The Utility of Cognitive Testing in the Nurse Anesthesia Admission Process as a Novel Predictor of Situational Awareness and Academic Success

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Abstract

This project sought to justify the use of cognitive testing within the nurse anesthesia admission process as a means to predict the development of situational awareness (SA) and academic success. Breakdowns in provider SA are found to be linked to medical error resulting in societal and financial consequences. Therefore, healthcare necessitates nurse anesthetists whom successfully graduate equipped with the level of SA needed to manage the dynamicity of this acute level of patient care. A challenge in academia, however, is predicting prospective students' abilities to master course objectives and develop this crucial trait once admitted. This is confounded by the scarcity of literature that supports admission criteria set by differing programs as well as nationally mandated criteria. Given the predictive relationship that cognitive testing, through the use of Raven's Progressive Matrices (RPM), has upon both the development of SA, as well as academic and job-related success, it was believed to be conceivable that use of this tool could fulfill a need for evidence-based criteria in the admission process that correlates with student success and the ability to develop SA. Through the use of this tool, this study examined prospective students' cognitive testing results in a correlational design against the traditional indices of admission set forth by the national standards and the program. The admission committee was surveyed post-admission decision to assess the value they ascribe to SA, de-identified score reports, and cognitive testing in the admission process. Implications of the final presentation demonstrate the utility of cognitive testing in the admission process as a means to assist faculty in admitting students with the greatest potential to successfully graduate as competent providers who embody SA in their practice.

The Utility of Cognitive Testing in the Nurse Anesthesia Admission Process as a Novel Predictor of Situational Awareness and Academic Success

Upon entry to their profession, certified registered nurse anesthetists (CRNAs) must be prepared to manage the inherent complexity of their practice in which crisis can rapidly progress to catastrophe. A key component of delivering care of this caliber amidst the complex environment of anesthesia is the construct of situational awareness (SA), without which, medical error is prone to occur (Flynn Sandaker, & Ballangrud, 2017; Gaba, Howard, & Small, 1995; Graafland, Schraagen, Boermeester, Bemelman, & Schijven, 2015; Schulz, Endsley, Kochs, Gelb, & Wagner, 2013; Wright & Fallacaro, 2011). SA is demonstrated as one's ability to perceive the elements of a stressful surrounding environment, comprehend their significance and project their future status so as to make astute decisions rapidly (Endlsey, 1988; Wright & Fallacaro, 2011). In order to graduate as such efficient and safe providers, student nurse anesthetists (SRNAs) must possess the qualities to develop this essential trait during their academic tenure. While SA may be cultivated, however, it is not a trait that is found to be universally attainable (Schulz et al., 2013).

Literature shows that those expected to be proficient in a field may have differing levels of SA, and demonstrate varying degrees of performance under stressful situations. These differences have been attributed to varying levels of cognition, where higher levels of cognition show a correlation with the degree of SA (Endsley & Bolstad, 1994; Schulz et al., 2013; Wright & Fallacaro, 2011). This is consistent with the theory described by Endsley and Garland (2000) that SA development is contingent upon one's cognitive abilities, in addition to other qualities like memory and automaticity. In exploring these relationships in SRNAs, Wright and Fallacaro (2011) found a significant correlation only between cognition and SA. With 20% of the variance in students' SA explained by the variance in their degrees of cognition, the study finds cognition to be the best predictive quality of SA development in SRNAs (Wright & Fallacaro, 2011).

A challenge for SRNAs is not only to graduate as proficient providers possessing SA, but also to successfully master course objectives in reaching this goal. In addition to predicting an SRNA's ability to develop the crucial construct of SA, cognition has proven itself in various avenues to also predict one's ability to succeed academically (Andrich & Styles, 1994; Jensen, 1980; Kuncel, Hezlett, & Ones, 2004; Lumsden, Bore, Millar, Jack, & Powis, 2005; Raven, Raven, & Court, 1998a). This is in contrast to currently utilized criteria in the nurse anesthesia admission process that aim to predict student success in a program, though are unfounded in evidence (Burns, 2011; Ortega, Burns, Hussey, Schmidt, & Austin, 2013; Wright & Fallacaro, 2011). Such criteria are inclusive of the minimum requirement of one year critical care experience (Council on Accreditation of Nurse Anesthesia Educational Programs [COA], 2014), a varying measure that does not necessarily demonstrate the quality of critical care experience, nor one that has shown to predict an SRNAs' levels of SA (Reese, 2002; Wright & Fallacao, 2011). Other assessment techniques utilized by programs are largely unstandardized and subjective, confounded by the potential for unapproved collaboration among nurse anesthesia program candidates regarding interview topics or examination questions (Fauber, 2006). Ultimately, such measures may be skewed in their abilities to predict program success and the development of SA, potentially resulting in the admission of students who may be unable to manage the complexity of their academic and clinical experiences (Burns, 2011; Wong & Li, 2011; Wright & Fallacaro, 2011).

Therefore, a need for a more objective, validated and reliable assessment tool in the interview process was identified. Given its predictive impact on SA development and academic success, it was believed that the implementation of a cognitive assessment that fit these criteria may have significant value in the selection of nurse anesthesia candidates with the greatest potential. The Raven's Practice Matrices (RPM) is a widely utilized tool that has demonstrated, with reliability and validity, its ability to measure cognition in prediction of both academic and job-related success (Jensen, 1980; Raven, 2000). It has also been previously correlated with SA as measured by the Wondrous Original Method of Basic Airmanship Testing- Complex Systems Operators (WOMBAT-CS Situational Awareness and Stress Tolerance Test), demonstrating cognition's predictive quality on this crucial construct (Wright & Fallacro, 2011). Raven's Advanced Progressive Matrices (APM-III), an updated version of the original RPM, is a computer based assessment that shares consistent reliability and validity with its predecessor and is designed for users like graduate students who tend to exhibit higher cognition than that of the average population (Raven, Raven, & Court, 1998b). Such a tool was therefore found to be optimally-suited to assess cognition in the SRNA for the purpose of predicting SA and academic success.

Employment of RPM in the nurse anesthesia admission process to predict SA and academic success has promise in positively effecting academia, the nursing anesthesia profession and the healthcare society at large. Incorporation of this tool into an admission process may help fill the evidentiary gaps of currently utilized criteria that may otherwise result in increased academic jeopardy and attrition, yielding pressing financial burden for students, nurse anesthesia programs, and universities at large (Burns, 2011; Wong & Li, 2011; Wright & Fallacaro, 2011). Afforded by the ability to predict SA development in the selection process through the use of RPM, programs may thereafter be more aptly suited to pursue continuing research that examines ways to then best develop SA in admitted students (Wright & Fallacaro, 2011). The admission and retention of successful and capable students may also lead to the future hiring of more qualified nurse anesthesia providers and faculty, bridging a need set forth by societal healthcare demands for competent, safe and efficient providers who embody SA (Burns, 2011; Wright & Fallacaro).

Background and Significance

Patient Safety

Patient safety is a critical feature of quality healthcare, and thus, both its maintenance and improvement are of the utmost concern. Threatening such endeavors is human error, most notably identified as a leading cause of death and injury in the United States in the National Academy of Sciences' Institute of Medicine report, "To Err is Human: Building a Safer Health System" (Kohn, Corrigan, & Donaldson, 1999). This report highlights the impact of human factors on errors in estimating that up to 770,000 patients are harmed and between 44,000 and 98,000 patients die each year from preventable medical errors (Kohn, Corrigan, & Donaldson, 1999). More recent reports approximate 250,000 deaths occur yearly in the United States as a result of medical errors (Andel, Davidow, Hollander, & Moreno, 2012).

High-risk specialties of healthcare confer a substantial contribution to these statistics, evidenced in the 30 to 50% of inpatient adverse events occurring specifically in surgery and anesthesia (Flynn et al., 2017; Kennerly et al., 2014). In a retrospective analysis of anesthesia-related intraoperative error, Cooper, Newbower, Long and McPeek (2002) found that 82% of these were related to human error versus equipment failure. Despite an overall decline in morbidity and mortality related to anesthesia events over the past two decades, Wright and Fallacaro (2011) recall that when patient complications do occur, they can be devastating, resulting in brain damage, paralysis, nerve injury, or death. In the work environment, anesthetists are inundated with information, both explicit and inconspicuous in nature. One’s attention must constantly shift while maintaining focus to make the most astute decisions based on rapidly-deduced data. It is therefore clear that patient safety is highly dependent on an anesthetist's awareness of the conditions and ability to effectively react in all domains preoperatively, intraoperatively and postoperatively (Fioratou, Flin, Glavin, & Patey, 2010).

Situational Awareness

It has been widely demonstrated that a key component to the vital maintenance of safety within dynamic and complex domains is the construct of situational awareness (SA) (Endsley 1988; Endsley & Bolstad, 1994; Schulz et al., 2013; Gaba et al., 1995; Wright & Fallacaro, 2014). A concept originating in the fields of military and aviation, SA has been defined by Endsley as the "perception of elements of the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (1995). In an expanded form, SA as mental model incorporates three hierarchical levels of mindfulness. Level 1 marks one's primary ability to perceive an issue. Level 2 marks one's comprehension to understand the issue's relevance. Level 3 denotes the ability to project future outcomes so as to effectively intervene, pertinent to the safety of an operation (Endsley, 1988; Endsley, 1995). SA is quantifiable through the use of the reliable and validated tools such as WOMBAT-CS, a computerized test developed to measure individual aptitude to perceive important details, prioritize their significant and project their sequelae while remaining vigilant within a high stress environment (LaRoche, Corl, & Roscoe, 2001; O'Hare, 1997). Designed for professionals in charge of complex operations that involve significant data input demanding evaluation, the operator's combined ability to master three-dimensional tracking, orientation, pattern recognition and short-term memory while monitoring peripheral indicators so as to reprioritize tasks has been found to be ultimately indicative of one's situational awareness (LaRoche, Corl, &

Roscoe, 2001).

The hierarchal components of SA and the necessity of a provider to meet operational demands have also been found to apply to anesthesia, where the stress levels and operational complexity experienced by providers similarly necessitate heightened awareness (Gaba et al., 1995; Schulz et al., 2013). While SA is a key component of delivering safe and effective anesthesia, its study within the profession lags in comparison to the in-depth investigation within the military and in aviation, where research has yielded ways to improve both the selection and training of individuals embodying SA (Flynn et al., 2017; Graafland et al., 2015; Wright & Fallacaro, 2011). In expansion of the definition of SA, Endsley identified five primary areas that may relate to individual differences in SA: spatial awareness, attention, memory, perception, and cognitive functions (1988). Endsley and Bolstad (1994) acknowledged both these attributes as well as experience through which the development of automaticity reduces the demands for task attention.

According to Endsley and Bolstad (1994), to make any improvements in SA, however, it is necessary to determine which factors allow one person to achieve better SA than another. Therefore, primary investigations of these factors in the field of aviation aimed to identify ways in which these attributes may set apart experts from novices within the field. Studied characteristics included length of experience (defined as automaticity), spatial awareness, attention, memory, perception, and cognitive functions. Of these, an individual's level of cognition surpassed all others as the most significant predictor of one's level SA. This was founded in a 10-fold difference in SA among highly experienced pilots, which was itself attributed to individual differences in cognitive capabilities (Endsley & Bolstad, 1994; Schulz et al., 2013). Given the emphasis of SA's essential role in promoting operational safety, it is therefore crucial that cognition, as a predictor of SA, be further explored to ensure optimal outcomes. Though the research of SA in the field of anesthesia is developing, SA in the medical field is similarly “integral for providing optimal performance during the treatment of patients” (Schulz et al., 2013). Wright and Fallacaro (2011) examined the trait in student registered nurse anesthetists (SRNAs), finding individual cognition levels to have a direct correlation with measured SA, consistent with the findings of Endsley and Bolstad (1994) as demonstrated in the aviation population. Given the significance of human error and resultant catastrophic outcomes in the medical field, attention to counteractive efforts to minimize error are essential. As has been done in other industries, this should be inclusive not only of SA, but its attributable predictors such as level of cognition.

Problem Statement

The aim of this project was to answer the following research question: Do students admitted into the [redacted] Nurse Anesthesia Doctor of Nursing Practice (DNP) program, based upon current admission criteria, possess higher cognitive scores as indicated by a validated and objective cognitive testing instrument compared to those not admitted into the program? The research was conducted during the fall 2018 interview process for anesthesia cohort admitted in spring 2019 so as to assess the value of the cognitive tool in future interview processes as a predictor of individual SA.

Needs Assessment

The need to objectively select nurse anesthesia candidates most capable of developing the necessary trait of SA to promote safe anesthesia practice propelled this investigation. Factors determining this need were exhibited both at the national, institutional and accreditation levels, and locally, at [redacted], with implications across the entire continuum.

Nationally, these factors are among the most widely accepted admission criteria for candidates supported by the COA, including licensure as a registered nurse and a minimum of one-year critical care experience (COA, 2014). The settings of applicants' previous critical care practice are most often an intensive care unit (ICU), the complex nature of which reflects the cognitive-processing demands of anesthesia. These national requirements are in addition to locally-set criteria for admission which is delineated by the individual COA accredited institutions. The culmination of these requirements is then embraced by faculties as a modicum demonstration of the critical thinking necessary for successful program completion (Wright & Fallacaro, 2011). Through the application and interview process, [redacted] University Nurse Anesthesia program seeks students most capable of success in the program, specifically afforded by their perceived level of cognition and situational awareness. Means of assessing these constructs include:

- Interview skills
- Writing sample
- Grade point average (GPA)
- Resume detailing critical care experience
- Letters of recommendation
- Critical Care Registered Nurse (CCRN) examination scores

While these criteria are maintained as predictors of student success, none are well described in research (Burns, 2011; Ortega at al., 2013; Wright & Fallacaro, 2011). Largely, the evaluation of such indices is at the discretion of the evaluating faculty. Exceptional to these varying criteria, however, is the national minimum criteria set forth by the COA. These include students who are, at the least, baccalaureate-prepared and registered as a professional nurse with a minimum of one year critical care experience (COA, 2014). Despite the standard requirements, Wright and Fallacaro (2011) found no correlation between length of ICU experience and levels of students' SA as they sought to explore the relationship of proposed predictors of the ability to develop SA in SRNAs. Additionally, it is proposed that length of ICU tenure does not necessarily reveal the quality of the one's experience, as the complexity of cases candidates have managed may differ (Reese, 2002). The culmination of these evidentiary gaps may result in students who fall short of honing the ability to manage the complexity of their academic and clinical experiences.

Confounding the lack of literature supporting current criteria, current assessment techniques utilized by individual programs are often subjective and unstandardized. Interview topics and examination questions are subject to unapproved collaboration among students which may skew the perception of potential candidates (Fauber, 2006). Ultimately, such measures may not be as predictive of success in a program nor its ability to predict the development of SA, creating a need for an alternative predictive measure founded in evidence.

A similar need has been noted in the medical school admission process, leading to research utilizing standardized cognitive test scores to ascertain whether they aligned with the outcome of medical school admission. Based on the percentage of students admitted who demonstrated cognitive scores significantly lower than the mean, researchers postulated that the use of a standardized tool may enhance the selectivity in a highly competitive program with limited capacity (Lumsden et al., 2005). Employment of a standardized cognitive tool in the nurse anesthesia admission process may similarly have potential to streamline its respective selection process. To this end, the PIs proposed the use of this objective measure to assess cognition and its inherent correlation with SA, which would afford the selection of the best candidates whom possess the necessary foundation to become safe and competent SRNAs and thereby future certified registered nurse anesthetists (CRNAs).

Aims and Objectives

The aim of this project was to assess whether cognitive testing at the admission process correlated with current admission criteria, admission status, and level of SA. It assessed whether the current admission criteria used by the [redacted] Nurse Anesthesia DNP program correlated well with a validated measure of cognitive skill during the admissions process. The objectives were as follows:

1. To explore the association between an objective measure of cognition and program admission status,
2. To compare cognitive scores as predictors of admission status versus current admission criteria (e.g., CCRN scores and interview rubric score),
3. To assess the feasibility of using a validated tool in the SRNA admission process.

Review of the Literature

A comprehensive literature review was conducted to investigate the history of SA and pertinence to the field of anesthesia, SA prediction and development in the SRNA, cognition as a predictive construct of SA, and then utilization of cognitive testing in academia. The databases utilized for this search included Medline, PubMed, The Cochrane Library, Cumulative Index of Nursing & Allied Heath (CINAHL), PsychInfo, OVID, and ERIC. In addition, a myriad of grey literature was pursed to enrich the totality of results obtained. Such sources include Google Scholar, National Guidelines Clearinghouse Agency for Healthcare Research and Quality (ARHQ), ResearchGate, Pearson Education Inc., and personal professional communication. Inclusion criteria included availability in the English language, full texts, and scholarly and peer reviewed articles. Initial searches that were limited to articles published within the last ten years demonstrated a scarcity of relevant results. Thus, the span of publication dates was widened to include those articles published within the last 20 years. Key terms used included *healthcare/medicine, patient safety, human error, nurse anesthetist, CRNA, student nurse anesthetist, SRNA, anesthesia, situational awareness, predictors of success, admission criteria, cognition, pattern recognition, G factor, advanced progressive matrices (APM), standard progressive matrices (SPM).* Each article was reviewed for relevancy, after which approximately 30 articles were maintained for further scrutiny. Ultimately, 16 were applicable and included in the review of the literature (Appendix C).

Situational Awareness in Anesthesia

The field of anesthesia is one demanding the utmost attention to detail and high-quality performance to ensure the safety of patients. This inherently requires that providers perform with expertise. Other domains that similarly require expert provision to ensure safe outcomes include the military and aviation. Constituting this level of optimal performance is the repeatedly studied construct of SA, which includes one's ability to perceive an issue, interpret its significance and project future outcomes, ultimately yielding effective decision making (Endsley, 1988; Endsley, 1995, Endsley & Boldstad, 1994). Sarter and Woods (1995) surmised that concepts related to SA may arise in other fields, including anesthesia. Gaba, Howard, and Small (1995) were the first to affirm this conjecture, discussing the similarly shared characteristics of anesthesia with aviation. These include dynamism, complexity, high information load, variable workload, and risk. The variables intertwined, Gaba et al. (1995) paint the picture of the anesthesia environment full of rapid changes with cues embedded in complex data influxes.

Amidst this turbulence, anesthesia providers must perform a variety of tasks, both routine and those that arise resultant of the changing patient status. The perceptual processes of providers are thus inevitably challenged to detect cues, interpret their significance and effectively intervene. In their work, Gaba et al. provide several exemplary accounts of this kind of challenge, and the resultant harm that may occur when the demands are unable to be met:

> During a simulated anesthetic, the anesthesiologist became concerned immediately after insertion of the breathing tube that no carbon dioxide could be detected in the gas exhaled from the patient. This can be an important cue that the breathing tube is incorrectly placed, but in this case there was abundant evidence to the contrary. While engaged in disturbance management of this problem, the anesthesiologist failed to maintain awareness of the blood pressure and heart rate, which were both decreasing catastrophically as a result of an independent second problem. An anesthetic vaporizer had been inadvertently set to deliver a high dose of anesthetic gas. (1995)

Gaba et al. (1995) emphasize that consistent with aviation, such human factors, as opposed to technical error, are the root of most preventable errors in anesthesia. In a retrospective analysis of anesthesia-related intraoperative error, Cooper, Newbower, Long and McPeek (2002) found that 82% of errors analyzed were related to human error versus equipment failure. Ongoing evidence-based investigation into over thousands of closed anesthesia malpractice claims through the ASA Closed Claims Project has led to the identification of several contributors to loss and injury. These are overwhelmingly due to human errors including lack of attention, haste, fatigue, stress, information overload, failure to communicate, unrecognized breathing circuit disconnection, mistaken drug administration, airway mismanagement, anesthesia machine misuse, and intravenous line disconnection (Wright, 2009)

Given the catastrophic potential of adverse outcomes, anesthesia related human errors necessitate continuous analysis and research (Wright, 2009). Rasmussen (2003) and Reason (1990) propose that in order to understand complex human errors, research should be directed toward the cognitive aspects of human behavior rather than on errors themselves. Further investigations have specifically found the loss of anesthesia provider SA amidst the complex and dynamic practice environment to be linked with human error (Flynn et al., 2017; Graafland et al., 2015; Wright & Fallacaro, 2011). Alarmingly, this loss of SA has been found to account for 81.5% of errors in anesthesia-related critical incidents (Schulz, Krautheim, Hackermann, Kruzer, Kochs, & Wagner, 2016). As anesthesia providers are inherently threatened with the loss of SA and human error, the investigation of human performance and ways in which to improve it are vital toward improving patient safety (Gaba, Howard, & Small, 1995).

Wright and Fallacaro (2011) similarly denote the importance of SA as a key component of delivering safe and effective anesthesia care. They emphasize that while the past two decades have seen a decline in morbidity and mortality in anesthesia-related events, the outcomes of complications are oftentimes devastating. According to the authors, the rarity of such events has posed a significant challenge to nurse anesthesia programs to effectively prepare SRNAs to manage high-stake, critical events. This is confounded by the insufficiency of evidence regarding the identification and development of SA in student nurse anesthetists (Fore & Sculli, 2013; Wright & Fallacaro, 2011). Guided Endsley's by theories that SA may be influenced by individual attributes (Endsley, 1988; Endlsey & Bolstad, 1994; Endsley & Garland, 2000), Wright and Fallacaro (2011) designed their study to identify potential characteristics that may similarly predict an SRNA's potential to develop SA. Of the attributes previously studied in the aviation industry, Wright and Fallacaro (2011) focused their correlations with the SA levels of SRNAs on the variables of cognition, working memory and automaticity, as these factors were believed to be the most modifiable within nurse anesthesia education.

Consistent with previous studies in the aviation field measuring SA, Wright and Fallacaro (2011) employed the WOMBAT-CS to quantify SRNAs' individual levels of SA. They then examined the individual attributes of memory and cognition. Automaticity, which has previously been described as resulting from experience, was measured by length of ICU tenure (Endsley, 1988; Endsley & Bolstad, 1994). Working memory was assessed using the valid and reliable Digit Span test, which is a subtest of the revised Wechsler Adult Intelligence Scale (WAIS-III). Cognition was measured using the valid and reliable Raven's Standardized Progressive Matrices (SPM). In exploring the relationships of these factors with SA in junior and senior SRNAs (n=71), Wright and Fallacaro (2011) found a significant correlation only between cognition and SA. Correlational output revealed a moderately strong association between cognition and SA (r = 0.442, p = .000). The coefficient of determination (r^2) between cognition and SA was calculated as 0.195, indicating that approximately 20% of the variance in SA is explained by the variance cognition. As no other theorized predictive constructs demonstrated a significant correlation with SA, cognition was ultimately found to be the best predictive quality of SA development in SRNAs (Wright & Fallacaro, 2011). These findings support previous findings seen in aviation that cognition serves as the most reliable predictor for one's ability to develop SA (Endsley & Bolstad, 1994; O'Hare, 1997; Schulz et al., 2013). Given the critical need in anesthesia reduce human error which has previously been found to be due the loss of SA, the authors warrant further examination of cognition as a predictor of SA. They note a potential benefit of utilizing cognitive testing specifically in the admission process, serving as a more reliable predictor, when compared with acute care experience, of an applicant's ability to manage complexity, make critical decisions, and solve unfamiliar problems. (Wright & Fallacaro, 2011). Ideally, its employment in the admission process would provide a needed, evidence-based way to evaluate candidates who may best develop SA and be better equipped when faced with crises (Burns, 2011; Wong & Li, 2011; Wright & Fallacaro, 2011**).**

Measuring Cognition

From the work of Wright and Fallacaro (2011) and others examining SA in the aviation industry (Endsley, 1988; Endsley & Bostad, 1994; O'Hare 1997), it is clear that while SA is essential to perform optimally in critical situations, its development may not be possible without a closer examination of the predictive attribute of cognition. Endsley & Garland (2000) suggest that cognitive processes such as pattern matching, conscious analysis, story building, and mental simulation, may be used by operators at various times to develop SA. Spearman (1904) hypothesized that human intelligence stems from an innate cerebral trait. He refers to this quality as the G factor (*g*), a quality which serves as the underpinnings of cognition necessary to all forms of problem solving. Spearman's intelligence theory demonstrates that an individual's scores on all cognitive examinations are positively correlated with *g*. Additionally, it is accounts for variances in performance secondary to individual differences in mental processing and efficiency (Kuncel et al., 2004; Jensen, 1998; Raven, Raven, & Court, 1998a).

Raven's SPM, the cognitive assessment utilized by Wright and Fallacaro (2011), is a measure of *g* in subjects six years and older with demonstrated reliability in various academic and occupational arenas (Andrich & Styles, 1994, Jensen, 1980; Kuncel et al., 2004; Raven, 1989; Raven, Raven, & Court, 1998a). More specifically, it is used as an assessment of deductive ability and rationalize complex situations, an ability that is believed to be independent of language and education level (Raven, 1989). Ultimately, the Raven's Progressive Matrices (RPM) have been found to best single indicators of general intelligence (g factor). This extends additionally to the updated version of Raven's SPM, Raven's APM-III (Kuncel et al., 2004; Jensen, 1998; Raven, Raven, & Court, 1998a). The APM-III, created for more advanced users such as those at the graduate level, allows for the ability to discriminate levels of cognition among those who would likely score in the top 25% of the SPM raw score (Raven, 1994; Raven, Raven, & Court, 1998b). Therefore, this tool negates a potential ceiling effect of scoring and more aptly discern levels of cognition among a homogeneously high-performing group of individuals. Furthermore, its item-banked format with promotes greater sustainability through its 279,841 unique test combinations (Pearson Education, Inc., 2017).

Cognitive Testing in the Admission Process & Predictions of Success

Given the contribution of medical error to patient mortality, it is imperative that the development of a trait as significant as SA be a priority in nurse anesthesia programs (Wright & Fallacaro, 2011). As SA has been found to be a trait not universally attainable, candidate selection with a focus on individual cognitive levels may offer predictive data of those who are most capable of developing SA during their matriculation (Endsley & Bolstad, 1994; O'Hare, 1997; Schulz et al., 2013; Wright & Fallacaro, 2011). Evaluation of an SRNA candidate's level of cognition at a program interview has the potential to yield a myriad of benefit. Logically, in order for competent SRNAs to complete a nurse anesthesia program, SRNAs must successfully master the course objectives. Among the literature, however, there exists a paucity of evidence examining currently used indices of the selection process that best predict academic success

(Burns, 2011; Ortega at al., 2013; Wong & Li, 2011; Wright & Fallacaro, 2011). Furthermore, a lack of research exists on how academic faculty should weigh objective measures set forth by the COA (2014), rendering candidate selection a heavily subjective process (Burns, 2011; Ortega et al., 2013; Wright & Fallacaro, 2011). Other literature has demonstrated the value of cognition as an objective predictor of success both academically and in the workplace (Kuncel et al., 2004). For instance, the incorporation of cognitive scores into the medical school admission process has served as a meaningful predictor of medical school success (Lumsden et al., 2005). While nurse anesthesia program directors, CRNA faculty, and experienced CRNAs are found to perceive cognition as a construct most predictive of student success (Reese, 2002), no research on this construct's predictive validity of student and job success has been performed in the SRNA population.

Given the correlation of cognition with SA previously described in the SRNA population and its prediction of academic success noted in others, it was believed that the employment of cognitive testing in the nurse anesthesia selection process would ensure students' mastery of course objectives while developing SA. The utilization of the sustainable and objective evidence-based Raven's APM-III in the admission process to assess cognition and its inherent correlation with SA development and academic success may serve ensure the selection of the candidates with the most potential to develop the necessary trait of SA (Burns, 2011; Ortega et al., 2013; Reese, 2002; Wright & Fallacaro, 2011).

Theoretical Framework

With patient safety as a core mission of this project, the Iowa Model-Revised was chosen as the theory of translation based upon its original concept to guide nurses in channeling knowledge into practice to improve patient outcomes. Not only has this guide proven useful in the clinical setting, but it has also been effective in many areas of academia, the setting within which this particular translation of evidence into practice will take place. Moreover, user feedback of the model over the course of many years has been embedded into improvements in the model's development, has filled translational gaps, and has facilitated sustainable change (Titler et al., 2001; University of Iowa Hospital and Clinics [UIHC], 2017). The user-friendly flow of the Iowa Model-Revised not only ensures clinical inquiry based on priority, but also provides guidance when further research is needed. Such a template will be invaluable to the fruition of this project.

The first step of the Iowa Model-Revised entails identifying triggering issues and/or related opportunities. Thus, starting here requires reflection of the problem at large, which is the compromise of patient safety linked to ineffective or detrimental decision making, and ultimately to breakdowns in practitioner SA (Fore & Sculli, 2013). This issue is particularly pressing in the field of anesthesia, where the stakes are high and the rapidity of changing states require the utmost attention, emphasizing the need for SA (Gaba et al., 1995). Therefore, identifying SRNA candidates best suited to develop this pivotal trait should be a priority of nurse anesthesia programs. This may be afforded in the use of cognitive testing given its demonstrated predictive quality of SA development (Wright & Fallacaro, 2011).

Having identified the aforementioned issue, from which stems opportunity, one is then streamlined to the following step of the Iowa Model-Revised, stating the purpose (UIHC, 2017). Given the predictive correlation noted between cognition and SA in nurse anesthesia candidates, and in effort to bolster more subjective interview processes currently employed, the purpose of this project is to implement the objective measure of cognitive testing to predict a candidates' ability to develop SA and master course objectives. This measure will expose candidates with the most statistically predictive attributes to serve as a foundation for safe and competent practice and aid in the successful transition to clinically-apt future CRNAs.

Consideration of the project's priority follows, guiding the next actions taken (UIHC, 2017). To this end, the purpose of this project has substantial priority, as the educational demand to produce competent CRNAs is further confounded by potential faults in the admission process, in which current criteria for candidate admission lack in evidence supporting the production of competent candidates (Wong & Li, 2011; Weight & Fallacaro, 2011). Pursuing onward in this systematic guide then requires the construct of a team tasked with gathering, appraising, and synthesizing the relevant body of evidence (UIHC, 2017). Despite the increased attention to SA in recent years, methodical evaluation of the available literature yields insufficient evidence regarding the development of SA in student nurse anesthetists (Fore & Sculli, 2013; Wright & Fallacaro, 2011). An advantage of the Iowa Model-Revised with regard to the proposed project is that, in the absence of sufficient evidence, an alternative opportunity to piloting and integrating practice change is mapped which prompts the conduction of further research. A hope is that the findings of this project will increase the robustness of the growing body of knowledge and thereby enhance the process of translational adoption.

Methodology

Setting

This project was conducted at [redacted]. The first phase of data collection occurred over the course of two days during the candidate interview process for the Doctor of Nursing Practice in Nursing Anesthesia program in November 2018. Cognitive testing of participants occurred in a computer lab in the [redacted], using Dell desktop computers.

Study Population

The total size of this sample size of this project was 37 voluntary interviewees out of 51 potential interview candidates. Subject recruitment commenced with the inclusion of recruitment flyers disseminated upon arrival to the interview sessions (Appendix H). Inclusion criteria included all those granted an interview for the Doctor of Nursing Practice in Nursing Anesthesia program and who were present for either of the two interview days. No specific exclusion criteria for the study population exists.

The authors of this project, senior SRNA students matriculated in Rutgers University DNP Anesthesia program, will hereby refer to themselves as the study's primary investigators (PIs) under the mentorship of Thomas J. Pallaria, DNP, APN/CRNA (Project Chair), Michael McLaughlin, DNP, APN/CRNA (Committee Member), Maureen McCartney Anderson, DNP, APN/CRNA (Committee Member), and Ann D. Bagchi, PhD, DNP, FNP-C, APN (Committee Member).

Study Intervention

Cognitive tool selection. The purpose of the project was to quantify the degree of cognition in each nursing anesthesia candidate so as to best predict students most capable of scholastic and clinical excellence. In doing so, the widely utilized and validated Raven's RPM was selected based on its practical and theoretical relationship demonstrated with SA and academic success (Andrich & Styles, 1994, Jensen, 1980; Kuncel et al., 2004; Raven, Raven, & Court, 1998a; Schulz, 2013; Wright & Fallacaro, 2011). Though a significant correlation was demonstrated between cognition and SA levels in junior and senior SRNAs, a limitation noted in study by Wright and Fallacaro (2011) was the low variability seen in the degrees of individual student cognition (Wright, 2009). This may have been due to a celling effect of the Raven's

SPM, wherein those who are more apt to perform at a superior level, such as graduate students, may homogenously perform at the top-tier scores (Pearson Education, Inc., 2017; Raven, 2000). In recent years, an updated version of the test, the Raven's APM-III, has been designed specifically for users who are inherently of a higher cognitive level compared with the those of the average population. The difference in the exam versions is not the construct of what is measured (cognition), but the level of difficulty. With this exception, both measure the g factor, each demonstrating construct validity and internal consistencies of reliability approaching .90. Regardless, the level of difficulty between each test has been shown to overlap considerably, such that the SPM covers a wide display of difficulties to almost that of APM's limit (Jensen, 1980; Raven, 2000).

Given the exclusive difference of an increased level of difficulty in the Raven's APM, it was chosen over the Raven's SPM, as it is reasonable to assume that these particular study participants have relatively higher degrees of cognition than the average population. With its use otherwise afforded by the construct validity the APM-III shares with the SPM, the PIs have noted several factors making this tool an appropriate use for the project.

- This tool may negate a ceiling effect of scoring and more aptly discern levels of cognition among a homogeneously high-performing group such as SRNA candidates (Pearson Education, Inc., 2017; Raven, 2000).
- The tool evaluates cognition with minimal influence of previous education or language barriers, serving as a means to effectively compare candidate cognition scores and their correlation with admission in a more objective manner. Coaching and training has also shown to have little effect on the test scores (Raven, 1994).

- The tool includes an item-banked feature, allowing for 279,841 randomly assigned unique test combinations (Pearson Education, Inc., 2017). This minimizes the ability of participants to leak components of the test to others which could hinder the potential sustainability of cognitive testing in the admission process.

Ultimately, the greatest conceived benefit of utilizing Raven's APM-III in the admission process is affording the selection of students most embodying the critical traits sought by faculty and necessary for the safety of patients. The PIs of this project theorized that the updated and advanced APM-III may serve a sensitive measure to discerns levels of cognition among a relatively homogeneous group of participants. Amidst the common use of anecdotal admission criteria in nurse anesthesia programs, the APM-III may offer greater sustainability as a much needed, evidence-based, objective admission selection tool in the prediction of SA and success (Burns, 2011; Ortega at al., 2013; Pearson Education, Inc., 2017; Raven, 2000; Raven, Raven, & Court, 1998b; Schulz, 2013Wong & Li, 2011; Wright & Fallacaro, 2011).

Tool administration. Administration of the computerized APM-III consists of two parts. In Part 1, the participant is posed with correctly aligning partial figures of varying patterns with the appropriate missing pieces that complete the picture along a continuum of difficulty. Similar exercises in Part 2 are brief and experimental, bearing no impact on the test results. The tool was developed by Pearson, a company with extensive experience safeguarding both program and examination data for various institutions. Study results are housed within an online portal secured by Pearson, which serves as the data custodian.

The intervention occured over the course of two scheduled anesthesia DNP candidate interview days (November 2018). In each scheduled day, there were two interview sessions, the first of which took place from 7:00 am to 11:00 am, and the second of which took place from

12:00 pm to 4:00 pm. Per current admission protocol, several weeks prior to either date and session, interview candidates self-scheduled his or her interview session time, with preferences allotted on a first-come first-serve basis of time-slot availability.

Upon arrival to their scheduled interview session, interviewees received a study recruitment flyer for review. They then entered a classroom where an introductory welcome session presented by the Program Director, Dr. Thomas Pallaria, commenced. At the end of this session, the PIs notified the candidates that following their respective interviews, they had the opportunity to voluntarily participate in the study indicated on the flyer in their welcome packet. They were notified of the start times which occurred in two different study sessions within each interview block to optimize the ability of students to attend following their interviews. As there were two interview days which each where divided into two interview blocks, the total number of study sessions was eight. Each study session was allotted fifty-five minutes total, 10 minutes of which was for to the description of this study and consent process, and the remaining 45 minutes of which was devoted to the administration of the APM-III. The morning study session times were 9:30 am to 10:25 am and 11:15 am to 12:10 pm. The afternoon study session times were 2:30 pm to 3:25 pm and 4:15 pm to 5:10 pm.

Students who completed their interview prior to the start of the next available session had the opportunity to interact with other students who volunteered to assist at the [redacted] Nurse Anesthesia interview days. Once the PIs finished briefly explaining this process, official individual interviews commenced. While the interviews were in session, the PIs prepared room 640B, the location of the intervention.

Admission committee survey. An anonymous, web-based decision survey, accessible through the private Qualtrics platform, was created by the PIs for the purpose of completion by the admission committee post-admission decisions. The committee was invited to complete the survey through a private hyperlink shared via university email. The survey consisted of 17 multiple-choice and Likert-scale questions with a goal to assess the value one ascribes to SA, de-identified score reports, and cognitive testing in the admission process. The committee was also presented with examples of de-identified score reports to assess their appraisal and utility of the report (Appendix E). As previously mentioned, these score reports are part of the data that is automatically generated at the completion of one's APM-III assessment for the purpose of interpreting the significance of raw theta scores. The survey was believed to take approximately five minutes to complete.

Outcome Measures

At the beginning of the sessions, the PIs described the project and proposed intervention, offering the candidates the opportunity to voluntarily participate. The PIs explained to the candidates the nature and purpose of the test as a measure of cognition. The PIs emphasized that participation in this study was not only voluntary, but would also be unbeknownst to the faculty interview panel and have no bearing upon their admission decision. Those who did not wish to participate had the opportunity to leave at this time. For those willing, the consent process then commenced. After the process of consent, the intervention began as described in the Study Intervention section. Nurse anesthesia faculty blinding to both participation as well as test scores was ensured as the PIs were the proctors of this session and only Dr. Ann Bagchi (Committee Member) had initial access to the resultant, identifiable data of cognitive testing.

While seated at individual computers, interviewees who consented to participate were directed to log into the online testing portal by using their unique [redacted] identification number [redacted]. The [redacted] is an identifier that is bestowed upon program applicants after application submission. The use of the RUID in this study was for primary identification of one's individual cognitive performance with one's respective admission decision and associated decisional factors, the aggregation of which was to be known only to Dr. Bagchi. Dr. Bagchi received the culmination of this data from two sources; RUID-identified cognitive scores were exclusively available to her through the secured online Pearson portal, and the corresponding RUID-identified admission decisions and decisional factors (i.e., cumulative GPA, CCRN score, interview score, years of ICU experience), were released directly to her by and under the authorization of Dr. Pallaria. After Dr. Bagchi aligned outcomes by RUID, she de-identified the data by replacing individual RUIDs with a non-meaningful identifier (i.e., "Student 1"). Dr. Bagchi then released the de-identified data to the PIs who were therefore blinded to individual candidate identity, cognitive performance, and admission status.

After students logged into the online testing portal, the test commenced. The APM-III was administered consistent with the Administration Best Practices of the APM-III (NCS Pearson Inc., 2007a). After each candidate logged into the computer and the initial instruction screen for the APM-III appears, the PIs explained that on-screen directions would prompt the process, which began with completing demographic information and practice questions. Participants were instructed to follow computer prompts to satisfy completion of the test.

The timed assessment started thereafter. A total of 40 minutes was allotted to complete 23 test items in Part 1, and a total of two minutes to complete Part 2, which included two experimental items that bared no impact on score results. Participants were be given an opportunity to ask questions before starting the assessment and were then be prompted to begin by clicking "Start Your Assessment" after the practice items. If a candidate's computer were to develop any technical issues during the assessment, the PIs planned to move the candidate to another computer at which he or she could log back into the system as previously done. If this did not correct the issue, the PIs planned to contact the technical support department of Pearson, Inc. No technical issues were encountered, however. Following participant completion of the test, scores were automatically and instantly uploaded to the secured Pearson's data portal, which was accessible only to Dr. Ann Bagchi for the alignment of identified data with admission outcomes and subsequent data de-identification for the PIs to then evaluate. These scores were reported in the form of theta scores which, created through an algorithm, take into account the difficulty of the items presented, which will vary slightly from test to test given its item banked format. Scores on a range of -4.000 (low ability) to +4.000 (high ability) can be used in statistics to then compare differences in candidates (Raven, Raven, & Court, 1998b). In addition to the raw theta scores, data included automatically generated score reports, narratives for the purpose of interpreting the significance of the raw theta scores. These reports were among the data that was de-identified. After all were complete with their assessments, candidates were thanked for their participation, and computers were checked by the PIs to ensure the assessment's closure (NCS Pearson Inc., 2007a).

Data obtained from the anonymous web-based admission committee post-admission decision survey was accessible only to the PIs. Raw data from the multiple-choice-questions and Likert-scale questions was analyzed using descriptive statistics.

Risks or Harms

Physical. While there were no foreseen physical harm to participants, the nature of the assessment is such that it is somewhat lengthy in nature and required one to remain seated at a computer desk for the duration. This itself may have caused a degree of discomfort, and thus, measures to increase participant comfort were undertaken. These included ensuring comfortable room temperature and seating as well as adequacy of lighting (NCS Pearson Inc., 2007a). Light snacks, refreshments, and a restroom break were offered to all prior to the commencement of testing.

Psychological/emotional. In the consent portion of the study, participants may have felt as though they were pressured to participate. This may have been due to several probable factors that could have originated from the perceived need to please the PIs or faculty, or concerns as to whether or not participation affects one's interview rating, admission status, or favorability from faculty if admitted. After completing the test, participants may have questioned their level of satisfactory performance. This may have caused undue distress if one felt as though he or she performed subpar.

Attempts to mitigate these hypothesized risks included the blinding of performer scoring to both faculty and participants. The PIs had access only to de-identified scores. Consistent with both [redacted] policy, protection of participant welfare was a priority, as was the protection of individual assessment scores, as releasing them to those without a legitimate need and/or proper training in interpretation would be unethical and poor assessment technique (Rutgers, The State University of New Jersey, 2013; Raven, Raven, & Court, 1998b). These standards were explained to the participants and upheld by the PIs. As such, requests for individual access to score reports were denied, as this information could be misleading and cause undue distress to one who is untrained in the statistical analyses necessary to extrapolate performance meaning (Raven, Raven, & Court, 1998b). Participants may have experienced a degree of pressure to participate resultant of the participation of their peers. To allay this, the PIs strongly emphasized both the voluntary nature of each intervention phase as well as the lack of the tests' impact upon their admission and student tenure.

Social. Participants may have experienced a sense of inferiority if other participants verbalized positive perceptions of their performances (i.e., ease of completion, sense of high scoring, etc.). Conversely, those felt as if they performed above average may thereby have felt superior among their respective cohort. The ultimate consequence may have been an instilled sense of competition among all. Furthermore, participants who felt as though they had performed poorly may have feared the consequences and/or judgement of PIs or faculty knowledge of individual performance.

These hypothetical risks were mitigated by the blinding of performer scoring to the PIs as well as the faculty, explaining to participants the measures that were to be taken to ensure data security and confidentiality, and by emphasizing that these scores had no impact on their admission and student tenure.

Economic risks of harm. There were no economic gains or losses for participants or PIs.

Subject Recruitment

The PIs will be responsible for all aspects of subject recruitment. Subject recruitment was initiated by enclosure of a recruitment flyer within the candidate information packet which was distributed to interviewees upon their arrival to their scheduled interview day (November 2018). The PIs were responsible for the creation and content of the recruitment flyer (Appendix H). Rutgers Anesthesia faculty members had no role in the subject recruitment process beyond introducing the PIs to the groups following the introductory presentation by Dr. Pallaria. At the study sessions offered, the PIs discussed with these candidates the risks, benefits, and purpose of the study. Prospective participants were assured that participation was voluntary and had no effect on their admission status or academic standing if admitted. They were informed that their identity and relative performance was to be confidential and secured from the PIs and all involved faculty. Participation in the study was known only to the PIs.

Post admission-decision, admission committee members were invited via university email to participate in the described voluntary survey.

Consent Procedure

Participants were consented by the PIs prior to the start of the respective test intervention and subsequent to the explanation of the pertinent study details. The consent process occurred in computer lab 640B located at Rutgers School of Nursing, Stanley Bergen building, Newark, New Jersey. The PIs distributed consent forms to all potential participants present for their individual review of its contents. The subjects were given time to ask questions before agreeing to participate through signing the consent form. In addition to reemphasizing the voluntary nature of the study, it was explained to participants that withdrawal from the study was permitted at any point and that neither participation, lack of participation, nor the decision to withdraw would have any impact on their academic standing. All aspects of blinding to assure confidentiality were strictly reinforced. The signed forms were collected by the PIs from those volunteering to participate in the study (Appendix H).

Admission committee consent to voluntarily participate in the post-admission decision survey was implied through completed of the web-based assessment. Data was secured and accessible only to the PIs.

Subject Costs and Compensation

The participants in this study did not incur any costs nor were they provided with any compensation.

Project Timeline

A project timeline was created to outline its trajectory and to assure deadlines were met to satisfy the requirements for successful completion of the DNP program at Rutgers School of Nursing, Newark, New Jersey. This timeline is from March 2018 to May 2020 (Appendix I). The project timeline has been periodically reviewed by the PIs and chairperson to assess for appropriate progression of this project.

Resources Needed & Economic Consideration

The PIs were granted approval for the Research Assistance Program (RAP) offered by Pearson's Inc. which provided a generous fifty-percent reduction in unit pricing on purchased assessments. Total expenses personally incurred by the PIs was $780 total; divided equally, this amounted to $390 per PI. Utilization of the [redacted] computer labs and space was available to the PIs and the participants at no additional cost. The use of Qualtrics portal was also available to the PIs and participating admission committee members at no cost.

Evaluation Plan

Data Maintenance and Security

Pearson's Code of Conduct clearly describes its responsibility for data security and confidentiality which is upheld by the most stringent safeguards of personal information protection (Pearson, 2018). Information collected and stored by Pearson's Inc. included mandatory and voluntary participant information. Mandatory information included participant personal information (RUID and email) and demographic data (current/most recent job title, current/most recent position type, current/most recent industry, current/most recent occupation). Voluntary demographics collected included the reason for assessment, gender, race/ethnicity, age range (years), years in current/most recent occupation, highest level of education completed, years of ICU experience and current country of residence. Pearson's database, which storehouses all demographic data and test scores, was accessible by a password that was known and maintained by the PIs. This data will be housed within Pearson's secured online testing database for seven years before the data is eliminated.

Transfer of data from this portal to an encrypted external drive was done by Dr. Bagchi for de-identification purposes. The de-identified data was accessible to the PIs on a password-protected, encrypted external drive. Once this material was transferred to a password-protected file on a secure university computer within the locked office of Dr. Bagchi, the data from the external drive was deleted. The data stored on the computer, inclusive of the study results, and signed consent forms stored in a locked file cabinet within the same room, will be retained for three years and then destroyed, consistent with the Basic HHS Policy for Protection of Human Research Subjects (2018). The protection of all materials relative to the testing, including results, will be accessible only by the PIs.

Anonymous post-admission survey data was housed on the secured, password-protected Qualtrics platform. This data will remain on the confidential Qualtrics platform as long as the university subscription with the portal remains active.

Data Analysis

This project incorporated univariate, bivariate and multivariate statistics for analyzation using the IBM SPSS Statistics package (SPSS). Data collected on all variables was assessed for normality, linearity, and homoscedasticity by examining histograms, normal curves, normal p-plots, scatter plots, skewness, and kurtosis, where appropriate. All associated assumptions for linear regression were met prior to proceeding with statistical analyses.

Part I (APM-III). Univariate measures incorporated descriptive statistics (i.e., means, frequencies, etc.) of demographics, decisional factors traditionally used for Rutgers University Nurse Anesthesia program admission (i.e., CCRN score, interview grading rubric), and APM-III scores. Bivariate statistics included the use of a Mann-Whitney U test for non-parametric data to compare group mean differences of APM-III scores of those admitted versus those not admitted, where admission status served as the dependent variable. Spearman's rho was used as a test of association for non-parametric data to determine the correlations between mean APM-III scores with the aforementioned decisional factors. Multivariate statistics examined which factors are most predictive of the dichotomous admission status via the use of a logistic regression.

Part II (Post-admission survey). Descriptive statistics were used to analyze the results of the post-admission survey.

Findings

Results Part I

It was anticipated that the findings offered by the statistical analysis of the data will reveal a relationship between APM-III scores and admission status, such that:

H_0: No association exists between APM-III and admission status.

H_1: These is an association between APM-III and admission status.

Statistical analyses were conducted as previously described. No significant difference was seen between APM-III scores of those admitted versus those not admitted ($p>.05$). Additionally, no significant associations were seen among APM-III scores and any other decisional factor of admission. Albeit insignificant, negative associations were seen among admission status when associated with CCRN scores, GPA, and years of ICU experience. Conversely, APM-III scores were positively correlated with admission, though this too was insignificant. A statistically significant relationship was seen between admission status and cumulative interview scores ($p < .05$). Ultimately, the PIs accept the null hypothesis as no significant association exists between APM-III and admission status.

Results Part II

Descriptive statistics were utilized for the post-admission survey as previously descried. After reading a brief description of the background and significance of SA, 88% of participating admission committee members believed SA to be “extremely important”, while only 53% felt current criteria predicts SA development “moderately well”. When it came to the value of identifying level cognition in the admission process, 87% responded that this construct was “extremely important”. Additionally, 88% of respondents felt that an objective cognitive report (such as the one in question) would likely influence their overall impression of a nurse anesthesia candidate and enrich overall their evaluation.

Recommendations and Discussion

This study ultimately sought to answer the question of whether those admitted to the program had higher cognitive scores than those not admitted. Though mean scores were indeed higher, this finding was not significant. Further discussion into the distribution of scoring is warranted, as the candidate with the highest score was not admitted, whereas the candidate with the lowest score was admitted. This raises the question of whether a candidate who was not admitted may have had significant potential to excel academically and develop SA. Additionally, this study did not reveal a significant relationship of APM-III with any other admission factor, nor was there any significant predictive relationship noted upon admission. This holds true, also, for all other factors of admission, such that no variable in particular displayed any significant relationship with admission. The exception is interview scoring, a measure that is subjective and influential in student admission.

If no other factor correlates with admission, this calls into question which measure is of most value to faculty as a reflection of the potential to succeed and graduate as a competent CRNA. While national requirements mandate a minimum one-year ICU experience in addition to being an RN, neither years of experience nor other measures were significantly related in this case.

While the evidence discussed demonstrates the objective APM-III's predictive power upon academic success and correlation with SA in the SRNA population, analysis of this construct in the admission process has not been previously explored. The closest cognitive correlates with cognition existing in the admission process may be the objective measures of CCRN and GPA. Limitations on the utility of these constructs, however, are worthy of discussion. While CCRN scores offer some standardization as the formatting of the test does not change among participants, one's GPA may be influenced by a variety of factors. These include the intensity of a program, accelerated versus traditional trajectories, and classes taken unrelated to science or nursing that may elevate or lower one's GPA. Though CCRN scores may offer a more equal playing field similar to that of the APM-III, CCRN may not be reflective of inherent intelligence, as rote memory may play a factor in scoring. Though memory was theorized by Endsley (2000) to be a contributive factor in the development of SA, Wright and Fallacaro (2011) did not find this correlation with SA in the SRNA population. This is in contrast to cognition as measured by RPM, shown to predict both academic success and SA. In contrast to CCRN scoring, the RPM is not influenced by memorization ability, level of education, or language. It is acutely unique in its ability to measure g factor and isolate the measure of cognition (Jensen, 1980).

What may be gathered from this project's results is the possibility that SRNA programs may be overlooking the most capable admission candidates. Although is it not feasible to determine the success of students who scored highly on the APM-III though were not offered admission, it is feasible to follow students who are admitted to further analyze the predictive power of cognition upon academic success. Future studies may attempt this by correlating these baseline APM-III scores with measures such as SRNA GPA or ranking at various intervals during students' academic tenure. Determining cognition's predictive power on SA may also be feasible by measuring SA via the WOMBAT-CS, correlating these scores against cognition and measuring the increase in SA at various points over one's academic tenure.

Upon evaluation of these results, one must consider limitations of the intervention. Given the administration of the APM-III following candidate interviews, candidates may have been stressed and mentally fatigued, and therefore have performed less than optimally. However, the field of anesthesia requires one to perform under similarly strenuous conditions while maintaining SA, and therefore, this intervention may have been an appropriately-timed challenge for potential students. Students may also have performed sub-optimally with the knowledge that the results of the APM-III had no impact on their admission status. In effort to minimize this potential limitation, professionalism was maintained and candidates were encouraged to do their best so as to inspire optimal performance. Another hindrance may be the duration of the APM-III assessment. While candidates were allotted 45 minutes to complete the assessment, the average time per candidate was 18 minutes, 41 seconds (minimum time 6 minutes, 31 seconds; maximum time 43 minutes, 28 seconds; standard deviation 9 minutes, 21 seconds). Test administration before or after future interviews may therefore be easily accommodated. Certain financial barriers and benefits have been identified, which are discussed below.

Economic/Cost Benefit

Healthcare. SA has been deemed a trait most crucial to one's safe and competent performance in anesthesia. Its deficiency may prove detrimental, as a reported 81.5% of human errors have been found to occur secondary to the breakdown of this essential construct (Schulz, et al., 2016). The cost to life is thus tremendous, with a 2016 study concluding that 250,000 Americans die each year from medical errors (Andel, Davidow, Hollander, & Moreno, 2012).

The financial cost to the United States is respectively profound, as this form of human error contributes to an annual debt of $19.5 billion, a hefty portion of the total $38 billion massed annually by cumulative medical error (Kohn et al., 1999). The economic impact has recently been found to be substantially greater in the application of quality-adjusted life years (QALYs) to the 180,000 to 250,000 medical error-related deaths per year. Assuming an average of 10 years of life lost at $75,000 to $100,000 annually, the loss in QALYs for those annual deaths is $73.5 billion to $98 billion (Andel et al., 2012). These calculations, however, are based upon the 98,000 deaths projected in the IOM's 1998 report *To Err is Human* (Kohn et al., 1999). If the estimate of one source, Health Affairs, is correct in estimating the number of preventable deaths to be approximately 10 times that of the IOM's 1998 report, the cost could be upwards of $735 billion to $980 billion (as cited in Andel et al., 2012). Experts continue to have difficulty fully capturing the issue, however, it is clear that the cost to healthcare and society is exorbitant (Andel et al., 2012).

There is thus substantial cost-benefit to the affordance of patient safety in the development of SA. Measures undertaken to predict and develop this necessary attribute should occur as early as the admission phase of nurse anesthesia school, so as to more confidently facilitate the growth of excellent providers who seek to optimize patient outcomes. This positive return on investment is in addition to the economic implications afforded by the improvement of attrition secondary to this focus, as discussed below.

Academia. Cost of the APM-III may preclude its adoption by anesthesia programs. While the PIs received a research grant offering a 50% discount for the price per assessment, the full cost of each assessment is $26, which may exceed certain program budgets. This limitation should be considered when weighed against the financial gains to be attained in the implementation of cognitive testing in the nurse anesthesia admission process.

Applicants to nurse anesthesia programs tend to be acutely similar in that their applications generally demonstrate possession of the satisfactory academic criteria and critical care nursing experience required for admission consideration. The challenge for faculty is to identify and select the small fraction of candidates who stand apart from the others in their potential to successfully meet curriculum objectives. This is further confounded by the lack of research offering guidance to nurse anesthesia program leaders when considering how to interpret factors such as the length of clinical experience and their relationship to academic success or future work performance. Thus, such criteria may not be comprehensive of the methods needed to predict academic progression (Burns, 2011; Ortega et al., 2013; Wright & Fallacaro, 2011).

This current lapse in the availability of predictive modalities of one's tenure success may result in the attrition of candidates who are unable to meet course requirements, leading to academic jeopardy. If this results in program dismissal, the negative financial implications are pressing for the students, nurse anesthesia programs, and universities at large. Therefore, the selection process of SRNAs demands close attention so as to aptly institute methods that afford the prediction of student success in academia and in one's prospective career as a competent anesthetist. This success may also lead to the future hiring of more qualified nurse anesthesia faculty, bridging a need set forth by societal healthcare demands (Burns, 2011). Thus, the vast local and global benefits of incorporating the APM-III as a validated, objective measure of cognition into the SRNA admission selection process greatly outweigh any nominal costs associated with the acquisition of the assessment tool.

Impact on Healthcare Quality and Safety

As noted previously, medical errors, particularly those associated with anesthesia, represent a leading preventable cause of death in the United States. Considering its link to enhanced provider performance, the successful development and maintenance of SA is a crucial factor in healthcare delivery and patient outcomes by reducing the potential for human error (Schulz et al., 2013). As cognitive testing may be utilized to identify individuals most likely to possess intrinsic cognitive abilities necessary for SA development, it may be invaluable within the SRNA admission selection process. It is theorized to not only predict success in academia, but has significant global implication in its ability to improve healthcare quality and patient safety (Schulz et al., 2016; Wright & Fallacaro, 2011).

Policy Implications

SA is a key and critical attribute in clinical decision-making at the forefront of patient care, especially in the dynamic field of anesthesia. Given the implications that a lack of SA may have on societal and financial healthcare costs, SA should be recognized as a universal factor in patient safety. To increase the development of this construct in the CRNA population through appropriate interventions, SA first needs to be examined in a theoretical context (Fore & Sculli, 2011; Schulz et al., 2013). Nested in such theory is the predictive relationship of cognition upon the development of SA. This correlation has been further studied, where substantial differences in levels of SA in highly experienced pilots were attributable to differences in cognitive capabilities (Endsley & Bolstad, 1994; Schulz et al., 2013). This correlation was also demonstrated in the SRNA population in which a direct positive linear relationship was noted between cognition and SA (Wright & Fallacaro, 2011).

With a more formalized understanding of cognition as a prerequisite that affects SA, programs to cultivate SA may be developed. The PIs conceive that this process should start at the admission process to the Nurse Anesthesia Program, in which objective measurement of candidates' baseline cognitive scoring may be indicative of those most capable of successful program completion and developing the level of SA needed for safe and competent practice. Given the manipulability of cognition in academia, interventions in both the classroom and simulation can employ modalities that foster the growth of cognition and its predictive development of SA (Schulz et al., 2013). The graduation of providers who may be prepared to meet the societal demands of ensuring quality care may provide a solution to the prevalent compromise of patient safety. The anticipated findings of this study may thus substantiate evidence in support of the creation of the following policies:

1. Locally, at [redacted] University, it is the goal of the PIs to influence the adoption of a standardized, evidence-based SRNA admission criteria inclusive of cognitive testing. Further policy may continue a focus on the development of key cognitive knowledge and skills that have been shown to increase levels of SA through the implementation of innovative, didactic courses specific to human factors and patient safety in nurse anesthesia (Schulz et al., 2013).

2. On a national level, it is the hope and goal of the PIs to contribute to a growing body of knowledge supporting the adoption of these interventions as an academic standard.

Translation

Translation to a broader group may be afforded by the generalizability offered by Raven's APM-III's measurement of cognition. It has been well established that a cognitive tool like APM-III confers "validity generalization," the extent that a body of evidence examining the same underlying construct can be adequately translated to a novel situation. In other words, the results of cognitive testing may allow for the generalization that high performance in one domain may correlate with higher performance and success across a multitude of domains. Of the educational tests available, APM-III demonstrates superior generalizability and reliability (Raven, Raven, & Court, 1998b).

The ability to use APM-III on a diverse population is partially afforded by the lack of correlational performance on the AMP-III with demographics such as gender. Though some correlation has been noted between increasing years of education and higher cognitive performance, the scores are generally independent of the former (Raven, 1989; Wright & Fallacaro, 2011). One study hypothesized that this effect may be due to the familiarity of those with higher education to solving abstract problems (Majdub, 1991). Other studies have spoken to the notion that the context of Raven's Matrices includes material not directly taught in academia, though may conversely serve as a good indicator of prospective academic performance (Andrich & Styles, 1994). Furthermore, the effect of prior knowledge and verbal ability is minimized by the test's non-verbal content, affording a clearer examination of an individual's intellectual potential with minimal confound of language. Additionally, the low readability level of the instructions, opportunity for practice items with associated rationale, and the online test administration yields even opportunities for users to perform on the test. This uniform nature of the test's standardization helps to increase the internal reliability of test scores, demonstrated at Chronbach's alpha 0.85, with a small degree of reliability deficiency owed to individual changes in performance that may occur over time (i.e., taking a lucky guess, being more alert or feeling less anxious) (NCS Pearson Inc., 2007b). Thus, because the nurse anesthesia program applicant pool is generally homogeneous in nature, their cumulative level of education, in addition to other demographic variables, are not theorized by the PIs to have an influential effect on cognitive scoring, as will be examined in this study's analysis.

Given the reliability and validity generalization of this tool, it may be inferred that others who would similarly fit the appropriate criteria of a typical APM-III user may also demonstrate higher performance in their respective domains relative to one's degree of cognitive performance. This may be inclusive of the SNRA population at large, the national demographics of which are hypothesized to closely match that of the study population**.** This may be supported by other studies which have demonstrated the utility of cognitive testing relative to academia and the medical field in the analysis of cognition as a trait most predictive of both academic and job-related success. Furthermore, a more recent meta-analysis revealed a cross-correlation of cognition and its prediction of both academic success and job-related achievement, offering further validation of Raven's Matrices (Kuncel et al., 2004). Cognition relative to the medical field has likewise been deemed predictive of success, though the standardized measure forming the basis of study has been the non-generalizable MCAT (Koenig et al., 1998). Other than studying cognition's correlation with SA, no research on this construct's predictive validity of student and job success has been studied in the SRNA population. However, it has been upheld by nurse anesthesia program directors, CRNA faculty, and experienced CRNAs as a construct perceived to be most predictive of student success (Reese, 2002).

With the research available, it is theorized by the PIs that those admitted with higher cognitive scores will more predictably master the course objectives necessary for graduation (Schulz et al., 2013). Should an outcome of this study demonstrate a significant correlation between admission status and cognitive functioning, this may support future academic implementation of its use in the admission process. While the objectivity afforded by cognitive assessment may demonstrate superiority to long-maintained criteria that are unfounded in evidence (e.g., the minimum one-year requirement), its use should not preclude that of other valuable measures in the interview process. For instance, cognitive testing confers no indication of one's verbal ability or personality traits like interpersonal or intrapersonal intelligence, stress tolerance, motivation, values, or emotional stability (Abdalgadr, 2009). Such attributes are necessary to support not only the SA needed to properly manage a critical situation, but that required to share pertinent knowledge with a medical team through verbal and nonverbal communication within a multidisciplinary environment (Schulz et al., 2013). Thus, other measures that may particularly hone in on effective communication and personality traits, such as the interview process, should continue to be pursued despite the potential adoption of cognitive testing (Burns, 2011).

Although Wright and Fallacaro (2011) demonstrated a correlation of cognition with SA through the use of a different version of RPM, Raven's SPM, there have been several previous works demonstrating the construct validity of Raven's SPM and Raven's APM. Both measure the same construct of the g factor with respective internal consistencies of reliability close to .90. This underscores that in the update of the exam, it was not the construct of what is measured that changed, but the level of difficulty (Jensen, 1980). Regardless, the level of difficulty between each test has been overlaps considerably, such that the SPM covers a wide display of difficulties to almost that of APM's limit (Raven, 2000).

Since the Raven's Progressive Matrices has been found to be the best single predictor of the g factor, or general intelligence, a trait found necessary to all forms of problem solving, transferability of Raven's APM-III to the general CRNA population may have utility in demonstrating potential workplace aptitude. Additionally, demonstration of good pattern-matching skills may transfer to one's ability to more quickly develop SA in a demanding situation that is afforded by the recall of a previously similar situation. This ultimately reduces cognitive burden which serves to increase the quality of SA (Schulz et al., 2013). This translation may be supported by APM-III's prediction of the ability to attain and maintain such a career requiring high levels of general mental ability (Raven, 1994; Raven, Raven, & Court, 1998b).

Dissemination

Participants have not and will not have knowledge of their individual scores on the Raven's APM-III. Aggregate, de-identified is ready for dissemination as the implantation phase and data analysis is complete. Participants have been encouraged to attend the DNP defense and any local or national conferences in which such data relative to the study results may be discussed.

Modes of sharing these results with the faculty stakeholders includes sharing with them the statistical data and its implications. Based on the described cost benefit, the institution of cognitive testing in future admission processes is encouraged.

Modes of sharing the results of this project with the professional community may include the project's possible publication. Thus far, a formal oral presentation has occurred at the New

Jersey Association of Nurse Anesthetists (NJANA) fall meeting in Woodbridge, New Jersey. The PIs were also selected to present their project poster at the 2019 Annual Congress in Chicago, Illinois, hosted by the American Association of Nurse Anesthetists (AANA).

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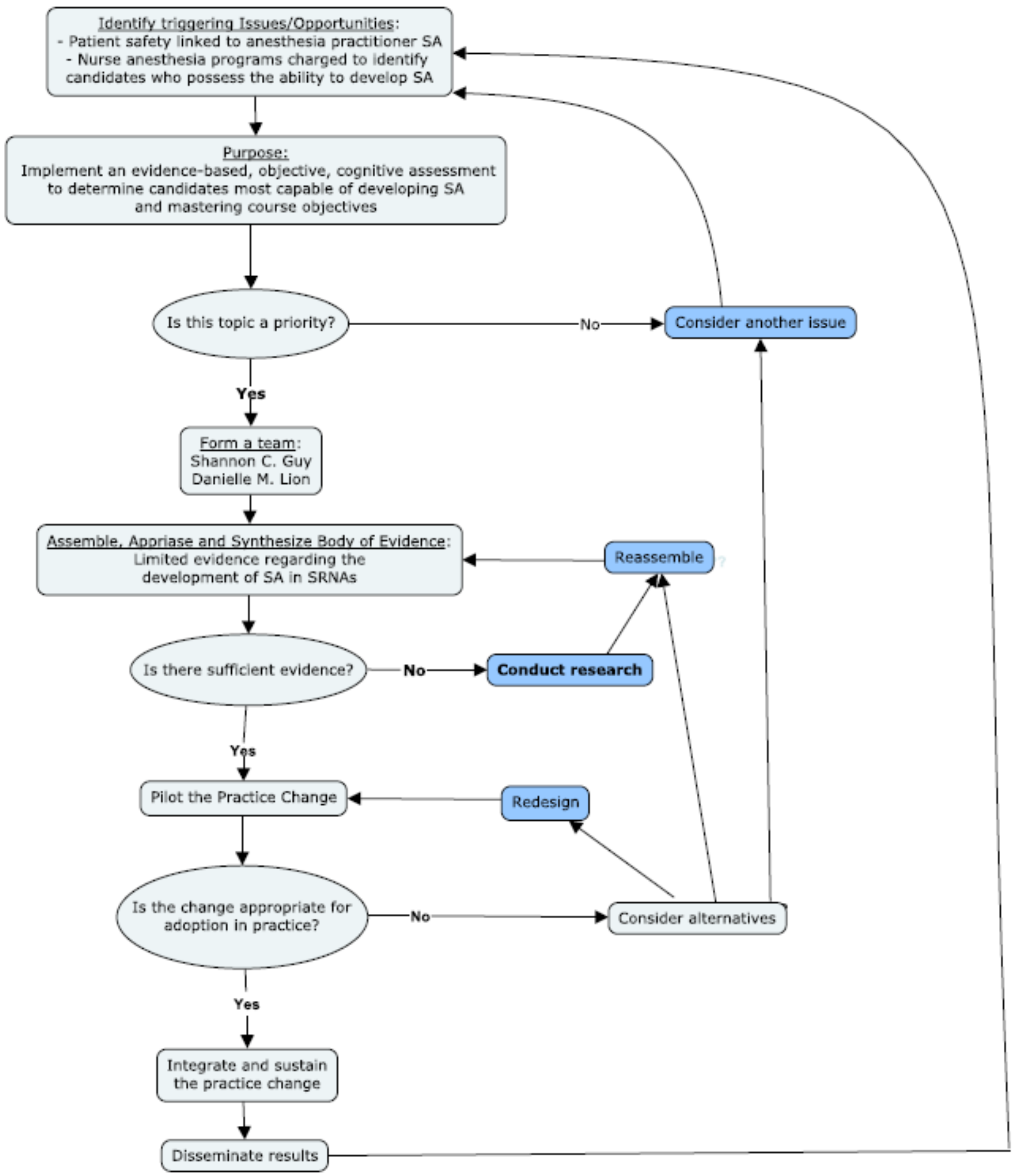
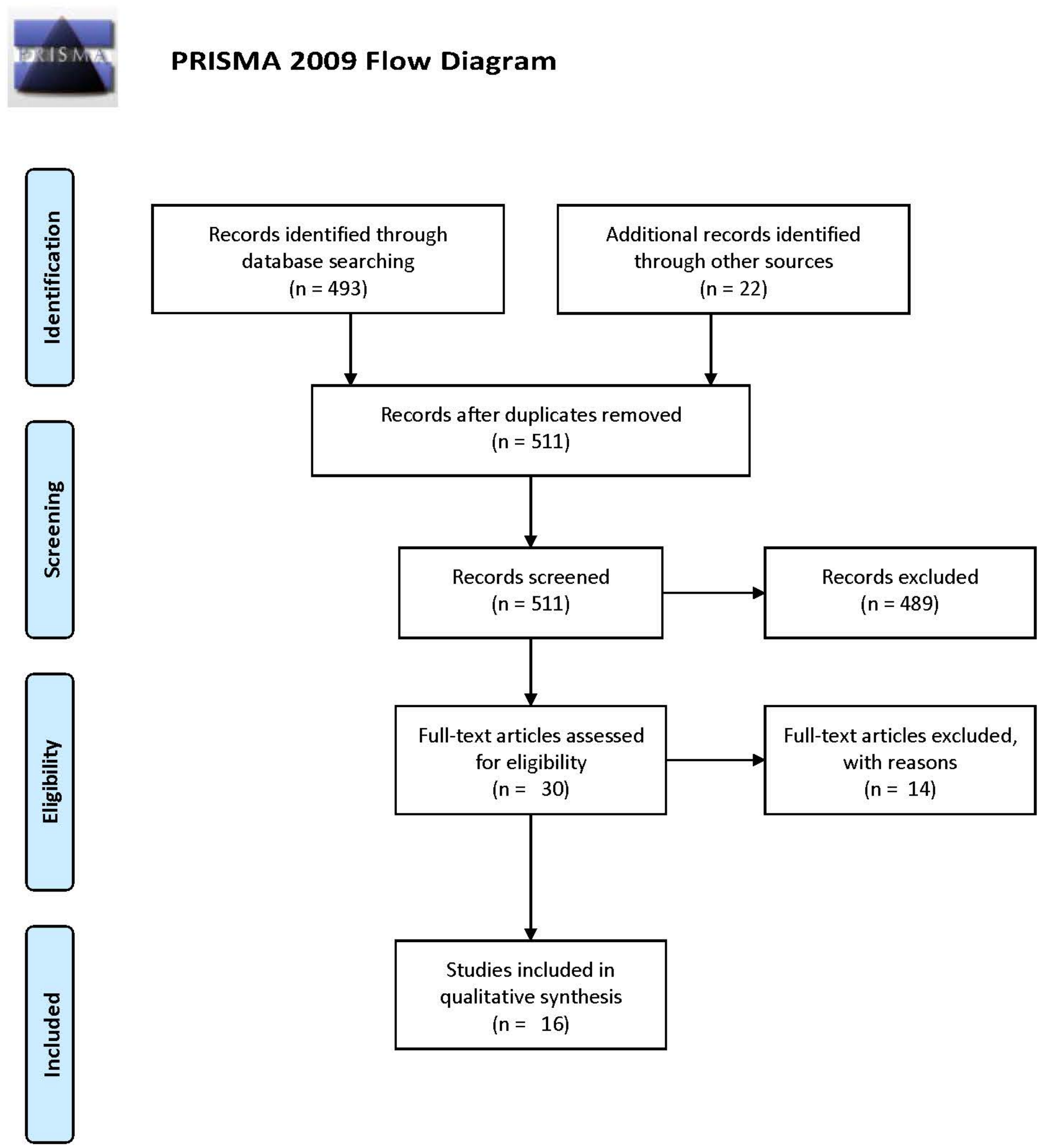
Appendix A
Concept Map



Adapted from University of Iowa Hospitals and Clinics [UIHC] (2017).

Appendix B
Prisma Table



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Appendix C

Table of Evidence

Question: Do students admitted into the [redacted] Nurse Anesthesia DNP program, based upon current admission criteria, possess higher cognitive scores as indicated by a validated and objective cognitive testing instrument compared to those not admitted into the program?

Article #	Author and Date	Evidence Type	Sample, Size, Setting	Study findings that help answer the EBP question	Limitations	Evidence Level and Quality
1	Burns (2011)	Quantitative correlational study	Of 108 program directors notified of study, 12 randomly selected, providing variable data for students (n= 914)	Study inspired by faculty challenges regarding admission criteria in light of schools' transition to doctoral program transition, nursing and faculty shortage, and financial implications related to rates of attrition. A 20 year literature review revealed no empirical evidence on admission variables and their relationship to academic progression, including the significance of ICU experience in the interview process. Concluded the need for leaders to reevaluate the weight given to current admission criteria (GPA, years of experience, the interview, etc.) and to conduct further research supporting best educational practices.	Findings are not generalizable beyond the field of nursing anesthesia. Authors report that although their study represents new evidence for consideration when selecting students to nurse anesthesia programs, additional research remains essential for refining the current admission selection process.	Level III, Quality A

2	Cooper et al. (2002)	Retrospective Analysis	47 interviews conducted with staff and resident anesthesiologists at one urban teaching institution.	A modified critical-incident analysis was used to examine the characteristics of human error and equipment failure in anesthetic practice. The objective was to determine patterns of frequently occurring incidents. Twenty-three categories of details were subjected and analyzed. Most (82%) preventable adverse events involved human error including drug error and circuit disconnect.	None identified.	Level III, Quality A
3	Endlsey & Bolstad (1994)	Quasi-experimental	25 male subjects participated in a portion of the study that measured their SA. Of the 25 subjects, 21 were available to participate in the attribute-measurement portion of the study. All subjects were experienced, former military fighter pilots.	The objective of this study was to determine whether SA abilities vary in any reliably consistent manner between individuals and to identify explicitly those characteristics that may contribute to high SA in individuals. A 10-fold difference in SA levels found among highly experienced pilots was attributable to individual differences in cognitive capabilities including attention-sharing, pattern-matching, and spatial processing. Therefore, in conclusion that experts differ in ability to develop SA based on these traits, proposed is the use of selection and focused training programs to enhance cognitive capabilities essential to SA development.	Domain studied is highly specific and therefore requires further study to increase generalizability of results.	Level II, Quality B

4	Flynn et al. (2017)	Quantitative, quasi-experimental pre-test, post-test design	Non-technical skills in a convenience sample of 14 full-time SRNAs with two years of clinical experience in a Norwegian university were rated on three different times during a 10-week simulation based program: during simulation, and both before and after a training course.	This study aimed to test the reliability of NANTS-no, a specially adapted behavioral marker system for nurse anesthetists in Norway, and explore the development of non-technical skills (inclusive of situational awareness) in student nurse anesthetists which contribute to optimal and safe anesthesia care. A statistically significant improvement in the participants' NTS across all four categories was demonstrated ($p < 0.01$). The study concludes the tool may have utility in simulation feedback as well as to aid in developing non-technical skills, though more research is needed.	Though NANTS-no was tested for inter-rater reliability and internal consistency using the whole sample, stability was tested using only half. Other methodological limitations to this study include the size and recruitment method of the sample and the lack of a control group with no exposure to the NTS program. This restricts the generalizability of the results	Level II, Quality B
5	Gaba et al. (1995)	Expert opinion	Review of relevant literature relating SA to the field of anesthesia	First review to describe the concept of SA's applicability to the field of anesthesia based upon the similarly shared characteristics of complexity, dynamicity and riskiness with the both military and the field of aviation in which SA was primarily described. The authors exemplify this by providing both real and simulated scenarios in which SA is necessary to optimize patient care.	As this study was the first to propose SA's relevancy to anesthesia, the authors acknowledge that its application needs to be more fully investigated using sophisticated techniques in both real and simulated work environments.	Level V, Quality B

6	Graafland et al. (2015)	Systematic Review	A search was conducted in various databases with predefined inclusion criteria up through June, 2014. Nine articles were considered eligible.	The primary objective was to assess the validity of methods for the needed improvement of SA in the operating room. The articles examined evaluated simulated crisis training and training course focused on non-technical skill development. Two studies spoke to construct validity of simulation training, though none showed effectiveness for surgical crisis training. The article maintains that there is a need for SA improvement, and that strategies to improve SA can be adopted from other industries.	The studies identified were small, and the risk of bias was moderate or high in eight of nine studies. Therefore, the strength of conclusions concerning the validity of the training methods is limited.	Level III, Quality B
7	Kuncel et al. (2004)	Meta-analysis	Literature review of studies involving prediction of graduate school and job performance by the Millers Analogies Test (MAT) using PsychLit (1887-2001), ERIC (1966-2000), and Dissertation Abstracts International (1861-2000), resulted in 163 samples from 127 studies yielding 229 correlations (n= 20,352).	MAT used in academic and career setting to reliably predict success and career performance secondary to its ability to reliably measure cognitive ability (g factor). Researchers found a strong correlation between MAT and Raven's Matrices as they are both used to measure general cognitive ability. Given the shared abilities of Raven's and MAT, analyses found that both tools can validly predict academic & vocational success.	The researcher noted the clustering technique was partially subjective; other valid methods of clustering were acknowledged by the authors. Additionally, the sample sizes of studies showed a broad range from very limited to very expansive. Lastly, the authors note a degree of confound that could result from employer's awareness of individuals' MAT scores.	Level III, Quality A

8	Lumsden et al. (2005)	Quantitative correlational design	Letters were sent to all [redacted] residents applying for entry to [redacted] medical schools in 2002; n= 510 volunteers out of 580 surveyed	The investigators utilized the PQA (Personal Qualities Assessment), a battery of psychometrics tests to measure cognitive ability, personality traits, and moral/ethical reasoning on medical school applicants. Of those applicants with relatively poor cognitive skills (>2 SD below the cohort mean score) along with extreme personality traits, 23% of would not have been selected for medical school had the given PQA battery been employed. Researchers hypothesize that those with poor cognitive skills may be less suited for a career in medicine compared to those with higher cognitive skills as cognitive skills alone have been shown to be reliable performance predictors. Researchers encourage the incorporation of a combined cognitive/personality assessment tool, such as the PQA, as an objective selection tool for medical students who are best suited for a career in medicine. The incorporation of such a test battery enhances the objectivity of the selection process. A long-term follow-up of the professional careers of those medical students who completed the PQA was undertaken.	The subsequent follow-up study later poor attrition and did not find correlation between PQA score and school performance.	Level II, Quality B

9	O'Hare (1997)	Quasi-Experimental	First experiment examined relationship of SA (indicated by WOMBAT scores) and independent measures of ability of 24 adults in jobs of varying qualification. Second experiment sought to determine validity of WOMBAT scoring as a predictor of exceptional performance in real world aviation assessing 8 elite soaring pilots and a control group of 12 non-pilots whom were a subset of the first experiment's participants.	Pattern recognition as evidenced by the Walter Reed Assessment Battery demonstrated a significant ability to predict individual levels of SA. Higher levels of experience and expertise correlated with higher levels of SA.	Time constraint for testees resulting in their completion of only 30 minutes of the WOMBAT testing.	Level II, Quality B

10	Ortega et al. (2013)	Systematic Review of articles pertaining to SRNA predictor of success from 1980 to 2011	n=19: 8 involved solely graduate nurse anesthesia programs; 9 involved graduate nursing programs without SRNAs or did not indicate whether they were included; 2 pertained to graduate nursing programs with SRNAs.	Applicants vary in how well they perform once enrolled into nurse anesthesia programs whether or not they meet or exceed the minimally-set criteria imposed by the COA and nurse anesthesia programs, leading to this review of evidence supporting admission criteria. While GPA was found to mostly strongly correlate with SRNA performance, the research is minimal and there is ultimately no consensus found on the admission factors predicting success. That which does exist is said to be weak, outdated, and with mixed student programs. Future study in the SRNA population of factors that predict program success after admission is warranted.	Researchers were limited by the lack of current, high-quality research within nurse anesthesia programs. No evidence from systematic reviews or meta-analyses were available for review. Additionally, participants included non-anesthesia programs.	Level III, Quality B
11	Raven et al. (1998b)	Expert opinion; product manual	Review of relevant literature relating Raven's Progressive Matrices and cognition	This manual describes research, development and standardization of APM-III item banked test version. Authors demonstrate consistent validity and reliability over hundreds of studies in numerous countries. Multiple studies showed positive correlation with measurement of general mental ability and overall job performance.	Possible bias as the research organization sponsoring the review also has the tool available for purchase.	Level V, Quality A

12	Reese (2002)	Comparison study of surveyed traits with descriptive and inferential statistics	Questionnaires were mailed to 83 NAEP Directors, 166 CRNA faculty who were randomly selected to participate by the NAEP directors as requested by the PIs, and 175 CRNAs in US; total n = 424	Cites flaws in currently used indices for admission to a nurse anesthesia program. For instance, the requirement of a minimum one-year critical care experience set forth by the COA does not predict the specific skill sets nor the quantity or quality of experiences expected to be gained during this year. The study thus seeks to unveil what this population finds to be the most important indices of academic success in school. The most important category was personal attributes, primarily defined by students' critical thinking skills, while traditional measures like GPA were the least of all. They conclude that further research is needed to determine predictors of success in a nurse anesthesia program and on different measures such as cognitive testing in the admission process.	Convenience sampling. Homogeneity of the study population may limit variability of responses. Generalizability of the results limited only to nurse anesthesia programs.	Level II, Quality B

13	Schulz et al. (2013)	Review article; Expert opinion	Review of relevant literature relating SA to anesthesia	Review that describes the concept of SA in the anesthesia environment with emphasis on its cognitive theoretical background. It denotes that SA is central to decision making and thus performance while reducing the potential for human error. It delineates that some anesthetists are more capable than others in attaining high levels of SA due to differences in individual levels of cognition, including attention sharing, pattern matching and spatial abilities. For instance, with sound pattern matching, cognitive workload decreases, thereby enhancing SA development. Additionally, improving cognitive skills and building those cognitive structures necessary for high levels of SA is highlighted as a means to develop this crucial trait.	The implementation of domain-specific and therefore goal-directed SA training in anesthesia requires further research. However, the authors agree that increasing a theoretical understanding of SA, its definition and applicability to anesthesia is necessary prior to its development.	Level V, Quality A

14	Schulz et al. (2016)	Qualitative retrospective cohort design	248 cases from the German Anesthesia Critical Incident Reporting Systems (CIRS) reviewed for inclusion criteria to yield n = 200 critical incident cases to be analyzed by two independent raters	Researchers attempted to determine the frequency of errors occurring at specific levels of SA in among CIRS cases in anesthesia and critical care. Cases analyzed qualitatively according to SA error taxonomy. SA error identified in 163 cases (81.5%), mainly resulting at SA levels II and III (perception and comprehension, respectively). Researchers illustrate the crucial role of SA for decision-making and performance.	Researchers limited by depth of CIRS narrative, at times relying on deductive reasoning. Additionally, researchers only identified one individual (not a system) SA error per case resulting in the critical action. Multifactorial errors were not considered. Limitations specific to the anonymous reporting of incidents must also be considered, such as the intentional omission of identifiers, and technical or medical limitations secondary to the role of reporter. The failure to voluntarily report incidents can result in only a minority of actual incidents available for review, and thus not representative of all true incidents.	Level III, Quality B

15	Wong & Li (2011)	First, a pilot study of expert CRNA clinical faculty was undertaken, followed by a prospective randomized survey of NAEP academic faculty	CRNA n=10, NAEP faculty n=25	The authors note a paucity of clinical performance predictors in nurse anesthesia, leading them to examine personal characteristics that confer safe nurse anesthesia practice. Their purpose was to suggest indices that may be used to predict clinical performance and assist in developing more stringent admission processes in the form of a test. Cites that the challenge of predicting clinical success is not specific to nursing anesthesia but has been cited and studied in medicine through the use of battery testing that, in part, assesses a candidate's cognitive ability as predictive of success.	Study seeks to draw upon personality traits that predict success, though notes that a paucity of studies have been done in nursing anesthesia to discuss any predictors determining clinical success.	Level III, Quality B

16	Wright & Fallacaro (2011)	Quantitative, non-experimental, correlational design	n= 111 SRNAs across 3 universities in the US	Authors found that while subject levels of memory and automaticity were not associated with SA as measured by the WOMBAT-CS, cognition levels as measured by Raven's SPM showed a significant, direct, positive linear relationship/ correlation with SA. The latter supports the theory of Endsley and Garland (2000) that cognition serves as a predictor of SA. Translated to this study, cognition is thus shown to best predict SA in the population of SRNAs.	While face validity of WOMBAT-CS in measurement of SA is affirmed in the SRNA population by this study through a comparison of anesthesia and aviation environments, further studies warrant empiric validation in the SRNA community. Attrition was of concern with the absence of 36 subjects' scores on the measurement of SA. Additionally, this was a convenience sample of schools in the southeastern part of the US, which may limit the generalizability of the findings.	Level II, Quality B

Appendix D

Raven's Advanced Progressive Matrices (APM-III) Sample Items

RAVEN'S™ Advanced Progressive Matrices (APM-III)

Sample Items

MORE INSIGHT
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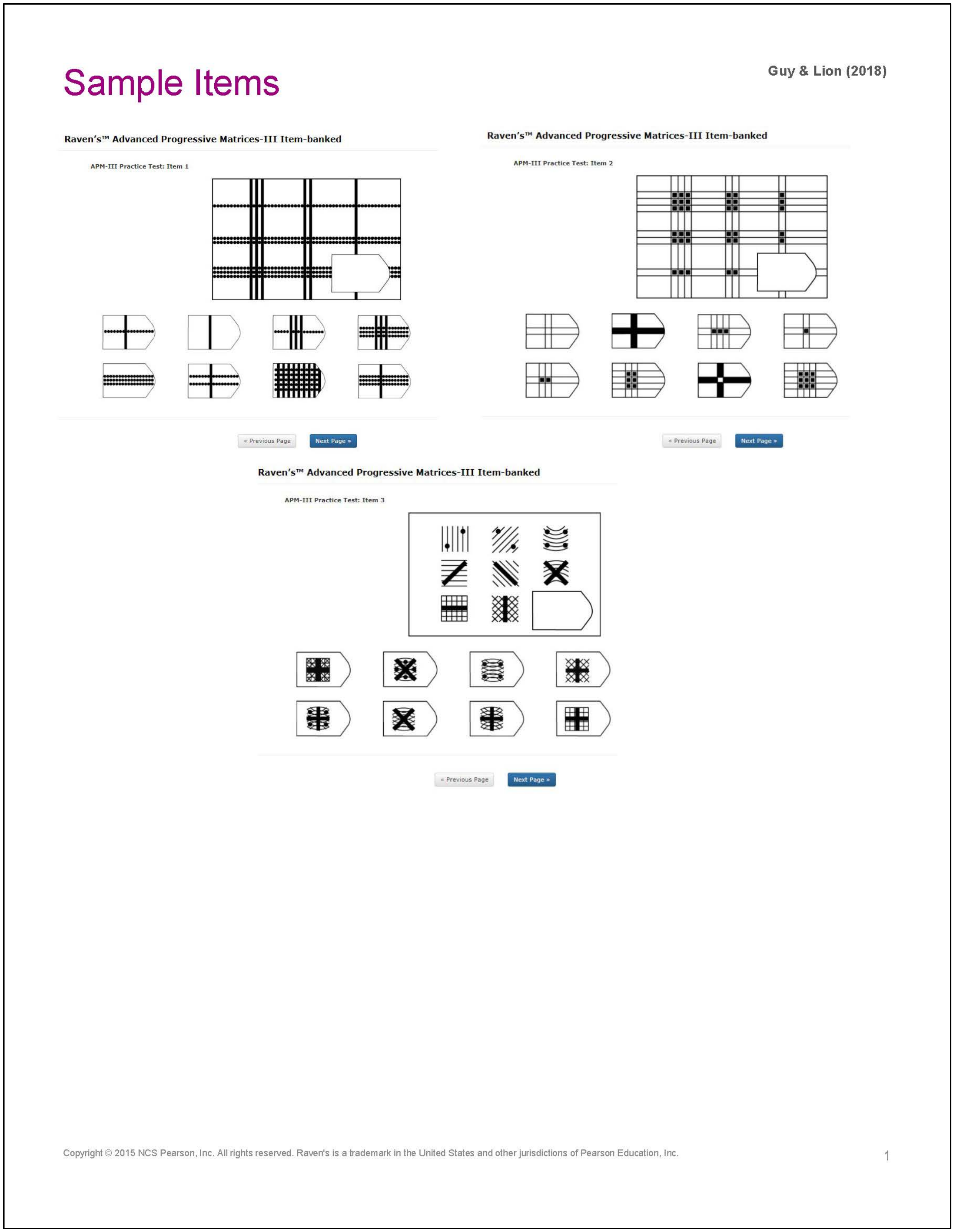
Sample Items
Guy & Lion (2018)
Raven's™ Advanced Progressive Matrices-III Item-banked
APM-III Practice Test: Item 1
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Raven's™ Advanced Progressive Matrices-III Item-banked
APM-III Practice Test: Item 2
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Raven's™ Advanced Progressive Matrices-III Item-banked
APM-III Practice Test: Item 3
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Appendix E

DNP Team Signature Page

Appendix F

Recruitment Flyer

RUTGERS
UNIVERSITY | NEWARK

Rutgers School of Nursing
Stanley S. Bergen Building
Rutgers, The State University of New Jersey
65 Bergen Street
Newark, NJ 07101-1709

Interested in promoting nursing research on the predictive power of cognition in nurse anesthesia?

- Participate in a DNP on cognition to promote nursing research titled:

The Utility of Cognitive Testing in the Nurse Anesthesia Admission Process as a Novel Predictor of Situational Awareness and Academic Success

- Our names are Shannon Guy and Danielle Lion and we are Nurse Anesthesia students at Rutgers University. After your interview, we invite you to participate in a completely voluntary research study that examines cognition in prediction of student and career success. You will be asked to perform a 45-minute computer-based cognitive assessment.

Location: [redacted]

Dates: October 24th & 25th, 2019

Times:

Morning sessions:	Afternoon session:
9:30am-10:45am	2:30pm-3:45pm
11:15am-12:30pm	4:15pm-5:30pm

If interested or have any questions, please contact the Principle Investigators:

Shannon Guy Danielle Lion

[redacted]

Version Number: #2
Version Date: 11/5/18

RESERVED FOR IRB STAMP

Appendix G

Consent Form

RUTGERS
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65 Bergen Street
Newark, NJ 07101-1709

CONSENT TO TAKE PART IN A RESEARCH STUDY

TITLE OF STUDY: The Utility of Cognitive Testing in the Nurse Anesthesia Admission Process as a Novel Predictor of Situational Awareness and Academic Success

Principal Investigators: Shannon C. Guy and Danielle M. Lion
This informed consent form provides information about a research study and what will be asked of you if you choose to take part in it. If you have any questions now or during the study, if you choose to take part in it, you should feel free to ask them and should expect to be given answers you completely understand. It is your choice whether to take part in the research. Your alternative to taking part is not to take part in the research.

After all of your questions have been answered and you wish to take part in the research study, you will be asked to sign this informed consent form. You are not giving up any of your legal rights by agreeing to take part in this research or by signing this consent form.

Who is conducting this research study?
Shannon Guy, SRNA and Danielle Lion, SRNA are the Principal Investigators of this research study. Principal Investigators have the overall responsibility for the conduct of the research. However, there are often other individuals who are part of the research team.

Ms. Guy may be reached at [redacted] and Ms. Lion may be reached at [redacted]

Ms. Guy, Ms. Lion, or another member of the study team will also be asked to sign this informed consent. You will be given a copy of the signed consent form to keep.

Why is this study being done?
This study is being done to assess whether there exists a significant correlation between cognitive test scores and the variables currently used to determine candidate selection in a nurse anesthesia program.

Who may take part in this study and who may not?
Nurse anesthesia interviewees can take part in this study. As obtaining situational awareness and mastering course objectives are necessary to become competent nurse anesthetists, assessing the utility of cognitive testing's predictive role is specific to this population of applicants.

Why have I been asked to take part in this study?
You are invited to take part in this study to assess your level of cognition and its association with assessment measures utilized by the selection committee as well as your interview outcome.

How long will the study take and how many subjects will take part?
Approximately 60 candidates will be invited to participate in this study. The cognitive assessment will take a maximum of 40 minutes. Participants may withdraw from the study at any point during the assessment.

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What will I be asked to do if I take part in this study?
You will be asked to complete an online cognitive assessment that tasks you with completing partial figures with the appropriate missing pieces that complete the picture. The patterns are randomly assigned from an item-bank that ensures similar degrees of difficulty experienced by all participates, even though no two tests are identical. Scores be automatically computed by the online portal and will be available to the PIs only.

What are the risks and/or discomforts I might experience if I take part in this study?
No greater than minimal risks are anticipated from taking part in this study. You may withdraw from the study at any time as participation is completely voluntary. Only the PIs are aware of your participation as well as your assessment scores which will be identifiable to them only by your [redacted] number. It is this identifier that the PIs will then use to align these scores with the aforementioned measures and outcome of admission to the program. The school faculty is unaware of both your participation in the study, as well as your cognitive score, should you chose to participate. Your decision to participate as well as your score will have no negative or positive effects on your admission decision, or academic standing if admitted. Likewise, there will be no consequences for not participating or withdrawing from the study at any time.

Are there any benefits to me if I choose to take part in this study?
If you chose to participate in this study, you will be contributing to the growth of research supporting the use of an evidence-based assessment tool in the nurse anesthesia admission process which has been shown to predict both academic and career success. There are no identified financial or academic benefits to participating in this study.

Will there be any cost to me to take part in this study?
There will be no cost to participate in this study.

Will I be paid to take part in this study?
You will not be paid to take part in this study.

Who might benefit financially from this research?
There are no financial gains to the PIs, participants or faculty from this research.

How will information about me be kept private or confidential?
Ms. Guy and Ms. Lion will collect the paper data which will be stored in a secured office in a locked filing cabinet. Data collected on the online portal will be transferred to an encrypted device accessible to only the PIs. The data will then be stored on a password-protected university computer in the same secured office. All data will be retained for three years and then destroyed, consistent with Rutgers University Policy. The protection of all materials relative to the testing, including results, will be accessible only by the PIs. All efforts will be made to keep your personal information in your research record confidential, but total confidentiality cannot be guaranteed.

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What will happen if I do not wish to take part in the study or if I later decide not to stay in the study?
It is your choice whether to take part in the research. You may choose to take part, not to take part or you may change your mind and withdraw from the study at any time. If you do not want to enter the study or decide to stop taking part, your relationship with the study staff will not change, and you may do so without penalty and without loss of benefits to which you are otherwise entitled.

You may also withdraw your consent for the use of data already collected about you, but you must do this in writing to Ms. Guy or Ms. Lion.

Who can I call if I have questions?

If you have questions about taking part in this study you can call:

Principle Investigators:

Shannon Guy	Danielle Lion
[redacted]	[redacted]

If you have questions about your rights as a research subject, you can call the IRB Director at:

IRB Director, Newark	Rutgers Human Subjects Protection Program, Newark
973-972-3608	973- 972-1149

PERMISSION (Authorization) TO USE OR SHARE INFORMATION THAT IDENTIFIES YOU FOR A RESEARCH STUDY

The next few paragraphs tell you about how investigators want to use and share identifiable information from your record in this research. Your information will only be used as described here or as allowed or required by law. If you sign this consent form, you agree to let the investigators use your identifiable information in the research and share it with others as described below. Ask questions if there is something you do not understand.

What information about me will be used?
Your information used in this study includes your disclosed demographics, your cognitive test score, your decisional admission criteria and interview outcome.

Who may use, share or receive my information?
The research team may use or share your information collected or created for this study with the following people and institutions:

- Rutgers University investigators involved in the study;

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Stanley S. Bergen Building
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Newark, NJ 07101-1709

- The company, [redacted] through which this cognitive assessment is administered, will have access to the demographics you disclose as well as your cognitive test scores.

Those persons or organizations that receive your information may not be required by Federal privacy laws to protect it and may share your information with others without your permission, if permitted by the laws governing them.

Will I be able to review my research record while the research is ongoing?
No. We are not able to share information in the research records with you until the study is over. To ask for this information, please contact the Principal Investigators, the people in charge of this research study.

Do I have to give my permission?

No. You do not have to permit use of your information. But, if you do not give permission, you cannot take part in this study.

If I say yes now, can I change my mind and take away my permission later?
Yes. You may change your mind and not allow the continued use of your information (and to stop taking part in the study) at any time. If you take away permission, your information will no longer be used or shared in the study, but we will not be able to take back information that has already been used or shared with others. If you say yes now but change your mind later for use of your information in the research, you must write to the researcher and tell him or her of your decision:

Principle Investigators:

Shannon Guy
[redacted]

Danielle Lion
[redacted]

How long will my permission last?
Your permission for the use and sharing of your information will last until the end of the research study.

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AGREEMENT TO PARTICIPATE

1. Subject consent:

I have read this entire consent form, or it has been read to me, and I believe that I understand what has been discussed. All of my questions about this form and this study have been answered. I agree to take part in this study.

Subject Name:______________________________

Subject Signature:______________________ Date:__________

2. Signature of Investigator/Individual Obtaining Consent:

To the best of my ability, I have explained and discussed all the important details about the study including all of the information contained in this consent form.

Investigator/Person Obtaining Consent (printed name):______________

Signature:______________________ Date: __________

Appendix H

DNP Project Timeline

The Utility of Cognitive Testing in the Nurse Anesthesia Admission Process as a Novel Predictor of Situational Awareness and Academic Success

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Research/Writing	Mar-18	8	Mar-18	8	100%
IRB Proposal Submission	Oct-18	1	Oct-18	1	100%
IRB Proposal Approval	Nov-18	1	Nov-18	1	100%
Data Collection	Nov-18	1	Nov-18	1	100%
Final Proposal Submission	Apr-19	1	Apr-19	1	90%
Proposal Presentation	Apr-19	1			0%
Final Project Presentation	Mar-20	1			0%