THE MEDIATING ROLE OF LEARNING STYLES AND STRATEGIES IN THE RELATIONSHIP BETWEEN COGNITIVE ABILITY AND ACADEMIC PERFORMANCE

by

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ABSTRACT

Cognitive ability has a strong and important relationship with academic performance. Numerous factors, however, affect a student's performance, including among others; learning style, or the way in which students typically receive and process information, and learning strategies, or the level at which students approach learning and studying. Current studies are, however, divided in their findings regarding the relationship between learning styles and strategies and academic performance as well as the mediatory role they may play.

The study sought to investigate the role of students' learning styles and strategies in the relationship between cognitive ability and academic performance, in order to advance an understanding of the role that they play in this relationship.

The study was conducted using a correlational research design within a cognitive psychology framework. Using convenience sampling, a total of 172 university students completed cognitive tests (Raven's Progressive Matrices and the Letter-N-Back) and a learning style and strategy survey. Structural equation modelling (SEM), specifically path analysis in combination with confirmatory factor analysis (CFA), was then used to test relationships between constructs.

Results from the first model suggest that higher cognitive abilities and the use of rehearsal (the surface learning strategy) each play a unique role in predicting academic performance (χ^2 (67, N = 172) = 145.31, p < .001). It, in addition, seems as if various components of learning style and strategy do not predict academic performance at all. A refined model of the relationship between constructs confirmed this (χ^2 (64, N = 172) = 70.51, p > .05). Learning styles along with the deep and metacognitive learning strategies were found to have no meaningful relation with academic performance. Cognitive abilities and rehearsal however were key predictors of performance.

Mediation analysis further identified rehearsal as a mediator in the relationship between cognitive ability and academic performance (χ^2 (65, N = 172) = 74.10, $p > .05$). Results show that cognitive ability indirectly affects academic performance through the surface learning strategy (rehearsal).

KEY WORDS: cognitive ability, executive function, academic performance, academic achievement, learning, learning style, learning strategy, approaches to learning, structural equation modelling, mediation, path analysis.

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CHAPTER 1:
INTRODUCTION TO THE STUDY

1.1. Introduction

This dissertation is a report of research conducted to understand the role of learning styles and learning strategies in the relationship between cognitive ability and academic performance. This first chapter presents a background to the research, specifies the problem statement, hypotheses, purpose and describes the significance of the study. A brief summary of the methodology utilised and an overview of subsequent chapters are, in addition, provided.

1.2. Background

Predicting and understanding individual differences in academic performance has long been a central issue for researchers, educators, policy makers, parents and students alike. This is because knowledge of the factors that influence academic performance, and the ability to accurately predict it, have powerful, practical implications for students' learning, performance and success.

Over the years, numerous studies have examined the multitude of factors determining academic performance, with cognitive ability arising as one of the strongest and most important factors. Numerous factors, however, affect a student's performance, including among others; learning style, or the way in which students typically receive and process information, and learning strategies, or the level at which students approach learning and studying. Current studies are, however, divided in their findings about the affect that these factors have on academic performance, as well as the mediatory role that they play.

The study sought to investigate the role of students' learning styles and strategies with regard to academic performance and also to investigate mediating effects in the relationship between cognitive ability and academic performance.

1.3. Problem statement

A review of the literature reveals that there is a strong relationship between cognitive ability and academic performance. The role of learning styles and strategies in this regard is, however, not as clearly understood.

In general, higher cognitive abilities relate to higher academic performance but this is not always the case. For example, one may have strong cognitive abilities, but may use particular learning styles and strategies - which may lead to lower than expected academic performance. Likewise, one may have lower cognitive abilities but may use a particular style and strategy that may lead to higher academic performance. Students' learning styles and learning strategies may therefore be influential to the extent that they intervene in the relationship between cognitive ability and academic performance. The study sets out to argue that learning styles and strategies may mediate the relationship between cognitive ability and academic performance.

1.3.1. Research questions

The primary aim of this research was to examine the role of learning styles and learning strategies in the relationship between cognitive ability and academic performance. The following research question was addressed:

Research Question**:** Do learning styles and learning strategies mediate the relationship between cognitive ability and academic performance, in a sample of university students?

Cognitive ability, learning styles and strategies and academic performance may, in addition, interact and relate in unique ways. A secondary aim was to investigate the effect of cognitive ability, learning styles and learning strategies on academic performance as well as to examine the relationships between each of the variables under investigation. A sub-question included:

Sub-question 1: What are the relationships between cognitive ability, learning styles, learning strategies and academic performance?

A final aim included examining any significant differences between genders, as this appears to be standard issue in current research and particularly in cognitive psychological research (Halpern, 2000). In agreement with Halpern (2000), it must be stressed that differences do not require a value judgement and the focus of this assessment was not on which gender was "better" but rather on whether there were any meaningful differences. The sub-question in this regard was:

Sub-question 2: Are there significant differences between genders with regard to cognitive ability, learning style or strategy and academic performance?

1.4. Purpose, aims and objectives

The aim of this research was to examine whether learning styles and learning strategies intervene in, or mediate, the relationship between the cognitive ability and academic performance of students. The purpose was to advance an understanding of the role of learning styles and learning strategies in the relationship between cognitive ability and academic performance. In order to obtain a deeper understanding of this complex relationship, it was necessary to gain insight into the cognitive abilities, learning styles, learning strategies and academic performance of students and analyse the relations between them.

Specific objectives of the research were to:

- Identify the learning styles and learning strategies of students
- Examine students' cognitive abilities
- Determine the academic performance of students
- Explore the relationships between each of the variables
- Determine if learning styles and strategies mediate the relationship between cognitive ability and academic performance

1.5. Hypotheses

The aim of the study, as mentioned previously, was to examine the effect of cognitive ability, learning styles and learning strategies on academic performance, with the mediating effect of learning styles and strategies of specific attention. In order to examine the effects of cognitive ability, learning styles and learning strategies on academic performance as well as whether learning styles and strategies mediate the relationship between cognitive ability and academic performance, the following hypotheses were tested:

Hypothesis 1: Higher cognitive abilities, will significantly and positively predict academic performance

Hypothesis 2: The deep and metacognitive learning strategies will significantly and positively predict academic performance

Hypothesis 3: The surface learning strategy will significantly and negatively predict academic performance

Hypothesis 4: The deep and metacognitive learning strategies will have significant and positive relations with cognitive ability

Hypothesis 5: Learning style will significantly and positively predict academic performance.

Hypothesis 6: Learning styles and strategies will mediate the relationship between cognitive ability and academic performance.

1.6. Overview of methodology

The objectives mentioned previously were pursued using a quantitative, correlational research design within a cognitive psychology framework. An electronic, group administered, Internet survey was used to collect information from participants who were university students, selected using convenience sampling. Descriptive and inferential statistics, specifically structural equation modelling and mediation analysis were then used to analyse the data.

1.7. Significance of the study

The significance of this study is paramount as it contributes valuable insight and theory into the role that learning styles and learning strategies play in the relationship between cognitive ability and academic performance.

The findings of this study may be utilised to inform study skills programs for students, to improve students' learning and academic performance and to inform pedagogy and vocational training. An awareness and understanding of one's learning styles and strategies and their associated strengths and weaknesses, may, in addition, enable individuals to lead with their learning style and strategy strengths whilst developing their weaknesses (Bouldin & Myers, 2002). This may ultimately lead to enhanced learning and ability (Lisle, 2007) and in turn to enhanced academic performance.

This study furthermore contributes to the limited South African knowledge base concerning learning styles and strategies and addresses an ambiguity in the literature with regard to the interchangeable use of learning styles and learning strategies. Findings may moreover stimulate future research on the topic.

1.8. Chapter overview

This research study is presented in five chapters. Chapter 2 presents a review of the literature, including definition and discussion of constructs and the relationships between them. Chapter 3 discusses the theoretical framework underpinning and informing the study and delineates the research methodology used including the research and sampling designs, procedure, measurement instruments and statistical analyses used. A discussion of mediation is also provided in this chapter. Chapter 4 presents the findings of the study and includes a sample profile as well as descriptive and inferential statistics. Chapter 5 then provides a discussion of the main findings, limitations of the study, recommendations and conclusion.

CHAPTER 2:
LITERATURE REVIEW

2.1. Introduction

The aim of this chapter is to provide a theoretical background and review of the literature concerning learning styles, learning strategies, cognitive ability and academic performance. The first sections of the chapter define and clarify the research constructs used in the study, namely; learning styles, learning strategies, cognitive ability and academic performance. In this first section, there is also a particular focus on learning styles as it is a construct that is vehemently debated within the literature. A comparison between learning styles and strategies is also provided.

Subsequent sections of the chapter then discuss previous literature and findings regarding relationships and mediatory roles among the variables studied. Lastly, the hypotheses based on the literature reviewed are provided along with the hypothesised theoretical model to be examined.

2.2. Academic performance

In examining the role of learning styles and learning strategies in the relationship between cognitive ability and academic performance, it is at first necessary to understand exactly what is meant by the term academic performance. Academic performance, also referred to as academic achievement, has been defined as "the specified level of attainment of proficiency in academic work designated by test scores" (Shamashuddin, Reddy, & Rao, 2008, p. 75). Similarly, Good (1973) defines academic performance as the knowledge that is gained, or the skills developed, in subjects or courses and is usually determined by test scores, marks assigned by teachers, or both. Academic performance, for the purpose of this study, refers to a student's level of academic achievement or how well they have done in their studies.

A review of the literature concerning academic performance reveals that predicting and understanding individual differences in academic performance have long been a central issue for researchers, educators, policy makers, parents and students alike. A search of 27 databases using Proquest, for example, returns thousands (23647) of articles, theses, dissertations and reports examining the factors affecting academic performance from the year 1947 to present. There is thus over 50 years of research examining the factors affecting academic performance. This research has used a variety of samples and contexts over the years, including mostly a variety of student populations.

Numerous factors have since been associated with academic performance and the list of factors has become large and diverse. The numerous factors, however, typically fall into two general categories namely; intellectual factors and non-intellectual factors (Crede´ & Kuncel, 2008; Deka, 2000). Intellectual factors include intelligence, tests of general cognitive ability and tests of specific cognitive abilities (Crede´ & Kuncel, 2008; Deka, 2000). Non-intellectual factors include, among others; personality factors, demographics, socio-economic factors, psychosocial factors, historical and familial factors, environmental factors, cultural factors, behavioral, attitude and motivational factors as well as the mental and physical health of individuals (Deka, 2000; McKenzie & Schweitzer, 2001).

While there are numerous factors involved, cognitive ability is a factor that has, over the years, emerged as one of the strongest predictors of academic performance (Crede´ & Kuncel, 2008; Deary, Strand, Smith & Fernandes, 2007; Gagne & St Pere, 2002; Gustafsson & Undheim, 1996; Neisser et al., 1996; Oswald, Schmitt, Kim, Ramsay, & Gillespie, 2004; Walberg, 1984). This strong predictor of performance is defined and discussed below.

2.3. Cognitive ability

A consistent definition of cognitive ability is difficult to identify. Carroll (1993) however proposes a reputable definition that requires an initial understanding of the terms ability, task and cognitive task. According to Carroll (1993):

> As used to describe an attribute of individuals, ability refers to the possible variations over individuals in the liminal levels of task difficulty (or derived measurements based on such liminal levels) at which, on any given occasion in which all occasions appear favourable, individuals perform successfully on a defined class of tasks. (p. 8)

A task, according to Carroll (1993) is then defined as "any activity in which a person engages, given an appropriate setting, in order to achieve a specifiable class of objectives, final results, or terminal state of affairs" (p. 8). A cognitive task is defined as "any task in which correct or appropriate processing of mental information is critical to successful performance" (Carroll, 1993, p. 10). Finally, a cognitive ability "is any ability that concerns some class of cognitive tasks, so defined" (Carroll, 1993, p. 10).

A cognitive ability can be described as a mental capacity, competency or skill needed to carry out, or perform, a cognitive task(s) (Colman, 2009; Galotti, 2008). For example, working memory is a cognitive ability or capacity to actively retain information temporarily, while at the same time manipulating that information or accessing other information (Dehn, 2008; Izawa & Ohta, 2005).

While there are numerous cognitive abilities, often they are positively correlated with each other. This positive correlation across abilities has, in turn, led to the acceptance of a general cognitive ability (Dickens, 2008). General cognitive ability commonly refers to one's overall cognitive ability and is often used synonymously with intelligence and measured with intelligence tests (Dickens, 2008).

This study examined cognitive abilities that together make up what is called executive function. These abilities include; attention, working memory, abstraction and mental flexibility. Executive function is, as such, the shorthand description of these complex cognitive processes that together are responsible for guiding, directing and managing cognitive functions (Strauss, Sherman & Spreen, 2006). Executive functions such as these are important for learning as they affect and impact on academic performance (Nosarti, Murray, & Hack, 2010; Shamashuddin et al., 2008). Academic success, in addition, is linked to the mastery of these cognitive processes (Shamashuddin et al., 2008). Working memory in particular is said to be principally important for the learning process (Graf & Kinshuk, 2008; Shamashuddin et al., 2008). Each of the cognitive abilities examined are defined and discussed below.

2.3.1. Attention and working memory

First proposed by Atkinson and Shiffrin (1968) and Baddeley and Hitch (1974), working memory is generally described as “the set of mechanisms capable of retaining a small amount of information in an active state for use in ongoing cognitive tasks” (Cowan et al., 2005, p. 43). Broadly defined it is the ability to actively retain information temporarily, while at the same time manipulating that information or accessing other information (Dehn, 2008; Izawa & Ohta, 2005). Although there are individual differences, working memory is seen as a limited capacity memory structure as it allows individuals to keep only a restricted amount of information (±7 items) active in the mind for a short period of time (Dehn, 2008; Galotti, 2008; Graf & Kinshuk, 2008).

Working memory plays a central role in cognitive functioning and is particularly important for the learning process (Dehn, 2008; Graf & Kinshuk, 2008; Meltzer, 2010). This is due to its involvement in management, manipulation and executive functions (Dehn, 2008). It has furthermore been found that those with poor working memory are more likely to perform poorly in key learning outcomes such as reading and mathematics (Alloway, Elliott, & Place, 2010). Poor working memory, in addition, is believed to lead to poor attention abilities

Attention is an umbrella term that refers to one’s mental effort or the amount of concentration devoted to a cognitive process (Galotti, 2008). Attention in general involves allowing certain stimuli, or information, precedence over the rest while ignoring the other information. It is also characterised by a limited capacity for processing information and although individuals can choose what they attend to, there is nonetheless a limitation on the amount that they can attend to at any one time. Their attention can, in addition, be easily distracted (Styles, 2006).

While working memory and attention are distinct, or unitary constructs, poor working memory and poor attention appear to co-occur. For example, it has been found that those with lower working memory are more likely to be inattentive, forgetful and easily distracted which may lead to mistakes and difficulties in their studies (Alloway et al., 2010). Compared with control groups, those who are inattentive tend to be impaired in tasks of working memory (Karatekin, 2004). The core cognitive deficit associated with poor attention is thus believed to be associated with working memory (Alloway et al., 2010). Attention is therefore important for, and relevant to, working memory processes and abilities (Izawa & Ohta, 2005) as poor working memory is said to lead to poor attention abilities.

2.3.2. Abstraction and mental flexibility

"The word abstraction connotes abstracting some unifying idea or principle on the basis of observation of diverse material" (Goldstein & Nussbaum, 1998, p. 317). It is hence defined as the ability to learn or form an abstract concept (Hersen, 2004). It involves using abstract representations of experience instead of direct sensory experience and interaction with the real world, in order to form concepts, mental sets and to solve problems (Goldstein & Nussbaum, 1998). Abstraction thus involves formulating conclusions using symbolic information, representations and examples, and the use of theories, metaphors and analogies (Goldstein & Nussbaum, 1998).

Mental, or cognitive, flexibility on the other hand, refers to one's capacity to be mentally or cognitively pliable. It is the ability to consider alternative responses, conclusions and answers, as well as to adapt and modify one's cognitions to situational demands (Cabrera, Chavez, Corley, Kitto, & Butt, 2006). It includes the ability to flexibly shift between tasks or to switch from one topic to another (Andrewes, 2001) and thus to disengage from one mental set and engage in an alternative line of thought (Ghacibeh, Shenker, Shenal, Uthman, & Heilman, 2006).

Abstraction and mental flexibility are closely linked as mental flexibility provides one with the ability to think conceptually and abstractly (Meriano & Latella, 2007). Both, in addition, involve activities that allow one to move beyond concrete thought.

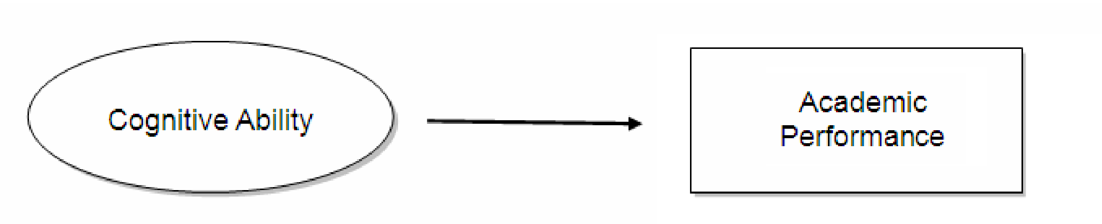
In summing up, different individuals have different capacities in each of these aspects of executive function, which in turn have been found to affect their learning and academic performance.

2.4. The relationship between cognitive ability and academic performance

Cognitive ability is considered a powerful predictor of academic performance (Gustafsson & Undheim, 1996; Neisser et al., 1996) as there is a vast amount of empirical evidence for a strong relationship between the two (Chamorro-Premuzic, 2007; Rohde & Thompson, 2007; Walberg, 1984). As measures of cognitive ability have a rich history of accounting for meaningful levels of variance in academic performance (Yen, Konold & McDermott, 2004) they have, as such, become known as relatively reliable predictors of academic performance.

The relationship between cognitive ability and academic performance (see figure 2.1) is said to be so strong that some authors do not believe that non-intellectual factors would have any significance in predicting academic performance (Gagné & St. Pére, 2002).

FIGURE 2.1: The relationship between cognitive ability and academic performance



NOTE: Arrow represents relation. This figure illustrates the relationship between cognitive ability and academic performance. This relationship has been evidenced in many studies.

In general, as ability increases so too does performance, however in reality a higher level of cognitive ability does not automatically equate to higher academic performance. This is because cognitive ability alone cannot account for all of the variation in academic performance and much of the variance in academic performance is yet to be explained (Kaplan & Saccuzzo, 2009; Mouw & Khanna, 1993; Rohde & Thompson, 2007).

While measures of cognitive ability can provide an indication of whether students have the ability to learn and understand complex material, they cannot for example, indicate whether students have the patterns of studying behaviors necessary to process, integrate, and recall the material (Crede´ & Kuncel, 2008, p. 427). Scores of cognitive ability alone cannot provide an understanding of why students with suitable levels of cognitive ability do not perform well. Many researchers have thus begun to look beyond intellectual predictors (Deangelis, 2003; Grigorenko & Sternberg, 2001; Mattern & Shaw, 2010; Sanford, 2009) and examine multiple factors and their relations to academic performance (Crede´ & Kuncel, 2008; Young, 2005).

A promising group of non-intellectual factors that have been found to affect academic performance are factors related to the studying and learning attributes and behaviors of students (Crede´ & Kuncel, 2008). According to Crede´ and Kuncel (2008), such factors have been found to exhibit relationships with academic performance that are approximately as strong as the relationship between academic performance and cognitive ability. An understanding of the relationship between cognitive ability and academic performance as well as the studying and learning attributes of students, such as learning styles and learning strategies, may yield promising results with important implications.

2.5. Learning styles and learning strategies

2.5.1. Learning styles

Learning styles is a complex construct, which is difficult to define, as there are many varied and contrasting definitions. There is, in addition, a lack of consistency in how the term has been used, as well as debates concerning what is encompassed by the construct. There are thus many definitions of learning styles available. For example, as many as 71 learning style models, or theories, have been identified (Coffield, Moseley, Hall, & Ecclestone, 2004), each with its own definition and descriptions. The numerous definitions overlap somewhat but may vary in terms of the behaviours predicted, how such behaviors are grouped and labeled, their stability over time and context, and the degree to which biological or social factors are thought to have an influence (Eaves, 2009).

In general, however, learning styles are described as the composite of characteristic cognitive, affective and physiological behaviours that serve as relatively stable indicators of how individuals perceive, interact with and respond to learning material and learning environments (Furnham, 2008; Sims & Sims, 1995).

The learning styles concept is, however, further complicated as it has been used to describe a range of individual difference constructs including; learning preferences, learning strategies, approaches to studying and cognitive style (Sadler-Smith, 2001). This has resulted in a lack of consistency in how the term has been used as well as confusion regarding what the concept encompasses (Cassidy, 2004; Coffield et al., 2004; Scott, 2010). Those using the term learning style should provide clear and unambiguous definitions, so that others are aware of what is meant by the term.

For the purpose of this research, learning styles was defined according to the Felder-Silverman Learning Style Model (FSLSM). According to the FSLSM, individuals have different strengths and preferences with regard to the way in which they receive and process information (Felder & Spurlin, 2005) and as a result learn information in different ways. Accordingly, learning style is defined as the way in which an individual typically and preferentially receives, perceives, processes and understands information (Felder & Silverman, 1988). Inherent in the concept of style is that individuals tend to exhibit consistent patterns across situations over time (Furnham, 2008). Learning styles are thus seen as relatively stable over time.

2.5.1.1. Felder-Silverman learning style model

The FSLSM characterises individuals as having a preference for one category over the other on four dimensions (Felder & Silverman, 1988). The four dimensions include the active-reflective, sensing-intuitive, visual-verbal and sequential-global learning style dimensions. Figure 2.2 below illustrates the FSLSM. Each style on a dimension has certain characteristics and tendencies, which are described below.

FIGURE 2.2: The four dimensions of the FSLSM

Sensing -- Intuitive

Visual -- Verbal

Active -- Reflective

Sequential -- Global

NOTE: This figure illustrates the four different FSLSM dimensions.

The FSLSM was chosen as it is used extensively by researchers and educators in the field and has recent influence in the field of learning styles (Scott, 2010). The FSLSM, in addition, describes the learning style categories in more detail and distinguishes between the degrees of preference for each category in four learning style dimensions (Felder & Silverman, 1988). The FSLSM therefore is not strictly bipolar as one's preference for a category in each of the four dimensions may be strong, moderate, mild or balanced. As the model is based on tendencies and preferences instead of mutually exclusive categories, this signifies that those with a strong tendency for certain behaviour can behave in different ways at times (Graf, Viola, Leo, & Kinshuk, 2007). While learning styles are viewed as relatively stable, it is accepted that there may be instances wherein a strong visual learner may be a strong verbal learner for example.

It is important to note that the FSLSM is not an original model but is based on a combination of existing learning style theories (Felder, 2007; Felder & Silverman, 1988). The sensing-intuitive dimension was constructed directly from the Myers-Briggs Type Indicator (MBTI) (Felder, 2007) and Jung's theory of psychological types (Felder & Silverman, 1988). The active-reflective dimension is based directly on David Kolb's experiential learning theory (Felder & Silverman, 1988). Numerous other theories were, in addition, drawn upon for each of the categories and dimensions (Felder, 2007).

2.5.1.1. (a) Sensing-intuitive dimension

As previously mentioned, the FSLSM's sensing-intuitive dimension is based on Jung's psychological types (Felder & Silverman, 1988). In his theory of psychological types, Jung noted that individuals differed in their adaptation and orientation to the world (Jung, 1971). Jung characterised this diversity between individuals, as well as within individuals, by categorising people into primary types of psychological function (Jung, 1971). He introduced sensation and intuition as the two ways in which individuals tend to perceive the world.

The sensing-intuitive dimension deals with whether an individual prefers or habitually uses sensory over intuitive perception (Felder & Silverman, 1988). The dimension, in addition, reflects one's preferred source of information, such as concrete or abstract information (Graf et al., 2007). Individuals with a strong preference for a sensing learning style, or sensors, favour concrete learning materials such as facts and data (Felder & Silverman, 1988). In general sensors can memorise facts well; they like to use standard methods to solve problems and are more methodical (Felder & Silverman, 1988; Lawrence, 1993). They are patient with detail and work carefully; however, this may lead them to have slower response times. Sensors, in addition, tend to dislike obstacles and the unexpected (Felder & Silverman, 1988).

A developed preference, or dominance, in intuition provides insight into complexity and the means to see abstract, symbolic and theoretical relationships, future possibilities and creative solutions (Lawrence, 1993). Those with an intuitive learning style favour abstract learning materials like principles, concepts and theories. Intuitors are therefore good at grasping new concepts, they also like innovation and imagination and are not particularly troubled by obstacles. They however dislike repetition and are easily bored by detail (Felder & Silverman, 1988). In general intuitors work quickly but they may be careless in doing so (Felder & Silverman, 1988).

According to the FSLSM, a sensor's performance should be slower in timed tests as they may have to read questions several times, paying careful attention to detail before beginning to answer them and as such they may run out of time. Intuitors, however, may also do poorly on timed tests because of their general impatience with details, leading them to begin answering questions before they have read them through thoroughly (Felder & Silverman, 1988, p. 676).

2.5.1.1. (b) Visual-verbal dimension

This dimension deals with the preferred mode of input for learning (Graf, Lin, & Kinshuk, 2008), or the way individuals tend to receive information best (Felder & Silverman, 1988). The dimension thus differentiates those who remember best from what they have seen from those who remember best from textual representations that are either written or spoken (Felder & Silverman, 1988; Graf et al., 2007; Graf et al., 2008).

Those with a visual learning style therefore remember best when pictures, diagrams, flow charts, timelines, films and demonstrations are presented or used (Felder & Silverman, 1988). Written or spoken words on the other hand may likely be forgotten. Verbal learners, in contrast, remember well when the material is heard and remember best when they hear and subsequently talk about the material. Discussions, verbal explanations and explaining material to others are therefore preferred (Felder & Silverman, 1988; Felder & Spurlin, 2005; Graf et al., 2007).

2.5.1.1. (c) Active-reflective dimension

This dimension differentiates the ways in which perceived information is processed (Graf et al., 2008). This complex process by which perceived information is converted into knowledge is divided into two groups, namely active and reflective (Felder & Silverman, 1988). The active and reflective dimensions are based on the active experimentation and reflective observation categories of David Kolb's experiential learning theory (Kolb, 1984). Active experimentation and reflective observation, as outlined by Kolb (1984), are seen as different approaches toward transforming or processing information. Active experimentation involves doing something in the external world with the information. One, for example, may discuss or explain the information to others or test it in some way (Felder & Silverman, 1988). Having an active learning style implies working actively with the material and applying it (Felder & Silverman, 1988; Graf et al., 2007). Active learners are also said to work well in groups (Felder & Silverman, 1988).

Reflective observation on the other hand involves examining and manipulating the information introspectively (Felder & Silverman, 1988), mentally or internally. Reflective learning can therefore be seen as a more passive processing style where one prefers to think about, and reflect on, the learning material (Graf et al., 2007). Reflective learning may involve postulating explanations or interpretations, drawing analogies, or formulating models for example (Felder & Silverman, 1988). Reflective learners generally work better by themselves or with, at most, one partner (Felder & Silverman, 1988).

Both active learners and sensing learners, discussed previously, favour the external world of phenomena and it may appear that the categories overlap. Similarly, reflective learners and intuitive learners are both involved in the internal world of abstraction. The categories, however, are independent as a sensing learner preferentially selects information available in the external world but could process it differently, that is either actively or reflectively. Intuitors likewise select information produced internally but may process it either reflectively or actively (Felder & Silverman, 1988, p. 678).

2.5.1.1. (d) Global-sequential dimension

This dimension deals with individuals' understanding of information, separating those who understand information holistically from those who understand in a step-wise, linear or sequential fashion (Felder & Silverman, 1988). Individuals with a sequential learning style understand material incrementally or partially (Felder & Silverman, 1988) and use logical, progressive steps to understand and subsequently answer questions and find solutions to problems (Graf et al., 2007; Graf et al., 2008). Sequential individuals may as such be stronger in convergent thinking and analysis (Felder & Silverman, 1988).

Individuals with global learning styles conversely use holistic thinking and learn in large disordered or random leaps (Felder & Silverman, 1988). They absorb information randomly and connections may be difficult for them to see at first. However, once more information is received, connections become apparent and suddenly the whole is understood. Global learners as a result may have difficulty when asked to offer an explanation as to how they reached a solution or answer (Felder & Silverman, 1988). Global learners may be better at divergent thinking and synthesis (Felder & Silverman, 1988).

Each of the four dimensions thus deal with habitual ways of detecting, inputting, processing and understanding information, and each category or style is associated with general characteristics and behaviour, which may influence learning and academic achievement.

2.5.2. Learning strategy

The learning strategies construct is much better conceptualised in the literature than the learning styles construct, but the term is, on occasion, used inconsistently in the literature. The term learning strategies is generally defined to describe what students do when they go about learning (Biggs, 1999). It refers to the way in which an individual sets about or approaches learning, for example superficially or on a deeper level of processing. Learning strategies have been defined as "individual differences in intentions and motives when facing a learning situation, and the utilisation of corresponding strategies (Diseth & Martinsen, 2003, p. 195). "Such approaches may also be considered to reflect different levels of processing" (Diseth & Martinsen, 2003, p. 195).

Different classifications of learning strategies exist (Diseth & Martinsen, 2003; Young, 2005), however three main strategies consistently appear in the literature, namely the deep learning strategy, the surface, or superficial, learning strategy and the strategic, or metacognitive, learning strategy.

Deep and surface learning strategies were first introduced in a study by Marton and Saljo (1976). In their study, Marton and Saljo (1976) gave students a segment of text to read and informed them that they would be asked questions afterwards. It was found that students differed in their strategies or approaches to learning as they either showed intentions to understand the learning material or had intentions only to reproduce the learning material. The former was classified as the deep learning strategy and the latter, the surface learning strategy.

2.5.2.1. The deep learning strategy

The deep learning strategy involves motivation and intention to understand when learning (Marton & Saljo, 1976). The deep strategy includes, among others, critical examination of new facts and ideas, linking them to existing cognitive structures and connecting them to real word contexts. This strategy involves organisation, elaboration and critical thinking and can be viewed as a more active strategy, with a higher level of engagement when learning or studying (Biggs, 1999; Young, 2005). Adopting a deep learning strategy is said to lead to greater understanding and long term retention of concepts, promoting comprehension and practical application (Biggs, 1999; Marton & Saljo, 1976).

2.5.2.2. The surface learning strategy

The surface learning strategy, in contrast, involves intentions to memorise and reproduce the material only. It includes accepting new facts and ideas uncritically as well as attempts to memorise them as isolated, unconnected items (Cooper & Forrest, 2009; Tight, 2009). Those who use a surface strategy are said to skim along the surface, remembering only disjointed facts and do not comprehend the meaning or point (Marton & Saljo, 1976). This strategy can therefore be seen as a more passive approach to learning, where learning content is seen simply as material to be learnt for an exam without much understanding and with no practical purpose. It can furthermore be seen that there is a large gap between the deep learning strategy and the surface learning strategy in terms of the level of cognitive engagement when learning (Biggs, 1999).

2.5.2.3. The metacognitive learning strategy

In addition to the deep and surface learning strategies, a strategic learning strategy was introduced by Entwistle and Waterston (1988) and Ramsden (1981). Within this approach, students aimed towards top achievement and performance by managing, planning and organising their time and intellectual resources to reach this goal. Students adopting this strategy thus plan and organise their efforts towards learning by creating conditions appropriate for optimal learning and studying. Students may, for example, gather and organise learning materials, use previous examination papers and course objectives to prepare a study schedule to follow (Diseth & Martinsen, 2003).

Students may then use either the deep, surface or combined strategies to learn, based on what is deemed necessary (Tight, 2009). This learning strategy, however, involves activities and mechanisms used for controlling and executing the learning process rather than strategies for learning per se (Diseth & Martinsen, 2003). This strategy involves metacognitive or self-regulatory behaviours that can be seen as an active strategy for going about learning and has been termed the metacognitive strategy.

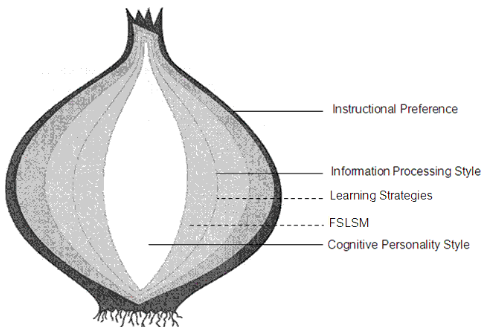
The specific learning strategy used may have implications for learning and academic performance, as it has been found that certain learning strategies are related to better academic performance (Diseth & Martinsen, 2003; Entwistle, Tait, & McCune, 2000; Newstead, 1992; Sadler-Smith, 1997). These relations will be discussed in subsequent sections, but learning styles and learning strategies are at first compared.

2.5.3. Comparison of learning styles and learning strategies

Learning styles, as previously mentioned, are seen as relatively stable in that they are enduring but can change in certain situations. According to a model developed by Curry (1983), learning strategies are also relatively stable, but may be less so than learning styles.

Based on extensive review and the psychometric properties of style measures, Curry (1983) proposed a model that would organise the many theories and models of cognitive and learning styles regardless of the terms used to describe the constructs. This model organises the theories into layers, resembling an onion, as seen in figure 2.3.

FIGURE 2.3: The onion model: the organisation of learning style and strategy theories and models



NOTE: Adapted from Curry (1983)

The outermost, observable layer of this onion is labelled instructional preference and includes models and theories that refer to individuals' choice of environment in which to learn. This outer layer is the least stable layer and is also the most easily influenced or changeable layer (Curry, 1983).

The middle layer of the onion, named information processing style, includes models that refer to individuals' ways of taking in, or processing information, such as Kolb's experiential learning theory. This processing does not directly involve the environment, and as such it is more stable than the outermost layer, but is still modifiable (Curry, 1983).

The innermost layer, the cognitive-personality layer, includes models referring to individuals' approaches to adapting and assimilating information and includes the MBTI. Constructs in this layer are very stable and are seen as underlying and relatively permanent personality dimensions. As Curry (1983) states: "these models form part of the construct description of personality" (p. 9).

The FSLSM learning styles are thus seen as more stable but not to the extent that they can be described as enduring traits, as in the case of personality. The FSLSM dimensions therefore do not describe personality traits but rather describe predominant or customary ways of receiving and processing information that are relatively stable but can change in some instances. Using Curry's (1983) onion model the FSLSM falls in the middle layer of the hypothetical onion and is perhaps closer to the innermost layer as it is based on Kolb's experiential learning theory as well as the MBTI.

Learning strategies, in addition, reflect typical approaches to learning but may change according to the context, type of content and type of learning task, and therefore fall into the middle layer of the onion as well. The way students go about learning is what they typically do and therefore does not describe their personality characteristics (Biggs, 1999). Learning styles can therefore be seen as more stable than learning strategies as the learning styles dimensions overlap with the MBTI, and thus personality, whereas strategies are less stable in that they are more context dependent (Richardson, 1994).

Both learning styles and learning strategies conceptually refer to cognitive processes such as reception, perception and level of information processing, and thus the middle layer of the onion. Learning styles, however, emphasise predominant or customary ways of receiving and processing information, and learning strategies emphasise the level of cognitive processing or engagement with learning. It can be seen that learning styles and learning strategies have important links to cognitive processes and abilities. They, in addition, may have important links to each other as relationships between them have been found (Wedderburn, 2006). For example, in a South African sample, it was found that a higher preference for intuitive and global learning styles was associated with the deep learning strategy (Wedderburn, 2006, p. 117).

2.6. Previous findings

This section provides an overview of the literature examining relationships between the variables in the study as well as results concerning mediatory roles and academic performance.

The primary aim of the study was to examine whether learning styles and learning strategies are influential to the extent that they intervene in, or mediate, the relationship between cognitive ability and academic performance. A literature search using various databases, such as CSA Illumina, Proquest and EbscoHost as well as searches of specific journal publications reveal that cognitive ability is strongly associated with academic performance, and that learning styles and learning strategies are factors that have been associated with academic performance, albeit inconsistently. However, few studies have examined the combined influence of these factors on academic performance. Knowledge regarding the mediation effects of learning styles and learning strategies on the relationship between cognitive abilities and academic performance is therefore limited.

As previously mentioned, a strong relationship between cognitive ability and academic performance is well documented (Crede´ & Kuncel, 2008; Deary et al., 2007; Gagne & St Pere, 2002; Gustafsson & Undheim, 1996; Neisser et al., 1996; Oswald et al., 2004;

Walberg, 1984). Recent findings however suggest that learning styles and learning strategies are also well related to academic performance (Aripin & Mahmood, 2008; Cano, 1999; Diseth & Martinsen, 2003; Entwistle et al., 2000; Hargrove, Wheatland, Ding, & Brown, 2008; Newstead, 1992; Sadler-Smith, 1997; Yeung, Read, & Schmid, 2005; Zywno & Waalen, 2002). What follows is a review of the literature regarding these relations as well as the intricate relationships between each of the variables under investigation. Thereafter literature concerning meditating roles is discussed.

2.6.1. The relationship between learning styles and academic performance

The research concerning learning styles and academic performance focuses largely on the "meshing hypothesis" or "learning styles hypothesis" - which is the view that teaching and instruction should be tailored to an individual's learning style (Constantinidou & Baker, 2002; Cook, Thompson, Thomas, & Thomas, 2007; Felder, 1993; Felder & Henriques, 1995; Ford & Chen, 2001; Gravenhorst, 2007; Massa & Mayer, 2006). Matching teaching styles to learning styles is said to lead to increased academic performance (Felder & Silverman, 1988; Hayes & Allinson, 1996). Pashler, McDaniel, Rohrer and Bjork (2008) however argue that there is no evidence in support of the meshing hypothesis in improving academic functioning and performance.

Several studies investigating the relationship between learning styles and academic performance, without the topic of matching instruction, are nonetheless available. The results are mixed with some finding significant differences in academic performance among different learning styles (Aripin & Mahmood, 2008; Cano, 1999; Hargrove et al., 2008; Yeung et al., 2005; Zywno & Waalen, 2002), some finding only indirect effects (Diseth & Martinsen, 2003) and others finding no significant variation (Prajapati, Dunne, Bartlett, & Cubbidge, 2011; Yildirim, Acar, Baker, & Sevinc, 2008).

Regarding the FSLSM specifically, results have shown that the reflective, intuitive, verbal and sequential learning styles may predict higher academic performance. In a study by Zywno and Waalen (2002) it was found that prior academic performance, which is a strong predictor of future performance, was higher in students with reflective, intuitive, verbal and sequential learning styles than students with sensing, visual and global learning styles (Zywno & Waalen, 2002).

Results have furthermore shown that reflective learning styles in particular may predict higher academic performance. Research conducted by Cano (1999) found that the more independent learners were, the more academic performance increased. Similarly, Yeung et al. (2005) found that introverted learners performed better than extroverted learners. Reflective learners favour the internal world of abstraction and work better alone rather than in groups (Felder & Silverman, 1988). These learners can thus be viewed as more independent and perhaps introverted. Reflective learning styles may therefore predict higher academic performance.

Performance for introverted learners, however, was found to decrease when students had an extreme or strong preference for introverted learning. It seems that a very strong preference for a certain learning style may actually impede academic performance (Yeung et al., 2005). Felder and Soloman (n.d.) maintain that a balance between the two categories on a dimension is more beneficial for optimal learning and performance. This is because a balanced learning style may allow an individual to make use of the strengths of each category. A balanced learning style allows students the flexibility to deal optimally with any kind of situation and seems a laudable goal for each student (Curry, 1990).

2.6.2. The relationship between learning strategies and academic performance

Entwistle et al. (2000), state that the relationship between learning strategies and academic performance has been fairly consistent. They suggest that in general the metacognitive strategy is positively correlated with academic performance and that the surface learning strategy is negatively correlated with academic performance. A review of the literature, however, confirms that results regarding this relationship are inconsistent. Cassidy and Eachus (2000), Diseth and Martinsen (2003) and Rodriguez (2009) for example have found that the relationship between the deep learning strategy and academic performance is weak. Entwistle and Wilson (1977) and Scmeck (1983) however believe that the deep strategy still leads to greater academic performance. In support of this Entwistle et al. (2000), Newstead (1992) and Sadler-Smith (1997) have found that the deep learning strategy is significantly predictive of academic performance.

While it has been found by most that the surface learning strategy is negatively associated with academic performance (Entwistle & Wilson 1977; Kember, Jamieson, Pomfret & Wong, 1995; Minnella, 2011; Newstead, 1992; Scmeck 1983), Diseth and Martinsen (2003) have found that the surface learning strategy is significantly predictive of academic performance. The metacognitive learning strategy, however, is consistently found to correlate positively with academic performance (Cassidy & Eachus, 2000; Diseth & Martinsen, 2003; Minnella, 2011).

The relationship between the deep learning strategy and academic performance remains unclear, with the surface learning strategy correlating negatively with academic performance in the majority of cases. The metacognitive strategy on the other hand seems to be a positive predictor of academic performance almost all the time. This may be due to the fact that students using the metacognitive strategy organise and try to efficiently maximise their learning and academic performance by using the appropriate strategy(s) for the task at hand.

2.6.3. The relationship between learning styles and cognitive ability

Research has found that in addition to relations with academic performance, learning styles correlate with various cognitive abilities as well. Learning styles have correlated with working memory capacity (Graf et al., 2008; Graf, Liu, Kinshuk, Chen & Yang, 2009), problem-solving (Choi, Lee, & Kang, 2009), critical thinking abilities (Zhang & Lambert, 2008), recall of names and faces (Neils-Strunjas, Krikorian, Shidler, & Likoy, 2001) and visualisation skills (Nussbaumer & Guerin, 2000).

Graf et al. (2008) and Graf et al. (2009) identified indirect relationships between the FSLSM learning styles and working memory capacity through examining the results of previous literature. It was found that individuals with intuitive, reflective and sequential learning styles tend to have a higher working memory capacity. In contrast, those with sensing, active, and global learning styles tend to have lower working memory capacity. Individuals with a verbal learning style tended to have a high working memory capacity however those with a visual learning style were found to have either high or low working memory capacity.

Graf et al. (2009) in addition performed an experiment to test the indirect relationships identified above. The results showed that active, reflective and sensing learning styles were in fact associated with a low working memory capacity. Those with a verbal learning style tended to have a high working memory capacity and visual learners had either high or low working memory capacity. No relationship was however found for the sequential and global learning styles (Graf et al., 2009).

Having a balanced learning style, or having no preference in a dimension, was furthermore related to having a high working memory capacity. Therefore the more balanced the learning style becomes; the higher working memory capacity tends to be (Graf et al., 2009). Again, as Felder and Soloman (n.d.) and Curry (1990) suggest, having a balanced learning style may be more beneficial.

2.6.4. The relationship between learning strategies and cognitive ability

While research regarding the relationship between learning styles and cognitive ability is available, research regarding learning strategies and their relation to cognitive abilities is not well studied or understood (Tickle, 2001). Researchers have previously noted the lack of research concerning the relationship between cognitive abilities and the use of different strategies (Snow & Lohman, 1984). Some researchers nonetheless argue that as cognitive ability increases, a student’s array of available strategies should also increase (Snow & Lohman, 1984). This then offers them an increased ability to adapt their study strategies to the demands of the situation (Crede´ & Kuncel, 2008). Accordingly, metacognitive and deep strategies may be related to higher cognitive abilities.

2.6.5. Additional links to cognitive ability

While the relations between learning strategies and cognitive ability are not well investigated, both learning styles and learning strategies may involve activities that are thought to enhance cognitive abilities. In a study by Jaeggi, Buschkuehl, Jonides, and Perrig (2008) it was found that the cognitive ability of working memory could be enhanced though training. The effects were dosage-dependant, meaning that the more one trained, the more gains there were in working memory. Even more notable was that the training that enhanced working memory also led to a significant improvement in scores on a completely unrelated cognitive task. Kuszewski (2011) is of the opinion that one can perform various activities in everyday life to train and enhance working memory in the same way, by seeking novelty, challenging oneself, thinking creatively, doing things the hard way and networking. These activities are believed to lead to enhanced ability. For example Kuszewski (2011) states that:

> Creative cognition involves divergent thinking (a wide range of topics/subjects), making remote associations between ideas, switching back and forth between conventional and unconventional thinking (cognitive flexibility), and generating original, novel ideas that are also appropriate to the activity you are doing. (para. 34)

Certain learning styles and learning strategies involve the very activities described above. For example those with intuitive learning styles, favour abstract learning materials like principles, concepts and theories (Felder & Silverman, 1988) and they typically use insight, innovation, imagination and creative solutions to learn (Lawrence, 1993). Certain learning styles may automatically involve the activities described by Kuszewski (2011). These activities according to Kuszewski (2011) lead to gains in both cognitive ability and learning styles and may relate to both cognitive abilities and academic performance.

Deeper learning approaches, in addition, involve the activities Kuszewski (2011) believes enhance cognitive abilities. For example, deeper approaches involve making connections between previous and new knowledge, connecting information from different subjects or modules, critical thinking and challenging arguments and facts. Deeper approaches may involve "doing things the hard way" and challenging one's self to learn more and think critically and creatively about the learning material as opposed to memorising the information as is. Thus cognitive abilities such as working memory, abstraction and mental flexibility and the use of deeper learning approaches may also be related.

2.6.6. Mediation literature

Mediation, or a mediating relationship, occurs when a given variable functions as a mediator, or intervening variable, in a relationship between the predictor variable and the outcome variable (Baron & Kenny, 1986; Peyrot, 1996). In this case the predictor variable is cognitive ability, the possible mediating variables are learning styles and learning strategies and the outcome variable is academic performance.

A consistent finding in reviewing the literature is that previous research regarding the mediation effects of both learning styles and learning strategies in the relationship between cognitive ability and academic performance is limited. A small number of similar studies are, however, available. In a study that examined the role of learning strategies and personality traits in the relationship between cognitive ability and academic performance, it was found that deep learning strategies fully mediate the effects of general cognitive ability on academic performance (Chamorro-Premuznic & Furnham, 2008). In contrast, in a comparable study investigating the mediation effects of a variety of study and learning behaviour variables, such as study skills, study habits and learning strategies, it was found that the effect of general cognitive ability on academic performance was only partly mediated by the acquisition of good study skills and that a strong direct effect of cognitive ability on academic performance remained (Crede´ & Kuncel, 2008).

In related research, the role of learning strategies in the relationship between personality and academic performance has been examined (Komarraju, Karau, Schmeck & Avdic, 2011). It was found that the relationship between the personality dimension of openness to experience and academic performance was mediated by deep learning strategies, specifically, synthesis-analysis and elaborative processing (Komarraju et al., 2011). It seems that the deep learning strategy in particular may be influential with regard to academic performance, yet the possible role of learning styles is unclear.

In summary, there are intricate relationships between cognitive abilities, learning styles, learning strategies and academic performance. Learning styles and learning strategies, in particular, may be influential to the extent that they mediate, or act as intervening variables in the relationship between cognitive ability and academic performance. Based on the literature reviewed previously it is expected that having a higher cognitive ability, will significantly and positively predict academic performance. **Hypothesis 1** is: Higher cognitive abilities, will significantly and positively predict academic performance.

It is, in addition, hypothesised that having either a deep or metacognitive learning strategy will significantly and positively predict academic performance, while a surface learning strategy will significantly and negatively predict academic performance (i.e. will correlate with lower performance). **Hypothesis 2** is: The deep and metacognitive learning strategies will significantly and positively predict academic performance, while **hypothesis 3** purports that: The surface learning strategy will significantly and negatively predict academic performance.

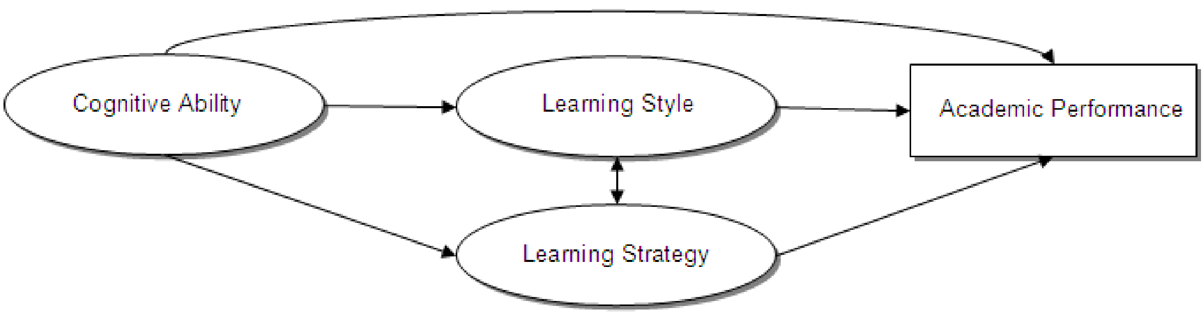
Having a deep learning strategy will, furthermore, significantly correlate with higher abstraction and working memory ability. **Hypothesis 4** is: The deep learning strategy will have a significant and positive correlation with cognitive ability**.**

It is furthermore expected that learning style will significantly and positively predict academic performance. **Hypothesis 5** is: Learning style will significantly and positively predict academic performance.

Lastly it is expected that learning styles and strategies will mediate the relationship between cognitive ability and academic performance, thereby demonstrating that they are important variables with regard to learning and academic performance. **Hypothesis 6** is: Learning styles and strategies will mediate the relationship between cognitive ability and academic performance.

The hypotheses discussed are based on previous literature and theory and resulted in the hypothesised theoretical model depicted in figure 2.4. It is important to note that the model was hypothesised from literature and was consequently constructed prior to any analysis.

FIGURE 2.4: Hypothesised theoretical model



NOTE: This is a simplified model depicting the hypothesised relationships and mediation between cognitive ability, learning styles and strategies and academic performance. A full extended model can be found in figure 1 of appendix C. Arrows represent relationships between variables. Observed variables, variables that were measured, are represented in rectangles and unobserved variables (including latent variables) are represented in ellipses.

2.7. Chapter summary

In summary, individual differences in learning style and learning strategy have been found to account for variations in academic performance. This, along with links to both cognitive ability and academic performance, give support to the argument that they may mediate the effect of cognitive ability on academic performance. Each of the variables investigated have been defined and discussed and previous literature regarding the relationships between them, as well as mediating roles, has been reviewed. The following chapter provides the research framework and methodology utilised.

CHAPTER 3:
RESEARCH METHODOLOGY

3.1. Introduction

This chapter discusses the research framework underpinning and guiding the study along with the research design and methodology used. The research methodology is discussed in line with the research aims and objectives, including a discussion of the design, sampling, data collection, and analysis used. Mediation is discussed to provide background information on (SEM), which was the statistical analysis technique used.

3.2. Theoretical framework

Cognitive psychology is a branch of psychology that is concerned largely with how people think, learn and remember (Galotti, 2008). The theoretical framework underpinning and guiding this research is cognitivism. Cognitivism is a scientific approach to studying human beings that stresses a focus on the human mind (Schuh & Barab, 2008). The central idea of the cognitive approach is that of information processing. The human mind is regarded as an information processor, or as a data-processing system, analogous to a computer (Gardner, 1987; Schuh & Barab, 2008). Individuals, and therefore students, are seen as information processors that represent, transform, act on and manipulate information. Cognitivism accordingly seeks an understanding of this information processing, in which the reception, organisation, encoding, and retrieval of knowledge in individuals is a focus (Schuh & Barab, 2008).

Cognitivism has roots in objectivist ontology (Baars, 1986; Duffy & Jonassen, 1992; Ertmer & Newby, 1993), where the world is real and external to the individual and can be studied objectively (Duffy & Jonassen, 1992; Ertmer & Newby, 1993). Thus an objective, material reality exists, independent of human beings and their understanding of it. Phenomena such as, perception and attention are seen as real and have properties and causes. Cognitive abilities, learning styles and strategies are thus seen as real phenomena that can be studied objectively and scientifically.

Having an objectivist ontological base, presupposes an objectivist epistemological perspective, wherein the mind creates representations of the world and the real. The external world is mirrored in the mind and to know is thus to have correct representations of the world (Schuh & Barab, 2008). However cognitivism, in addition, has rationalist epistemological roots. Rationalism views reason as the principle source of knowledge (Schuh & Barab, 2008). Cognitivism therefore prescribes that knowledge of the world and reality is gained through representation and reason.

Cognitivism's rationalist perspective furthermore purports that human subjects are independent and autonomous entities. Cognitivist assumptions place the individual as autonomous and proactive. Students are, as such, proactive participants in the learning process and can develop and enhance their learning.

This paradigm provided the theoretical framework that guided the research, the research question and methodology chosen to investigate it. The analysis and interpretation were directed by this framework as well.

3.3. Research question and aims

In the previous chapter it was established that cognitive ability is strongly related to academic performance, and that this relationship is, and has been, continuously supported in the literature. A large amount of the variation in academic performance however remains unaccounted for and numerous other factors have accounted for meaningful portions of this variation.

Individual differences in learning style and learning strategy are variables, in this regard, that have been found to account for meaningful levels of variation in academic performance. It was therefore hypothesised that learning styles and strategies may be influential to that extent that they may mediate, or act as intervening variables, in the relationship between cognitive ability and academic performance.

An individual, for example, may have lower cognitive abilities but may have a balanced learning style that is more flexible and may use deeper learning strategies that result in deeper understanding - which may lead to higher academic performance. In contrast, one may have higher cognitive abilities but use superficial or surface learning strategies and have strong preferences for a certain style - which may lead to lower performance. Learning styles and strategies may mediate the effect of cognitive ability on academic performance. Cognitive ability may therefore produce changes in the use of learning styles and strategies, which in turn may produce changes in a student's academic performance. Stated differently, cognitive ability may have an indirect affect on academic performance through the use of particular learning styles and strategies.

As learning styles and strategies may function as mediators to the extent that they account for the relation between cognitive ability and academic performance, the following research question was addressed:

Research question: Do learning styles and learning strategies mediate the relationship between cognitive ability and academic performance, in a sample of university students?

The literature discussed in the previous chapter established that the constructs defined and discussed may also be related in various and important ways. An additional aim furthermore included examining any significant differences between genders. Sub-questions in this regard were:

Sub-question 1: What is the relationship between cognitive ability, learning styles, learning strategies and academic performance?

Sub-question 2: Are there significant differences between genders with regard to cognitive ability, learning style or strategy and academic performance?

As the aim was to examine relationships and mediating roles among variables, a quantitative research methodology using a correlational research design was used. This methodology is furthermore in line with the cognitivist ontological and epistemological perspectives outlined previously.

3.4. Research methodology

3.4.1. Correlational research design

Research designs that examine relationships among or between variables are referred to as correlational research designs (Heppner, Wampold, & Kivlighan, 2008). Correlational research designs are used to search for and describe relationships, or correlations, between naturally occurring, measured variables (Gravetter & Forzano, 2008; Jackson, 2009; Stangor, 2011). It is thus a passive design in which the variables of interest are measured without being manipulated (Whitley, 2002).

In addition to identifying and describing relationships, correlational designs can be used to make predictions from one variable to another (Jackson, 2009) and can be used to examine mediation or possible mediating relationships between variables (Stangor, 2011). As the present study was interested in furthering understanding of the relationship between cognitive ability and academic performance, its complexities and possible intervening variables a mediational analysis was considered.

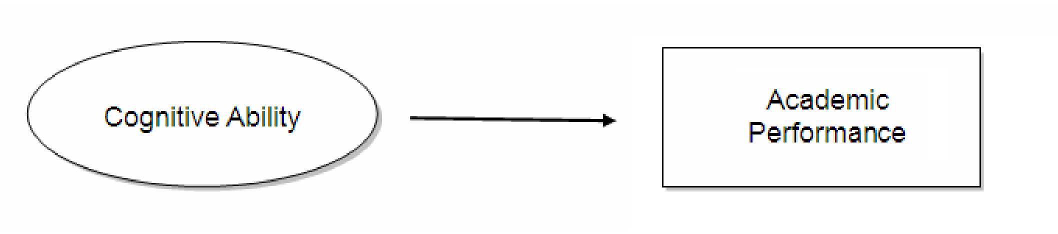
Mediation and mediational modelling is concerned with explaining the mechanism by which a known predictor variable (cognitive ability) exerts its influence on an outcome variable (academic performance). In this way, mediation offered the present study a method to further understand the strong relation between cognitive ability and academic performance, and to examine the role that learning styles and strategies play.

Mediation occurs when a given variable functions as a mediator, or intervening variable, in a relationship between the predictor variable and the outcome variable (Baron & Kenny, 1986; Peyrot, 1996). It is important to note the difference between mediation and moderation. A moderator variable, as opposed to a mediator variable, is a variable that affects the direction and/or strength of the relation between a predictor and outcome variable whereas a mediator variable would explain the relationship between cognitive ability and academic performance (Baron & Kenny, 1986).

Within a correlational research design, a mediating variable is a variable that is affected by the predictor variable which in turn affects the outcome variable (Stangor, 2011). In this case the predictor variable is cognitive ability, the possible mediating variables are learning styles and learning strategies and the outcome variable is academic performance.

Mediation is used when a strong relation exists between a predictor and outcome variable and one wishes to explore the mechanisms behind that relation (Frazier, Tix & Barron, 2004). Consider the relationship identified between cognitive ability and academic performance in the previous chapter. This is an unmediated relationship where cognitive ability (the predictor variable) has a strong and direct effect on academic performance (the outcome variable) (Baron & Kenny, 1986). This relationship is illustrated in figure 3.1.

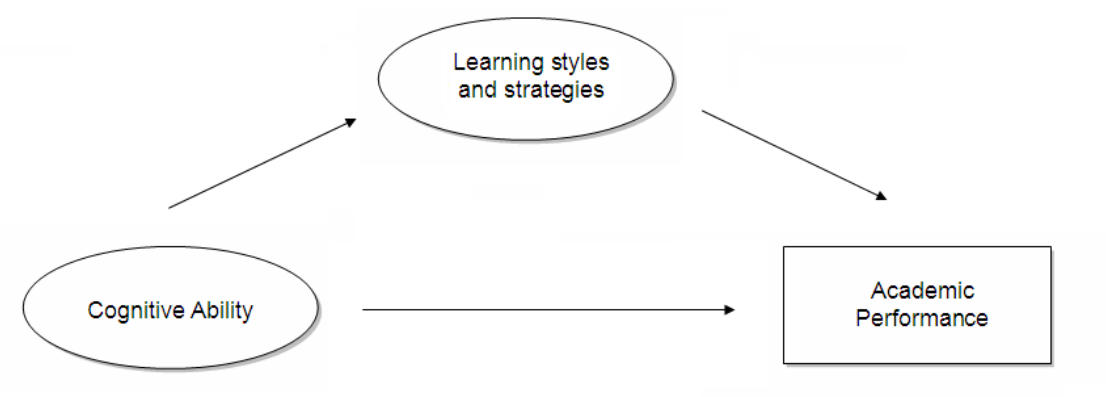
FIGURE 3.1: Illustration of unmediated and direct relationship



NOTE: Directed arrow represents relationship. This relationship is direct and unmediated.

The effect of cognitive ability on academic performance may however be mediated by, as argued, learning styles and learning strategies. In this regard, it is hypothesised that cognitive ability affects learning styles and strategies, which in turn affect academic performance. This possible mediated relationship is illustrated in figure 3.2 below.

FIGURE 3.2: Illustration of mediated relationship



NOTE: Directed arrows represent relationships. This is a mediated relationship, where cognitive ability affects academic performance, indirectly through learning styles and learning strategies. This is a mediation model, meaning that it is statistical statement (Hoyle, 1995), expressed here as a diagram, about a hypothesised relationship based on previous literature and theory.

The mediators intervene in the direct relationship where cognitive ability effects academic performance indirectly through learning styles and learning strategies (Baron & Kenny, 1986). Mediator variables assist in explaining why a relationship between two variables occurs (Stangor, 2011). Investigating whether learning styles and learning strategies play a mediating role may offer insight into the cognitive ability-academic performance relationship.

An important limitation of correlational research, however, is that it cannot be used to draw conclusions about cause-and-effect relationships (Stangor, 2011). This is because within a correlational research design, variables are not manipulated and participants are not assigned to control and experimental groups (Salkind, 2010; Urdan, 2005). It is thus important to clarify that when using mediation models, all of the usual cautions about causation from correlational data apply (Todman & Dugard, 2007). This is because mediation modelling uses causal modelling and not causal inference. In other words, assumptions are made in the development of a model and certain causal relations are merely proposed. These propositions are then tested using correlation and regression coefficients and causality cannot be demonstrated. Support for causal hypothesis and effects is thus only represented diagrammatically (Foster, Barkus & Yavorsky, 2006).

Despite this limitation, correlational research has the advantage of allowing researchers to study behaviour as it occurs in everyday life (Stangor, 2011). Use of a correlational research design enabled the researcher to identify whether learning styles and learning strategies play a mediating role in the relationship between cognitive ability and academic performance.

A correlational research design, using mediation, was appropriate as the design was applicable to the aims and objectives of the study, could be used for investigating whether variables measured were related (Jackson, 2009; Stangor, 2011) and could broaden understanding of the complex relationships and pathways between variables (Foster et al., 2006; Levine & Parkinson, 1994), as well as the possible causal mechanisms underlying them (Frazier et al., 2004).

3.4.2. Sampling

The study population, or group that was of interest (Babbie, 2010), was university students. This particular population group was chosen as they are routinely involved in learning and academic performance. School children were not chosen because of ethical concerns regarding age and informed consent.

Participants were selected from this population using convenience sampling. Convenience sampling is a sampling method that recruits participants based on their availability and willingness to respond (Gravetter & Forzano, 2008; Johnson & Christensen, 2010). Students in the psychology department, that is, students taking a psychology module at university in the first, second, third and honours years, were targeted because of their availability to the researcher. This population consisted of approximately 6279 students, including, both males and females of various races with ages ranging between 18 and 61.

The target sample size was set at approximately 200 participants, as 10 cases per variable are regarded a sufficient amount of data for the analysis method to be used (Foster et al., 2006). This, in addition, is a recommended minimum amount (Weston & Gore, 2006). This sample size is said to provide sufficient statistical power.

3.4.3. Participant recruitment

Students were invited to participate in the study via class visits and through their online student profiles. This invitation disclosed the nature and purpose of the study, how to go about participating as well as why it would be beneficial to participate.

3.4.4. Data collection

An electronic web-survey was used to collect participant information. Questionnaires and tests were self-administered (completed by the participants themselves) electronically, via a computer connected to the World Wide Web. Computer based assessment (CBA), or computer based testing (CBT), is a method of administering tests wherein responses are electronically recorded, assessed or both using a computer or equivalent electronic device (Miller, Vandome, & McBrewster, 2010). CBT was used only to capture participants' responses, which were analysed later using Statistical Package for the Social Sciences (SPSS) and a program called R (The R Project, n.d.).

CBT has certain advantages over traditional paper-and-pencil survey methods including; more efficient administration, increased efficacy in scoring, a significant decrease in errors when capturing data and the ability to obtain more complex information from participants, such as their response times (Miller et al., 2010).

Electronic surveys in particular are more flexible as they offer the ability to include complex questions and survey logic (Schutt & Nestor, 2011) that, in addition, offer more control and thus greater standardisation. For example, the specific sequencing of questions can be strictly controlled and questions that are inapplicable to certain participants can be hidden from view (Schutt & Nestor, 2011). In contradiction to Schutt and Nestor (2011), electronic surveys also offer the ability to ensure questionnaire completion, as participants may be alerted that some questions have not been answered or may not be permitted to submit and exit the survey unless all questions have been answered. This in turn decreases the likelihood of missing data.

Research also suggests that participants find CBT more enjoyable than traditional paper-based tests (Foxcroft, Seymour, Watson, & Davies, 2002) as interactive instructions, easy to use buttons and drop down lists for multiple option questions can all be built into the survey (Schutt & Nestor, 2011).

A lack of computer literacy is however often cited as a main disadvantage of CBT (Foxcroft & Roodt, 2006). All students targeted in this study, however, have undergone 12 years of formal schooling as well as a compulsory computer course in the first year of university and are expected to be computer literate.

3.4.4.1. Measurement instruments

After obtaining informed consent, participants were asked to complete a demographic questionnaire, the Inventory of Learning Styles (ILS), a learning strategies survey and the Executive Function Battery of the University of Pennsylvania's Computerised Neuropsychological Test Battery (PennCNP).

3.4.4.1. (a) Demographic information

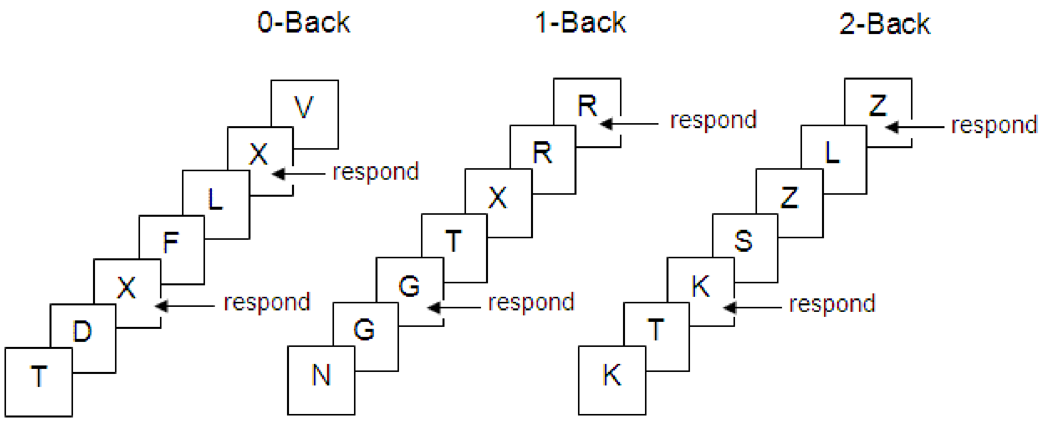
Demographic information was obtained through use of a demographic questionnaire which gathered information on the participants' age, gender, race, home language, faculty and year of study.

3.4.4.1. (b) PennCNP

Subtests of the University of Pennsylvania's Computerised Neuropsychological Test Battery (PennCNP) were used to measure and operationalise the cognitive abilities chosen. Specifically the Executive Function and Abstract Reasoning test battery was used for obtaining information on cognitive abilities. The measures included; the Letter-N-Back test (LNB2) and a shortened form of the University of Pennsylvania's RAVEN, the SRAVEN.

The LNB2 is a computerised test that measures attention and working memory (Cassimjee & Murphy, 2010). In this task, participants are asked to attend to letters flashing on the screen and respond through use of the space bar on the keyboard. The test operates according to three different principles: 0-back; 1-back and 2-back. During the test, participants were asked to respond to a letter that flashed for 500 milliseconds, which was followed by a blank page lasting for 2000 milliseconds. Participants had 2.5 seconds to respond. If a participant responded correctly in this timeframe, this was labelled as a true positive response. During the 0-back session participants were asked to respond to a particular letter whenever it appeared on the screen. For example whenever X appeared, participants should have pressed the spacebar. With regard to the 1-back, participants should have responded when the letter flashing on the screen was the same as the previous letter displayed. In the 2-back, participants should have responded when the current letter was the same as the one before the previously viewed letter. An example illustrating the 0, 1 and 2-back trials can be seen in figure 3.3. The amount of true positive responses and reaction times across and within all trials were used to measure performance on this test (Cassimjee & Murphy, 2010).

FIGURE 3.3: Illustration of 0-back, 1-back and 2-back trials



NOTE: Adapted from Shucard, Lee, Safford & Shucard (2011).

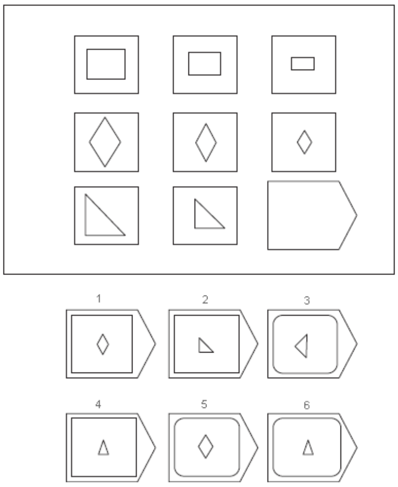
N-Back type tasks are used extensively in research as measures of working memory but have not been as adequately validated (Jeaggi, Buschkuehl, Perrig & Meier, 2010; Kane, Conway, Miura & Colflesh, 2007). Few studies have examined the psychometric properties of N-Back tasks and results are largely contradictory. Despite this, Jeaggi et al. (2010) propose that the task seems useful for research purposes. Studies have, in addition, found adequate concurrent and face validity as well test-retest reliability (Braver et al., 1997; Hockey & Geffen, 2004). Hockey and Geffen (2004) for example found that performance scores on a Letter-N-Back task were moderately reliable and that there was high test–retest reliability for response times recorded across all levels of the task. The LNB2 has, furthermore, been used in the South African context (Cassimjee & Murphy, 2010).

The SRAVEN, on the other hand, is a computerised measure of abstraction and mental flexibility (Cassimjee & Murphy, 2010). It is a shorter version of the University of Pennsylvania's RAVEN, which is a computerised version of the Raven's Advanced Progressive Matrices (RAPM).

In this test, participants are asked to complete a presented design by choosing one of several options that would complete the pattern. The test consists of nine such items drawn form the RAVEN's 60 questions, in which spatial, design and numerical relations must be conceptualised (Gur et al., 2001). Items increase in difficulty as participants' progress through the task. For example questions 1 and 2 have 6 responses to choose from and questions 3-9 have 8 responses. The total number of correct responses and reaction time for correct responses were used to measure performance on this task (Cassimjee & Murphy, 2010).

Reliability and validity studies of the computerised SRAVEN are limited but studies have found that the RAPM, from which the SRAVEN is derived, has sound reliability and validity (Paul, 1985; Raven, Raven & Court, 1998). Studies have also shown the internal consistency of the RAPM to be efficient with estimates ranging from α = .60 - .98 with a median of .90 for total score (Strauss et al., 2006). Concurrent validity has also been established (Strauss et al., 2006). As the SRAVEN is a non-verbal test, it is this aspect that allows for an evaluation of cognitive abilities without influence from linguistic, educational or cultural factors (Raven et al., 1998). The SRAVEN can thus be considered a fairer and more suitable test of cognitive ability given South Africa's multicultural society and it has furthermore been used in the South African context (Cassimjee & Murphy, 2010).

FIGURE 3.4: Example of matrix type item



NOTE: This is a matrix type problem that is based on the RAVEN and illustrates an example item of the SRAVEN. Participants must complete the pattern with, in this case, six options to choose from. Figure adapted from Wiley, Jarosz, Cushen & Colflesh (2011).

3.4.4.1. (c) The Index of Learning Styles

In order to identify learning styles, the Index of Learning Styles (ILS) by Felder and Soloman (n.d.) was used. The ILS is provided in appendix B. The ILS is an instrument that aims to asses learning styles based on the four dimensions of the FSLSM (Felder & Silverman, 1988) discussed in the previous chapter. It is a widely used and popular measure of learning styles (Genovese, 2004; Litzinger, Ha Lee, & Wise, 2005; Scott, 2010) and has been used in the South African context (McChlery & Visser, 2009).

The instrument consists of 44 forced choice items, 11 for each of the four dimensions. There are two possible responses for each item, with each response corresponding to one or the other category in the dimension. For example, “I understand something better after I; (a) Try it out or (b) think it through” is a question pertaining to the active-reflective learning style dimension. The instrument is scored by counting the number of items answered in each of the two response categories and deducting the smaller response score from the larger one. The resulting score shows a preference strength for each of the four scales. A score of 1-3 indicates a mild preference for one or the other category in each scale and that the individual is fairly well balanced on the two dimensions of that scale. A score of 5-7, indicates a moderate preference and a score from 9-11 indicates a strong preference (Felder & Soloman, n.d.).

The internal consistency of the active-reflective dimension of the ILS is on average α = .57, for the sensing-intuitive dimension α = .71, for the visual-verbal dimension α = .62 and for the global-sequential dimension α = .51 (Felder & Spurlin, 2005; Litzinger et al., 2005). The internal consistency values for each of the dimensions of the ILS are acceptable according to Tuckman (1999). Test-retest reliability coefficients for each dimension of the ILS have been found to be significant. For the active-reflective dimension test-retest reliability is on average r = .74, for the sensing-intuitive dimension r = .75, for the visual-verbal dimension r = .69 and for the global-sequential dimension r = .61 (Felder & Spurlin, 2005). The instrument demonstrates test-retest reliability. The instrument furthermore has demonstrated construct validity (Felder & Spurlin, 2005; Litzinger et al., 2005) as determined by participant feedback and factor analysis (Litzinger et al., 2005). Livesay, Dee, Nauman, and Hites (2002) and Zywno (2003) conclude that the reliability and validity data of the ILS make it a suitable instrument for assessing learning styles.

De Bello (1990) suggests when considering a learning style model, it should demonstrate reliability and validity evidence for both the model and its measure and the model should be utilised in research and practitioner based work. The FSLSM has, as previously outlined, demonstrated reliability and validity, is used frequently by researchers and educators and has recent influence in the field of learning styles (Scott, 2010).

3.4.4.1. (d) Learning strategies

Learning strategies were measured using a self-regulated learning strategies index developed by (Young, 2005), and can be found in appendix B. Young (2005) constructed and based the index on the Motivated Strategies for Learning Questionnaire (Pintrich & De Groot, 1990), the College Students' Self-Regulated Learning Questionnaire (Hwang & Vrongistinos, 2002), and items from Somuncuoglu and Yildirim 's(1999) Self- Regulated Learning Questionnaire. Duplicated items and items pertaining to constructs other than learning strategies such as test anxiety, effort management, and persistence, were eliminated in order to create a 17 item index. The items measure the surface, deep and metacognitive learning strategies. For example, "I try to memorise everything that might be asked in the exam" is an item measuring the surface learning strategy. The items are randomly ordered, and participants are asked to rate the extent to which they use a given strategy, on a 5-point scale, from never to always (Young, 2005). Young's (2005) index has acceptable validity, as multicollinearity subscale validity and external validity are within acceptable levels. Regarding multicollinearity, variance inflation factors reported ranged between 1.2 and 1.8, suggesting the degree of multicollinearity is acceptable (Young, 2005). External validity of the index was examined by investigating the theoretical relationships of the construct with other constructs in its nomological net (Young, 2005). Seven different measures of self-reported performance were found to significantly correlate with the index (r = .19 to .36, $p < .001$). Suggesting that the learning strategy index has a sufficient degree of external validity (Young, 2005).

The index was developed by Young (2005) for his study and thus reliability and validity statistics are limited. Its use in the South African context is, in addition, narrow.

3.4.4.1. (e) Academic performance

Participants' academic performance was measured using an average of their marks in the first semester of the year. These marks involved a tallying or average of various assignments and test scores during the semester and are scored on a percentage scale from 1-100. Test scores are a common measure of academic performance (Klitgaard, 1985; Mattison, 2008; Prince, 2004; Soh, 2011).

Due to the argument that averaging numeric grades can be misleading (Soh, 2011), the robustness of this measure of performance was assessed using coefficients of variation for each participant in order to determine the variation in each of their test scores during the semester. A larger percentage in variation would indicate greater fluctuation in performance throughout the year and deem the measure unreliable. Results however showed that academic performance data did not fluctuate to the extent that using averages of participants' test scores was unreliable. Results and further discussion are provided in the following chapter (chapter 4).

3.4.5. Procedure

Participants were not exposed to any risk or harm, psychological or otherwise, and ethical standards were ensured throughout. Ethical permission is provided in appendix A. Participants received an information sheet informing them of the purpose and aims of the study, and that their participation would be confidential and voluntary. Participants that agreed to take part in the study were required to fill out an informed consent form, which was signed and dated by the participant (also in appendix A). Consent was obtained for a second time, electronically, before continuing with the web survey.

All of those who consented to voluntarily participate were asked to complete the electronic web survey. Participants completed the questionnaires and tests discussed previously, at the Computer Based Test laboratory at the university. Participants were instructed to follow the on screen instructions, to answer honestly and that discussion was not permitted. Confidentiality was emphasised throughout. A total of 9 sessions were held, with an average of 19 students in each session, each lasting 50 minutes.

3.4.6. Statistical procedures

Raw data from each questionnaire was captured automatically into an electronic database and later downloaded. The data was then prepared in a manner suitable for use in SPSS and R and subsequently transferred. Descriptive statistics and inferential analysis was then performed.

3.4.6.1. Descriptive statistics

Sample means, standard deviations, measures of central tendency and measures of dispersion were calculated for each of the variables. Frequency distributions for age, gender, race, language, faculty and year of study were also calculated. Relationships between variables, that is, sub-question 1 were examined using bivariate correlations. These results are reported in the next chapter (chapter 4).

3.4.6.2. Inferential statistics

In order to address sub-question 2, regarding gender differences, independent samples *t*-tests were used. In order to explore and analyse relationships and mediating roles among variables, a statistical technique called structural equation modelling (SEM) was used. SEM can be best defined as a multivariate analysis technique that is essentially a fusion of factor analysis, regression and path analysis (Kaplan, 2000; Schumacker & Lomax, 2004; Ullman, 2001). In this way, SEM is seen as more of a confirmatory technique but can also be used for exploratory purposes (Schreiber, Nora, Stage, Barlow & King, 2006).

The use of SEM allows for the analysis of relationships among latent variables, in this case, cognitive ability, learning style and learning strategy. SEM has two components: a measurement model - essentially a confirmatory factor analysis (CFA) and a structural model (path analysis). SEM includes CFA as the model seeks to confirm whether the underlying theoretical constructs are reflected in the observed data, testing the reliability of observed variables (Schreiber et al., 2006). Theoretical constructs, or latent variables tested were cognitive ability, learning style and learning strategy.

The structural model utilises path analysis in order to display the interrelations among latent constructs and observable variables in the proposed model as a succession of structural equations - akin to running several regression equations (Schreiber et al., 2006). Path analysis can be defined as “a statistical technique that makes use of multiple regression to test causal relationships between variables” (Foster et al., 2006, p.89).

This enables researchers to test theoretical propositions regarding how constructs are theoretically linked and the directionality of significant relationships (Schreiber et al., 2006), effectively testing how well the observed data fits the hypothesised model (Blunch, 2008). Path analysis demonstrates which hypotheses are better supported by the data (Todman & Dugard, 2007).

SEM was chosen as it can be used to provide a quantitative test of the theoretical model hypothesised (see figure 2.4 in the previous chapter) and it is an appropriate technique when more than one measure per construct has been used. SEM was chosen as it is best suited to cases where there are multiple predictors, multiple outcomes or multiple mediators (Frazier et al., 2004). In this case there where multiple mediators, namely; learning styles and learning strategies The advantages of using SEM, as opposed to multiple regression, are that the use of SEM can control for measurement error and that the degree of model fit can be obtained (Frazier et al., 2004).

It is essential to once again note that the use of SEM and path analysis do not demonstrate causality. Graphical representations and regression coefficients are simply used in order to investigate proposed relationships between variables (Foster et al., 2006). The graphic illustrations add richness to data and can demonstrate relationships' strength and direction, as well as possible causal mechanisms (Foster et al., 2006).

Weston and Gore (2006) discuss six steps in SEM, namely; model specification, identification, data preparation and screening, estimation, evaluation and modification. The steps of model specification and identification have been completed, the result of which is the hypothesised model, figure 2.4 in the previous chapter. Data collected was then prepared and screened and SEM was conducted in order to test hypotheses 1-6. This was done through use of the SEM package in R. R is a free and open source statistical software that provides a number of statistical tests, including linear and nonlinear modelling, that allow researchers to fit observed and latent variable models

(Fox, 2006; The R Project, n.d.). The final steps of SEM are addressed in the next chapter (chapter 4).

3.5. Chapter summary

This chapter provided an overview of the theoretical framework underpinning the study and the research design utilised. Mediation was also discussed within a correlational research design to provide a backdrop to the statistical analysis method of SEM. The following chapter presents and discusses the results of the statistical analysis regarding the sample, relationships between variables, gender differences and whether learning styles and learning strategies mediate the relationship between cognitive ability and academic performance.

CHAPTER 4:
RESULTS

4.1. Introduction

This chapter presents the findings of statistical analyses conducted on data collected from participants. Descriptive and inferential statistics were utilised to analyse the collected data using SPSS and freeware called R. Descriptive statistics and correlations were obtained using SPSS. The research question, sub-question 1 and all hypotheses (1-6) were tested using SEM in the programme R. Sub-question 2 was tested through the use of independent samples *t*-tests in SPSS.

At first a description of the sample and descriptive statistics, including variable distributions and reliability, are provided. Thereafter the results of SEM and mediation analysis are presented and the chapter is concluded.

4.2. Sample profile

The sample, as mentioned in the previous chapter, was obtained using non-probability convenience sampling. The final sample consisted of 172 university students, of which 85.5% were female and 14.5% were male. The mean age of the sample was 21.49 years, with participants ranging between 18 and 61 years of age. Majority of participants were White (69.8%) and English speaking (35.5%). Most participants were in their first year of study (34.9%) within the Faculty of Humanities (80.2%). Table 4.1 contains a breakdown of the sample according to the demographic variables measured and figures 4.1 - 4.6 further illustrate the sample’s characteristics.

TABLE 4.1: Breakdown of sample according to demographic factors

Demographic Factor	**Original responses listed in order of magnitude**
Age	Range:18-61; Mode: 20 Mean: 21.49; SD: 4.63
Gender	Female: 147 (85.5%) Male: 25 (14.5%)
Home Language	English: 61 (35.5%); Afrikaans: 58 (33.7%); Setswana:15 (8.7%); Other:10 (5.8%); Sesotho sa Leboa: 6 (3.5%); Sesotho: 6 (3.5%); IsiZulu: 5 (2.9%); siSwati: 4 (2.3%); IsiNdebele: 3 (1.7%); IsiXhosa: 2 (1.2%); Xitonga: 2 (1.2%)
Race	White: 120 (69.8%); Black: 47 (27.3%); Indian: 2 (1.2%); Other: 2 (1.2%); Coloured: 1 (0.6%)
Faculty	Humanities: 138 (80.2%); Natural and Agricultural Sciences: 19 (11%); Education: 8 (4.7%); Law: 2 (1.2%); Economic and Management Sciences: 3 (1.7%); Other: 1 (0.6%); Theology: 1 (0.6%)
Year of study	First Year: 60 (34.9%); 3rd Year: 48 (27.9%); 2nd Year: 39 (22.7%); Honours: 22 (12.8%); Masters: 3 (1.7%)

NOTE: N = 172

None of the participants selected Tshivenda as a home language and other languages included; Portuguese, German, Sepedi, Chinese, French and Mandarin. Other races included; Asian. None of the participants were from the Faculty of Health Sciences.

FIGURE 4.1: Age

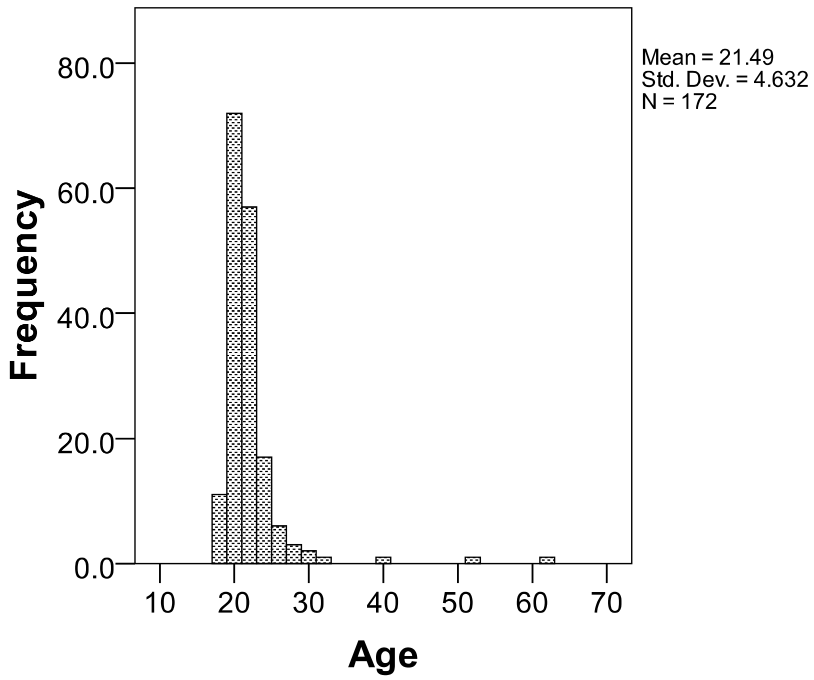


FIGURE 4.2: Gender

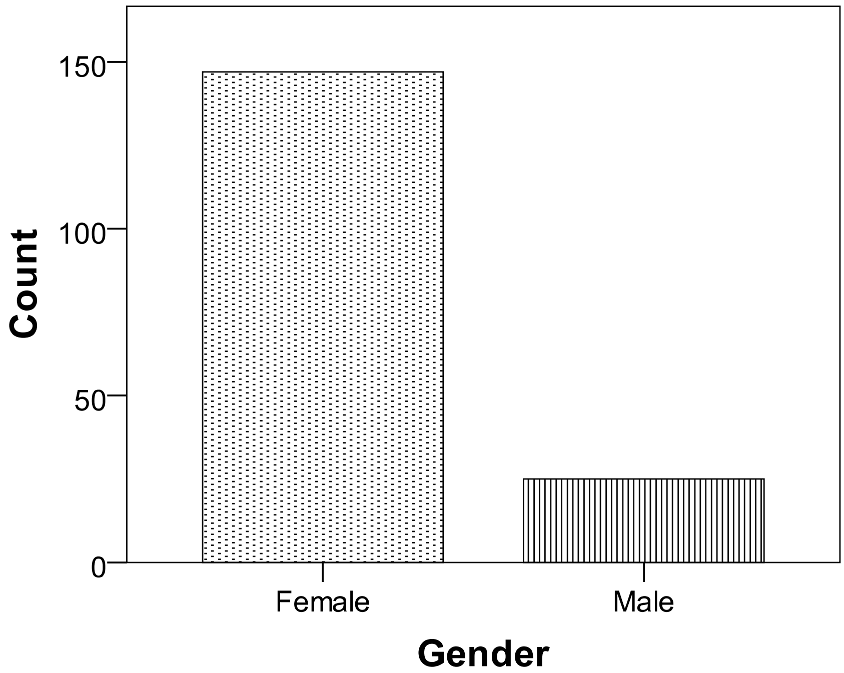


FIGURE 4.3: Home language

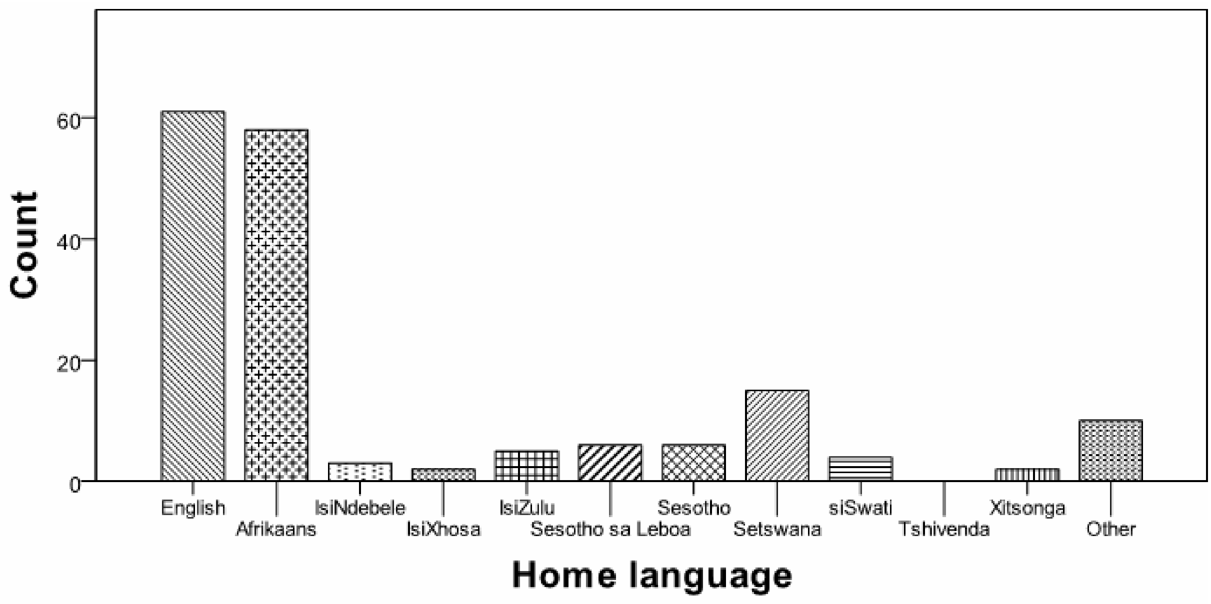


FIGURE 4.4: Race

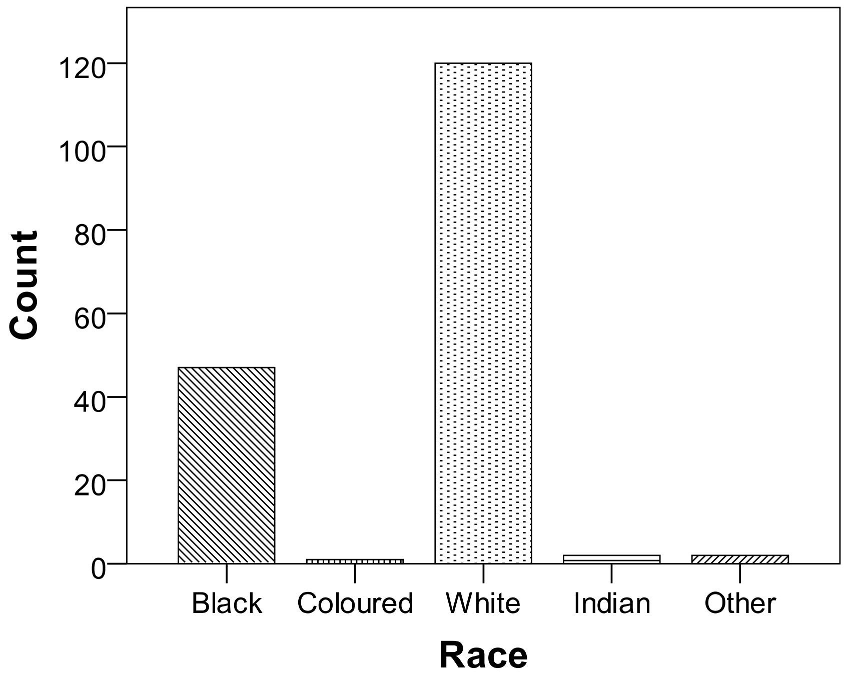


FIGURE 4.5: Faculty

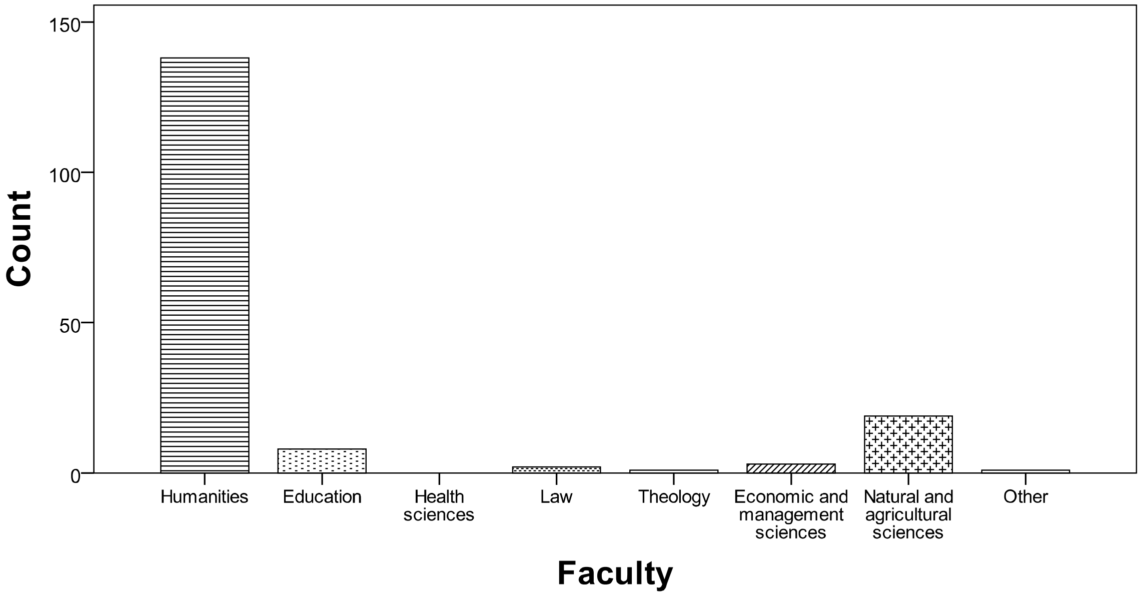
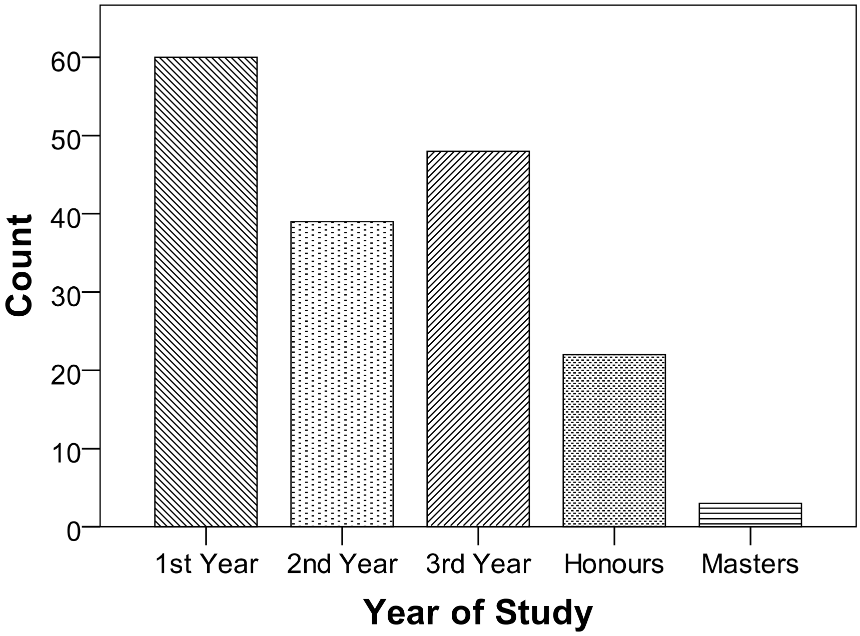


FIGURE 4.6: Year of study



4.3. Descriptive statistics

The following sections provide a summary of the descriptive statistics and the distribution of scores obtained from the Index of Learning Styles, the learning strategies questionnaire, the SRAVEN, the LNB2 and the academic performance of students as well as the reliability coefficients for each. Means, standard deviations and other basic descriptive statistics for the learning style measures are presented in table 4.2, and for the cognitive measures in table 4.5

TABLE 4.2: Basic descriptive statistics for learning styles and strategies

Variable	Mean	Std. Error of Mean	SD	Median	Mode	Range
Learning Styles						
Active learning style	4.85	0.18	2.32	5.00	4	10
Reflective learning style	6.15	0.18	2.32	6.00	7	10
Sensing learning style	6.39	0.21	2.70	7.00	9	11
Intuitive learning style	4.61	0.21	2.70	4.00	2	11
Visual learning style	6.31	0.19	2.49	6.50	7	11
Verbal learning style	4.69	0.19	2.49	4.50	4	11
Sequential learning style	6.15	0.17	2.24	6.00	6	11
Global learning style	4.85	0.17	2.24	5.00	5	11
Learning Strategies						
Rehearsal	3.89	0.06	0.80	4.00	4	4
Superficial learning strategy	3.89	0.06	0.80	4.00	4	4
Organisation	3.18	0.08	0.80	3.00	3	4
Elaboration	3.77	0.07	0.91	4.00	4	4
Critical Thinking	3.74	0.07	0.96	4.00	4	4
Deep Cognitive learning strategy	3.52	0.06	0.73	4.00	4	3
Planning	4.08	0.07	0.90	4.00	4	4
Monitoring	4.28	0.06	0.83	4.00	5	3
Regulating	3.63	0.08	1.04	4.00	4	4
Metacognitive learning strategy	3.83	0.06	0.73	4.00	4	4

NOTE: *N* = 172, *SD* (standard deviation)

4.3.1. The Index of Learning Styles

Normality plots, values of skewness and values of kurtosis (see appendix C) show that the ILS data is normally distributed. A Cronbach's alpha (α) of .687 shows that the test, however, has only minimally acceptable reliability (Nunnally & Burnstein, 1994; DeVellis, 1991). This may reflect the less established nature and dispute in the literature regarding the construct of learning style discussed in chapter 2.

The ILS interprets a score between 1-3 as indicating a mild or balanced preference for a dimension; 5-7 a moderate preference and 9-11 a strong preference. These stipulations were used in the interpretation of the data, according to the FSLSM. The distribution of preference for each of the four dimensions was also analysed.

Table 4.2 provides the descriptive statistics for the ILS. Higher mean scores indicate the more predominant learning styles among the group. The sensing learning style is the most predominant style in the group. The sensing mean score value (M = 6.39, SD = 2.70) shows a moderate preference for this learning style in the group on average and indicates that the group will learn more easily under such learning structures. The visual dimension, mean score (M = 6.31, SD = 2.49), is the second most preferred learning style. This average score also indicates a moderate preference for this learning style among the participant group. The intuitive learning style has the lowest mean score, (M = 4.61, SD = 2.70), indicating that it is the least preferred learning style among the group.

Table 4.3 provides more information on the distribution of learning styles among the group, including the strength of preferences. The table (table 4.3) indicates that 59.9% of the students in the study were found to have a reflective learning style preference, 64% a sensing preference, 65.1% a visual preference and 62.8% a sequential preference. Regarding balance of style, 90.7% of participants were unbalanced across all dimensions and 9.3% of the sample was balanced.

TABLE 4.3: Distribution of learning style preference and strength of preference

Learning Style	Percentage	Learning Style Strength	Percentage
Active	40.1%	Moderate Active	11%
Reflective	59.9%	Strong Active	1.7%
		Moderate Reflective	19.2%
Sensing	64%	Strong Reflective	8.7%
Intuitive	36%	Balanced	59.3%
Visual	65.1%	Moderate Sensing	26.7%
Verbal	34.9%	Strong Sensing	12.8%
		Moderate Intuitive	15.7%
Sequential	62.8%	Strong Intuitive	4.7%
Global	37.2%	Balanced	40.1%
Overall Balanced across dimensions	9.3%	Moderate Visual	23.8%
Overall Unbalanced across dimensions	90.7%	Strong Visual	9.9%
		Moderate Verbal	10.5%
		Strong Verbal	4.1%
		Balanced	51.7%
		Moderate Sequential	18.6%
		Strong Sequential	7.6%
		Moderate Global	7%
		Strong Global	3.5%
		Balanced	63.3%

NOTE: $N = 172$

4.3.2. Learning strategies questionnaire

The learning strategies questionnaire, for the sample (N = 172) used in the current study, had a respectable level of reliability, according to DeVellis (1991), with an overall alpha level of $\alpha = .776$. The planning sub-strategy and the metacognitive learning strategy were, however, slightly leptokurtic regarding their distribution, indicating few outliers. The data overall did not deviate significantly from normal (see appendix C).

Descriptive statistics for the learning strategies questionnaire can be found in table 4.2. Higher mean scores indicate that a particular learning strategy or sub-strategy is used more often. The monitoring sub-strategy had the highest mean score ($M = 4.28$, $SD =$

0.83), which indicates that this sub-strategy of the metacognitive learning strategy is used often by participants. The second highest mean score (*M* = 3.89, *SD* = 0.80), which is for rehearsal, which makes up the surface learning strategy, shows that participants often use this strategy as well. Table 4.4 provides more information on the distribution of learning strategies in the sample. It can be seen from the table (table 4.4) that 48.8% of students indicate that they often use the surface learning strategy (rehearsal). A further 22.1% indicated that they always use this strategy. 48% stated that they often used the deep cognitive strategies and 55% often used metacognitive strategies. None of the students indicated that deep cognitive strategies were never used and only 0.6% stated that they never use either the superficial or the metacognitive strategies.

TABLE 4.4: Distribution of learning strategies used

Learning strategy	Used	Percentage
Superficial	Never	0.60%
	Rarely	2.90%
	Sometimes	25.60%
	Often	48.80%
	Always	22.10%
Deep Cognitive	Never	0%
	Rarely	8.10%
	Sometimes	37.80%
	Often	48.30%
	Always	5.80%
Metacognitive	Never	0.60%
	Rarely	2.30%
	Sometimes	26.20%
	Often	55.20%
	Always	15.70%

NOTE: *N* = 172

4.3.3. Cognitive measures

The tests used to measure cognitive ability included the Letter-N-Back (LNB2) and the Short Raven's Progressive Matrices (SRAVEN). The total number of correct responses (accuracy) and reaction time for correct responses (in milliseconds) were selected as performance measures for the tests.

Both the SRAVEN and LNB2 data were non-normally distributed (see appendix C). Total scores for each test were negatively skewed, indicating that students performed well on each test. Response times for each test were, in contrast, positively skewed indicating that students tended to use less time to complete the tests. The degree of skewness however is not extreme. The LNB2 scores in particular, however, were significantly leptokurtic. These deviations from normality must be kept in mind as they may affect the results obtained and the interpretation thereof. The finding that students tended to do well on the cognitive measures should therefore be kept in mind during interpretation.

Regarding reliability using the sample obtained in the current study (N = 172), the SRAVEN had an overall alpha level of α = .646. This indicates that the test has an undesirable level of reliability, as ability tests should have reliability coefficients closer to .80 (Nunnally & Burnstein, 1994; DeVellis, 1991). The LNB2, for the current study's sample (N = 172), however had respectable reliability with an overall alpha level of α = .782.

Table 4.5 provides the descriptive statistics for the cognitive measures used in the study. The mean score for the LNB2 as a whole (LNB True Positive Responses) was (*M* = 43.30, *SD* = 2.47). The average time in milliseconds to complete the test (LNB Response Time) is indicated by a mean score of (*M* = 423.54, *SD* = 85.77). All other descriptive values for the 0-back, 1-back and 2-back trials of the test are provided in the table (table 4.5).

The mean score for the SRAVEN (SRAVEN Total Correct Responses) is (*M* = 45.44, *SD* = 8.99). The average time taken to complete the test (SRAVEN Correct Responses Time (ms) was (*M* = 19861.33, *SD* = 9598.35).

TABLE 4.5: Basic descriptive statistics for cognitive measures

Variable	Mean	Std. Error of Mean	SD	Median	Mode	Range
SRAVEN						
SRAVEN Total Correct Responses	45.44	0.69	8.99	49	52	40
SRAVEN Correct Responses Time (ms)	19861.33	731.87	9598.35	18461	15531[a]	64570
LNB2						
LNB True Positive Responses	43.30	0.19	2.47	44	45	20
LNB Response Time	423.54	6.54	85.77	406	375	530
LNB True Positive Responses: 0-Back	14.88	0.06	0.84	15	15	10
LNB Response Time: 0-Back	399.51	5.12	67.18	390	375	499
LNB True Positive Responses: 1-Back	14.71	0.07	0.94	15	15	9
LNB Response Time: 1-Back	436.09	7.98	104.60	407	375	610
LNB True Positive Responses: 2-Back	13.70	0.12	1.55	14	15	6
LNB Response Time: 2-Back	476.37	9.56	125.37	445	375	765

NOTE: *N* = 172, a. Multiple modes exist, with the smallest value shown

4.3.4. Academic performance

Table 4.6 provides descriptive statistics for the variable of academic performance. The average academic performance for the sample was 64.77% (*M* = 64.77, *SD* = 10.86). The higher the mean is, the higher the percentage level for a student's academic performance.

The coefficient of variation for each participant was calculated in order to determine the variation of performance for each participant during the year. Coefficient of variation (CV) values ranged from 0% to 53% (*M* = 14.11%, *SD* = 7%). A larger percentage in variation would indicate more fluctuation in performance throughout the year. Performance scores throughout the year did not fluctuate to the extent that the average performance was unreliable. This is due to the fact that 86.6% of academic performance scores have a CV value of 20% or less and 64.5% have a CV value of 15% or less. 2.3% of academic performance scores have CV values of more than 30%. The academic performance data is considered reliable and was, in addition, normally distributed (see appendix C).

TABLE 4.6: Basic descriptive statistics for academic performance

Variable	Mean	Std. Error of Mean	SD	Median	Mode	Range
Academic Performance	64.77	0.83	10.86	65.29	60	57.17
Coefficient of variation per case for academic performance*	0.14	0.01	0.07	0.14	0.05	0.52

NOTE: N = 172, except where * N = 165

4.4. Bivariate correlations

The following sections provide a summary of the Pearson's bivariate correlations performed to investigate the relationships between the variables under study.

Table 4.7 illustrates the Pearson product-moment correlation coefficients representing the relationships between variables. Correlations are then reported according to relationships stemming from sub-question 1 presented in chapter 1 and 2 previously.

TABLE 4.7: Correlations between variables

	Active style	Reflective style	Sensing style	Intuitive style	Visual style	Verbal style	Sequential style	Global style	LNB Correct Responses	LNB Total Time	Correct 0-Back	LNB 0-Back Total Time	Correct 1-Back	LNB 1-Back Total Time
Active style	-													
Reflective style	-1.000	-												
Sensing style	.010	-.010	-											
Intuitive style	-.010	.010	-1.000	-										
Visual style	.264	-.264	-.126	.126	-									
Verbal style	-.264	.264	.126	-.126	-1.000	-								
Sequential style	-.016	.016	.369	-.369	.023	-.023	-							
Global style	.016	-.016	-.369	.369	-.023	.023	-1.000	-						
LNB Correct Responses	-.099	.099	-.024	.024	-.115	.115	.023	-.023	-					
LNB Total Time	-.169	.169	-.056	.056	-.054	.054	-.103	.103	-.162	-				
Correct 0-Back	-.057	.057	.080	-.080	-.100	.100	.053	-.053	.578	-.044	-			
LNB 0-Back Total Time	-.242	.242	-.017	.017	-.076	.076	-.112	.112	-.130	.844	.036	-		
Correct 1-Back	-.140	.140	-.008	.008	-.161	.161	-.077	.077	.733	-.109	.328	-.123	-	
LNB 1-Back Total Time	-.143	.143	-.054	.054	-.085	.085	-.131	.131	-.178	.943	-.074	.749	-.121	-
Correct 2-Back	-.041	.041	-.076	.076	-.031	.031	.055	-.055	.835	-.167	.181	-.152	.382	-.170
LNB 2-Back Total Time	-.075	.075	-.073	.073	.029	-.029	-.076	.076	-.105	.852	-.028	.592	-.060	.790
Correct SRAVEN	.057	-.057	.004	-.004	.087	-.087	.097	-.097	.231	-.277	.010	-.260	.229	-.243
SRAVEN Total Time	-.078	.078	.019	-.019	-.028	.028	-.115	.115	.032	.167	.018	.189	.188	.116
Rehearsal	-.006	.006	.107	-.107	-.074	.074	.176	-.176	-.025	-.161	.068	-.112	.043	-.192
Organisation	.096	-.096	.065	-.065	-.080	.080	.065	-.065	.019	.086	.061	.063	.044	.070
Elaboration	-.038	.038	-.133	.133	-.126	.126	-.132	.132	.095	-.060	-.042	-.119	.202	-.050
Critical Thinking	.046	-.046	-.281	.281	-.057	.057	-.202	.202	.062	-.027	-.030	-.096	.079	-.008
Planning	-.028	.028	.067	-.067	-.154	.154	.079	-.079	.056	.009	.206	-.012	.019	.014
Monitoring	.012	-.012	.088	-.088	-.161	.161	.156	-.156	.050	-.176	.098	-.123	.039	-.151
Regulating	-.054	.054	.044	-.044	-.084	.084	-.057	.057	-.007	-.139	.004	-.126	.080	-.140
Superficial strategy	-.006	.006	.107	-.107	-.074	.074	.176	-.176	-.025	-.161	.068	-.112	.043	-.192
Deep strategy	.062	-.062	-.174	.174	-.117	.117	-.118	.118	.100	.001	.023	-.085	.161	.011
Metacognitive strategy	.003	-.003	.116	-.116	-.176	.176	.047	-.047	-.001	-.120	.092	-.078	-.021	-.117
Academic Performance	-.059	.059	-.060	.060	-.114	.114	.149	-.149	.120	-.156	-.059	-.103	.111	-.156

TABLE 4.7: Continued.

	Correct 2-Back	LNB 2-Back Total Time	Correct SRAVEN	SRAVEN Total Time	Rehearsal	Organisation	Elaboration	Critical Thinking	Planning	Monitoring	Regulating	Surface strategy	Deep strategy	Metacognitive strategy	Academic Performance
Correct 2-Back	-														
LNB 2-Back Total Time	-.116	-													
Correct SRAVEN	.223	-.252	-												
SRAVEN Total Time	-.072	.182	.193	-											
Rehearsal	-.102	-.140	-.073	.109	-										
Organisation	-.030	.040	.014	.088	.173	-									
Elaboration	.052	-.028	.053	-.022	.086	.188	-								
Critical Thinking	.066	.037	.041	.002	-.014	.159	.573	-							
Planning	-.034	.053	-.054	.132	.150	.327	.142	.110	-						
Monitoring	.002	-.142	.142	.062	.285	.285	.262	.142	.291	-					
Regulating	-.062	-.099	.004	.090	.331	.430	.306	.115	.338	.400	-				
Superficial strategy	-.102	-.140	-.073	.109	1.000	.173	.086	-.014	.150	.285	.331	-			
Deep strategy	.049	.061	.054	.054	.089	.575	.705	.714	.235	.295	.302	.089	-		
Metacognitive strategy	-.039	-.088	-.012	.070	.278	.453	.248	.137	.631	.671	.700	.278	.306	-	
Academic Performance	.156	-.171	.263	.109	.187	.123	.123	.056	.024	.140	.076	.187	.129	.107	-

4.4.1. The relationship between cognitive ability and academic performance

Academic performance was significantly and negatively correlated with total response time on the LNB2, $r = -.156$, p (two tailed) $< .05$. Faster response times on the LNB2 are associated with higher academic performance. Academic performance, in addition, correlated significantly with total response time for the 1-back trial, $r = -.156$, p (two tailed) $< .05$ and the 2-back trial, $r = .156$, p (two tailed) $< .05$, as well as the total score for the 2-back trial, $r = -.171$, p (two tailed) $< .05$.

There was a significant, positive correlation between academic performance and total score on the SRAVEN, $r = .263$, p (two tailed) $< .001$. Higher scores on the SRAVEN are therefore associated with higher academic performance.

4.4.2. The relationship between cognitive ability and learning style

There were significant correlations between the total time taken on the LNB2 and the active-reflective learning style dimension. Specifically, there was a significant, negative relationship between total time taken on the LNB2 and the active preference, $r = -.169$, p (two tailed) $< .05$ and a significant positive relationship between the total time and the reflective preference, $r = .169$, p (two tailed) $< .05$. An increase in the active preference relates to taking less time to complete the LNB2, and an increase in the reflective preference relates to taking more time to complete the LNB2.

Similarly, significant correlations were found between the total time taken on the 0-Back trial for the LNB2 and the active-reflective dimension. There was a significant, negative relationship between total time on the 0-back trial and the active preference, $r = -.242$, p (two tailed) $< .001$ and a significant positive relationship between the total time and the reflective preference, $r = .242$, p (two tailed) $< .001$.

Total score for the 1-back trial of the LNB2 had a significant correlation with the visual-verbal learning style dimension, correlating negatively with the visual preference, $r = -.161$, p (two tailed) $< .05$ and positively with the verbal preference, $r = .161$, p (two tailed) $< .05$. A greater preference for visual learning is associated with a decrease in total score on the 1-back trial, and a greater preference for the verbal learning style is associated with an increase in total score on the 1-back trial.

4.4.3. The relationship between cognitive ability and learning strategy

There was a significant, negative correlation between total response time on the LNB2 and rehearsal or the superficial learning strategy, $r = -.161$, p (two tailed) $< .05$ and total response time and the monitoring sub-strategy, $r = -.176$, p (two tailed) $< .05$. Similarly, total response time on the 1-back trial of the LNB2 correlated significantly with the superficial learning strategy, $r = -.192$, p (two tailed) $< .05$, and the monitoring sub-strategy, $r = -.151$, p (two tailed) $< .05$. An increase in the use of the superficial learning strategy or the monitoring sub-strategy is associated with a decrease in the amount of time taken on the LNB2 1-back trial and overall time taken.

The total score for the 0-back trial of the LNB2 correlated significantly with the planning sub-strategy, $r = .206$, p (two tailed) $< .05$. Higher scores for the 0-back trial are associated with more frequent use of planning.

The elaboration sub-strategy and total score on the 1-back trial were significantly correlated, $r = .202$, p (two tailed) $< .05$. Higher scores on the 1-back trial are therefore associated with more frequent use of elaboration.

There was a significant, positive correlation between the deep learning strategy and total correct responses on the 1 back trial of the LNB2, $r = .161$, p (two tailed) $< .05$. Higher scores on the 1-back trial are associated with more frequent use of the deep learning strategy.

4.4.4. The relationship between learning style and learning strategy

There were significant correlations between the sensing-intuitive dimension and the critical thinking sub-strategy. The sensing preference was negatively correlated, $r = -.281$, p (two tailed) $< .001$, and the intuitive preference was positively correlated, $r = .281$, p (two tailed) $< .001$. A higher preference for sensing is associated with less frequent use of the critical thinking sub-strategy while a higher preference for intuition is associated with more frequent use of the critical thinking sub-strategy.

There were also significant correlations between the sensing-intuitive dimension and the deep-cognitive learning strategy, with a negative correlation between the sensing preference and this strategy, $r = -.174$, p (two tailed) $< .05$ and a positive correlation with the intuitive dimension, $r = .174$, p (two tailed) $< .05$. A higher preference for sensing is associated with less frequent use of the deep learning strategy while a higher preference for intuition is associated with more frequent use of the deep learning strategy.

A number of significant relationships were found between the sequential-global learning style dimension and the learning strategy variables. The sequential preference correlated positively with rehearsal or the superficial learning strategy, $r = .176$, p (two tailed) $< .05$ while the global preference correlated negatively, $r = -.176$, p (two tailed) $<$ .05. Illustrating that an increase in the sequential preference is associated with more frequent use of the superficial learning strategy and an increase in the global preference is associated with less frequent use of this strategy.

The sequential preference furthermore correlated negatively with the critical thinking sub-strategy, $r = -.202$, p (two tailed) $< .05$ while the global preference correlated positively, $r = .202$, p (two tailed) $< .05$. An increase in the sequential preference is associated with a decrease in the use of critical thinking, while an increased preference for global learning is related to increased use of critical thinking.

The sequential preference correlated positively with the monitoring sub-strategy, $r =$ .156, p (two tailed) $< .05$ while the global preference correlated negatively, $r = -.156$, p (two tailed) $< .05$. An increased preference for the sequential learning style is thus associated with more frequent use of monitoring while an increased global preference is associated with less frequent use.

The visual-verbal learning style dimension correlated significantly with the planning and monitoring sub-strategies and metacognitive learning strategy. The visual preference correlates negatively with each respectively, $r = -.154$, p (two tailed) $< .05$, $r = -.161$, p (two tailed) $< .05$, $r = -.176$, p (two tailed) $< .05$, while the verbal dimension correlates positively with each respectively, $r = .154$, p (two tailed) $< .05$, $r = .161$, p (two tailed) $< .05$, $r = .176$, p (two tailed) $< .05$. A greater preference for visual learning is associated with less frequent use of planning, monitoring and the metacognitive strategy, while a greater preference for verbal learning is associated with more planning, monitoring and more frequent use of the metacognitive learning strategy.

4.4.5. The relationship between learning style and academic performance

There were no significant correlations between the learning style dimensions and academic performance.

4.4.6. The relationship between learning strategy and academic performance

There was a significant positive correlation between rehearsal and academic performance $r = .187$, p (two tailed) $< .05$. An increased use of the superficial learning strategy is thus associated with increased academic performance.

4.5. Group differences

In following conventions regarding gender differences in the cognitive psychology arena, differences between male and female participants were investigated. The sub-question investigated was; Are there significant differences between genders with regard to cognitive ability, learning style or strategy and academic performance?

No significant differences in scores of academic performance or cognitive ability between female and male participants were found. There were, however, significant differences between male and female participants with regard to learning styles and strategies.

On average, female participants were significantly more sensing (Female: *M* = 6.66, *SD* = 2.58, Male: *M* = 4.80, *SD* = 2.89), *t*(170) = 3.27, $p < .05$, while male participants were significantly more intuitive (Female: *M* = 4.34, *SD* = 2.58, Male: *M* = 6.20, *SD* = 2.89), *t*(170) = -3.27, $p < .05$.

Male and female participants also differed significantly on the visual-verbal learning style dimension. Male participants were significantly more visual (Female: *M* = 6.15, *SD* = 2.50, Male: *M* = 7.24, *SD* = 2.31), *t*(170) = -2.04, $p < .05$. Female participants were significantly more verbal (Female: *M* = 4.85, *SD* = 2.50, Male: *M* = 3.76, *SD* = 2.31), *t*(170) = 2.04, $p < .05$.

Female participants use organisation as a learning strategy significantly more than male participants (Female: *M* = 3.24, *SD* = 1.01, Male: *M* = 2.80, *SD* = 0.76), *t*(170) = 2.10, $p < .05$. Female participants, in addition, use planning significantly more than male participants (Female: *M* = 4.14, *SD* = 0.86, Male: *M* = 3.68, *SD* = .1.03), *t*(170) = 2.42, $p < .05$. On average, male participants use critical thinking more often than female participants (Female: *M* = 3.67, *SD* = 0.99, Male: *M* = 4.16, *SD* = 0.62), *t*(170) = -3.26, $p < .05$.

4.6. Structural equation modelling

In this section the results of SEM are reported. Weston and Gore (2006) discuss the six steps in SEM, namely; model specification, identification, data preparation and screening, estimation, evaluation and modification. This section of the chapter discusses the last three steps (the previous steps were discussed earlier in chapter 3). The process for these final steps and the data analytic strategy was as follows. First, a CFA was done for each of the constructs. Next, these constructs were utilised in a SEM, comprising of cognitive ability, learning styles and strategies as well as academic performance. Model fit was then examined according to customary guidelines and based on fit, a stepwise “confirm and update” procedure, in line with recommendations put forward by Jöreskog (1993) was then performed. Modification indices were also used in order to refine the model. Mediation models were then constructed and evaluated.

The resulting measurement and structural models are reported below. Correlation matrices were used instead of covariance matrices. The correlation matrix was provided previously (see table 4.7) and parameter estimates and standard errors from each model are presented and discussed throughout the text, full model parameters are provided in tables 2 to 5 of appendix C. Regarding correlations between observed variables (table 4.7), correlations higher than r = .85 can indicate potential problems (Kline, 2005). Specifically they may indicate multicollinearity. There were, however, no observed variables that had correlations higher than this. There were furthermore no missing data, and as such no cause for concern regarding problems created by this. Maximum likelihood was the parameter estimation method utilised. Maximum likelihood estimation was chosen as it is robust against moderate deviations from normality (Anderson & Gerbing, 1984), which was deemed necessary as the cognitive variables, specifically LNB2 variables, were moderately non-normal.

4.6.1. Model 1

The hypothesised theoretical model (figure 2.4 in chapter 2) was entered into R and tested using the SEM package[1]. As shown in table 4.8 below, results suggested that the model did not fit the data well. The full structural model can be found in figure 4.7 on page 77.

TABLE 4.8: Fit Indices: Model 1

	χ^2	*df*	*p*	RMSEA	CFI	SRMR
Model	145.31	67	.001	0.08	0.72	0.10
Acceptable range			> .05	< .05	> .90	<.80

[1] The SEM package is an additional program that is downloaded and used in R to perform structural equation modelling.

As different measures of fit capture different elements of the model and the popular chi-square statistic has various limitations (Blunch, 2008; Hooper, Coughlan & Mullen, 2008; Hu & Bentler, 1995; Tanaka, 1993), a selection of different fit measures were used to indicate the fit of the model. These indices were chosen based on common guidelines (Weston & Gore, 2006) and have, in addition, been found to be the most insensitive to sample size, model misspecification and parameter estimates (Hooper et., 2008). The indices are reported in table 4.8 previously and discussed below.

The chi-square statistic is the common statistic used to evaluate the fit of structural models (Hu & Bentler, 1995). This goodness-of-fit statistic essentially indicates to what extent an expected model is different from the observed values (Field, 2009: Hu & Bentler, 1995) and thus tests the null hypothesis:

H0: There will be no significant difference between the predicted model and the data observed.

When using the chi-square statistic for SEM models (in contrast to standard chi-square analyses), a researcher wants to accept the null hypothesis, and would therefore prefer a non-significant chi-square statistic. A non-significant chi-square value indicates that the model is acceptable and that the null hypothesis is accepted (Barrett, 2007; Field, 2009; Hu & Bentler, 1995). Model 1 however has a significant chi-square value, χ^2 (67, $N = 172$) = 145.31, $p < 0.01$ and thus indicates an unacceptable model fit.

Another common fit index is the root mean square error of approximation (RMSEA). RMSEA values should be .05 or less to signify good model fit and values higher than .10 are considered unacceptable (Blunch, 2008; MacCallum, Browne, & Sugawara, 1996). The RMSEA value of the model = .08, indicating a poor fit according to Blunch (2008) or mediocre fit according to MacCullum et al. (1996).

The standardised root mean square residual (SRMR) is another common absolute fit indicator and values less than .05 indicate a good fit (Blunch, 2008). Blunch (2008) suggests that values up to .08 can signify good fit, however, the model's SRMR = .10, and is thus a poor fit. Bonette's comparative fit index (CFI) for the model = .02 and also indicates that the model has poor fit as values of CFI should be greater than .90 to reflect good fit (Blunch, 2008).

The hypothesised model does not appear to be a good fit to the data as fit indicators are not within the bounds of the criteria. As a result, the model was refined using modification indices. The relationships between the variables under investigation were nonetheless examined and are described below as these relations are expected to remain relatively similar in modified models.

4.6.1.1. Model 1 parameter estimates

Relationships between variables are designated by path coefficients and show which variables exert effects on others as well as whether the relationships are direct or indirect (Foster et al., 2006). A direct effect is the influence of one variable on another that is not mediated by any other variable in the model (Everitt & Dunn, 2001). An indirect effect, in contrast, is the effect of one variable on another that is mediated, or passed through, at least one other variable in the model (Everitt & Dunn, 2001).

The number of parameter estimates specified for the initial model was 38, of which 27 were significant and 11 were non-significant. Most of the proposed parameters were significant, however, some were not in the expected directions. The standardised parameter estimates (analogous to regression coefficients) for the path coefficients of the first model are reported in table 4.9 below.

The first hypothesis on the impact of higher cognitive ability on academic performance was supported by the model. Cognitive ability was found to have a significant, direct and positive influence on academic performance (cognitive ability $\beta = .37$, $z = 2.62$, $p = .009$). The second hypothesis, the impact of deep and metacognitive learning strategies on academic performance, was however not supported. Both the deep and the metacognitive learning strategy had no effect on academic performance (deep strategy β = .10, *z* = 0.60, *p* = .549; metacognitive strategy β = -.02, *z* = -0.18, *p* = .855).

The third hypothesis was also not supported as the surface learning strategy showed a direct, significant and positive effect on academic performance (β = .22, *z* = 2.63, *p* = .009).

As for the fourth hypothesis regarding the deep and metacognitive learning strategies and cognitive ability, no evidence was found to support it (deep strategy β = .10, *z* = 0.79, *p* = .429, metacognitive strategy β = .03, *z* = 0.17, *p* = .868). There was, in addition, no support for the fifth hypothesis regarding learning styles and academic performance (β = .01, *z* = 0.05, *p* = .964).

TABLE 4.9: Parameter estimates: Model 1

	Relationship between variables		**β**	***z***	***p***
Hypothesis 1	Cognitive ability	Academic performance	0.37	2.62	.009**
Hypothesis 2	Deep strategy	Academic performance	0.10	0.60	.549
	Metacognitive strategy	Academic performance	-0.03	-0.18	.855
Hypothesis 3	Surface strategy	Academic performance	0.22	2.63	.009**
Hypothesis 4	Deep strategy	Cognitive ability	0.10	0.79	.429
	Metacognitive strategy	Cognitive ability	0.03	0.17	.868
Hypothesis 5	Learning style	Academic performance	0.01	0.05	.964
Other significant paths	Metacognitive strategy	Learning style	0.39	2.61	.009**
	Deep strategy	Metacognitive strategy	0.56	3.65	.000*
	Deep strategy	Learning style	-0.34	-2.60	.009**

NOTE:* represents $p < .001$, ** represents $p < .05$

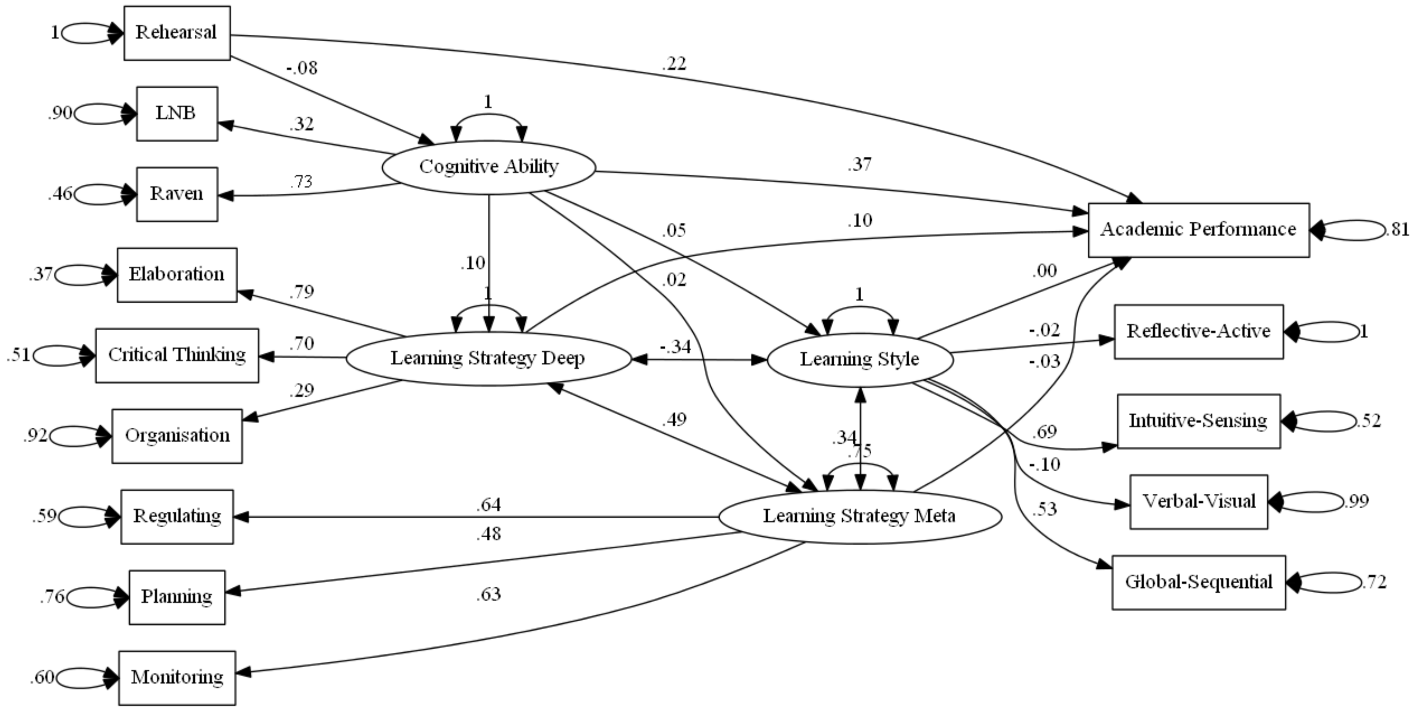
The paths from cognitive ability and the surface learning strategy to academic performance were direct, positive and significant. This suggests that higher cognitive abilities and more frequent use of rehearsal are predictive of higher academic performance. Specifically cognitive ability had a moderate effect on academic performance (cognitive ability β = .37, z = 2.62, p = .009) while the surface learning strategy had a smaller effect (surface strategy β = .22, z = 2.63, p = .009).

It is apparent from the standardised results that, in agreement with previous literature and findings, cognitive ability has more influence in this set of observations than any of the other variables, including rehearsal, in predicting academic performance.

There were also significant relationships between the deep learning strategy and learning style (β = -.34, z = -2.60, p = .009), the deep learning strategy and the metacognitive learning strategy (β = .56, z = 3.65, p = .000) as well as between the metacognitive strategy and learning style (β = .39, z = 2.61, p = .009). These relations were however bi-directional meaning that, while relationships exist, the direction is uncertain.

It is important to note, however, that the model did not fit the data well, and was as such re-specified. In light of controversial debate regarding re-specification of models (Bollen & Long, 1993), it must be noted that all adjustments were post hoc modifications. The second resulting model and parameter estimates are discussed in the section to follow.

FIGURE 4.7: Structural equation model 1



NOTE: Observed variables are represented in rectangles and unobserved variables (including latent variables and errors) are represented in ellipses and circles. Directed arrows indicate regression coefficients and bi-directional arrows represent covariance (Fox, 2006). The regression coefficient/variance was fixed to 1 in order to minimise the number of estimated parameters in the model and estimate/control the unobserved error term (Schreiber et al., 2006).

4.6.2. Model 2

In model 1 it was shown that learning styles had no effect on academic performance (β = .01, *z* = .05, *p* = .964). Further examination of factor loadings between observed and latent variables, with regard to learning style, showed that the intuitive-sensing learning style dimension and the global-sequential learning style dimension had strong, significant and positive correlations with the construct of learning style (intuitive-sensing β = .69, *z* = 3.32, *p* = .001, global-sequential β = .53 z = 3.21, *p* = .001). These two learning style dimensions deal with the ways in which individuals tend to perceive the world, their preferred source of information as well as their understanding of the information.

The reflective-active and visual-verbal learning style dimensions, however, had non-significant relations with the learning style construct that were small and negative (reflective-active β = -.02, *z* = -.23, *p* = .818, visual-verbal β = -.10 *z* = -.92 *p* = .356). These dimensions do not load onto learning style as expected and indicate a potential problem with the measurement model. These dimensions deal with the ways in which perceived information is used and the preferred mode of input for learning. As the reflective-active and visual-verbal dimensions have non-significant loadings they therefore do not load onto the same learning style construct as the intuitive-sensing and global-sequential dimensions. It thus seems that in measuring learning styles two different constructs have in fact been measured.

As previously mentioned, Joreskog's (1993) "confirm and update" approach was used in order to refine the first model and it was decided based on common recommendations (Weston & Gore, 2006) that learning style be divided into two sub-constructs, namely; learning style 1 and learning style 2.

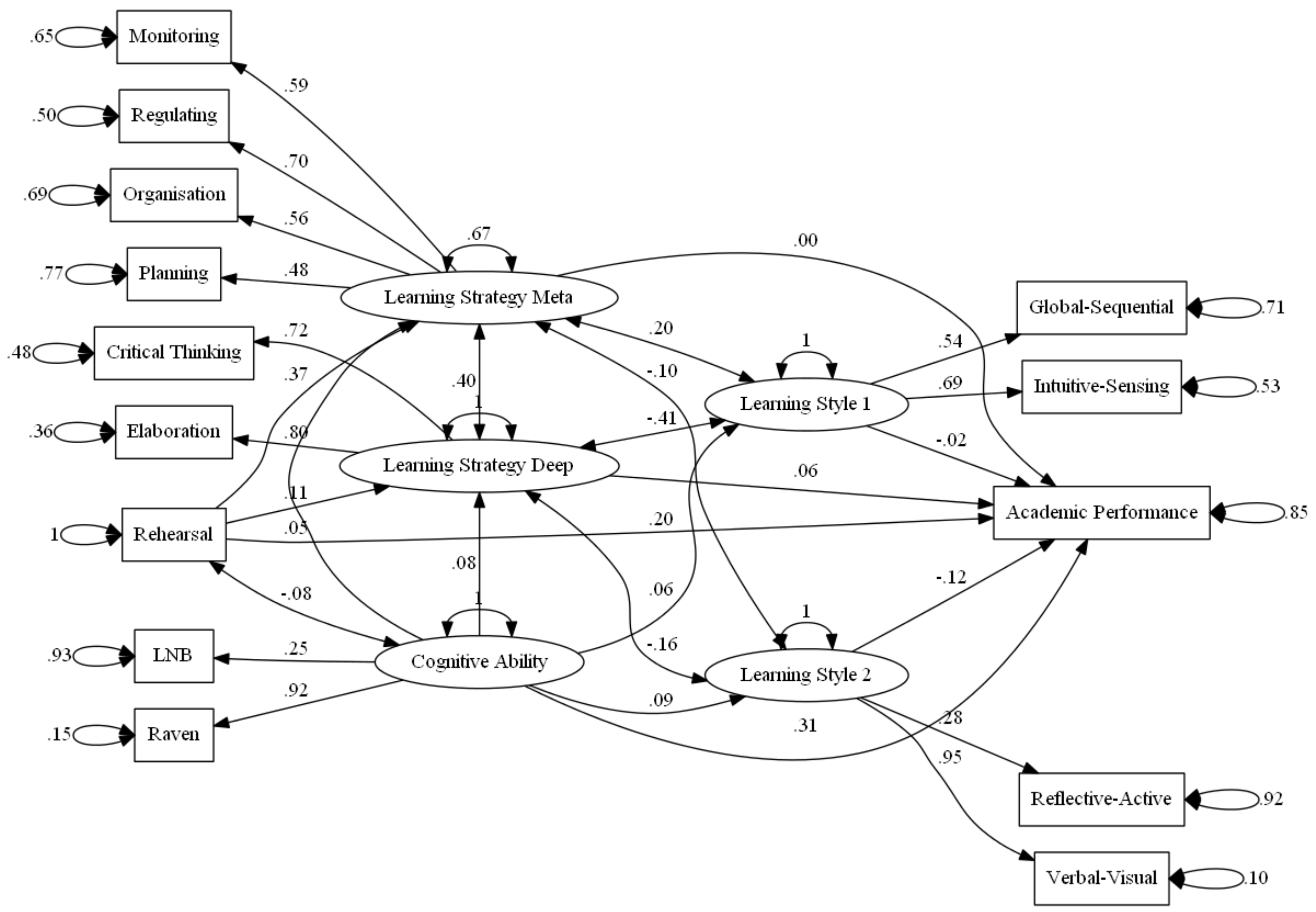
Modification indices furthermore suggested the following two changes. The first was that organisation be moved to the metacognitive learning strategy. This was because organisation did not correlate as strongly with the deep learning strategy construct (organisation β = .28, *z* = 3.19, *p* = .001), when compared to elaboration and critical thinking (elaboration β = .79, z = 8.95, p = .000, critical thinking β = .70, z = 8.16, p = .000). The second suggested change was that rehearsal influences the metacognitive learning strategy.

The result of these changes was a non-significant model (see table 4.10), meaning a well fitted model, the path diagram of which is found in Figure 4. 8. Using the same fit indicator criteria as above, the model fitted the data well. This is evidenced by a non-significant chi-square value, χ^2 (61, N = 172) = 70.51, p > .05 and thus indicates an acceptable model fit. The RMSEA value of .03 is below .05 and the CFI Value of .97 is greater than .90, both signifying good model fit. The SRMR of .06, in addition, shows good model fit as this value is close to .05 and less than .08. Together these fit statistics show a good model that is well fitted to the data. This second model accurately represents the relationships among cognitive ability, learning styles and strategies and academic performance and the observed variables with which they are associated. In addition, the fit is good, despite having a smaller sample size (N = 172) with a complex model (Weston & Gore, 2006).

TABLE 4.10: Fit Indices: Model 2

	χ^2	*df*	*p*	RMSEA	CFI	SRMR
Model	70.51	61	.20	0.03	0.97	0.06
Acceptable range			> .05	< .05	> .90	<.80

FIGURE 4.8: Structural equation model 2



NOTE: The second refined model is the result of changes suggested from the initial model and includes all possible mediators

4.6.2.1. Model 2 parameter estimates

Table 4.11 below reports the parameter estimates for the second model. The paths from cognitive ability and the surface learning strategy to academic performance remained significant, direct and positive. Cognitive ability continued to show a direct, positive and significant relationship with academic performance, with only a marginal decrease in effect size (β = .31, z = 2.022 p = .043). Rehearsal, or the superficial learning strategy, also had a direct, positive and significant relationship with academic performance, with a slight decrease in effect size (β = .20, z = 2.24, p = .025).

The relationships between the deep and metacognitive learning strategies and academic performance remained non-significant (deep strategy β = .06, z = 0.47, p = .636, metacognitive β = .00, z = 0.02, p = .983), as did the relationships between the deep and metacognitive strategies and cognitive ability (deep strategy β = .08, z = 0.80, p = .426, metacognitive strategy β = .07, z = 0.59, p = .558).

Learning style, that is learning style 1 and learning style 2, in addition remained non-significant with regard to their relationships with academic performance (learning style 1 β = -.02, z = -0.19, p = .846, learning style 2 β = .13, z = -1.13, p = .260).

In this second refined model, hypothesis 1 remained supported while, hypotheses 2-5 remained unsupported.

Table 4.11: Parameter estimates: Model 2

	Relationship between variables		β	*z*	*p*
Hypothesis 1	Cognitive ability	Academic performance	0.31	2.02	.043*
Hypothesis 2	Deep strategy	Academic performance	0.06	0.47	.636
	Metacognitive strategy	Academic performance	0.00	0.02	.983
Hypothesis 3	Surface strategy	Academic performance	0.20	2.24	.025*
Hypothesis 4	Deep strategy	Cognitive ability	0.08	0.80	.426
	Metacognitive strategy	Cognitive ability	0.07	0.59	.558
Hypothesis 5	Learning style 1	Academic performance	-0.02	-0.19	.846
	Learning style 2	Academic performance	0.13	-1.13	.260
Other significant relations	Deep strategy	Metacognitive strategy	0.48	3.60	.000**
	Surface strategy	Metacognitive strategy	0.45	4.15	.000**
	Deep strategy	Learning style 1	-0.42	-3. 74	.000**

NOTE ** $p < .001$, * $p < .05$.

Regarding other identified relationships, the relationship between the deep learning strategy and the metacognitive strategy remained significant (β = .48, *z* = 3.60, *p* = .000). New relationships resulting from the refined model included a significant, positive relation between the surface learning strategy and the metacognitive strategy (β = .45, *z* = 4.15, *p* = .000). The deep learning strategy, in addition, was shown to negatively relate to learning style 1 (β = - .42, *z* = -3.74, *p* = .000).

It appears that the difference between the first and second model is slight. The differences between the two models described, however, are significant (χ^2: 145.31 - 70.505 = 74.805, *df*: 67 - 61 = 6, $p < .01$). The second model is therefore a significant improvement from the first and furthermore indicates no difference between the observed and expected models.

Standardised results from the second model confirm previous literature and findings that cognitive ability is related to academic performance. Findings furthermore confirm that rehearsal is also an important factor with regard to academic performance.

4.6.3. Mediation

Regardless of the statistical procedure used, the steps necessary to test for mediation remain similar. The steps outlined by Kenny and colleagues (Baron and Kenny 1986; Judd and Kenny 1981; Kenny, Kashy & Bolger, 1998) are a popular, if not the default method, of establishing mediation. There are four steps and they are summarised as follows:

Step 1: The predictor variable should correlate with the outcome variable

Step 2: The predictor variable should correlate with the mediators

Step 3: Mediators should affect the outcome variable

Step 4: The predictor variable should no longer have any effect on the outcome variable when the mediator has been controlled

Later, Kenny et al. (1998) specified that only steps 2 and 3 were essential and that step 4 was necessary only in the case of complete mediation.

In more recent thinking it has also been noted that the steps discussed should not be stated in terms of statistical significance but rather in terms of zero and non-zero coefficients. David Kenny has been quoted as saying that:

> The steps are stated in terms of zero and nonzero coefficients, not in terms of statistical significance, as they were in Baron and Kenny (1986). Because trivially small coefficients can be statistically significant with large sample sizes and very large coefficients can be non-significant with small sample sizes, the steps should not be defined in terms of statistical significance. Statistical significance is informative, but other information should be part of statistical decision making. For instance, consider the case in which path a is large and b

> is zero. In this case, c = c'. It is very possible that the statistical test of c' is not significant (due to the collinearity between X and M), whereas c is statistically significant. It would then appear that there is complete mediation when in fact there is no mediation at all. (Kenny, 2011)

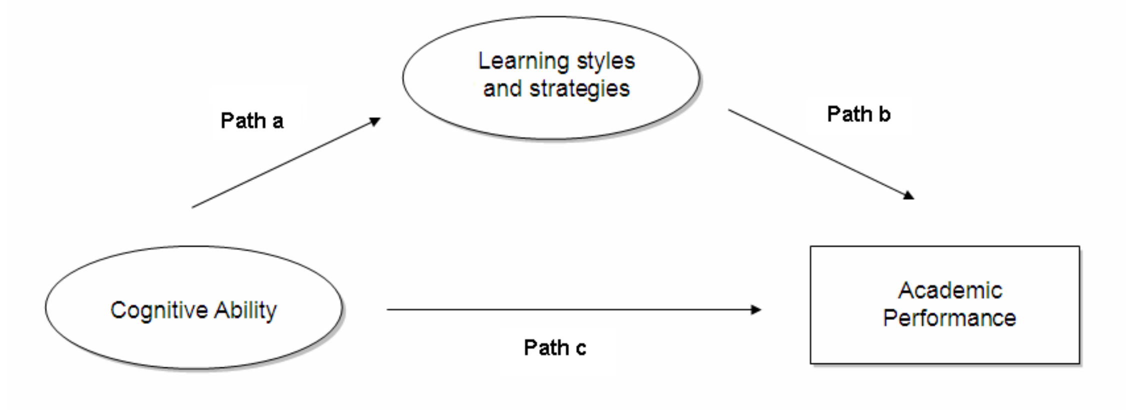
A zero coefficient shows that there is no relationship between variables while a non-zero correlation coefficient shows that the variables are related. Regarding the four steps one should consider the significance of the relationship but should more importantly check the size of the coefficient or strength of relationship between variables to identify if the condition is adequately met.

Rucker, Preacher, Tormala and Petty (2011) in accord suggest that researchers interested in understanding intervening effects (mediation) should not limit themselves by placing undue emphasis on significance of relationships.

4.6.3.1. Mediation analysis

The first step in the mediation analysis is to establish that there is an effect or relationship that can be mediated. This step should show that the predictor variable (cognitive ability) is correlated with the outcome variable (academic performance), and that path “c”, in figure 4.9 has a coefficient greater than 0.00 (Kenny, 2011).

FIGURE 4.9: Illustration of mediation paths



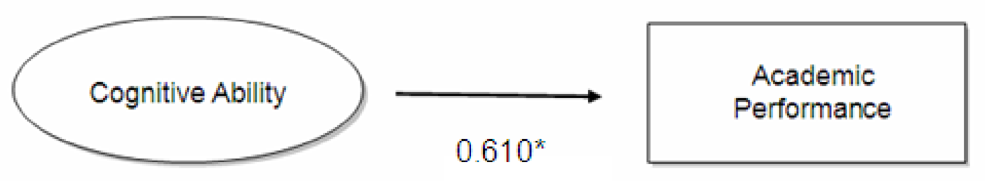
A third structural equation model testing this relation between cognitive ability and academic performance without mediators was tested. This involved removal of the paths between hypothesised mediator variables and academic performance. Results included a good fitting model. See table 4.12 below for fit indices. The full structural model is in figure 4.11.

TABLE 4.12: Fit indices: Model 3

	χ^2	***df***	***p***	**RMSEA**	**CFI**	**SRMR**
Model	82.63	66	.081	0.04	0.94	0.06
Acceptable range			> .05	< .05	> .90	<.80

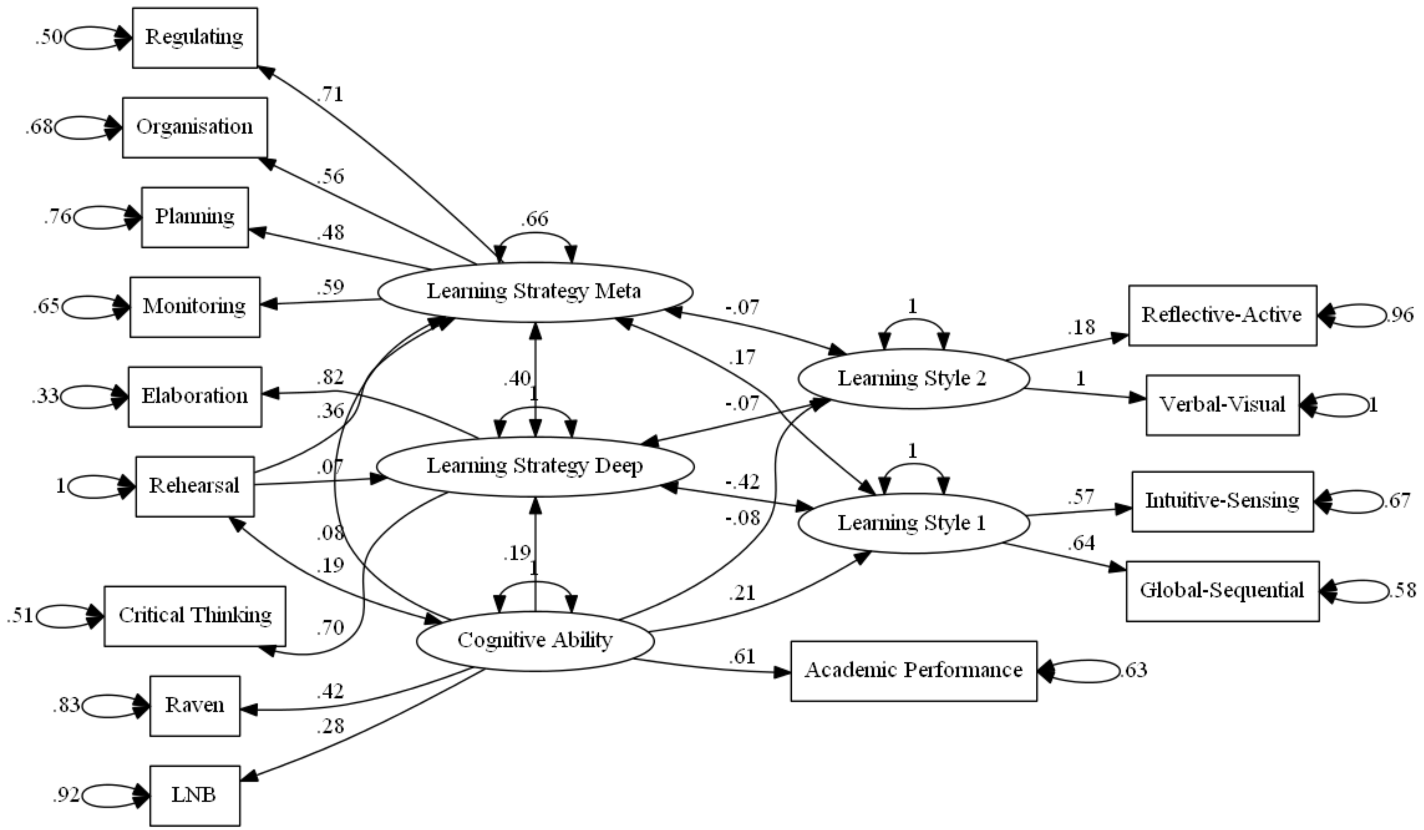
Results showed that there was a strong and positive relationship between cognitive ability and academic performance that was, in addition, significant (β = .61, z = 3.80, p = .000). Path “c” (see figure 4.9 previously and figure 4.10 below) is a significant, strong, direct and positive relationship. Returning to the first step in establishing mediation, results showed that there was an effect or relationship present to mediate.

FIGURE 4.10: Relationship present to mediate



NOTE: Directed arrow represents the relationship that is strong, direct, positive and significant. Significance is denoted by *. There is thus a relationship present to mediate.

FIGURE 4.11: Structural equation model 3



NOTE: All of the proposed mediators have been removed from this third model in order to establish that there is an effect present to mediate.

The second step is to establish that there is a relationship between the predictor variable and the mediating variables (Kenny, 2011). There should therefore be a significant path, or at least a coefficient greater than zero regarding the relationship between cognitive ability and the mediator variables (path “a” in figure 4.9 previously). The parameter estimates for these relationships are shown in table 4.13

Regarding learning style 1 as a mediator, path “a” is small, positive and non-significant (β = .21, z = 1.34, p = .180), for learning style 2 path “a” is also small and non-significant but is negative (β = -.08, z = -0.48, p = .629). Regarding the deep and metacognitive learning styles, paths “a” are small, positive and non-significant (deep strategy β = .19, z = 1.40, p = .161, metacognitive strategy β = .09, z = 0.60, p =.550). With regard to the surface learning strategy, path “a” was small, positive and non-significant but tended towards significance (β = .19, z = 1.70, p = .089).

TABLE 4.13: Parameter estimates between predictor and mediator variables

Relationship between variables		**β**	**z**	***p***
Cognitive ability	Learning style 1	0.21	1.34	.180
	Learning style 2	-0.08	-0.48	.629
	Surface strategy	0.19	1.70	.089*a*
	Deep strategy	0.19	1.40	.161
	Metacognitive strategy	0.09	0.60	.550

NOTE: *a* = tends towards significance

The second model had 44 estimated parameters, of which 27 were significant and 17 were non-significant, this third model included 39 parameters of which 27 were significant and 12 were non-significant. In comparing parameter estimates from model 2 and this third mediation model, the elimination of possible mediators led only to a slight change in the relationship between cognitive ability and academic performance. The relationship increased in strength and significance from β = .312, z = 2.02, p = .043 to β = .610, z = 0.40, p = .000. This reiterates that there is a relationship present to mediate.

Step three of the mediation analysis must next show that the mediators affect the outcome variable (Kenny, 2011). That is, the path from the mediators to academic performance (path “b” in figure 4.9 previously) must be significant or at least have a coefficient greater than zero. Table 4.14 shows the parameter estimates of these relationships.

TABLE 4.14: Parameter estimates between mediator variables and academic performance

Relationship between variables		**β**	**z**	***p***
Learning style 1	Academic Performance	-0.02	-0.19	.846
Learning style 2		-0.13	-1.13	.260
Surface strategy		0.20	2.24	.025*
Deep strategy		0.06	0.47	.636
Metacognitive strategy		0.00	0.02	.983

NOTE: ** $p<.001$, *$p<.05$

Learning style 1 and 2, as well as the deep and metacognitive learning strategies have coefficients that are mostly close to zero, ranging from 0 to .13 and thus indicate weak relationships with academic performance. These poor relations are, in addition, non-significant. The surface learning strategy on the other hand had a stronger relation that was also significant ($\beta = .20$, $z = 2.00$, $p = .025$).

Both paths “a” and “b” were small and non-significant for the variables learning style 1, learning style 2, the deep strategy and the metacognitive strategy. The second and third steps of mediation were not met. Variations in the level of cognitive ability did not significantly account for variations in these variables (path “a”), and variation in these variables did not significantly account for variation in academic performance (path “b”). Mediation therefore does not hold with regard to learning style 1, learning style 2, the deep learning strategy and the metacognitive learning strategy.

Regarding the surface learning strategy (rehearsal), however, path “b” was medium, positive and significant while path “a” was smaller and non-significant, but tended towards significance.

Due to the strong relationship between the surface strategy and academic performance (path “b”) and the propensity towards significance in path “a”, it was decided that the surface learning strategy was a likely mediator and that the mediation analysis should continue using this variable as the mediator.

A fourth model was entered to test the possible mediation. Results showed a good fitting model (see table 4.15 below) and that rehearsal is likely a mediating variable of the relationship between cognitive ability and academic performance.

TABLE 4.15: Fit indices: Final model

	χ^2	d*f*	*p*	RMSEA	CFI	SRMR
Model	74.103	65	.206	0.029	0.97	0.06
Acceptable range			> .05	< .05	> .90	<.80

The mediation is seen in the fact that path “c” is reduced when rehearsal is entered as a mediator from β = .61, $z = 3.98$, $p = .000$ to β = .39, $z = 3.11$, $p = .002$ (see figure 4.12 and 4.13). Results have shown the surface learning strategy exhibits typical mediator behavior. Results furthermore implicate rehearsal as a partial mediator in the relationship between cognitive ability and academic performance. This means that part of the effect of cognitive ability is mediated by the use of rehearsal, but other parts are either direct or mediated by other variables not included in the model.

FIGURE 4.12: Rehearsal partially mediates the relationship between cognitive ability and academic performance

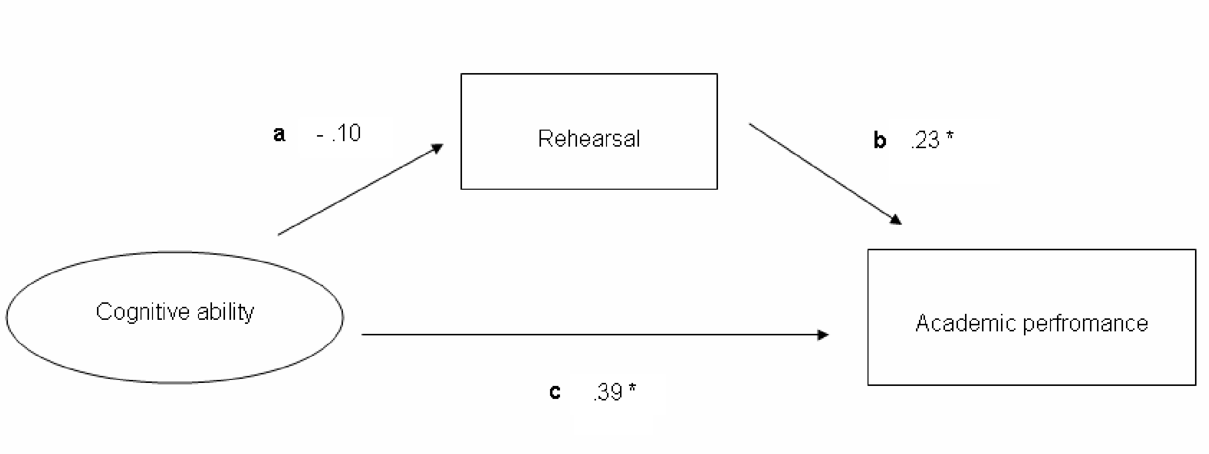
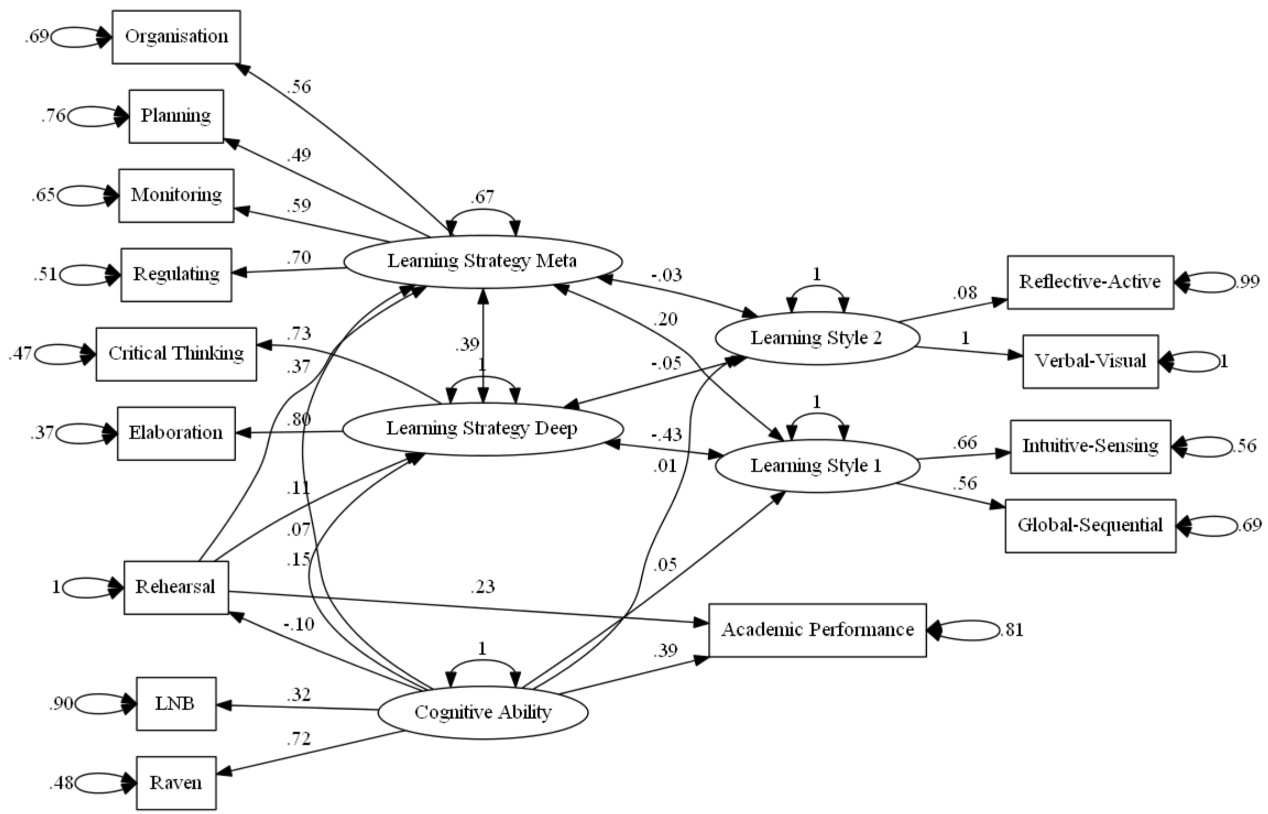


FIGURE 4.13: Structural equation model 4



NOTE: The relationship between cognitive ability and academic performance is reduced when rehearsal is added as a mediator, indicating that rehearsal partially mediates this relationship.

The fourth step is not necessary as it is required only for complete mediation or when the predictor variable no longer has any effect on the outcome variable when the mediator has been controlled for (Kenny, 2011). In this case, only partial mediation occurred.

This four-step approach is not intended to test the statistical significance of the mediation effect and therefore it is imperative that the mediation model be examined for improvement, in order to see if the added path has decreased the chi-square value.

In order to do so the chi-square values and degree of freedom of model 3 and the final model (model 4) are subtracted, and the significance value is then calculated.

$$\chi^2 \text{ of model 3} - \chi^2 \text{ of model 4} = 82.63 - 74.103 = 8.527$$

$$df \text{ of model 3} - df \text{ of model 4} = 66 - 65 = 1$$

Calculating the significance value from $\chi^2 = 8.527$, $df = 1$ results in a p value of .004. This shows that there is a significant improvement in the model with the surface learning strategy added as a mediator. The surface learning strategy had a significant impact and it can be assumed that it partially mediates the relationship between cognitive ability and academic performance.

There is thus evidence to support that the surface learning strategy acts as a partial mediator and the null hypothesis “learning styles and strategies will not mediate the relationship between cognitive ability and academic performance” is partially rejected.

4.7. Chapter Summary

The results of the statistical analyses conducted were reported in this chapter. The chapter was opened with a description of the sample and presented descriptive statistics, including bivariate correlations, for each of the variables. This was followed by a discussion of differences between genders. Results of SEM and mediation analysis were then presented. Central findings in this regard included: a refined model that fitted the data well and mediation modelling that show the surface learning strategy as a mediator in the relationship between cognitive ability and academic performance. A discussion of these results in line with the literature presented in chapter 2, as well as the implications and recommendations thereof, are presented in the following chapter (chapter 5).

CHAPTER 5:
DISCUSSION

5.1. Introduction

This final chapter restates the research problem and aims of the study and provides a brief overview of the methodology used. At first findings regarding learning styles and strategies and gender differences are discussed. Next the structural models and mediation are summarised and their results are discussed. Each of the hypotheses stated in chapter 1 and 2 are discussed, as is the main research question. Limitations of the study are then highlighted and recommendations, including those for future research are made. The dissertation is then concluded.

5.2. Summary of study

The present study sought to obtain a better understanding of the strong relationship between cognitive ability and academic performance. It has been shown that this relationship is robustly supported by a large body of literature that spans several decades. Cognitive ability has therefore consistently demonstrated a strong and important relationship with academic performance, where higher cognitive abilities are, in general, related to higher academic performance and vice versa.

Higher cognitive abilities, however, are not the only predictors of academic performance as numerous factors can affect a student's performance. It has been previously discussed that factors, such as learning styles and strategies, may be influential to the extent that they intervene in the relationship between cognitive ability and academic performance.

As the study was interested in furthering understanding of this relationship and its complexities, a mediational analysis was considered. Mediation and mediational modelling is concerned with explaining the mechanism by which a known predictor variable exerts its influence on an outcome variable. In this way, mediation offered the present study a method to further understanding of the strong relation between cognitive ability and academic performance.

The role of learning styles and strategies in the relationship between cognitive ability and academic performance was the primary aim of the study, where the question: Do learning styles and learning strategies mediate the relationship between cognitive ability and academic performance, in a sample of university students, was asked. A quantitative, correlational research design using SEM as the method of analysis and mediation was chosen to in order to achieve this aim and subsequently answer this question.

5.3. Findings with regard to learning styles and strategies

It was discussed in the literature chapter (chapter 2) that the learning styles construct is not as well conceptualised or agreed upon as the learning strategies construct. Results from the present study reflect this discussion in finding that the measure of learning styles had only minimal reliability (α = .687), while the learning strategies measure in contrast had a respectable level of reliability, (α = .776).

According to Weston and Gore (2006), measures that are reliable will be better indicators of the latent variable they are said to measure. SEM showed this to be true in that some of the indicators of learning styles did not relate well to the latent learning style variable, but that indicators of learning strategy related well to latent strategy variables overall. Learning strategies were therefore shown to be a more reliable and better conceptualised construct than learning styles. In contrast to Livesay et al. (2002) and Zywno (2003), the reliability and validity of the ILS were not sufficient and it was therefore not as suitable an instrument in this case.

Although the learning style measure and construct did not function well, it was nonetheless found that learning styles did not relate to academic performance or cognitive ability, and in addition did not function as a mediator variable.

Despite the fact that learning styles had no significant relationship with cognitive ability or academic performance, and were not identified as mediating variables, correlations did identify some interesting relationships. It was found that an increased preference in the active learning style relates to taking less time to complete the measure of attention and working memory (LNB2), while an increase in the reflective style relates to taking more time to complete it. According to the FSLSM, a sensor's performance should be slower in timed tests as they may have to read questions several times, paying careful attention to details before beginning to answer them and as such they may run out of time (Felder & Silverman, 1988). Similarly, it seems that this is true of reflective learners. Too much reflecting and thinking may, in addition, result in using up too much time, and consequently poor performance on timed tests. This is in contrast to findings discussed previously, in chapter 2, regarding the reflective learning style as a style that, in particular, would be a good predictor of higher academic performance.

The active and verbal learning styles in contrast are associated with higher scores of working memory and attention. This finding is both in accordance and in contradiction with previous literature (Graf et al., 2008; Graf et al., 2009). The verbal learning style was previously found to correlate with better working memory while the active learning style was associated with poorer working memory.

Learning styles did not relate to cognitive ability or academic performance, however learning strategies, particularity the superficial strategy, did relate to academic performance. Specifically, more frequent use of rehearsal was associated with an increase in academic performance.

This finding is in contrast to previous findings, as most have found that the surface learning strategy is negatively associated with academic performance (Entwistle & Wilson 1977; Kember et al., 1995; Minnella, 2011; Newstead, 1992; Schmeck 1983). In addition, the metacognitive strategy did not relate to performance which is in sharp contrast to previous findings that suggest it is a positive predictor of academic performance in almost all cases (Cassidy & Eachus, 2000; Diseth & Martinsen, 2003; Minnella, 2011).

Diseth and Martinsen (2003) have nonetheless found that the surface learning strategy is significantly predictive of academic performance, and this finding has been repeated in this study.

Students are thus using mostly memorisation techniques to learn and study material, and from this obtain higher grades than those who use the other strategies. This frequent use of memorisation as a strategy is furthermore reflected in the predominant learning style among the students, which was the sensing learning style. Literature indicates that students with this style in general can memorise facts well (Felder & Silverman, 1988; Lawrence, 1993). Thus this sample of students not only has a higher preference for memorisation strategies but, according to literature, is good at memorisation as well. While learning styles do not account for any variation in academic performance, they do seem to provide support for the learning strategies students used.

5.3.1. Explanation of findings

According to learning strategy theory, by using the surface strategy more often, students are repeatedly using limited levels of cognitive engagement when preparing for tests and exams (Biggs, 1999), but yet are obtaining higher scores or grades. Several possible explanations exist that may explain this finding and include, but are not limited to the following.

The first may be, that students may not have complete understanding and comprehension of the material that they are learning and therefore that they may have only disjointed isolated fragments of the material that they do not remember in the long run (Cooper & Forrest, 2009; Tight, 2009). It may mean then, that they simply reproduce knowledge. If this is so, students may have difficulties applying and adapting their knowledge later on and in other situations, such as in the working world.

Another possible explanation, that is important to note, is that the particular testing methods educators and institutions use may influence the strategy chosen by students. For example, if students are required only to list, name and choose from a list of options they may more likely use the superficial learning strategy. If the test on the other hand requires an in depth discussion and critique on a particular topic, students may rather opt for deeper strategies. It was mentioned previously in chapter 2, that strategies are less stable in that they are more dependent on context (Richardson, 1994). The type of strategy used may thus depend on particular form and type of assessment, or the context.

This is supported by results from a study conducted by Abd-El-Fattah (2011) which showed that university students adjust their learning strategies to those in line with the cognitive processing demands of testing. Learning strategies in addition were found to mediate the relationship between the type of test items expected and test performance (Abd-El-Fattah, 2011). Students' academic performance may thus be a function of the particular type of assessment they prepare for and encounter. De Carvalho Filho (2009) and Zopp (1998) have, in addition, shown that the type of test can significantly affect students' performances.

It seems that factors such as the way in which test questions are structured, or the degree of processing required by different types of questions, may affect a student's performance, through the type of learning strategy they have chosen to prepare for a test (de Carvalho Filho, 2009)

This study has identified that there may be a need to question the manner in which academic performance is measured in studies of this nature. This is because the way in which academic performance is measured may simply reflect the nature of assessments themselves. Academic performance is typically, if not exclusively, measured using an average of test or exam scores and depending on the type of assessment, different results may be obtained. This is because if only one type of assessment is used, for instance, listing and naming, only proficiency in memorisation skill may be measured and not how a student achieves academically. It is thus important that a variety of different kinds of assessment are used when assessing academic performance.

It may be valuable for future studies to describe the tests and exams used in order to obtain the combined score used as a measure of academic performance. What kinds of tests were used as well as what the tests intended to asses could be discussed, for example.

More frequent use of memorisation as a learning strategy and its positive relation to academic performance may alternatively imply that the deep and metacognitive learning strategies are not necessarily required for obtaining higher grades. These strategies may still be necessary for long term retention and understanding of material learned (Biggs, 1999) and for the planning and organisation of one's studies. Finally, the results found could also indicate that rehearsal may, in fact, be an effective strategy for understanding and long term retention of material studied.

In summary, the way in which students typically receive and process information was shown to have no relation to academic performance and cognitive ability. The surface learning strategy however had a significant relationship with academic performance.

5.3.2. Interactions between style and strategy

In addition to the findings mentioned previously, the study found that learning styles and learning strategies related to each other in various ways. Sensors were found to use critical thinking and deep learning less frequently while intuitors use critical thinking and deep learning more frequently. This appears in line with previous literature that states having dominance in intuition involves insight into complexity, innovation and imagination (Felder & Silverman, 1988; Lawrence, 1993) - perhaps through the use of cognitive abstraction or deep and critical thinking.

With regard to visual learners, they often did not use planning, monitoring or the metacognitive strategy overall, but verbal learners indicated that they often plan and monitor their learning –frequently using the metacognitive learning strategy. It was in addition found that sequential learners frequently use the superficial learning strategy and often monitor their studies but do not use critical thinking as often. Global learners on the other hand do not use the superficial learning strategy or monitor their studies as often but frequently use critical thinking strategies. This frequent use of critical thinking may reflect the notion that global learners may be better at divergent thinking and synthesis (Felder & Silverman, 1988), and perhaps use more mental flexibility.

The interactions identified appear to provide some insight, albeit speculated, into the different learning style dimensions.

5.4. Gender differences

In keeping with conventions in the cognitive psychology arena, gender differences between male and female participants with regard to cognitive ability, learning style, learning strategy and academic performance were investigated**.** No differences between males and females were found with regard to cognitive ability and academic performance, however, some significant differences were found between males and females regarding learning styles and strategies.

Female participants were more sensing in their learning style while male participants were more intuitive in their learning style. Male and female participants also differed significantly on the visual-verbal learning style dimension, with male participants preferring visual modes of input and female participants preferring verbal modes of input.

It was found that male participants use the critical thinking sub-strategy more often than female participants. Female participants on the other hand were found to use the organisation sub-strategy significantly more than male participants. Female participants in addition used planning significantly more than male participants. It can thus be put forward that female students may spend more time planning and organising their studies, than do male students. In answering sub-question 2, there are some significant differences with regard to the learning strategies and styles of men and women, however, no differences were found with regard to cognitive ability or performance.

The significant differences found between genders may be an indication that gender is a possible moderator variable. As previously mentioned, there is a difference between a mediator and a moderator variable. A moderator variable is a variable that influences the strength of a relationship between two other variables, whereas a mediator variable explains the relationship between the two other variables (Baron & Kenny, 1986). Gender may thus influence the strength of relationships between cognitive ability, learning strategy and academic performance.

5.5. Discussion of structural models and mediation

Results from the first structural equation model showed that higher cognitive abilities and the use of the surface learning strategy each play a unique role in predicting academic performance (χ^2 (67, N = 172) = 145.31, $p < .001$). It, in addition, suggested that learning style does not predict academic performance at all.

A refined model of the relationship between constructs subsequently showed that higher cognitive abilities and the use of the surface learning strategy do play a unique role in predicting academic performance (χ^2 (61, N = 172) = 70.50, $p > .05$). A third model showed that cognitive ability did in fact have a strong, direct and positive relationship with academic performance (χ^2 (66, N = 172) = 82.63, $p > .05$).

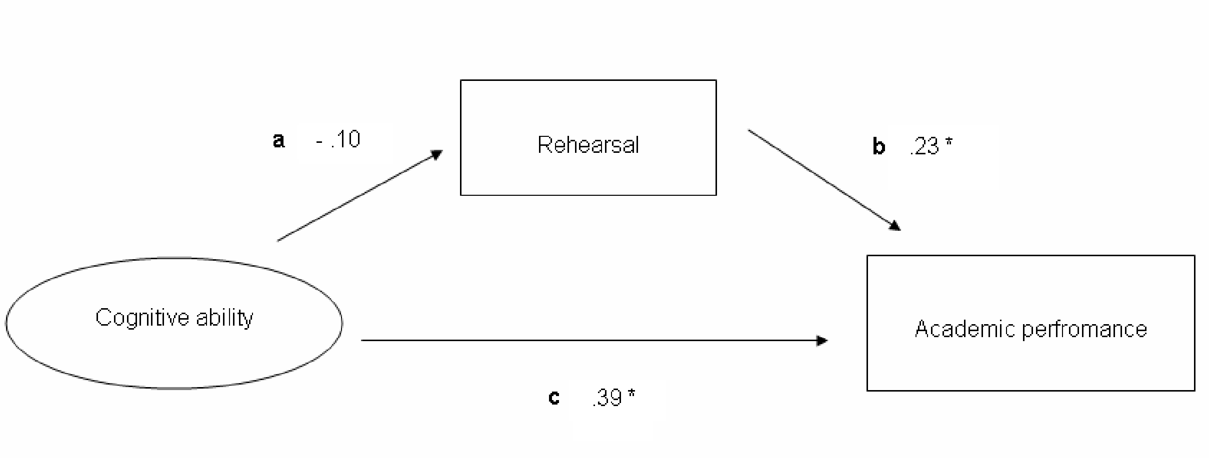
The study found that cognitive ability was significantly related to academic performance, with higher cognitive ability associated with higher academic performance. Specifically, speed and accuracy on the cognitive measures were associated with achieving higher grades through the year. These findings confirm previous findings that suggest higher academic performance is the product of superior cognitive abilities, and in particular, of superior executive functions.

In accordance with previous literature, results showed that higher academic performance is in fact associated with increased information processing speed, superior abstraction and mental flexibility, as well as superior attention and working memory. Executive functions therefore appear to be essential for academic performance as previously described in literature (Nosarti et al., 2010; Shamashuddin et al., 2008).

Focusing on the question of whether styles and strategies mediate this relationship, learning styles, as previously stated, did not account for any of the variation found in academic performance. It was however found that one of the levels at which students' approach learning and studying, specifically the surface learning strategy, was a significant predictor of academic performance. In particular, more frequent use of rehearsal predicted academic performance.

A fourth mediation model, where rehearsal was added as a mediator provided tentative evidence for mediation. Despite that the relationship between cognitive ability and rehearsal (path "a" in figure 5.1) was not significant, addition of rehearsal to the model significantly decreased the relationship between cognitive ability and academic performance from $\beta = .61$, $z = 3.98$, $p = .000$ to $\beta = .39$, $z = 3.11$, $p = .002$ (χ^2 (65) = 74.10, $p > .05$). Cognitive ability thus produces changes in the use of rehearsal, which in turn produces changes in a student's academic performance. Stated differently, cognitive ability has an indirect affect on academic performance through the superficial learning strategy (rehearsal), as in figure 5.1.

FIGURE 5.1: The surface learning strategy (rehearsal) as a mediator



When the mediator variable is added to the relationship between the independent variable and the dependent variable, the effect of cognitive ability on academic performance changes. If the effect no longer occurs (coefficient is zero), the mediation effect is said to be a complete mediation. This however was not the case. The effect was only reduced from .61 to .39, and thus the mediation effect was only partial. Partial mediation means that part of the effect of cognitive ability is mediated by the use of rehearsal, but other parts are either direct or mediated by other variables not included in the model. Cognitive ability therefore indirectly affects academic performance through rehearsal, but other unknown factors are involved as well.

This identification of rehearsal as a partial mediator clarifies part of the mechanism by which cognitive abilities result in better academic performance. The model thus suggests that the mechanism through which a student performs well academically is possibly through the frequent use of rehearsal. Memorisation of learning materials may thus be the way in which students are obtaining higher grades at university.

The model, moreover, suggests some interesting, yet unconfirmed relationships. Path "a", the relationship between cognitive ability and rehearsal, although not significant, was negative (β = -.10, z = 0.90, p = .368). This offers a possible, yet unconfirmed, interpretation that those students with higher cognitive ability use less rehearsal, while those with less cognitive ability use more rehearsal.

If this line of tentative interpretation is followed, students with lower cognitive ability may thus perform well academically possibly because of their frequent use of rehearsal. This, however, does not mean that students with higher cognitive abilities, using less rehearsal, would perform less well academically, as higher ability students may still explain the strong significant and positive relationship between cognitive ability and academic performance. What it may possibly mean, is that cognitive ability is a moderator variable. Thus along with gender, cognitive ability may act as a moderator. Both gender and cognitive ability may influence the strength of relationships between strategy and academic performance. These speculations are, however, tentative and would need to be examined. The examination of which is beyond the objectives of this study.

5.6. Answers to research question and hypotheses

5.6.1. Hypothesis 1

It was at first hypothesised that higher cognitive abilities, would significantly and positively predict academic performance. This hypothesis is accepted as results showed that cognitive ability had a significant, strong and positive relationship with academic performance.

5.6.2. Hypothesis 2

The second hypothesis was that the deep and metacognitive learning strategies would significantly and positively predict academic performance. This hypothesis is not accepted as neither the deep, nor the metacognitive learning strategy showed a significant relationship with academic performance.

5.6.3. Hypothesis 3

The surface learning strategy will significantly and negatively predict academic performance was the third hypothesis. This too is not accepted as the opposite was in fact found. In contrast to majority of previous literature, results showed that the surface learning strategy (rehearsal) had a moderate, significant and positive relationship with academic performance.

5.6.4. Hypothesis 4

The fourth hypothesis stated that the deep and metacognitive learning strategies would have significant and positive relations with cognitive ability. This cannot be accepted as neither showed a significant relation with cognitive ability.

5.6.5. Hypothesis 5

Hypothesis five predicted that learning style would significantly and positively predict academic performance. This hypothesis is not accepted as learning style showed no relation with academic performance even when the constructs were improved during modification in SEM.

5.6.6. Hypothesis 6

Learning styles and strategies will mediate the relationship between cognitive ability and academic performance was the final hypothesis. According to the findings of the study, hypothesis 6 is partly and tentatively accepted as the surface learning strategy was found to partially mediate the relationship between cognitive ability and academic performance.

It was found that academic performance is a function of an individual's use of rehearsal when approaching learning and studying. The use of rehearsal was, in turn, informed by their cognitive ability. In other words it was found that the use of rehearsal mediates the effect of cognitive ability on academic performance. In answering the research question:

Do learning styles and learning strategies mediate the relationship between cognitive ability and academic performance, in a sample of university students?

Only the surface learning strategy was found to mediate, and specifically partially mediate, the relationship between cognitive ability and academic performance, in the sample of university students.

5.8. Limitations

While SEM analysis allowed for accurate testing of the hypothesised theoretical model and for assistance in establishing construct validity (Pearl, 2000; Tabachnick & Fidell, 2007), certain limitations must also be considered. The main design limitation is that there is a limit to the inferences that can be made when using the correlational design (Levine & Parkinson, 1994), as the well know maxim states: “correlational does not prove causation” (Shadish, Cook, & Campbell, 2002, p. 7). This is because variables were not manipulated and participants were not assigned to control and experimental groups (Salkind, 2010; Urdan, 2005).

While inferring causality is limited, the direction and strength of relationships as well as direct and indirect effects can be identified. In addition, information about likely causal relationships and pathways among variables as well as tentative evidence of possible mediating relationships between variables can be provided (Stangor, 2011). The relationships and mediation identified have tentative evidence to support them. Likely causal relationships have been identified and future studies can focus on these likelihoods using experimental exploration and causal inference (Salkind, 2010; Stangor, 2011).

As convenience sampling is a non-probability sampling technique, there was, in addition ,an inherent bias that the sample was unlikely to be representative of the population being studied. This is because some groups within the sample may be under-represented or over-represented and those who are willing to participate may be different to those who are not (Johnson & Christensen, 2010). The use of this sampling technique may have placed limits on the study's external validity and the generalisability of its findings (Shadish et al., 2002).

Convenience samples however are not necessarily always unrepresentative of the population. Problems of representativeness can be overcome by describing the characteristics of those participating in detail. In this way, whether or not the sample actually represents the population can be determined by the reader (Johnson & Christensen, 2010). Generalisations to the general population and students at large are, nevertheless, unlikely. The findings may, however, be generalisable to other psychology students and to students in similar fields of the social sciences.

Another possible limitation is that the quality of a survey can be undermined by inaccurate and dishonest responses (Gravetter & Forzano, 2008) and there is no guarantee that participants were open and honest in completing the various measures. It is however likely that; ensuring confidentiality, self-administration and questions that were not of a sensitive nature reduced the likelihood of such dishonesty and inaccuracy in this study (Nederhof, 1985; Singer, von Thurn & Miller, 1995).

Non-normal data proposed a limitation to the study and the interpretations that could be made from findings, however, deviations from normality were moderate and SEM using maximum likelihood estimation is said to be robust to even moderate violations of normality (Anderson & Gerbing, 1984). However the deviations from normality encountered coupled with a smaller sample size (less than the minimum of 200) produces a threat to the study. Additional caution is recommended when considering the results of the study. With this in mind, it is also important to note that alternative inferences cannot be ruled out.

A last important limitation of the study was that the FSLSM did not have good construct validity and that this was reflected in the SEM results. In future, an alternative measure could replace the Felder-Solomon Index of Learning Styles, as its usefulness in the present study was limited.

5.9. Recommendations

A general recommendation includes that the types of tests and examinations presented to students be considered or reviewed. This is because the particular type of questions, and expected level of comprehension they incorporate, may induce students to learn superficially through memorisation or rote learning. Testing could include more comprehension and critique based questions and material, depending on the level required. Educators could, otherwise, take steps to ensure that students have retained and comprehended the material learned, such as testing the students again at a later stage. For example, through use of informal ‘pop quizzes’ or informal oral examinations, in order to determine if students remember and understand the information educators intend to impart.

It is also recommended, as previously discussed, that future studies investigating academic performance should describe the tests and exams used in order to obtain an average score as a measure of academic performance. For example what kinds of tests were used as well as what the tests intended to asses.

5.10. Recommendations for future research

Future research could focus on the importance of rehearsal and, in particular, on the authenticity of this importance. For example research could ascertain if understanding and long term retention is effectively obtained through rehearsal. Researchers could examine whether those who use predominantly the superficial learning strategy actually retain and comprehend material later on. Research in the future could furthermore use bigger sample sizes and normal and longitudinal data, in order to more accurately determine true mediation.

Research could, in addition, investigate whether the findings of the present study regarding the effect of rehearsal on academic performance as well as its mediatory role are generalisable to subject populations other than those of the humanities and social sciences.

As students may adjust their learning strategy according to the type of test to be completed studies in future could examine whether meaningful relationships appear when the sample is divided by year level. Lastly, as results have suggested that gender and cognitive ability may be possible moderator variables, future research could investigate this avenue as well.

5.11. Conclusion

The results of the present study provide an integration of several important aspects of cognitive ability, learning and performance by examining their interactions and relations. In conclusion, it can be emphasised that individual differences in academic performance are strongly related to cognitive ability and whether one uses the surface learning strategy when learning. Specifically the surface learning strategy (use of rehearsal or memorisation) mediates the strong relationship between cognitive ability and academic performance. The level at which students approach learning and studying, or the amount of cognitive engagement used when learning, thus plays a significant role, and in particular a mediating role, with regard to academic performance.

On a final note, this dissertation has introduced the argument that learning styles and strategies may mediate the relationship between cognitive ability and academic performance. It was discussed how this possible mediatory role was investigated, including the research framework and methodology used. The results of this investigation were that the surface learning strategy partially mediates the relationship between cognitive ability and academic performance. The results were reported and discussed, which included discussion of the study's drawbacks. Recommendations were then provided on the bases of the findings and discussion.

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APPENDIX A: PERMISSION DOCUMENTS

Ethical Approval

Our Ref: Ms P Woest / 26239729
Tel: 012 420 2736
Fax: 012 420 2698
E-mail: petru.woest@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Humanities

16 August 2011

Ms CM Robertson
28 Greenwich Village
Vickers Street
Jansen Park
BOKSBURG
1459

Dear Ms Robertson

TITLE REGISTRATION: FIELD OF STUDY – MA: RESEARCH PSYCHOLOGY

I have pleasure in informing you that the following has been approved:

TITLE: **The mediating role of learning styles and strategies in the relationship between cognitive ability and academic performance**

SUPERVISOR: **Prof D Maree**

I would like to draw your attention to the following:

1. **ENROLMENT PERIOD**
   (a) You must be enrolled as a student for at least one academic year before submission of your dissertation/essay.
   (b) Your enrolment as a student must be renewed annually before 31 March, until you have complied with all the requirements for the degree. You will only be able to have supervision if you provide a proof of registration to your supervisor.

2. **APPROVAL FOR SUBMISSION**
   On completion of your dissertation/essay enough copies for each examiner as well as the prescribed examination enrolment form which includes a statement by your director of studies that he/she approves of the submission of your dissertation/essay, as well as a statement, signed by you in the presence of a Commissioner of Oaths, must be submitted to Student Administration.

3. **NOTIFICATION BEFORE SUBMISSION**
   You are required to notify me at least three months in advance of your intention to submit your dissertation/essay.

4. **INSTRUCTIONS REGARDING THE PREPARATION OF THE DISSERTATION/ESSAY AND THE SUMMARY APPEAR ON THE REVERSE SIDE OF THIS LETTER.**

Yours sincerely

for **DEAN: FACULTY OF HUMANITIES**

GW-505E

Informed Consent Form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Psychology

Claire Robertson
claire.r@tuks.co.za
+27724376103

Research Study: The mediating role of learning styles and strategies in the relationship between cognitive ability and academic performance.

Dear Participant

Please read the information below carefully before committing to participate in this study. This study is interested in how students learn, their abilities and performance. The purpose of the study is to investigate whether students' learning styles, learning strategies and abilities affect their performance. We are interested in your answers and the responses you provide are highly valued.

You will be required to answer a number of different questions during this session, which should take approximately 50 minutes to complete. We are also interested in the average mark of all your modules in 2011 and will use them in the study, with your consent, if you agree to participate. Your participation in this study is voluntary and you may withdraw at any time without offering any explanation or suffering any consequences. You do not need to share any information you feel uncomfortable disclosing.

All the information you provide will be kept confidential. Your personal details will not be shared with anyone and the report will include only a discussion of general trends with no references made to individual persons.

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YUNIBESITHI YA PRETORIA

PLEASE DETACH THIS PAGE AND HAND IT IN

I ______________________ indicate that I understand the nature of this study and give consent to participate,

_________________ Signature

_________________ Date

APPENDIX B: INSTRUMENTS

INDEX OF LEARNING STYLES

Barbara A. Soloman
First-Year College
North Carolina State University
Raleigh, North Carolina 27695
Richard M. Felder
Department of Chemical Engineering
North Carolina State University
Raleigh, NC 27695-7905

DIRECTIONS
Circle "a" or "b" to indicate your answer to every question. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently.

1. I understand something better after I
(a) try it out.
(b) think it through.

2. I would rather be considered
(a) realistic.
(b) innovative.

3. When I think about what I did yesterday, I am most likely to get
(a) a picture.
(b) words.

4. I tend to
(a) understand details of a subject but may be fuzzy about its overall structure.
(b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
(a) talk about it.
(b) think about it.

6. If I were a teacher, I would rather teach a course
(a) that deals with facts and real life situations.
(b) that deals with ideas and theories.

7. I prefer to get new information in
(a) pictures, diagrams, graphs, or maps.
(b) written directions or verbal information.

8. Once I understand
(a) all the parts, I understand the whole thing.
(b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
(a) jump in and contribute ideas.
(b) sit back and listen.

10. I find it easier
(a) to learn facts.
(b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
(a) look over the pictures and charts carefully.
(b) focus on the written text.

12. When I solve math problems
(a) I usually work my way to the solutions one step at a time.
(b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
(a) I have usually gotten to know many of the students.
(b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
(a) something that teaches me new facts or tells me how to do something.
(b) something that gives me new ideas to think about.

15. I like teachers
(a) who put a lot of diagrams on the board.
(b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
(a) I think of the incidents and try to put them together to figure out the themes.
(b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
(a) start working on the solution immediately.
(b) try to fully understand the problem first.

18. I prefer the idea of
(a) certainty.
(b) theory.

19. I remember best
(a) what I see.
(b) what I hear.

20. It is more important to me that an instructor
(a) lay out the material in clear sequential steps.
(b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
(a) in a study group.
(b) alone.

22. I am more likely to be considered
(a) careful about the details of my work.
(b) creative about how to do my work.

23. When I get directions to a new place, I prefer
(a) a map.
(b) written instructions.

24. I learn
(a) at a fairly regular pace. If I study hard, I'll "get it."
(b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
(a) try things out.
(b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
(a) clearly say what they mean.
(b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
(a) the picture.
(b) what the instructor said about it.

28. When considering a body of information, I am more likely to
(a) focus on details and miss the big picture.
(b) try to understand the big picture before getting into the details.

29. I more easily remember
(a) something I have done.
(b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
(a) master one way of doing it.
(b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
(a) charts or graphs.
(b) text summarizing the results.

32. When writing a paper, I am more likely to
(a) work on (think about or write) the beginning of the paper and progress forward.
(b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
(a) have "group brainstorming" where everyone contributes ideas.
(b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
(a) sensible.
(b) imaginative.

35. When I meet people at a party, I am more likely to remember
(a) what they looked like.
(b) what they said about themselves.

36. When I am learning a new subject, I prefer to
(a) stay focused on that subject, learning as much about it as I can.
(b) try to make connections between that subject and related subjects.

37. I am more likely to be considered
(a) outgoing.
(b) reserved.

38. I prefer courses that emphasize
(a) concrete material (facts, dat(a).
(b) abstract material (concepts, theories).

39. For entertainment, I would rather
(a) watch television.
(b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
(a) somewhat helpful to me.
(b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
(a) appeals to me.
(b) does not appeal to me.

42. When I am doing long calculations,
(a) I tend to repeat all my steps and check my work carefully.
(b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
(a) easily and fairly accurately.
(b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
(a) think of the steps in the solution process.
(b) think of possible consequences or applications of the solution in a wide range of areas

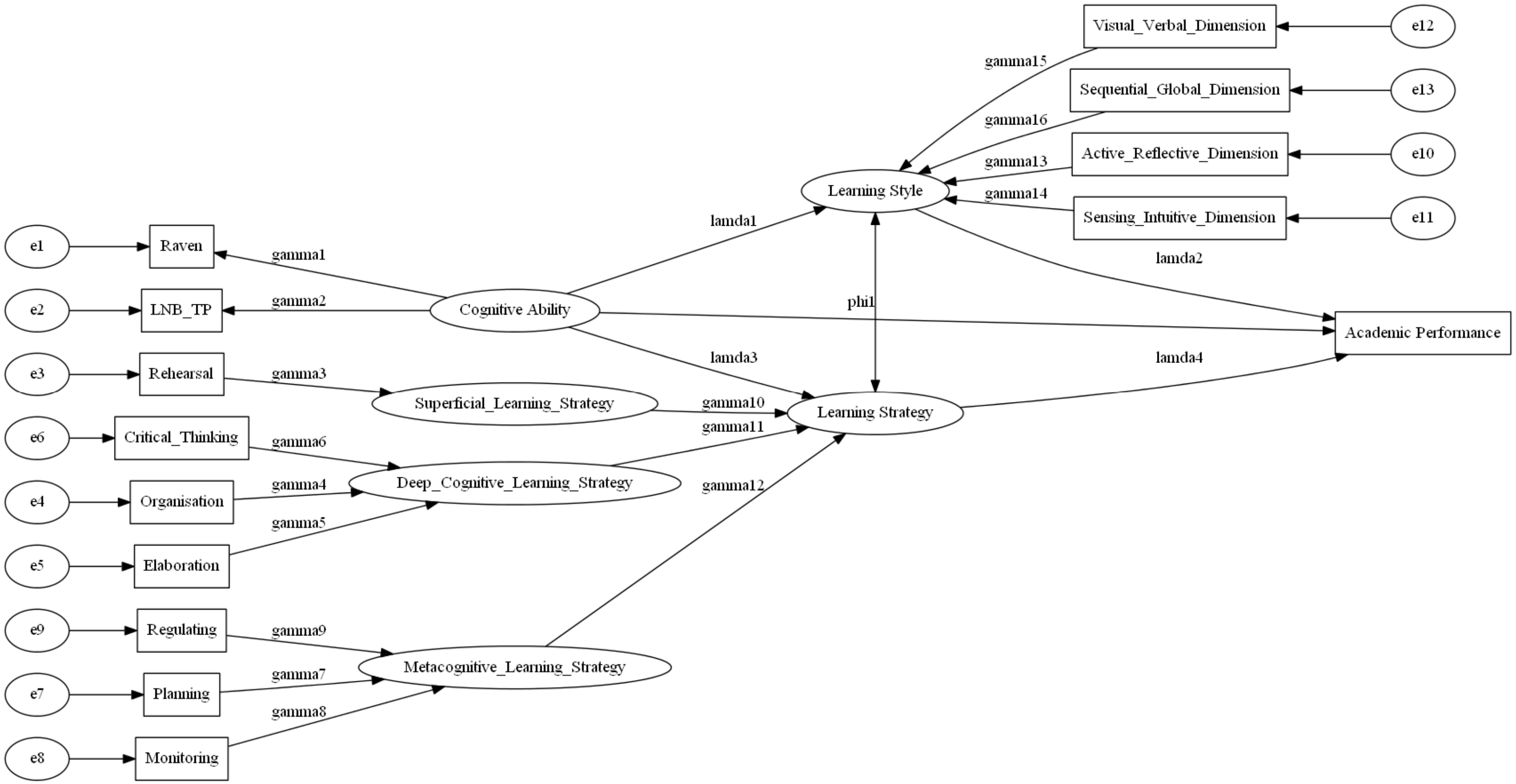
Learning Strategies questions

Strategy	*Subscale*	*Formative Indicators*
Superficial	Rehearsal	I try to memorize everything that might be asked on the exam.
		I memorize lists of important terms and concepts.
		I read my class notes and the course readings over and over again so I will remember them.
Deep cognitive	Organization	I go over my class notes and make an outline of important concepts and ideas.
		I organize the information from all my class notes and the readings into simple charts, diagrams, or tables.
		I write brief summaries of the main ideas and concepts from the readings and the lectures
	Elaboration	I try to make connections between the readings and the concepts from lectures in order to comprehend the course as a whole.
		I try to relate concepts and ideas from this course to those in my other courses whenever possible.
		I try to apply ideas from course readings to other class activities such as lecture and discussion.
	Critical Thinking	I think about possible alternatives whenever I hear an assertion or conclusion in this class.
		I try to decide if there is supporting evidence for conclusions, interpretations, or theories that are presented.
Metacognitive	Planning	I set goals for myself in order to direct my study activities.
		I skim through the chapter to see how it is organized before I read it thoroughly.
	Monitoring	If I become confused about something I read, I go back to my previous notes and sort it out.
		I try to determine which concepts I don't understand well.
	Regulating	I ask myself questions to make sure I understand the material.
		I try to determine the way I study according to the course requirements and the instructor's teaching style.

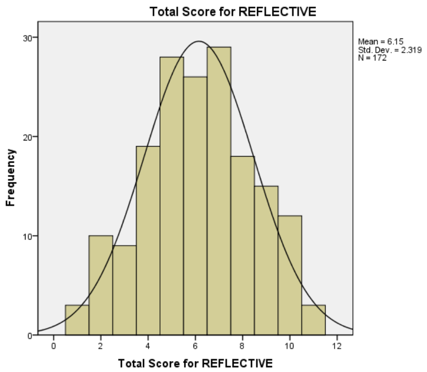
NOTE: All items scored on a 5-point scale ranging from 1 (*never*) to 5 (*always*).

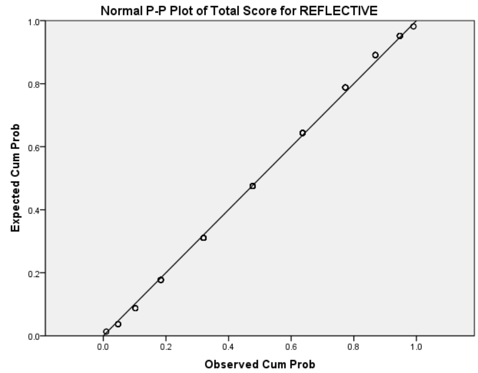
APPENDIX C:
FIGURES, GRAPHS AND TABLES

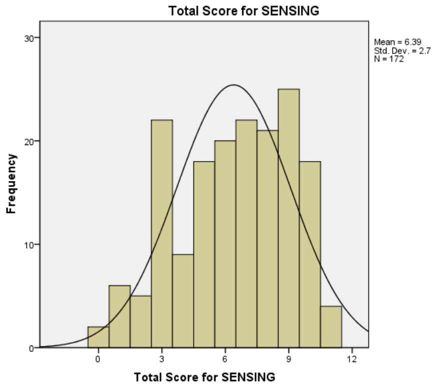
FIGURE 1: Extended hypothesised model

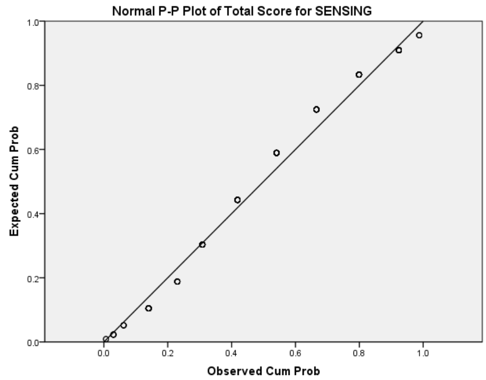


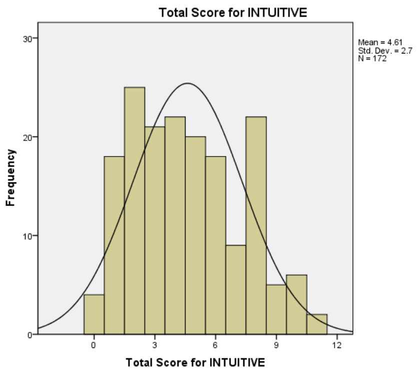
GRAPHS: Normality plots

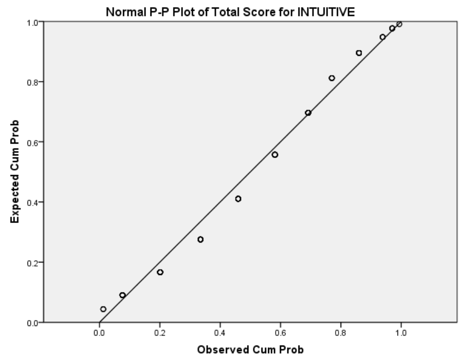


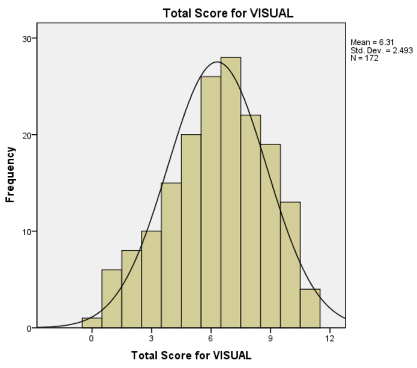


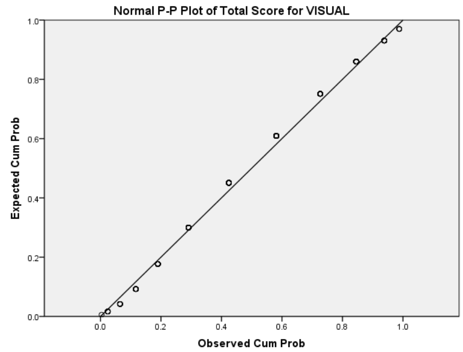


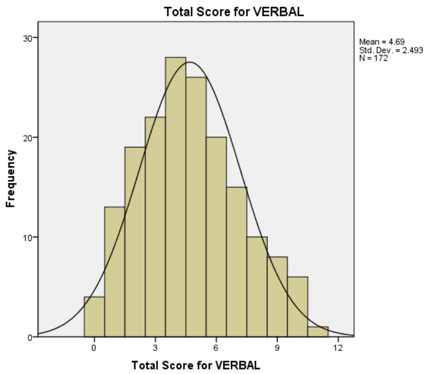


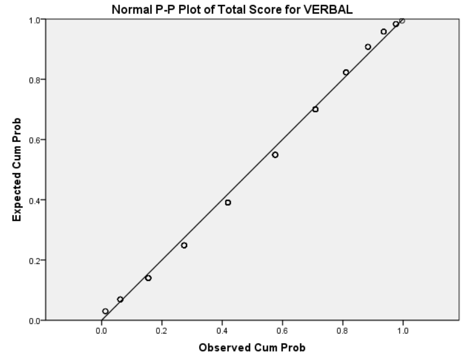


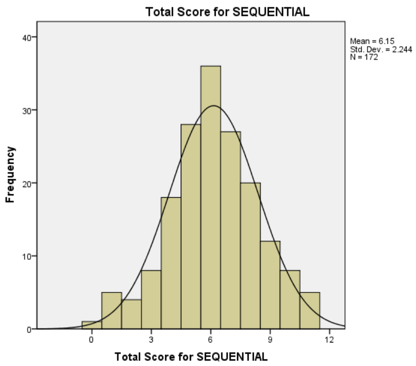


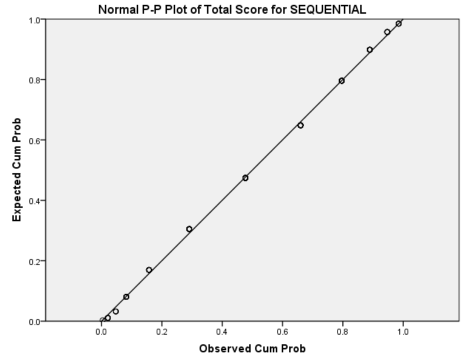


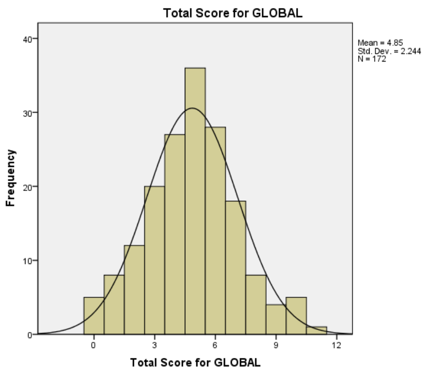


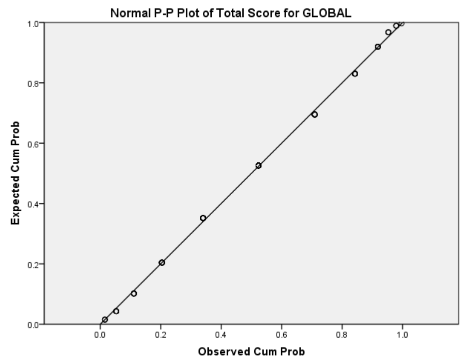

Total Score for VERBAL
Mean = 4.69
Std. Dev. = 2.493
N = 172
Frequency
Total Score for VERBAL

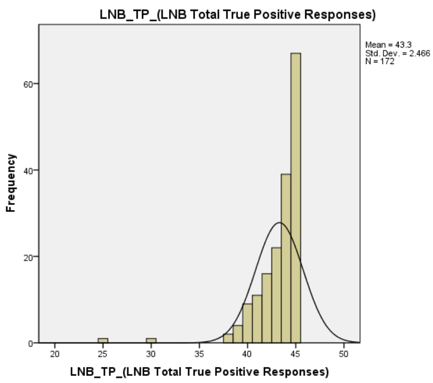

Normal P-P Plot of Total Score for VERBAL
Expected Cum Prob
Observed Cum Prob

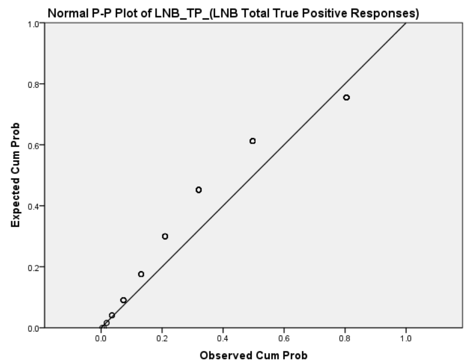

Total Score for SEQUENTIAL
Mean = 6.15
Std. Dev. = 2.244
N = 172
Frequency
Total Score for SEQUENTIAL

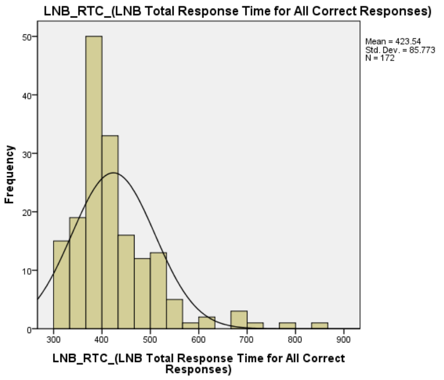

Normal P-P Plot of Total Score for SEQUENTIAL
Expected Cum Prob
Observed Cum Prob

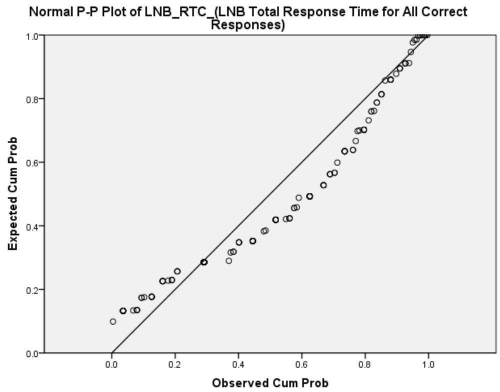

Total Score for GLOBAL
Mean = 4.85
Std. Dev. = 2.244
N = 172
Frequency
Total Score for GLOBAL

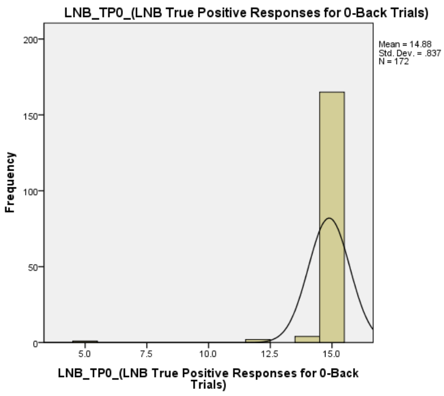

Normal P-P Plot of Total Score for GLOBAL
Expected Cum Prob
Observed Cum Prob

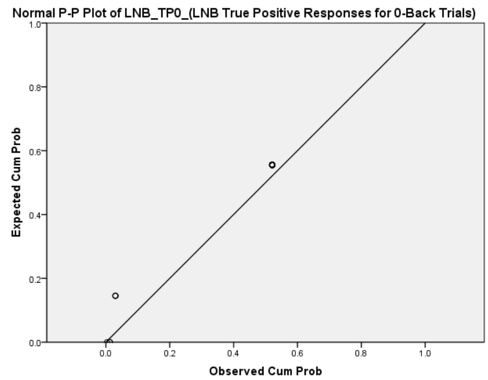

LNB_TP_(LNB Total True Positive Responses)
Mean = 43.3
Std. Dev. = 2.466
N = 172
Frequency
LNB_TP_(LNB Total True Positive Responses)

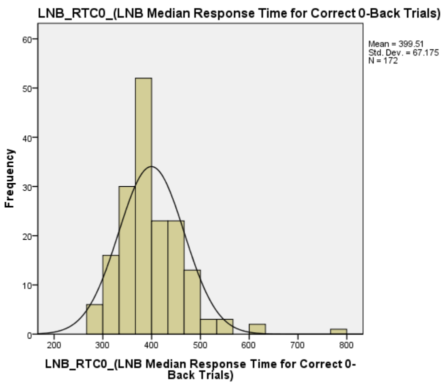

Normal P-P Plot of LNB_TP_(LNB Total True Positive Responses)
Expected Cum Prob
Observed Cum Prob

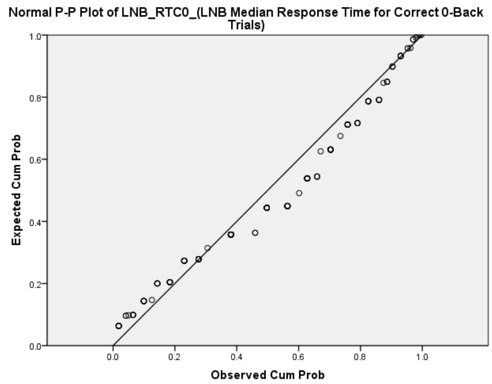

LNB_RTC_(LNB Total Response Time for All Correct Responses)
Mean = 423.54
Std. Dev. = 85.773
N = 172
Frequency
LNB_RTC_(LNB Total Response Time for All Correct Responses)

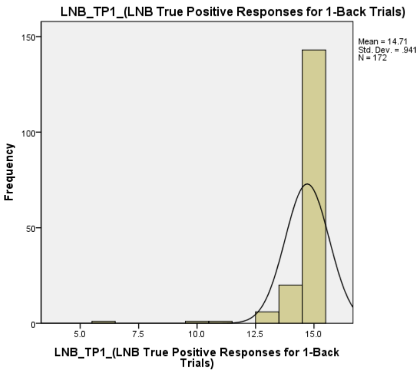

Normal P-P Plot of LNB_RTC_(LNB Total Response Time for All Correct Responses)
Expected Cum Prob
Observed Cum Prob

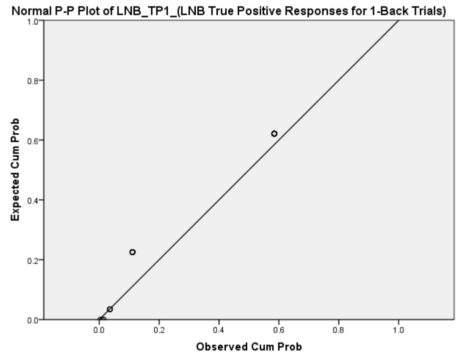

LNB_TP0_(LNB True Positive Responses for 0-Back Trials)
Mean = 14.88
Std. Dev. = .837
N = 172
Frequency
LNB_TP0_(LNB True Positive Responses for 0-Back Trials)

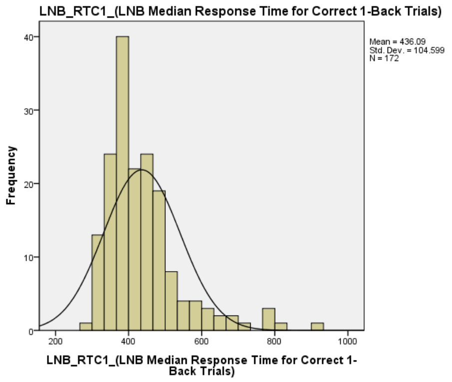

Normal P-P Plot of LNB_TP0_(LNB True Positive Responses for 0-Back Trials)
Expected Cum Prob
Observed Cum Prob

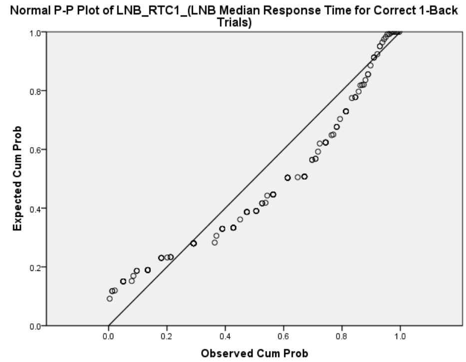

LNB_RTC0_(LNB Median Response Time for Correct 0-Back Trials)
Mean = 399.51
Std. Dev. = 67.175
N = 172
Frequency
LNB_RTC0_(LNB Median Response Time for Correct 0-Back Trials)

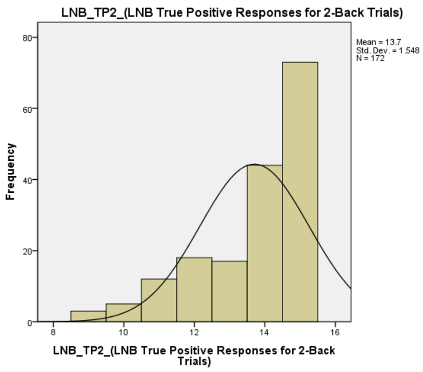

Normal P-P Plot of LNB_RTC0_(LNB Median Response Time for Correct 0-Back Trials)
Expected Cum Prob
Observed Cum Prob

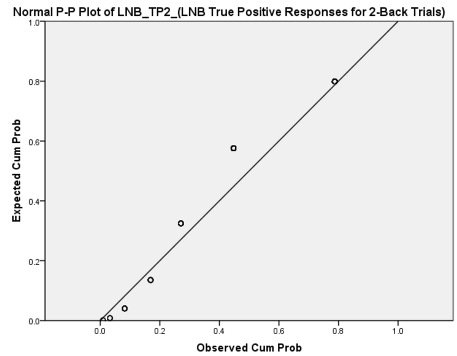

LNB_TP1_(LNB True Positive Responses for 1-Back Trials)
Mean = 14.71
Std. Dev. = .941
N = 172
Frequency
LNB_TP1_(LNB True Positive Responses for 1-Back Trials)

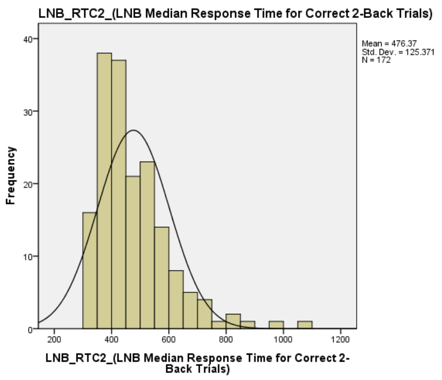

Normal P-P Plot of LNB_TP1_(LNB True Positive Responses for 1-Back Trials)
Expected Cum Prob
Observed Cum Prob

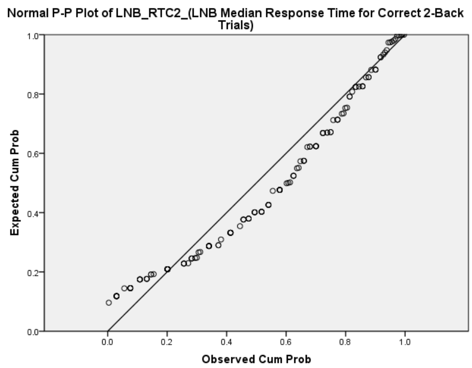

LNB_RTC1_(LNB Median Response Time for Correct 1-Back Trials)
Mean = 436.09
Std. Dev. = 104.599
N = 172
Frequency
LNB_RTC1_(LNB Median Response Time for Correct 1-Back Trials)

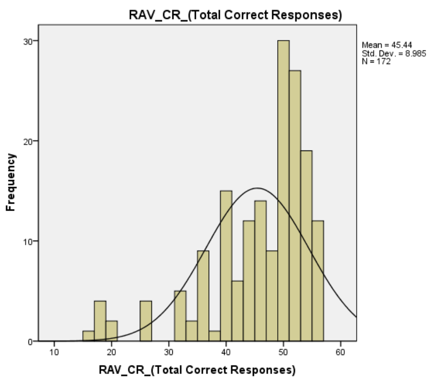

Normal P-P Plot of LNB_RTC1_(LNB Median Response Time for Correct 1-Back Trials)
Expected Cum Prob
Observed Cum Prob

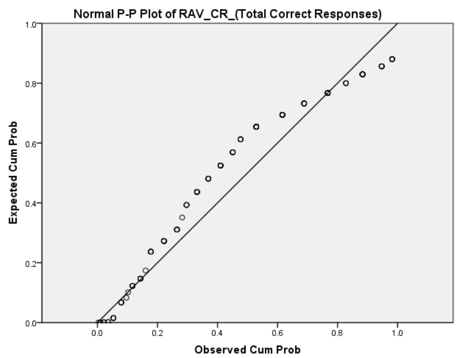

LNB_TP2_(LNB True Positive Responses for 2-Back Trials)
Mean = 13.7
Std. Dev. = 1.548
N = 172
Frequency
LNB_TP2_(LNB True Positive Responses for 2-Back Trials)

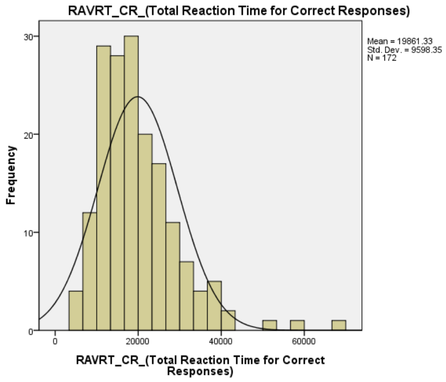

Normal P-P Plot of LNB_TP2_(LNB True Positive Responses for 2-Back Trials)
Expected Cum Prob
Observed Cum Prob

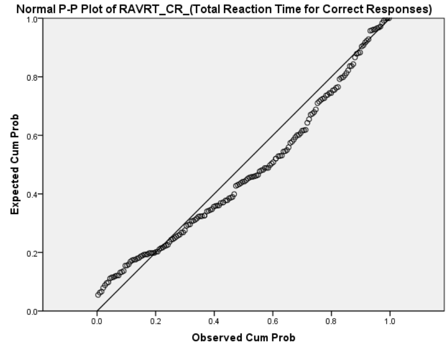

LNB_RTC2_(LNB Median Response Time for Correct 2-Back Trials)
Mean = 476.37
Std. Dev. = 125.371
N = 172
Frequency
LNB_RTC2_(LNB Median Response Time for Correct 2-Back Trials)

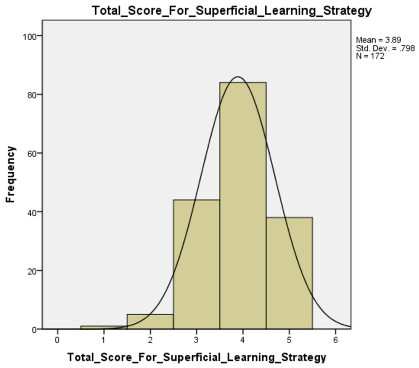

Normal P-P Plot of LNB_RTC2_(LNB Median Response Time for Correct 2-Back Trials)
Expected Cum Prob
Observed Cum Prob

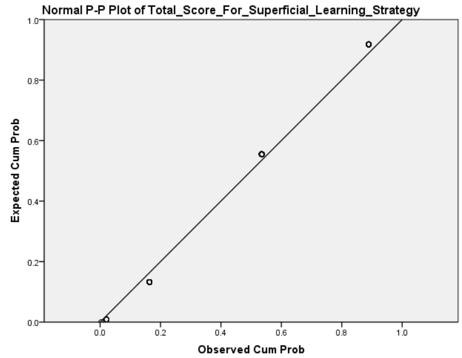

RAV_CR_(Total Correct Responses)
Mean = 45.44
Std. Dev. = 8.985
N = 172
Frequency
RAV_CR_(Total Correct Responses)

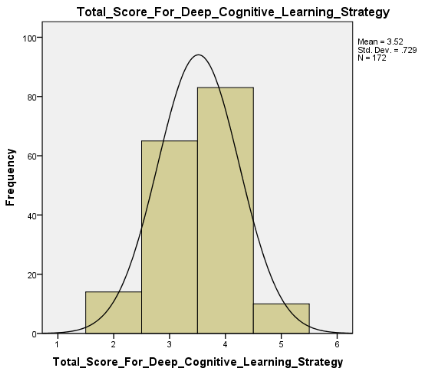

Normal P-P Plot of RAV_CR_(Total Correct Responses)
Expected Cum Prob
Observed Cum Prob

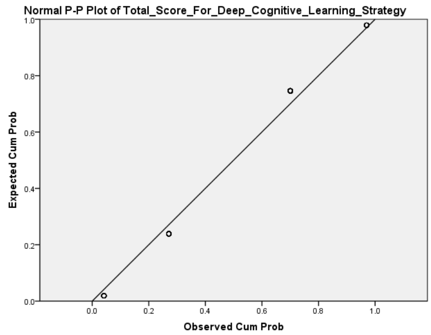

RAVRT_CR_(Total Reaction Time for Correct Responses)
Mean = 19861.33
Std. Dev. = 9598.35
N = 172
Frequency
RAVRT_CR_(Total Reaction Time for Correct Responses)

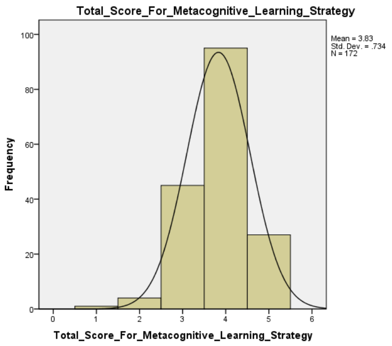

Normal P-P Plot of RAVRT_CR_(Total Reaction Time for Correct Responses)
Expected Cum Prob
Observed Cum Prob

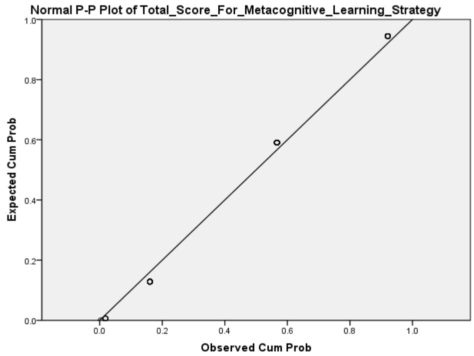

Total_Score_For_Superficial_Learning_Strategy
Mean = 3.89
Std. Dev. = .798
N = 172
Frequency
Total_Score_For_Superficial_Learning_Strategy

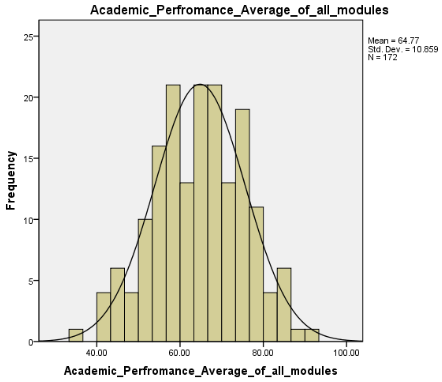

Normal P-P Plot of Total_Score_For_Superficial_Learning_Strategy
Expected Cum Prob
Observed Cum Prob


Total_Score_For_Deep_Cognitive_Learning_Strategy
Mean = 3.52
Std. Dev. = .729
N = 172
Frequency
Total_Score_For_Deep_Cognitive_Learning_Strategy


Normal P-P Plot of Total_Score_For_Deep_Cognitive_Learning_Strategy
Expected Cum Prob
Observed Cum Prob


Total_Score_For_Metacognitive_Learning_Strategy
Mean = 3.83
Std. Dev. = .734
N = 172
Frequency
Total_Score_For_Metacognitive_Learning_Strategy


Normal P-P Plot of Total_Score_For_Metacognitive_Learning_Strategy
Expected Cum Prob
Observed Cum Prob


Academic_Perfromance_Average_of_all_modules
Mean = 64.77
Std. Dev. = 10.859
N = 172
Frequency
Academic_Perfromance_Average_of_all_modules

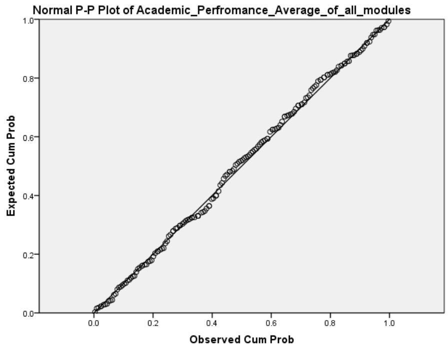

Normal P-P Plot of Academic_Perfromance_Average_of_all_modules
Expected Cum Prob
Observed Cum Prob

TABLE 1: Values of skewness and kurtosis

	Skewness		Kurtosis	
	Statistic	**Std. Error**	**Statistic**	**Std. Error**
Total Score for ACTIVE	0.056	0.185	-0.554	0.368
Total Score for REFLECTIVE	-0.056	0.185	-0.554	0.368
Total Score for SENSING	-0.341	0.185	-0.811	0.368
Total Score for INTUITIVE	0.341	0.185	-0.811	0.368
Total Score for VISUAL	-0.316	0.185	-0.493	0.368
Total Score for VERBAL	0.316	0.185	-0.493	0.368
Total Score for SEQUENTIAL	-0.112	0.185	0.030	0.368
Total Score for GLOBAL	0.112	0.185	0.030	0.368
LNB_TP_(LNB Total True Positive Responses)	-3.644	0.185	21.227	0.368
LNB_RTC_(LNB Total Response Time for All Correct Responses)	1.967	0.185	5.356	0.368
LNB_TP0_(LNB True Positive Responses for 0-Back Trials)	-10.267	0.185	116.696	0.368
LNB_RTC0_(LNB Median Response Time for Correct 0-Back Trials)	1.798	0.185	7.030	0.368
LNB_TP1_(LNB True Positive Responses for 1-Back Trials)	-6.031	0.185	47.064	0.368
LNB_RTC1_(LNB Median Response Time for Correct 1-Back Trials)	1.873	0.185	4.281	0.368
LNB_TP2_(LNB True Positive Responses for 2-Back Trials)	-1.177	0.185	0.544	0.368
LNB_RTC2_(LNB Median Response Time for Correct 2-Back Trials)	1.604	0.185	3.793	0.368
RAV_CR_(Total Correct Responses)	-1.408	0.185	1.815	0.368
RAVRT_CR_(Total Reaction Time for Correct Responses)	1.582	0.185	4.625	0.368
Total_Score_For_Rehersal	-0.427	0.185	0.214	0.368
Total_Score_For_Organisation	-0.040	0.185	-0.394	0.368
Total_Score_For_Elaboration	-0.564	0.185	0.041	0.368
Total_Score_For_Critical_Thinking	-0.617	0.185	0.316	0.368
Total_Score_For_Planning	-0.884	0.185	0.619	0.368
Total_Score_For_Monitoring	-1.006	0.185	0.326	0.368
Total_Score_For_Regulating	-0.537	0.185	-0.064	0.368
Total_Score_For_Superficial_Learning_Strategy	-0.427	0.185	0.214	0.368
Total_Score_For_Deep_Cognitive_Learning_Strategy	-0.244	0.185	-0.233	0.368
Total_Score_For_Metacognitive_Learning_Strategy	-0.443	0.185	0.729	0.368
Academic_Performance_Average_of_all_modules	-0.160	0.189	-0.390	0.376

TABLE 2: Model 1: Full parameter estimates

		β	Std Error	*z*	*p*
1	Total_Score_For_Regulating <--- Learning_strategy	0.560	0.092	6.104	0.000
2	Total_Score_For_Organisation <--- Learning_strategy2	0.284	0.089	3.194	0.001
3	Total_Score_For_Planning <--- Learning_strategy	0.422	0.085	4.989	0.000
4	Total_Score_For_Monitoring <--- Learning_strategy	0.550	0.092	5.943	0.000
5	Total_Score_For_Elaboration <--- Learning_strategy2	0.791	0.088	8.947	0.000
6	Total_Score_For_Critical_Thinking <--- Learning_strategy2	0.698	0.086	8.158	0.000
7	Learning_strategy <--- Learning_strategy2	0.561	0.154	3.651	0.000
8	ILS_IS <--- Learning_style	0.692	0.214	3.231	0.001
9	ILS_GS <--- Learning_style	0.533	0.166	3.206	0.001
10	ILS_RA <--- Learning_style	-0.024	0.102	-0.230	0.818
11	ILS_VV <--- Learning_style	-0.103	0.111	-0.923	0.356
12	RAV_CR_Total_Correct_Responses <--- Cognitive_ability	0.730	0.240	3.045	0.002
13	LNB_TP_Total_True_Positive_Responses <--- Cognitive_ability	0.319	0.127	2.516	0.012
14	Learning_strategy2 <--- Cognitive_ability	0.103	0.130	0.790	0.429
15	Academic_Performance_Average_of_all_modules <--- Learning_style	0.008	0.168	0.046	0.964
16	Academic_Performance_Average_of_all_modules <--- Learning_strategy	-0.025	0.135	-0.182	0.855
17	Academic_Performance_Average_of_all_modules <--- Learning_strategy2	0.098	0.163	0.600	0.549
18	Academic_Performance_Average_of_all_modules <--- Cognitive_ability	0.372	0.142	2.616	0.009
19	Academic_Performance_Average_of_all_modules <--- Total_Score_For_Rehearsal	0.216	0.082	2.628	0.009
20	Cognitive_ability <--- Total_Score_For_Rehearsal	-0.079	0.108	-0.733	0.463
21	Learning_style <--- Cognitive_ability	0.049	0.154	0.321	0.749
22	Learning_strategy <--- Cognitive_ability	0.026	0.157	0.166	0.868
23	Total_Score_For_Rehearsal <--> Total_Score_For_Rehearsal	1.000	0.108	9.245	0.000
24	Total_Score_For_Organisation <--> Total_Score_For_Organisation	0.919	0.103	8.907	0.000
25	Total_Score_For_Elaboration <--> Total_Score_For_Elaboration	0.368	0.106	3.479	0.001
26	Total_Score_For_Critical_Thinking <--> Total_Score_For_Critical_Thinking	0.507	0.094	5.403	0.000
27	Total_Score_For_Planning <--> Total_Score_For_Planning	0.765	0.099	7.702	0.000

TABLE 2: Continued

		β	Std Error	*z*	*p*
28	Total_Score_For_Monitoring <--> Total_Score_For_Monitoring	0.601	0.110	5.447	0.000
29	Total_Score_For_Regulating <--> Total_Score_For_Regulating	0.586	0.112	5.253	0.000
30	ILS_RA <--> ILS_RA	0.999	0.108	9.241	0.000
31	ILS_IS <--> ILS_IS	0.520	0.285	1.823	0.068
32	ILS_VV <--> ILS_VV	0.989	0.108	9.134	0.000
33	ILS_GS <--> ILS_GS	0.715	0.180	3.963	0.000
34	RAV_CR_Total_Correct_Responses <--> RAV_CR_Total_Correct_Responses	0.463	0.343	1.352	0.177
35	LNB_TP_Total_True_Positive_Responses <--> LNB_TP_Total_True_Positive_Responses	0.898	0.117	7.652	0.000
36	Academic_Performance_Average_of_all_modules <--> Academic_Performance_Average_of_all_modules	0.813	0.124	6.574	0.000
37	Learning_strategy <--> Learning_style	0.391	0.150	2.609	0.009
38	Learning_strategy2 <--> Learning_style	-0.342	0.132	-2.599	0.009

TABLE 3: Model 2: Full parameter estimates

		β	Std Error	*z*	*p*
1	Total_Score_For_Regulating <--- Learning_strategy_meta	0.577	0.075	7.668	0.000
2	Total_Score_For_Organisation <--- Learning_strategy_meta	0.456	0.072	6.300	0.000
3	Total_Score_For_Planning <--- Learning_strategy_meta	0.396	0.072	5.474	0.000
4	Total_Score_For_Monitoring <--- Learning_strategy_meta	0.482	0.073	6.641	0.000
5	Total_Score_For_Elaboration <--- Learning_strategy_deep	0.799	0.093	8.626	0.000
6	Total_Score_For_Critical_Thinking <--- Learning_strategy_deep	0.717	0.089	8.029	0.000
7	Learning_strategy_meta <--- Learning_strategy_deep	0.483	0.134	3.600	0.000
8	ILS_IS <--- Learning_style_1	0.686	0.141	4.860	0.000
9	ILS_GS <--- Learning_style_1	0.536	0.120	4.469	0.000
10	ILS_RA <--- Learning_style_2	0.276	0.168	1.648	0.099
11	ILS_VV <--- Learning_style_2	0.946	0.526	1.798	0.072
12	RAV_CR_Total_Correct_Responses <--- Cognitive_ability	0.923	0.370	2.495	0.013
13	LNB_TP_Total_True_Positive_Responses <--- Cognitive_ability	0.25	0.124	2.011	0.044
14	Learning_strategy_deep <--- Cognitive_ability	0.081	0.102	0.796	0.426
15	Academic_Performance_Average_of_all_modules <--- Learning_strategy_deep	0.06	0.133	0.473	0.636
16	Academic_Performance_Average_of_all_modules <--- Cognitive_ability	0.312	0.154	2.022	0.043
17	Learning_strategy_meta <--- Cognitive_ability	0.066	0.113	0.586	0.558
18	Academic_Performance_Average_of_all_modules <--- Learning_strategy_meta	0	0.105	0.021	0.983
19	Learning_style_2 <--- Cognitive_ability	0.094	0.108	0.873	0.383
20	Academic_Performance_Average_of_all_modules <--- Learning_style_2	-0.13	0.112	-1.127	0.260
21	Learning_style_1 <--- Cognitive_ability	0.06	0.113	0.528	0.597
22	Academic_Performance_Average_of_all_modules <--- Learning_style_1	-0.02	0.124	-0.194	0.846

TABLE 3: Continued

		β	Std Error	*z*	*p*
23	Academic_Performance_Average_of_all_modules <--- Total_Score_For_Rehearsal	0.201	0.090	2.239	0.025
24	Learning_strategy_meta <--- Total_Score_For_Rehearsal	0.452	0.109	4.147	0.000
25	Learning_strategy_deep <--- Total_Score_For_Rehearsal	0.106	0.086	1.239	0.215
26	Total_Score_For_Rehearsal <--> Total_Score_For_Rehearsal	1.000	0.108	9.247	0.000
27	Total_Score_For_Organisation <--> Total_Score_For_Organisation	0.686	0.089	7.671	0.000
28	Total_Score_For_Elaboration <--> Total_Score_For_Elaboration	0.362	0.116	3.107	0.002
29	Total_Score_For_Critical_Thinking <--> Total_Score_For_Critical_Thinking	0.486	0.103	4.729	0.000
30	Total_Score_For_Planning <--> Total_Score_For_Planning	0.763	0.093	8.194	0.000
31	Total_Score_For_Monitoring <--> Total_Score_For_Monitoring	0.649	0.088	7.374	0.000
32	Total_Score_For_Regulating <--> Total_Score_For_Regulating	0.497	0.086	5.752	0.000
33	ILS_RA <--> ILS_RA	0.923	0.131	7.059	0.000
34	ILS_IS <--> ILS_IS	0.528	0.180	2.936	0.003
35	ILS_VV <--> ILS_VV	0.097	0.990	0.098	0.922
36	ILS_GS <--> ILS_GS	0.712	0.130	5.487	0.000
37	RAV_CR_Total_Correct_Responses <--> RAV_CR_Total_Correct_Responses	0.147	0.675	0.218	0.827
38	LNB_TP_Total_True_Positive_Responses <--> LNB_TP_Total_True_Positive_Responses	0.937	0.113	8.305	0.000
39	Academic_Performance_Average_of_all_modules <--> Academic_Performance_Average_of_all_modules	0.849	0.122	6.981	0.000
40	Learning_strategy_meta <--> Learning_style_1	0.245	0.129	1.897	0.058
41	Learning_strategy_deep <--> Learning_style_1	-0.418	0.112	-3.739	0.000
42	Learning_strategy_meta <--> Learning_style_2	-0.128	0.124	-1.026	0.305
43	Learning_strategy_deep <--> Learning_style_2	-0.163	0.126	-1.300	0.194
44	Cognitive_ability <--> Total_Score_For_Rehearsal	-0.079	0.088	-0.900	0.368

TABLE 4: Model 3: Full parameter estimates

		β	Std Error	*z*	*p*
	Total_Score_For_Regulating <--- Learning_strategy_meta	0.575	0.075	7.652	0.000
2	Total_Score_For_Organisation <--- Learning_strategy_meta	0.457	0.072	6.332	0.000
3	Total_Score_For_Planning <--- Learning_strategy_meta	0.397	0.072	5.507	0.000
4	Total_Score_For_Monitoring <--- Learning_strategy_meta	0.480	0.072	6.634	0.000
5	Total_Score_For_Elaboration <--- Learning_strategy_deep	0.801	0.096	8.378	0.000
6	Total_Score_For_Critical_Thinking <--- Learning_strategy_deep	0.687	0.089	7.692	0.000
7	Learning_strategy_meta <--- Learning_strategy_deep	0.467	0.135	3.449	0.001
8	ILS_IS <--- Learning_style_1	0.559	0.121	4.638	0.000
9	ILS_GS <--- Learning_style_1	0.631	0.132	4.793	0.000
10	ILS_RA <--- Learning_style_2	0.174	0.320	0.545	0.586
11	ILS_VV <--- Learning_style_2	1.504	2.720	0.553	0.580
12	RAV_CR_Total_Correct_Responses <--- Cognitive_ability	0.417	0.123	3.392	0.001
13	LNB_TP_Total_True_Positive_Responses <--- Cognitive_ability	0.282	0.111	2.530	0.011
14	Learning_strategy_deep <--- Cognitive_ability	0.195	0.195	1.401	0.161
15	Academic_Performance_Average_of_all_modules <--- Cognitive_ability	0.610	0.610	3.975	0.000
16	Learning_strategy_meta <--- Cognitive_ability	0.094	0.094	0.598	0.550
17	Learning_style_2 <--- Cognitive_ability	-0.082	- 0.082	-0.483	0.629
18	Learning_style_1 <--- Cognitive_ability	0.212	0.212	1.342	0.180
19	Learning_strategy_meta <--- Total_Score_For_Rehearsal	0.436	0.111	3.938	0.000
20	Learning_strategy_deep <--- Total_Score_For_Rehearsal	0.070	0.091	0.775	0.439
21	Total_Score_For_Rehearsal <--> Total_Score_For_Rehearsal	1.000	0.108	9.247	0.000
22	Total_Score_For_Organisation <--> Total_Score_For_Organisation	0.683	0.089	7.651	0.000
23	Total_Score_For_Elaboration <--> Total_Score_For_Elaboration	0.332	0.123	2.695	0.007
24	Total_Score_For_Critical_Thinking <--> Total_Score_For_Critical_Thinking	0.509	0.103	4.952	0.000
25	Total_Score_For_Planning <--> Total_Score_For_Planning	0.761	0.093	8.181	0.000
26	Total_Score_For_Monitoring <--> Total_Score_For_Monitoring	0.651	0.088	7.387	0.000

TABLE 4: Continued

		β	Std Error	*z*	*p*
	Total_Score_For_Regulating <--> Total_Score_For_Regulating	0.500	0.086	5.790	0.000
28	ILS_RA <--> ILS_RA	0.969	0.152	6.386	0.000
29	ILS_IS <--> ILS_IS	0.673	0.136	4.958	0.000
30	ILS_VV <--> ILS_VV	-1.276	8.180	-0.156	0.876
31	ILS_GS <--> ILS_GS	0.583	0.159	3.664	0.000
32	RAV_CR_Total_Correct_Responses <--> RAV_CR_Total_Correct_Responses	0.826	0.122	6.794	0.000
33	LNB_TP_Total_True_Positive_Responses <--> LNB_TP_Total_True_Positive_Responses	0.921	0.110	8.383	0.000
34	Academic_Performance_Average_of_all_modules <--> Academic_Performance_Average_of_all_modules	0.627	0.181	3.474	0.001
35	Learning_strategy_meta <--> Learning_style_1	0.217	0.136	1.598	0.110
36	Learning_strategy_deep <--> Learning_style_1	-0.435	0.119	-3.671	0.000
37	Learning_strategy_meta <--> Learning_style_2	-0.080	0.164	-0.490	0.624
38	Learning_strategy_deep <--> Learning_style_2	-0.076	0.154	-0.495	0.620
	Cognitive_ability <--> Total_Score_For_Rehearsal	0.188	0.111	1.699	0.089

TABLE 5: Model 4: Full parameter estimates

		β	Std Error	*z*	*p*
1	Total_Score_For_Regulating <--- Learning_strategy_meta	0.574	0.075	7.622	0.000
2	Total_Score_For_Organisation <--- Learning_strategy_meta	0.459	0.073	6.320	0.000
3	Total_Score_For_Planning <--- Learning_strategy_meta	0.397	0.072	5.483	0.000
4	Total_Score_For_Monitoring <--- Learning_strategy_meta	0.483	0.073	6.641	0.000
5	Total_Score_For_Elaboration <--- Learning_strategy_deep	0.785	0.092	8.529	0.000
6	Total_Score_For_Critical_Thinking <--- Learning_strategy_deep	0.719	0.089	8.069	0.000
7	Learning_strategy_meta <--- Learning_strategy_deep	0.471	0.135	3.500	0.000
8	ILS_IS <--- Learning_style_1	0.663	0.135	4.908	0.000
9	ILS_GS <--- Learning_style_1	0.555	0.120	4.610	0.000
10	ILS_RA <--- Learning_style_2	0.082	0.725	0.113	0.910
11	ILS_VV <--- Learning_style_2	3.219	28.353	0.114	0.910
12	RAV_CR_Total_Correct_Responses <--- Cognitive_ability	0.719	0.193	3.735	0.000
13	LNB_TP_Total_True_Positive_Responses <--- Cognitive_ability	0.321	0.113	2.841	0.004
14	Learning_strategy_deep <--- Cognitive_ability	0.151	0.123	1.228	0.219
15	Academic_Performance_Average_of_all_modules <--- Cognitive_ability	0.390	0.125	3.111	0.002
16	Learning_strategy_meta <--- Cognitive_ability	0.081	0.137	0.589	0.556
17	Learning_style_2 <--- Cognitive_ability	0.009	0.087	0.105	0.916
18	Learning_style_1 <--- Cognitive_ability	0.050	0.136	0.366	0.714
19	Academic_Performance_Average_of_all_modules <--- Total_Score_For_Rehearsal	0.225	0.076	2.943	0.003
20	Learning_strategy_meta <--- Total_Score_For_Rehearsal	0.454	0.110	4.129	0.000
21	Learning_strategy_deep <--- Total_Score_For_Rehearsal	0.115	0.087	1.315	0.188
22	Total_Score_For_Rehearsal <--> Total_Score_For_Rehearsal	1.000	0.108	9.247	0.000
23	Total_Score_For_Organisation <--> Total_Score_For_Organisation	0.683	0.089	7.640	0.000
24	Total_Score_For_Elaboration <--> Total_Score_For_Elaboration	0.374	0.114	3.273	0.001
25	Total_Score_For_Critical_Thinking <--> Total_Score_For_Critical_Thinking	0.476	0.103	4.607	0.000
26	Total_Score_For_Planning <--> Total_Score_For_Planning	0.762	0.093	8.180	0.000
27	Total_Score_For_Monitoring <--> Total_Score_For_Monitoring	0.648	0.088	7.355	0.000

TABLE 5: Continued

		β	Std Error	*z*	*p*
28	Total_Score_For_Regulating <--> Total_Score_For_Regulating	0.503	0.086	5.824	0.000
29	ILS_RA <--> ILS_RA	0.993	0.160	6.218	0.000
30	ILS_IS <--> ILS_IS	0.560	0.166	3.363	0.001
31	ILS_VV <--> ILS_VV	-9.364	182.549	-0.051	0.959
32	ILS_GS <--> ILS_GS	0.691	0.132	5.229	0.000
33	RAV_CR_Total_Correct_Responses <--> RAV_CR_Total_Correct_Responses	0.483	0.265	1.819	0.069
34	LNB_TP_Total_True_Positive_Responses <--> LNB_TP_Total_True_Positive_Responses	0.897	0.111	8.061	0.000
35	Academic_Performance_Average_of_all_modules <--> Academic_Performance_Average_of_all_modules	0.814	0.118	6.901	0.000
36	Learning_strategy_meta <--> Learning_style_1	0.245	0.130	1.885	0.059
37	Learning_strategy_deep <--> Learning_style_1	-0.436	0.112	-3.882	0.000
38	Learning_strategy_meta <--> Learning_style_2	-0.038	0.344	-0.112	0.911
39	Learning_strategy_deep <--> Learning_style_2	-0.047	0.417	-0.112	0.911
40	Cognitive_ability <--> Total_Score_For_Rehearsal	-0.096	0.105	-0.912	0.362