DxR Scenario 4—Mr. Pilsner				
DxR Scenario 5—Mr. Sprague				
DxR Scenario 6—Mrs. Swenson				

For each of the 6 scenarios, examine the hypothesis list. Please determine if each is a plausible hypothesis. Cross off hypotheses that are not plausible. Please add any other plausible hypotheses to the list.

Corelli Scenario
Mr. William Corelli is a 45 year old man who presents to your office with complaints of recurrent substernal burning in the lower part of his anterior chest. There is occasional radiation of the pain to the left shoulder. The problem has been present intermittently for two or three weeks.

HPI
I had an episode of lower chest pain one week ago which lasted about an hour. I was worried so I went to the Emergency room to get checked out and the doctor told me I didn't have a heart attack and that I should see my own doctor for follow-up on this matter. I've been having some discomfort in my lower chest intermittently for some time. I have not had any pain as severe as that one. But I do have a vague left sided chest discomfort which hurts a little when I push on my ribs. I also have a lot of gas and a fowl taste in my mouth when I burp. I've had one similar episode several years ago. I forgot what the Doctor told me I had but he did tell me to take antacids and the pain went away eventually. When I get these symptoms, I also feel slightly dizzy. Not enough to lose my balance and not enough to lose focus in my eyes. But enough so that I have to sit down for a minute or two. Then I'm better and I get on with my work.

Final Dx
The complete diagnosis for this patient is Barrett's Esophagitis and hypertension.

Hypothesis list
GERD
Barrett's esophagitis
Barrett's esophagus
h. pylori gastritis
helicobacter pylori gastritis
hiatal hernia
gastritis
gastroesophageal reflux disease
gastro-esophageal reflux disease—gerd
dyspepsia
cardiac disease
coronary insufficiency
PE
rule out acute myocardial infarction
gall bladder disease
peptic ulcer disease
hiatal hernia
esophagitis
GI malignancy
pancreatitis
cholecystitis
costochondritis

pneumonia
bronchitis
pulmonary embolism - PE
pericarditis
pleuritis
stress disorders
hypertension

Ganter Scenario
Mrs. Ida Mae Ganter, an 86-year-old female, was referred to Family Practice by the Office on Aging for evaluation of "memory loss".

HPI
Ida Mae Ganter is an 86 year old widow who is brought to the Family Practice office by a caseworker from the Area Office on Aging for evaluation of "memory loss." Mrs. Ganter admits that she's been "a little bit forgetful" at times, but aside from some visual problems due to cataracts, she insists that she's "getting along just fine." Ganter: "I have been a little bit forgetful for about six months, I guess. I have a little trouble concentrating, too."

Final Dx
The complete diagnosis for this patient includes primary degenerative dementia of Alzheimer type, and cataracts.
Hypothesis list
primary degenerative dementia of Alzheimer type
Alzheimer's disease
nonreversible dementia
cognitive dysfunction – moderate
rule out thyroid disorder
rule out cardiac origin i.e. arrhythmia
cerebral emboli
syphilis
chronic encephalitis
neoplasm of brain or meninges
hypoglycemia
hypoparathyroidism
DEMENTIA
Drugs
Emotional illness (including depression)
Metabolic/endocrine disorders (hypothyroidism, for example)
Eye/ear
Neurological (Parkinson's disease, stroke, normal pressure hydrocephalus)
Tumors/trauma, Infection (including neurosyphilis)
Alcohol/anemia.
rule out focal/lateralizing signs: cranial nerves, reflexes, sensory, motor, and cerebella
hepatic encephalopathy
uremia
cerebritis
vasculitis
cataract
lens opacity
lens opacification

Jackson Scenario
Mr. Tommy Jackson, an 18 year-old, presents to your office complaining of recent onset of abdominal pain.

HPI
I have this horrible pain in my belly. I was playing tennis when it first started about five hours ago. It was in my lower right side and I thought it was a pulled muscle. I sat down trying to relax, but it didn't go away. The pain is worse if I try to straighten up and it feels better if I sort of bend forward. It's a burning pain in the lower right side of my belly. I felt nauseous and I drank some 7 Up but that made me feel worse. I don't feel sore in my back and I can walk alright.

Final Dx
The complete diagnosis for this patient is acute appendicitis.

Hypothesis list
acute appendicitis
abdominal pain may originate in any organ
infection
abscess
organ infarction
inguinal hernia
terminal ilium
tuberculosis (tb)
intussusceptions
mesenteric adenitis
mesenteric infarcts
diverticulitis
colitis
cancer of colon
meckel's diverticulum
renal calculi
inflamed gallbladder

Pilsner Scenario
Mr. Harry Pilsner, a 76 year-old male, is being seen for evaluation of "bloating".

HPI
I feel bloated and have a pulsating feeling in my belly. I noticed this about six months ago. It seems to be getting worse lately. I can feel the pulsating when I am lying down, and I feel bloated all of the time. I do have arthritis a little, but it doesn't keep me from getting around. I also have this limp from an old farming accident. My main concern is the feeling in my belly. Another doctor said I might have something wrong with an artery in my belly. That worries me.

Final Dx

The complete diagnosis for this patient is abdominal aortic aneurysm.

Hypothesis list
abdominal aortic aneurysm (aaa)
rule out disorders affecting bowel motility and/or absorption
neoplastic,
vascular
endocrine/metabolic
neurologic
infectious categories
diabetes mellitus resulting in enteric neuropathy
CHF
mesenteric vascular atherosclerotic disease
intestinal malabsorption caused by hepatic parenchymal disease
Crohn's Disease
tropical sprue
celiac sprue
amyloidosis
scleroderma
small bowel lymphomas
regional ileitis
parenchymal liver disorders (many)
intrahepatic or extrahepatic cholelithiasis,
sequestration of bile salts by agents like cholestyramine
delayed gastric emptying resulting from diabetes
chronic duodenal ulcer disease (esp. Zollinger-Ellison disease)
carcinoma of the stomach,duodenum,
pancreas,
medications such as opiates or anticholinergics.
vagotomy or prior gastric surgery
hypothyroidism and disorders of calcium metabolism
pancreatitis
peritonitis
appendicitis
intra-abdominal abscess
infections of the gut, such as Salmonellosis or enteric parasites
malabsorption can also occur with alteration of gut bacterial flora, as occurs with strictures, fistulas, diverticuli, or antibiotics.
carcinoid syndrome
Whipple's Disease
Hartnup disease
progressive arterial occlusive disease due to Kohlmeier-Degos disease
vascular tumors
arteriovenous malformations
arterial aneurysms (e.g. renal, mesenteric)
atherosclerosis, or atheroembolic sequelae

adhesions from prior surgeries
bowel obstruction
bacterial overgrowth syndromes (e.g. blind loop syndrome)
malabsorption
recurrence of previously resected neoplasms

Sprague scenario
Mr. David Sprague, a 42-year-old male, is being seen for evaluation of chronic headache.

HPI
I've had this headache pretty constantly for 22 years, and it seems to be bugging me more lately. I don't know if it is really any worse, but it's making me feel dragged out. I feel like I don't pay attention to my work; I'm not as sociable and outgoing as I used to be, which is important for my work. It's a real pain in the neck. It seems to be centered sort of in the back of my throat or deep in here just under my ear (points to the corner of his jaw below the ear) but real deep in, and when it gets worse it spreads to the side of my head (spreads hands and places it over the left side of his face and temple). I really don't like having to take all the pills that I take for it, but if I don't take them I can't function. I take aspirin mostly. It helps the pain a bit, but it never really goes away.

Final Dx

The complete diagnosis for this patient includes carcinoma of the tongue.

Hypothesis list
trigeminal neuralgia
glossopharyngeal neuralgia
carcinoma
cancer
mass
thyroid cancer
thyroiditis
squamous cell carcinoma
sarcoma
rhabdomyoma
lymphoma
neuroma
salivary gland tumor
thyroid carcinoma
metastatic adenocarcinoma
tumors compressing the spinal cord and/or nerve roots
ear pain
rule out neoplastic compression syndromes (including pontocerebellar angle tumors such as acoustic neuromas and meningiomas, Jugular Foramen or Vernet's syndrome, Collet-Sicard syndrome)

Swenson Scenario
Ms. Donna Swensen is 52 years old, and is being seen for evaluation of back pain.

HPI
Yesterday I slipped on a waxed floor while I was walking through the lobby of an office building. I fell and hit my right hip and spine. There was a sudden really intense pain in my lower back, and it was hard to stand up after I fell. The pain is very sharp, and it's still hard for me to stand up or walk. It's debilitating. It makes it hard to do anything - I can't even do my daily routine because the pain is so bad. Any movement makes it worse. The pain is in the lower part of my back, but nowhere else. I was afraid I might have broken something, so I decided to come in and see you.

Final Dx
The complete diagnosis for this patient includes vertebral compression fracture secondary to osteoporosis.

Hypothesis list
osteoporosis
domestic violence
contusion
herniated nucleus pulposa
herniated disc
low bone density
osteopenia
degenerative arthritis
spinal stenosis
metastasis
vertebral compression fracture
vertebral fracture
compression fracture

Appendix C

Letter to Potential Subjects

DUQUESNE UNIVERSITY

SCHOOL OF NURSING
FISHER HALL

600 FORBES AVENUE
PITTSBURGH, PA 15282
TEL 412.396.6550
FAX 412.396.6346
www.nursing.duq.edu

Dear ___________ (insert recent graduate name),

Understanding how beginning clinicians make clinical decisions is very important to those who are educating clinicians. I am a Family Nurse Practitioner, Assistant Professor of Nursing at Slippery Rock University and a doctoral student at Duquesne University School of Nursing. My dissertation is studying how beginning nurse practitioners make clinical decisions.

I am asking you to participate in my dissertation study. Should you decide to participate, you will be asked to work through four Diagnostic Reasoning (DxR) cases (up to the point of making the clinical diagnosis). It is expected that it will take most subjects 30 to 60 minutes for each scenario and therefore approximately 2 to 4 hours to partially complete the four cases. You will be provided with general feedback on the four cases when you have completed them all. Individual feedback about your specific performance will be provided to you within two weeks of completing the DxR cases. In recognition of your participation you will be compensated for your time and expertise with $100 upon completion of all scenarios. You will also be reimbursed at the federal rate (58.5 cents per mile) for round-trip mileage to the testing site.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will not be disclosed under any circumstances. All information will be kept in a locked file cabinet in my office. My research advisor(s) and I will be the only persons with access to the data collected. There is no risk associated with this study and no consequences for withdrawal. If you have any questions about the study, you can contact me at (814) 671-6174.

If you are interested in participating in this study, please sign and return the consent forms to me in the pre-stamped self-addressed envelope provided.

Sincerely,

Kerry S. Risco, MSN, CRNP, NP-C, WCC
Doctoral Candidate
Duquesne University School of Nursing
Pittsburgh, PA 15282

Appendix D

Instructions for Subjects

The following instructions will be provided to the subjects:

1. Please complete the demographic data form.
2. You will receive four DxR scenarios. You must proceed to work through the scenarios in the order the patients were assigned to you. Please do not discuss the scenarios with others because people will work through the scenarios in different orders.
3. At the end of the scenario, please make a final diagnosis. This is the diagnosis that you think is the best description of the patient's condition. At this point please also be certain that all hypotheses that you considered are also on the list of diagnostic hypotheses in the DxR program.
4. After the first scenario take a 5-minute break.
5. After the second scenario take a 15-minute break.
6. After the third scenario take a 5-minute break.
7. After you have completed the four scenarios you will receive a check for $100, fill out a form for travel reimbursement, and then you may leave for the day.
8. Individual feedback about your specific performance will be provided to you within two weeks of completing the scenarios.

Appendix E

Institutional Review Board

DUQUESNE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

424 RANGOS BUILDING ♦ PITTSBURGH PA 15282-0202

Dr. Paul Richer
Chair, Institutional Review Board
Human Protections Administrator
Phone (412) 396-6326 Fax (412) 396-5176
e-mail: richer@duq.edu

July 24, 2008

Ms. Kerry Risco
11118 Charles Street
Meadville PA 16335

Re: Problem definition and hypothesis generation by family nurse practitioners (Protocol # 08-86)

Dear Ms. Risco:

Thank you for submitting your research proposal to the IRB.

Based upon the recommendation of IRB member, Dr. Kathleen Sekula, along with my own review, I have determined that your research proposal is consistent with the requirements of the appropriate sections of the 45-Code of Federal Regulations-46, known as the federal Common Rule. The intended research poses no greater than minimal risk to human subjects. Consequently, the research is approved under 45CFR46.101 and 46.111 on an **expedited** basis under 45CFR46.110.

Attached is the consent form with our approval and expirations dates. You should use it as original for copies that you distribute.

This approval must be renewed in one year as part of the IRB's continuing review. You will need to submit a progress report to the IRB in response to a questionnaire that we will send. In addition, if you are still utilizing your consent form in one year, you will need to have it renewed. In correspondence please refer to the protocol number shown after the title above.

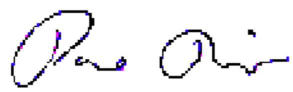
If, prior to the annual review, you propose any changes in your procedure or consent process, you must inform the IRB of those changes and wait for approval before implementing them. In addition, if any unanticipated problems or adverse effects on subjects are discovered before the annual review, they must be reported to the IRB Chair before proceeding with the study.

When the study is complete, please provide us with a summary, approximately one page. Often the completed study's Abstract suffices. You should retain a copy of your research records, other than those you have agreed to destroy for confidentiality, over a period of five years after the study's completion.

Thank you for contributing to Duquesne's research endeavors.

If you have any questions, feel free to contact me at any time.

Sincerely yours,



Paul Richer, Ph.D.

C: Dr. Kathleen Sekula
Dr. Linda Goodfellow
IRB Records

Appendix F

Duquesne University Consent to Participate

Duquesne University
Institutional Review Board
Approval Date: July 24, 2008
Expiration Date: July 24, 2009

DUQUESNE UNIVERSITY

600 FORBES AVENUE ♦ PITTSBURGH, PA 15282

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE: Problem Definition and Hypothesis Generation by Family Nurse Practitioners

INVESTIGATOR:
Kerry S. Risco MSN, CRNP, NP-C, WCC
11118 Charles Street
Meadville, PA 16335
(814) 333-2809
(814) 671-6174

ADVISOR: (if applicable:)
Linda Goodfellow, PhD, RN
Associate Professor
Duquesne University School of Nursing
517 Fisher Hall
Pittsburgh, PA 15282
(412) 396- 6548

SOURCE OF SUPPORT: This study is being performed as partial fulfillment of the requirements for the doctoral degree in nursing at Duquesne University. This study received partial support from Eta Chapter, Sigma Theta Tau, Inc. 2008. This study also received partial support from Epsilon Phi Chapter, Sigma Theta Tau, Inc., 2008.

PURPOSE: You are being asked to participate in a research project that seeks to investigate how recent graduates from a FNP program make clinical decisions. You will be asked to work up four patients using the DxR software only to the point of making the final diagnosis.

These are the only requests that will be made of you.

RISKS AND BENEFITS: There are no risks greater than those encountered in everyday life. Some benefits to participation include the opportunity to care for standardized patients and receive feedback on that experience. Light refreshments will be provided. No other direct benefits exist other than the satisfaction of having participated in a research study.

COMPENSATION: Subjects will be compensated for their travel at 58.5 cents/mile and $100 for their time. Participation in the project will require no monetary cost to you.

CONFIDENTIALITY: Your name will never appear on any survey or research instruments. No identity will be made in the data analysis. All written materials and consent forms will be stored in a locked file in the researcher's home. Your response(s) will only appear in statistical data summaries. All materials will be destroyed at the completion of the research.

Duquesne University
Institutional Review Board
Approval Date: July 24, 2008
Expiration Date: July 24, 2009

RIGHT TO WITHDRAW: You are under no obligation to participate in this study. You are free to withdraw your consent to participate at any time.

SUMMARY OF RESULTS: A summary of the results of this research will be supplied to you, at no cost, upon request.

VOLUNTARY CONSENT: I have read the above statements and understand what is being requested of me. I also understand that my participation is voluntary and that I am free to withdraw my consent at any time, for any reason. On these terms, I certify that I am willing to participate in this research project.

I understand that should I have any further questions about my participation in this study, I may call

- Kerry Risco, MSN, CRNP, NP-C, WCC at 814-333-2809 or 814-671-6174; email at kerry.risco@sru.edu or write to 11118 Charles Street Meadville, PA 16335.
- Linda Goodfellow RN, PhD, Advisor, at 412-396-6548.
- Dr. Paul Richer, Chair of the Duquesne University Institutional Review Board at 412-396-6326.

____________________________________ ________________
Subject's Signature Date

____________________________________ ________________
Researcher's Signature

Appendix G

DxR Overview Statistics