

https://dspace.org/

Can working memory work for university students? the relationship between working memory and academic success.

Paton, Tristan

2012-03-15
http://hdl.handle.net/10539/11436

Downloaded from a DSpace repository. https://dspace.org/

CAN WORKING MEMORY WORK FOR UNIVERSITY STUDENTS? THE RELATIONSHIP BETWEEN WORKING MEMORY AND ACADEMIC SUCCESS

Tristan Paton (0609510G)

A Research Report submitted to the Faculty of Humanities, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Masters of Education in Educational Psychology by Coursework and Research Report.

Johannesburg, November 2010

Declaration

I hereby declare that this research report is my own independent work, has not been presented for any other degree at any other academic institution, or published in any form.

It is submitted in partial fulfilment of the requirements for the degree of Masters of Education in Educational Psychology by Coursework and Research Report at the University of the Witwatersrand, Johannesburg.

Tristan Paton
(0609510G)

November 2010

Acknowledgements

In relation to the following study, the following people are thanked for their invaluable contributions.

To Professor Kate Cockcroft, my supervisor and mentor, thank you so much for taking the time and having the patience to help me produce this body of research. Your knowledge truly is astounding and your interest in Cognition, ever curious nature and great sense of humour have made the process of conducting this research with you as fun as it has been interesting. Thank you so much!

To my brothers Randall and Dylan, thank you for your ongoing support and excellent camaraderie over the years. Without either of you I would not have gotten this far in my studies, and life. Takk!

To my family – Gran, Dad, Chris and Lizzy – thank you for putting up with me over the years and helping me to get to this point.

To all my friends (especially Mandy) thank you for helping me to stay sane this year. Thanks to Juliana, Claire and Cara for your academic support in the M. Ed group.

To Nicky, Jarrod, Mike, Gill M. and Enid, thank you for your wealth of statistical knowledge, consultations and general advice.

To the great staff and students of the University of the Witwatersrand, thank you for being there for me over the last 5 years, my time with you has been great.

This material is based upon work supported by the National Research Foundation (NRF). Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and therefore the NRF does not accept any liability in regard thereto.

Abstract

This study examined performance on the Memory Quotient Tester (MQT) and the Raven's Advanced Progressive Matrices (RAPM) in relation to academic performance in a sample of 51 Psychology students. The relationship between working memory (MQT), non-verbal intelligence (RAPM), demographic factors and academic success were determined. Results indicated no significant relationship between working memory and academic success in undergraduate Psychology courses, whereas the first set of the RAPM revealed some significance in relation to both academic success and the variables of race and language. This indicates the possible role of eductive reasoning in tertiary level academic success.

Keywords: Working memory; non-verbal intelligence; university performance; race; language

Table of Contents

Cover Page 1

Declaration 2

Acknowledgements 3

Abstract 4

Table of Contents 5

Lists of Tables and Figures 7

Chapter 1: Introduction and Literature Review 8

Introduction 8

Working Memory Discussion 9

Non-Verbal Intelligence Discussion 20

Tertiary Level Academic Success 25

Conclusion 27

Chapter 2: Method 28

Introduction 28

Research Design 28

Sample 29

Instruments 30

Demographic Questionnaire 30

Ravens Advanced Progressive Matrices (RAPM) 30

The Memory Quotient Tester Online Working Memory Test (MQT) 32

Procedure 33

Data analysis 35

Threats to Validity 35

Chapter 3: Results 36

Introduction 36

Discussion of Sample characteristics 37

Discussion of Sample divisions 37

Discussion of Distribution 38

Discussion of Parametric Assumptions 39
Discussion of Instrument Reliability 40
Research Question 1 41
Research Question 2 41
Research Question 3 43
Research Question 4 44
Research Question 5 46
Conclusion 49

Chapter 4: Discussion 50
Introduction 50
Working Memory and Academic Performance 50
Non-verbal intelligence and Academic Performance 53
Race and Language results 53
Academic success results 55
Working Memory and Non-Verbal Intelligence 55
Gender Differences 55
Limitations of the current study 56
Directions for future research 57
Conclusion 58

Reference List 59

Appendices
APPENDIX A: STUDENT'S INFORMATION LETTER 67
APPENDIX B: CONSENT FORM 68
APPENDIX C: DEMOGRAPHIC QUESTIONNAIRE 69
APPENDIX D: ETHICS APPLICATION 73
APPENDIX E: ETHICAL CLEARANCE CERTIFICATE 79

List of Tables and Figures

Tables

Table 1: Descripitve Statistics for Dichotomised Variables 36

Table 2: Distribution Statistics for Analysis Variables 39

Table 3: Kolmogorov-Smirnov tests for normality on the variables of the study 40

Table 4: Cronbach's Alphas for Raven's Set I, Raven's Set II and Raven's Total Score 40

Table 5: Correlation Matrix for Main Variables in the study 42

Table 6: Differences in Working Memory performance between three groups of students 43

Table 7: Differences in Working Memory Variables between three mark groups, group analyses in pairs 44

Table 8: Kruskal-Wallis results for the differences in Raven's Scores between three mark groups 44

Table 9.1: Differences in Raven's Advanced Progressive Matrices Variables between three mark groups, group analyses in pairs 45

Table 9.2: Differences in Raven's Advanced Progressive Matrices Variables between three mark groups, group analyses in pairs as per a 2 sample *t*-test 45

Table 10.1: Wilcoxon Two Sample test comparisons for the Ethnic groups 46

Table 10.2: Two sample *t*-test results for the Ethnic groups 46

Table 11.1: Wilcoxon Two Sample test comparisons for the English first and second language groups 47

Table 11.2: Two sample *t*-test results for the English first and second language groups 47

Table 12.1: Wilcoxon Two Sample test comparisons for the Average and Below Average and the Above Average Other perception of neighbourhood socioeconomic status groups. 48

Table 12.2:2 sample *t*-test results for the Average and Below Average and the Above Average Other perception of neighbourhood socioeconomic status groups. 48

Table 13.1: Wilcoxon Two Sample test comparisons for gender groups 49

Table 13.2:2 sample *t*-test results for gender groups 49

Figures

Figure 1: Baddeley (2000) Model of working memory 10

Chapter 1: Introduction and Literature Review

Introduction

Throughput rates in tertiary education in South Africa are in need of improvement. Despite higher registration rates at tertiary institutions, throughput rates have decreased in recent years and the viability of degrees are being questioned (Council on Higher Education, 2010). An investigation of the relationships between working memory, non-verbal intelligence and tertiary level academic success offers a possible means of identifying factors that will predict academic success at university level, as well as providing a means to improve the throughput rate at universities. In recent years, a vast body of research and literature regarding the role of working memory in early education has emerged providing promising insight into the role that this cognitive process plays in various scholastic skills, such as the acquisition of reading (Swanson & O Connor, 2009) and mathematics skills (Alloway, Banner & Smith, 2010). Working memory has shown great predictive value in the scholastic success of young children (Gathercole, Brown & Pickering, 2003) and has also been found to be free of the effects of socioeconomic status (Engel, Santos & Gathercole, 2008). These studies focused on the links between working memory and primary school academic success. Thus, working memory was investigated in the current study as a possible factor in tertiary level academic success. Non-verbal intelligence is also a widely researched construct despite the wide range of cognitive skills this construct encompasses. Research into non-verbal intelligence has shown gender (Rushton & Skuy, 2000) and racial differences (Rushton, Skuy & Fridjhon, 2003). Measures of non-verbal intelligence are also arguably seen as being culturally unfair (Owen, 1992). While both of these constructs have been studied extensively, the majority of published studies have focused on children and theories developed thus relate to this population group. Both of these constructs have also yielded inconsistent results and thus need further research in order to understand these variables more completely. In relation to education, cognitive abilities are not the only determinants of scholastic success and it is ever more apparent that in South Africa, access to educational resources, as well as the demographic differences between learners are some of the factors that affect the success of students in tertiary institutions (CHE, 2010). Thus, the current study aimed to investigate working memory, non-verbal intelligence and academic success,

in an attempt to provide an understanding of some of the cognitive factors needed for tertiary level academic success.

Since working memory and non-verbal intelligence are key variables in this investigation, the theoretical backgrounds and relevant research for both will be explained. The literature review will also consider issues pertinent to tertiary education in the South African context.

The following discussion commences with a critical evaluation of recent research as well as theory to fully explain the construct of working memory, its links to education and its use in cognitive testing.

Working Memory Discussion

By definition, working memory is the "the temporary storage system under attentional control that underpins… complex thought" (Baddeley, 2007, p.1). Hitch and de Ribaupierre (1994) add that the information that is temporarily stored is also processed by all cognitive tasks. From this definition one can see that information is held in one's memory temporarily (thus, in one's short term memory store) and that this is processed or manipulated while it is in the short term memory store. This represents the Baddeley and Hitch Model (1974) of working memory, although other models of working memory exist (e.g. Anderson, Reder & Lebiere, 1996; Ericsson & Kintsch, 1995), the current study used the Baddeley and Hitch (1974) (as cited in Baddeley, 2007) model as its theoretical foundation as it is supported by a substantial body of research (e.g. Baddeley *et al*., 1975, as cited in Baddeley, 2007; Engel *et al*., 2008; Fougnie & Marois, 2007; Robbins *et al*., 1996, as cited in Baddeley, 2007)

This definition, while encompassing what working memory is, is a great simplification of the various parts that make up working memory. A visual representation of the various parts of working memory is provided in Figure 1. It is also important to note that working memory is not synonymous with short term memory. The latter refers to the retention of information over a period of seconds to minutes (Gazzaniga, Ivry & Mangun, 2009). This

may then seem quite similar to working memory, however where the two differ is that working memory is short term memory with the added roles of the cognitive tasks that help to process and manipulate the information being remembered in the short term memory (Gazzaniga *et al*., 2009).

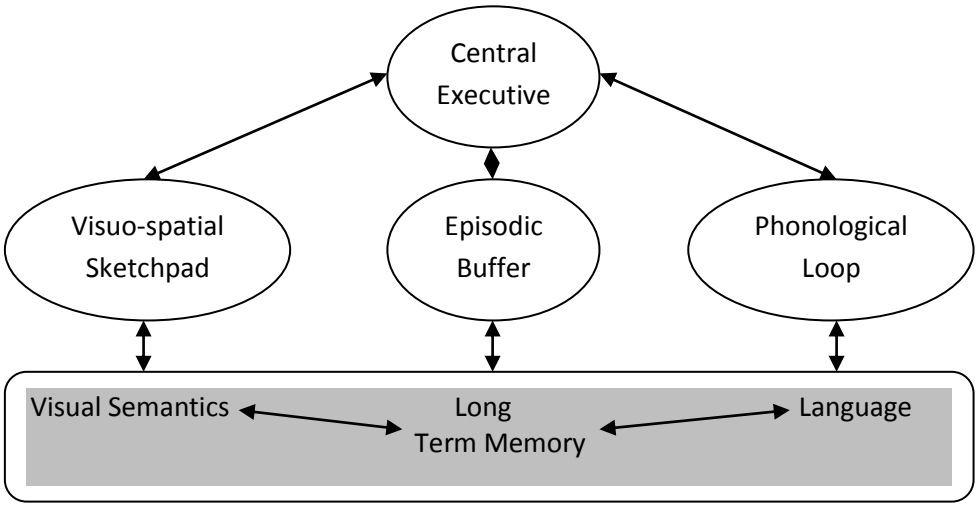

Figure 1. Baddeley (2000) Model of working memory

(Baddeley, A. (2003). Working Memory: Looking back and looking forward. *Nature Reviews. Neuroscience, 4.* 829).

As can be seen from Figure 1, working memory consists of four main parts – the central executive, the visuo-spatial sketchpad, the episodic buffer and the phonological loop (Baddeley, 2003). The original model of working memory conceptualised by Baddeley and Hitch (1974) (as cited in Baddeley, 2007) included the central executive, the phonological loop and the visuo-spatial sketchpad. The episodic buffer was added later by Baddeley (2000). A brief explanation of each of the components of working memory is provided below.

Baddeley (1986), describes the central executive as the component of working memory that selects the strategies and integrates the information necessary to complete the working memory tasks at hand. Thus, from this description it can be seen that the central executive is indeed central, but not a memory system per se. Rather, it would appear that the central executive is perhaps more of an attentional system that selectively deploys

the other working memory components. This then makes the central executive an over-arching system that manages what is commonly referred to as the three slave systems (Baddeley, 1986). The central executive has been significantly less studied than the other aspects of working memory. However, there is research evidence for the existence of the central executive. For instance, the central executive has been implicated as playing a possible role in inattention blindness (Fougnie & Marois, 2007). In the latter study, it was found that, by increasing the demand on working memory at a central executive level, there was a commensurate increase in inattention blindness to task-irrelevant stimuli. This study demonstrates that, when tasks require increased attentional resources, the central executive is required to mediate the use of the different slave systems, and this increased load has secondary effects on attention as a whole. However, the central executive may not be the sole possible cause for the increased inattention blindness in this study as it is possible that the inattention blindness is specific to a particular modality (i.e. visual or auditory) and the increased load on either the visuo-spatial or phonological working memory systems could have caused this inattention blindness. Based on these findings, Fougnie and Marois (2007) suggest that executive functioning is an over-arching attentional system that not only mediates the functioning of the three working memory slave systems but also has a role in attention as a whole.

This overarching nature of the central executive is not to be understated, nor is the role that it plays in attention. The role of working memory in attention has in the past been proposed (Cowan, 2005) and this role can be divided into the ability to focus, divide and switch attention (Baddeley, 2007). The ability to focus attention and maintain focus is arguably the most important feature of working memory as the information held in temporary storage has to be processed before being forgotten. Research into the attentional control in complex tasks has revealed that the attentional control capacity is limited and that by disrupting the functioning of the central executive, attention to a task is impaired. One such an example revealed that when highly skilled chess players had to generate random sequences of numbers (which research has proven to be a very demanding task), while playing chess, their chess playing abilities became impaired (Robbins *et al*., 1996, as cited in Baddeley, 2007). What this study revealed is that when the load on attention is too great, two complex tasks cannot be performed simultaneously. In relation

to the attentional load limitations is the ability that the central executive has to divide attention resources. This ability has been studied by investigating the abilities of Alzheimer's patients to perform tasks alone and simultaneously (Baddeley *et al*., 1991, as cited in Baddeley, 2007). The tasks that the subjects in the study were required to perform were the tracking of a cursor on a computer screen and the recitation of random number sets. What the results of these studies showed is that the Alzheimer's patients showed little deterioration when performing single tasks, even as their disease progressed. Their ability to perform multiple tasks simultaneously deteriorated as their disease progressed and it has been theorised that this relates to dual task co-ordination which is a specific function of the central executive, and can be seen as one's ability to perform multiple tasks through shifting and maintaining focus on the multiple aspects of the various tasks (Baddeley *et al*., 1991, as cited in Baddeley, 2007). The shifting of attention also forms an important aspect of central executive functioning. In the dual task studies it was important that the subjects focus on one task sufficiently to perform it while shifting their additional attention to focus on the other task so as to perform that too. Other studies, such as one in which subjects had to alternatively add or subtract 1 from a list of numbers while simultaneously reciting items from familiar sets (such as the days of the week), revealed that the attentional aspect of this task implied again a limited attentional capacity, as well as the fact that switching of tasks placed a great load on the executive processes of working memory (Baddeley *et al*., 2001 as cited in Baddeley, 2007). Added to this is the fact that, during these studies, it was found that the central executive had a role in shifting attentional away from irrelevant stimuli, with this role representing another aspect of focused attention which would enable the central executive to use its limited attentional load most efficiently and inhibit incorrect responses to the tasks. What the above arguments indicate is that the central executive plays a vital role in attention, as well as in the utilisation of the slave systems.

Of the slave systems, the visuo-spatial sketchpad is the component of working memory that retains information that, as the name implies, is visual in nature. Thus, the information to be processed here would be the locations of objects, as well as their spatial orientation (Baddeley, 1998). The visuo-spatial sketchpad consists of the inner scribe and the visual cache. Some researchers (e.g. Logie, 1995) argue that the visual and spatial aspects of working memory represent different cognitive functions. The visual aspect,

retains information regarding static visual images in the visual cache. This is simply a mental representation of a previously seen visual image that is held in temporary storage. The spatial aspect of working memory retains the information pertaining to movement and movement sequences in the inner scribe (Logie, 1995). Evidence for this distinction between visual and spatial abilities comes from observations of sufferers of a condition called Optic Ataxia. These patients have lesions in the left and right posterior parietal cortex and present with normal visual acuity and normal perception of visual space, as well as unimpaired motor abilities. However, they show an inability to use visual perception to guide movement accurately and thus display behaviours such as over-extending their arms while reaching for objects. This indicates an accurate visual cache but an inaccurate inner scribe, or simply put, accurate visual information without proper spatial action (Logie, 1995). Thus, the visuo-spatial slave system of working memory relies on mental representations and knowledge of movements in order to remember visually presented information.

The second slave system, the phonological loop, is the component of working memory that is involved in the remembering and processing of auditory material. This component consists of two subcomponents, namely the phonological store and the articulatory rehearsal process (Baddeley, 1998). A practical example of the phonological loop in practice would be the remembering of a telephone number that is unfamiliar. Here the telephone number would be stored in the phonological store while being maintained by the articulatory rehearsal process, which would be the subvocalisation of the telephone number until such time as it could be dialled or written down. The phonological store is the short term acoustic store for sound inputs that would exceed sensory memory whereas the articulatory rehearsal process uses subvocalisations in order to remember seen or heard material over the term (Gazzaniga *et al*., 2009). Research has provided evidence for the existence of the phonological loop. For example, in one study participants were asked to remember strings of letters and repeat them at a later stage. An analysis of the incorrect responses showed that these responses tended to sound similar to the correct letter (i.e. “T” and “G”), rather than looking similar to the correct letter (i.e. “Q” and “G”) (Gazzaniga *et al*., 2009). This can be inferred to be because of the fact that a verbal strategy is used that would cause the incorrect responses to be based on phonics rather than visual appearance (although other strategies could technically have been used). Additional evidence for the

phonological loop comes from studies investigating the word length effect, articulatory suppression and the phonological similarity effect. The studies relating to the word length effect have tested subjects' abilities to remember lists of words, while gradually increasing the length of the words to be remembered. What such studies have shown is that the longer the words to be remembered are, the fewer subjects are able to remember (e.g. Baddeley *et al*., 1975, as cited in Baddeley, 2007). Similarly, words with the same number of syllables, but that are longer sounding, tend to show a similar pattern with fewer longer sounding words being remembered. Baddeley (2007) hypothesised that this is due to the fact that the longer words would take longer to subvocalise and thus decay would occur in the words to be remembered. This then provides evidence for the articulatory rehearsal process (as the longer words and longer sounding words would take longer to rehearse and thus would not be maintained sufficiently to prevent decay), as well as for the phonological store (as longer words would require greater memory reserves to be stored). Articulatory suppression studies also provide evidence for the role of articulatory rehearsal in working memory. In order to suppress articulatory rehearsal, subjects are given lists of consonants to remember, while also uttering the word "the". Similar to the word length effect studies, it was found that by impairing the subvocal rehearsal process, the ability to recall was impaired (Baddeley, 1986, as cited in Baddeley, 2007). The phonological similarity effect, is the finding that recall is impaired when items to be recalled sound similar (such as a sequence of similar sounding consonants – e.g. C, G, T, D etc) or that errors in recall occur when a word to be recalled is replaced by a similar sounding word (Henson, Norris, Page & Baddeley, 1996). Thus, similar to the visuo-spatial sketchpad, it appears that the phonological loop is comprised of two distinct systems, with these being supported by research evidence.

The episodic buffer is believed to be the link between long term memory and the central executive. This system theoretically combines visual, phonological and spatial information to form a cohesive whole (Baddeley, 2000). Important to note in relation to the episodic buffer, is that its role is essentially one of binding, as it integrates information to forms episodes or chunks (Baddeley, 2007). A theoretical example of this could be the abovementioned example of remembering a telephone number. Here, the phonological loop would not be the only working memory component being utilised as parts of the

information (such as the area code) may actually be part of existing long term memory knowledge. The central executive would use the episodic buffer to access information in long term stores (such as knowledge of area codes) while using the phonological loop and/or the visuo-spatial sketchpad to remember the other digits in the number. The telephone number would then form a chunk of information based on the processes outlined above and would thus be recalled as such, rather than as individual digits. What this example shows is how the various components of working memory operate in conjunction with one another, suggesting that it would be difficult to study the various components individually. Research into the episodic buffer has largely focused on the abovementioned binding that the episodic buffer is said to perform. For instance, a study by Wheeler and Treisman (2002, as cited in Baddeley, 2007) indicated that when subjects were given shapes to recall, performance was impaired when both a shape and a colour were required to be remembered. This was argued to be due to the effect of the increased attentional demand and provided evidence against the existence of the episodic buffer. However, a follow up study was conducted in which subjects were shown either four shapes, four colour patches or four coloured shapes and then were shown a single item and asked whether this item had been one of the four that they recently seen (Allen, Baddeley and Hitch, 2006). What this study showed is that the detection of the correct coloured shapes was as good as the detection of colours or shapes independently. This is evidence for the binding role of the episodic buffer. To test the attentional assertion put forward by Wheeler and Treisman (as cited in Baddeley, 2007), Allen *et al*. (2006) required the participants to count backwards in threes while completing the abovementioned task. Although this did impair the performance on the task, that impairment was no greater for the bound image that combined shape and colour than it was for the task requiring identification of shape or colour single features. This provides some evidence for the existence of the episodic buffer.

The next section provides a critical examination of relevant research into working memory and its role in academic performance. A critical stance was maintained when reviewing the literature as the validity of some of the results are questionable for reasons such as the conclusions being based on anecdotal evidence using samples as small as three university students and six chimpanzees that were tested for their visuo-spatial working memory abilities (Cook & Wilson, 2010). The review of the literature revealed that a great

body of varied research on working memory exists. The literature review here focused on that research which highlights the role of working memory in academic success, learning and cognitive testing as this is relevant to the current study. Factors such as the impact of socioeconomic status on working memory were also examined.

In terms of academic success, considerable research has linked working memory to many aspects of learning such as reading disabilities (Swanson, Kehler & Jerman, 2010), sentence comprehension (Lopez-Higes, Valdehita, Aragoneses & Del Rio, 2010) and reading comprehension (Swanson & O Connor, 2009). As is evident from these examples, many of the investigations into working memory and academic success centre around reading. What has been found in these studies, which were based on primary school aged children, is that working memory performance can significantly impact on children's reading acquisition and later reading abilities. These studies concluded that reading and arithmetic development are linked to the development of working memory skills. These studies compared typically developing seven to thirteen year old children to those with attentional, arithmetic, or reading difficulties (Siegel & Ryan, 1989; Swanson & Siegel, 2001). What these studies postulate is that the phonological loop would be the site of the reading differences found in children as this aspect of working memory is essential in the remembering of speech-based information. A study using a sample of 966 individuals between the ages of 6 and 49 years old similarly found that deficits in working memory are characteristic of individuals with reading disabilities. This study concluded however that this was due to problems with inhibition of irrelevant information and thus the working memory deficits were at an executive level rather than at a phonological loop level (Chiappe, Hasher & Siegel, 2000). From this research and many other studies, it can be seen that there are multiple links between working memory and reading (e.g. Aarnoudse-Moens, Smidts, Oosterlaan, Duivenvoorden & Weisglas-Kuperus, 2009; Berninger, Abbott, Swanson & Lovitt, 2010; Chiappe *et al*., 2000; Siegel & Ryan, 1989; Swanson *et al*., 2010 & Swanson & O Connor, 2009).

Such links are important to a discussion of working memory and academic success, since reading is a critical aspect in children's academic success. Improving children's reading abilities results in simultaneous improvements in their academic performance (Lockwood, McCombs & Marsh, 2010). Since reading is a vital route to learning and knowledge

acquisition, if reading is in any way compromised by working memory deficits, then it can be argued that academic performance could also be compromised. What is however problematic with the reviewed literature on the links between working memory and reading abilities is the fact that most of the research has been conducted on young samples who were learning to read (e.g. Aarnoudse-Moens *et al*., 2009; Berninger *et al*., 2010; Swanson *et al*., 2010; Swanson & O Connor, 2009). Thus, it would appear that there is a gap in the literature in terms of studies that focus on the links between working memory and academic success in early adulthood. Thus, the current study aims to add to the existing body of working memory research by including a population that has not been extensively researched.

In relation to academic skills and success, studies investigating working memory in relation to performance in reading and mathematics have found that working memory is a better predictor of academic success than a person's IQ (Alloway, 2009). Thus, it can be tentatively inferred that working memory appears to be a cognitive ability that overarches many scholastic abilities and at the same time a useful tool in assessment, as will be mentioned. Decreased working memory abilities tend to impair learner's abilities to follow simple classroom instructions as well as their ability to attend to and cope with more complex classroom activities that would involve the storage and processing of material. This was demonstrated in a study of 80 children between the ages of nine and ten years old who were all administered the Working Memory Rating Scale and then tested with standardised tests of literacy and numeracy. The results showed that the children with poorer working memory scores performed worse than the group of children with normal working memory scores (Alloway, Gathercole & Elliott, 2010). Thus, working memory deficits do not only relate to cognitive and/or scholastic abilities, but rather that they also relate to classroom behaviours that would enable effective learning in a classroom setting. It is clear from this that the role of working memory in learning is far more extensive than just the effect that it has on reading, and thus it can be argued that studies looking at working memory in relation to academic success as a whole would perhaps be more valid as they would be able to consider all of the effects that working memory would have in relation to learning. Further evidence for the role that working memory plays in academic success is the fact that it has

been found to accurately predict academic success, as determined by literacy attainment, for a period of three years (Gathercole *et al*., 2003).

Further research linking working memory to academic success has revealed that the effect of working memory is mediated by factors such as cognitive style. Cognitive styles are modes of perceiving, remembering and thinking that differ between individuals (Halpern, 1986). An example of a cognitive style would be hypothesising as this method (in which a hypothetical outcome to a behaviour) would reflect an individual's mode of thinking. In a study by Alloway *et al*. (2010), the role of working memory, cognitive style and academic success was investigated in a sample of 13 year olds. What was found in the study is that the in participants with high working memory scores, cognitive styles did not matter and these students achieved greater academic success regardless of which cognitive style they used. However, in participants with low working memory scores it was found that cognitive styles became important in determining academic success, and in particular the combination of low working memory and analytic thinking style predicted the poorest academic achievement. Thus, the cognitive styles appeared to be compensatory mechanisms for poor working memory (Alloway *et al*., 2010).

Studies of learning disabled children also reveal a link between working memory and academic success (McNamara & Wong, 2003). This study explored 60, 10 to 12 year old children's abilities to recall academic and everyday information. What was found is that the learning disabled students (20 students in the sample) had poorer recall of both academic and everyday information when compared to the non-learning disabled students, as well as the fact that the learning disabled students performed poorly academically when compared to the non-learning disabled group. The poorer recall of academic information appears to be related to the poor academic performance, but the study could not conclusively link this to working memory problems. However, this information is valuable in understanding the role of working memory in academic success.

Another factor that must also be considered in relation to working memory research and academic success is whether the academic success measured in the studies is an accurate reflection of the participants' potential. Many of the published studies focus on specific cognitive skills (such as reading comprehension) and thus only looked at those

particular aspects in isolation so as to remove the effects of any extraneous variables (e.g. Swanson & O Connor, 2009). Thus, these studies aimed to investigate one aspect by manipulating the conditions under which that aspect was investigated so as to understand the role that working memory has in relation to that aspect. From a research perspective this is good practice as this makes the research experimental and means that the studies can control the variables of interest reasonably well (Shipman, 1995). However, this could potentially make those studies ecologically invalid or not applicable to a real world setting. Although there are obviously many benefits to studying a variable in isolation, that variable is unlikely to exist in isolation in a real world setting. Thus, by exploring students' university results in relation to their working memory abilities in the present study, ecological validity is enhanced. However, the applicability to a larger context is limited by the fact that only Psychology students were used in the current study.

Working memory is also a cognitive process that underlies many other cognitive functions, and as such it would be an important component of standardised measures of IQ. This is evident in the fact that in recent revisions of Wechsler Intelligence tests working memory now is an index (Kaufman & Lichtenberger, 1999). As a cognitive process, working memory is also seen as an inherent skill rather than a form of taught knowledge and in terms of learning, working memory would aid learning but would itself not be learnt (Baddeley, 2007).

To broaden the scope of discussion, the relationship between socioeconomic status (SES) and working memory is considered. Research suggests that working memory is free of the effects of socioeconomic status (Engel *et al*., 2008). The Engel *et al*. (2008) study was conducted in Brazil with 40 children from differing SES backgrounds. The study assessed each child's socioeconomic status (as per parental occupation), working memory and verbal (receptive and expressive) skills. The children from the lower SES groups had significantly lower receptive and expressive language scores than the higher SES children and yet no significant difference was found in the working memory scores between the SES groups. Only the phonological loop and central executive assessed in this study. In relation to the current study, the findings of the Engel *et al*. (2008) study are relevant because socioeconomically South Africa and Brazil share similarities as both countries have a high

range of socioeconomic standards. Thus, despite the contextual differences between the two studies, the findings of the Brazilian study may give insight into the current study.

Thus, to conclude the discussion on working memory, it is evident that working memory is a necessary ability to study in relation to academic success. However, the factors that potentially relate to and affect working memory also need to be considered. The effects that working memory has on other cognitive processes would similarly add understanding to the roles that it could play in academic success.

Non-Verbal Intelligence Discussion

Having discussed working memory and its implications, another aspect of cognitive functioning will be explained, namely that of general intelligence or "g". Non-verbal general intelligence would logically be linked to tertiary level academic success. It is also important to note that general intelligence is linked to working memory (Williams, Myerson & Hale, 2008). The discussion on general intelligence will begin with its definition and explanation and will then follow on to a critical discussion of the recent and relevant research on general intelligence and academic success.

The concept of general intelligence emerged from the observation by Spearman that if an individual was to perform well on one cognitive task, they were likely to perform well on other cognitive tasks too (Williams *et al*., 2008). The commonality in performances across cognitive tasks is what Spearman (1904) described as being the general intelligence factor. Spearman's model, although theoretical, was conceptualised through factor analytic methods that resulted in the identification of a common factor ("g") underlying performance in a range of cognitive tasks that in turn helped to develop the theory of general intelligence (Jensen, 2005).

It is difficult to describe exactly what general intelligence is due to the varied nature of measurable cognitive abilities which correlate significantly with general intelligence (Jensen, 2005). Due to the fact that general intelligence is comprised of so many cognitive skills it is difficult to give a unitary description or definition of general intelligence. Thus, in the current study, the conceptualisation of general intelligence that forms the basis of the

Raven's Advanced Progressive Matrices (RAPM) will be used to describe general intelligence (Raven, 1994), and will from this point be referred to as non-verbal intelligence. The reason for this decision is due to the RAPM being a widely used instrument to measure non-verbal intelligence that is also agreed to be one of the best measures of non-verbal intelligence (Lohman, 2005). The RAPM has also been used extensively with South African populations (e.g. Rushton & Skuy, 2000; Rushton *et al*., 2003). For this reason, it was selected for use in the current study.

Non-verbal intelligence consists of two related abilities, eductive reasoning and reproductive intelligence, both of which are assessed in the RAPM (Raven, 1994). Eductive or induction reasoning, is widely seen as the ability to use abstract rules of thinking, make comparisons and draw analogies (Necka & Orzechowski, 2005). This aspect of non-verbal intelligence has been widely studied as many researchers have tried to unlock the cognitive processes that underlie induction (Carroll, 1976; Hunt, 1980; Sternberg, 1977). The results of these studies indicate that induction is difficult to isolate as a set of abilities, or a single ability due to the fact that the divide between thinking (which is seen as a fluid cognitive process) and intelligence (which is seen as a solid, crystallised structure that represents an ability or set of abilities) makes such an endeavour practically impossible (Necka & Orzechowski, 2005). Thus, in much the same way in which non-verbal intelligence as a whole proved to be difficult to coherently define, induction too seems to be difficult to isolate as a definable entity. In this study, the definition of induction was based on the conceptualisation used as the basis of the RAPM. Raven (1994) explains induction as the ability to identify patterns through making comparisons and noticing changes in the visual matrices of the RAPM. Induction, in relation to the RAPM, is the ability to *learn* and understand the pattern of the matrices, and from that select the correct option (out of the eight options given) that will complete the matrix. The debate regarding the nature of this ability is that some studies speculate an underlying genetic ability (Lubinski, 2009) and others suggest the involvement of fluid cognitive processes such as working memory (Williams *et al*., 2008). In support of the argument that working memory forms a basis for non-verbal intelligence, working memory load and not passive short term memory is a good predictor of general fluid intelligence (Conway, Cowan, Bunting, Therriault & Minkoff, 2002).

Research into the role of inductive reasoning in academic success has revealed that training in inductive reasoning, followed by a standard school lesson increased the effect size of the learning during the lesson and the increase in learning was greater than when the lesson was preceded by intelligence testing training (Klauer & Phye, 2008). The inductive training gave the participants in the study the problem-solving and reasoning abilities used in induction, which they were able to transfer to the learning of academic subject matter. The above study used a sample of school children between the ages of five and 16 years old which are younger than the sample in the current study. Despite this the age range is wide and a large sample of 3600 American participants was used and the study gives an indication that the induction can assist with learning, and that induction as a skill can be taught, by focusing on specific principles such as drawing inferences (Klauer & Phye, 2008).

Related to the conceptualisation of induction as learning is reproductive reasoning. The latter concept appears to be much more coherent than induction as it is the ability that allows the application of previously learnt knowledge to other examples and across a wide range of cognitive tasks (Raven, 2004). Thus, this ability is the process of taking knowledge learnt from induction and applying it to examples that are governed by the same principles.

When reviewing the research into the induction and reproductive reasoning aspects of non-verbal intelligence, the results have been shown to be varied and in some cases inconsistent. An area of great inconsistency in non-verbal intelligence research is that of the differences that exist between population groups. For instance, in relation to race, several studies have found differences in non-verbal intelligence between racial groups in South Africa that would indicate that the RAPM is culturally biased and thus not appropriate for use within the South African context (e.g. Owen, 1992). The reason that race is an important variable is that in the South African context race is still linked to social, economic and educational disadvantage (Robbins, 2001). However, the abovementioned study used the Raven's Standard Progressive Matrices which is the intermediate version of the instrument, and not the instrument used in the current study. There are a number of factors that need to be considered critically in relation to the Owen (1992) study and the current study. For instance, the fact that the Raven's Standard Progressive Matrices was deemed culturally unfair does not then mean that the RAPM, which is the measure of non-verbal intelligence used in the current study, has the same flaws. Furthermore, the sample of the Owen (1992)

study was younger than the sample in the current study and thus the effect of cognitive maturation and the development of higher cognitive functions would have to be considered as it has been found that working memory, for example, develops continually throughout the teenage years and only reaches its highest point in the mid thirties (Alloway & Alloway, 2010). Another important contextual factor that would need to be considered is the fact that the Owen study, conducted in 1992, could potentially have in some way been affected by the Apartheid education system that persisted until 1994 (Robbins, 2001).

More recent studies using the RAPM as the measure of non-verbal intelligence also found differences between racial groups in the South Africa (Rushton & Skuy, 2000; Rushton *et al*., 2003), these pointed to years of disadvantage and deprivation in the African samples as reasons for these differences. These studies used the RAPM and the samples were also students from an urban university in Gauteng, following closely the demographic and methodological characteristics of the current study. With these studies education may potentially have been an issue as some of the students would have been educated in a disadvantaged Apartheid era system (Robbins, 2001). Yet another factor to be considered is that differing racial or ethnic groups can have different home languages (Harrison, 1990). This variable is important as it forms one of the key variables in the current study. Literature predicts poorer academic performance for learners who do not speak the language used as the medium of instruction as their first language (Reid, 1990; Valdes, 1990). Similarly, regardless of the second language learner's proficiency in the language of instruction at schools or universities, language carries cultural messages and thus the culture mismatch may then also negatively impact that second language learners education and cognitive development as a result (Holly, 1990). As this argument demonstrates, there are many factors that could account for the racial differences found in the three abovementioned studies. It is important that the context in which the participants were raised and other issues, such as language differences, be fully considered in order to fully understand the nature of the differences between the subjects.

In terms of demographic factors, gender is also important in the current study because of existing research indicating sex differences in RAPM performance. However, in terms of performance on the RAPM, the gender divide is inconsistent. For instance, some studies found gender differences (e.g. Abad, Colom, Rebollo & Escorial, 2004; Lynn, 2002; Rushton

& Skuy, 2000) whereas other studies into non-verbal intelligence as assessed by the RAPM have found no gender differences (e.g. Israel, 2006; Rushton *et al*., 2003). One possible explanation for the inconsistency is that fact that differences of the Raven's Matrices have been found to favour females until roughly the age of 12 where this difference ceases. Thus, at this point there tends to be no difference in Raven's scores until the age of 17 years where the Raven's matrices tend to favour males (Lynn, Allik & Irwing, 2004). These differences may reflect differing cognitive maturation rates between males and females (Lynn *et al*., 2004). Another hypothesis that could explain the gender difference is the differing visuo-spatial abilities that would be necessary to perform well in the various Raven's matrices (Halpern, 1986). What has been found in this regard is that adult males tend to have superior visuo-spatial abilities than adult females and this could then be a possible factor in the gender differences found in non-verbal intelligence (Halpern, 1986). Thus, the difference in performance on the Raven's matrices could be due to a difference in cognitive skills between the genders. Moving away from the argument that underlying cognitive skills account for gender differences, self-fulfilling prophecies, developmental issues, sex-related brain differences and sex-linked social practices could also account for the differences in performance on the RAPM (Halpern, 1986). However, a lengthy discussion of these factors in gender differences would only serve to reiterate the point that there are many factors that contribute to these differences and thus the issue at hand is both a complex and multifaceted one.

Yet another issue regarding research into non-verbal intelligence is the issue of ecological validity. As mentioned earlier, ecological validity refers to the validity of findings in a real world setting (Raab & Gigerenzer, 2005). In relation to non-verbal intelligence this issue would appear to be pertinent as the above review of the literature has indicated that non-verbal intelligence underlies performance on many cognitive tests (Necka & Orzechowski, 2005). Thus, the construct validity of non-verbal intelligence for many of these studies can be said to be quite poor if two studies that are both claiming to be testing ecological validity are in fact measuring two distinct and separate cognitive functions. As to what these cognitive functions are it is speculated that working memory may form the basis of what is currently conceptualised as being non-verbal intelligence. For example, when considering the gender differences found on the RAPM it was mentioned that this

difference could be attributed to differences in visuo-spatial abilities. Thus, it may be that working memory and non-verbal intelligence share a common factor or that working memory forms part of what is conceptualised as being non-verbal intelligence. This notion is interesting and these variables have been studied comparatively in order to explain individual differences in cognitive performance (Williams *et al*., 2008). Adding to the complexity of non-verbal intelligence is the fact that other cognitive skills form aspects of non-verbal intelligence. For example, processing speed, another cognitive construct, is speculated to be important to non-verbal intelligence (Jensen, 1998).

To conclude the discussion on non-verbal intelligence, it is evident that the notion of non-verbal intelligence is not yet a solitary one, but rather that there multiple views that are based on a large and varied body of research. Thus, further research into non-verbal intelligence will possibly clarify the conceptualisation of the construct by exploring what it has in common with other cognitive abilities, in the case of the current study, working memory.

Tertiary Level Academic Success

Having discussed working memory and non-verbal intelligence, academic success at university will be discussed as it is this variable to which the others are related in the current study. In order to place the current research in context, the state of tertiary education in South Africa will be discussed. The Council on Higher Education's (CHE) March 2010 report will be used as the basis for the discussion as it not only focuses on tertiary education, but it is also the most recent document of its type (CHE, 2010).

At present, the enrolment of students in tertiary education level has shown a great increase in terms of numbers, racial ratios and gender ratios. For example, the current number of tertiary enrolments in South Africa stands at 761 000 students which shows a significant gain from the 425 000 that were enrolled in 2007 (CHE, 2010). In 2007, 67% of enrolled students were African which has also increased considerably from the 43% of enrolled African students in 1998. This improvement can be said to be substantial, but perhaps not yet sufficient when considering that the African population constitutes roughly

80% of the population of South Africa (Rushton & Skuy, 2000). Women are also entering tertiary education at a rate that makes their presence in tertiary education more representative of the population as a whole (CHE, 2010). This shift in the demographic composition of tertiary education institutions, as well as the increased number of enrolled students, can be seen as improvements in terms of access to the tertiary education system in South Africa.

However, there are also many problems with the South African tertiary education system. Despite the increased enrolments, the rates of failures and deregistrations are problematic and seen as a major problem facing South African universities (CHE, 2008). The tertiary education statistics indicate that the current system shows patterns similar to those found in apartheid times with students from particular racial and socioeconomic backgrounds finishing their degrees timeously and with good results while others do not (CHE, 2010). In 2003, a crude estimation of the ratio of enrolments to graduations at the university at which the current study was conducted showed that for every five students that enrolled, only one would graduate (CHE, 2010).

Related to the poor graduation rates (relative to the enrolment rates) is the fact that postgraduate graduations have decreased in recent years (CHE,2009). Even if students are to graduate and fulfil their academic requirements, another issue is the quality of the degree which they are receiving and the satisfaction of the employers once they enter into a particular field of work (CHE,2010).

Thus, from the above discussion and statistics it is evident that although improvements have been made in terms of giving students access to tertiary education, there are clearly many factors that prevent students that enrol from graduating. Regardless of the students that do not graduate, those who do graduate with undergraduate degrees may not then pursue postgraduate degrees or may not succeed in obtaining postgraduate degrees should they pursue them (CHE,2010).

To address these issues, the CHE has outlined potential obstacles that could be hindrances to the throughput rates and these include a lack of preparedness for tertiary education, lack of resources in terms of books and electronic media, lack of financial resources, and the fact that many students have to work while studying in order to finance

their studies (CHE, 2010). These, according to the CHE, could cause dropouts and/or failures, but could also cause time taken to complete the degree to be longer than necessary or could impact on the quality of the students degree should they obtain it (CHE, 2010). As a whole it would appear that further investigation is needed in order to correct for the problems mentioned above. Consequently, the current study aimed to investigate working memory and non-verbal intelligence so as to understand the roles that these cognitive constructs may play in tertiary level academic success.

Conclusion

In conclusion, it has been shown in the literature review, that tertiary education in South Africa needs improvement to create throughput rates that are not disproportional to the enrolment rates, and that are more representative of the population of South African in terms of the demographics of race, gender and socioeconomic status. The literature review has also shown working memory and non-verbal intelligence, two prominent and widely studied cognitive constructs, have connections to academic success. Thus, although there are undoubtedly many factors that influence success or failure at tertiary level, the current study aimed to investigate the role of working memory and non-verbal intelligence to determine which, if either, is the better predictor of academic success, as well as to determine whether these relationships differed by gender, SES or ethnic group.

Chapter 2: Method

The current study aimed to investigate the roles that non-verbal intelligence and working memory play in academic success at a tertiary level. Due to the nature of the study a sample of university students was used. The following section outlines the various methodological aspects of the research.

Research Design

The current study employed a positivist research paradigm as the underlying assumption is that the relationships between working memory, non-verbal intelligence and academic success can be measured and that there is a shared understanding of what these constructs are. Thus the current study aimed to make the unknown known (Philips & Berbules, 2000).

The current study was non-experimental and ex post facto in nature as none of the variables in the study were manipulated and none of the participants were randomly assigned into groups. Thus, the variables in the study (working memory, non-verbal intelligence, academic success and various demographic variables) are seen as naturally occurring phenomena that were recorded for purposes of the study (Spector, 1986). Since the study utilised one sample of first, second and third year Psychology students, it was thus cross-sectional as it was not looking at multiple samples over a period of time, but rather comparing groups collected at one point in time (Rosnow & Rosenthal, 1996). The current study can also be described as exploratory as it is not trying to prove causation, but examined the potential relationships between variables. The study can similarly be described as being exploratory as it compared groups (such as gender, socioeconomic, language etc) to see whether significant differences exist between these groups (Bickman, Rog & Hedrick, 1998).

The quantitative approach to the current research, in which numerical data was collected and analysed, however limits the current study as no depth or description can be drawn from the findings (Shipman, 1997). The quantitative approach that the current study took may be criticised as being reductionist as it looked at a number of measurable variables

to objectively explain academic success, without considering the roles that many other variables such as motivation and self discipline may have, or the subjective nature of learning. As such, mixed methods approach would have been the ideal methodology for the current study as both the objectivity of quantitative research and the subjectivity and depth of qualitative research would have been incorporated into the research design (Scheurich, 1997). However, due to time constraints, a purely quantitative approach was followed as this yielded as much data as possible within the short amount of time that was available. As the study was exploratory in nature, the quantitative approach was also fitting as it aimed to uncover potential relationships between working memory, non-verbal intelligence and academic success (with working memory and non-verbal intelligence being the independent variables and academic success being a dependent variable). Thus, the findings of the current study could then direct future research using a mixed method design for the reasons mentioned above.

Sample

The sample was a non-probability, convenience sample that consisted of students at a Gauteng university, registered for the Psychology I, II or III courses. Initially, only students registered for the Psychology I course were going to be used in the study, however, due to a poor turnout, Psychology II and III students were included so as to increase the sample size. The final sample consisted of 51 participants, with the data collected over 15 sessions of two hours per session. Participation in the study was voluntary and the research participants were invited to participate in the current study by the researcher approaching them during class time, through written invitations via email and facebook as well as text messages. Participant information letters were given out (Refer to Appendix A: Student's Information Letter) at the sessions and the participants were encouraged to read these letters before commencing data collection as they contained all of the information regarding the study. Informed consent was obtained from each participant before the data was collected (Refer to Appendix B: Consent Form).

No participants were omitted from the final sample as all of the participants completed all aspects of the study.

Instruments

1) Demographic Questionnaire

The demographic questionnaire (Refer to Appendix C: Demographic Questionnaire) was developed by the researcher to obtain information such as age, ethnicity, first language and current level of tertiary education from the participants. It also included items that specified the type of secondary level education that the student received (e.g. whether the student went to a public or private school and whether their education was Outcomes Based Education/OBE or pre-OBE schooling) as this may have impacted on their working memory or RAPM performance. The demographic questionnaire also had items that assessed each participant's motivation to study Psychology, to account for students that may have chosen to take Psychology I as a single credit and thus may not put in as much effort as the students that are considering majoring in Psychology. The questionnaire also contained items that were used to assess each student's socioeconomic status based on their parental occupation and self reported neighbourhood wealth (Oppenheimer, 1966). These questions were open ended and asked the participants to state their parents' careers and the level to which the parent studied.

All respondents completed the demographic questionnaires in approximately five minutes and in adequate detail for the data to be used. The researcher was present the entire time the questionnaires were being completed to answer any questions that the participants had regarding any of the questions. Thus, it can be concluded that all of the questions were completed correctly and thus the data from the demographic questionnaire was valid.

2) The Raven's Advanced Progressive Matrices (RAPM) (Raven, 2004)

The Raven's Advanced Progressive Matrices was used to obtain an estimate of nonverbal intellectual functioning for all of the participants. The RAPM non-verbally assesses an individual's ability to use logic to solve a series of three-by-three black and white diagrams (Raven, 2004). The solving of the diagrams requires that the participant choose from eight options the figure that will complete the image. The selection of the

appropriate figure requires that the individual recognises the pattern of the picture as a whole and thus chooses the appropriate figure that will complete this picture (this selection thus being a logical conclusion). The logic behind the selection is based on the fact that progressive changes happen in the rows and columns of the figure and from these changes the correct image to complete the image can be deduced (Skuy *et al*., 2002).

The items in the test gradually increase in difficulty enabling the RAPM to assess an individual's ability to learn or to transfer previously learnt knowledge to a different example requiring the same skill or knowledge (Raven, 2004). To accomplish this, the RAPM has two sets, Set I and Set II. Set I has 12 items that increase in difficulty. This set also helps to familiarise the participants with the test as well as helping them to establish the rules that govern the solving of the test items. Set II was administered directly after Set I. Set II has 36 items that also increase in difficulty. The use of the different sets helps to give an indication of the participants' eductive and reproductive abilities as being able to solve the easier items of Set I would show the ability to learn (eductive ability) and then the ability to apply this learnt skill to the more difficult items in Set II would show the application of learnt knowledge across different contexts (reproductive ability) (Rushton & Skuy, 2000).

In terms of scoring, the RAPM manual allows the researcher to place participant's scores within percentiles, following the distribution of non-verbal intelligence in the standardised population (Kamin, 2006). For the current study, a score was calculated on each set of the RAPM in order to correlate each with academic success.

The psychometric properties of the test reveal that the RAPM has reliability coefficients that range from 0.7 to 0.9, while the test-retest reliability coefficients for the RAPM range from 0.83 to 0.93 when used with a range of samples, including South African students (Skuy *et al*., 2002; Skuy, 2003). Validity for the RAPM was ascertained through comparing the RAPM to the Stanford-Binet Intelligence Test, with validity coefficients ranging from 0.5 to 0.86 (Freeman, 1962).

The RAPM has previously been researched on a South Africa sample of university students and was found to be both reliable and valid (e.g. Rushton & Skuy, 2000; Rushton, Skuy & Bons, 2004; Rushton *et al*., 2003; Skuy, *et al*., 2002). These studies have shown internal consistency coefficients of 0.8 (e.g. Skuy, 2003 and Skuy *et al*., 2002).

3) The Memory Quotient Tester Online Working Memory Test (MQT) (Alloway, 2007)

In order to assess working memory, the MQT, an online version of the Automated Working Memory Assessment (AWMA) was used (Alloway, 2007). The MQT required the participants to complete three tests, namely – a Numbers Game, a Letters Game and a Shapes Game, each of which is described here.

With each of the tests, the participant is shown a demonstration on how the test is meant to be completed. Should the participants have chosen, they could watch the demonstration multiple times. Each of the tests is structured in such a way that each test starts off with three items that the participant must correctly remember and then gradually moves up to nine items. The MQT also has a discontinuation rule that stops the test once the participant has made a predetermined number of consecutive mistakes. Therefore, the MQT test time varied greatly amongst the participants as some progressed further along the test than others.

The first test is the Numbers Game in where participants were required to watch as numbers appear on the screen and then correctly click the numbers in backwards order after all of the numbers have been shown. This tests the participants' phonological loop as the numbers must be remembered and acted upon. This would not simply be the participants' verbal short term memory as the numbers had to be manipulated. This test gives a single score called the number score, which reflects the number of correctly remembered responses.

The second test is the Letters Game in which the participants were shown a letter in black and then shown another letter (either the same letter or a different one) in red and asked to indicate whether it was the same as the original letter or not. Following that, the participants were then asked to remember all of the black letters in order and click on them in the proper order. Thus, the comparison between letters required the participants' short term memories only and acted as distracters whereas remembering the sequence of the letters despite the distractions required the participants' working memory abilities. The remembering of the letters in sequence would then require the participants' phonological

loops as despite the interference from the distracters the correct sequence of letters would have to be remembered by means of the phonological loop. Arguably, the visuo-spatial sketchpad could also be used if the participant chooses to visualise the letters and the same could then be said for the Numbers Game. The Letters Game yields two scores, a letter score which is a reflection of the number of letters remembered in the correct order and a letter processing score which reflects the number of correct discriminations between the proper letters and the distracter letters.

The final test is the Shapes Game in which the participants viewed a coloured shape at one location in a three by three grid. Following that the participants were shown a coloured shape (that could either match the original shape or colour or not) and were asked if the two coloured shapes were the same or different. For the shapes to match they had to match on both shape and colour. Following the indication of whether the shapes were the same or not the participants had to indicate where on the grid the coloured shape had been. In the items in which there was more than one shape that appeared in the grid, the participants were asked to remember the locations of the shapes in order. This test relies on the visuo-spatial sketchpad as not only the location of the shapes must be remembered, but the visual aspects of the shapes must be remembered simultaneously. The two scores derived from the Shapes Game are the shape score, which is the number of locations that are remembered in the correct sequence, and the shape processing score which is the number of correct comparisons made between the shape and the distracter shape.

The test is appropriate as it has been found to be free of the effects of socioeconomic status and language and thus can be administered to a diverse population group (Engel *et al*., 2008).

Procedure

Ethical clearance was obtained from the University's Non-Medical Ethics committee (Refer to Appendix E: Ethical Clearance Certificate, Protocol Number: H100310) and the researcher approached Psychology I classes to invite students to participate. After several data collection sessions, Psychology II and III classes were also approached.

The actual data collection sessions were conducted in a computer laboratory and the results were collected over fifteen data collection sessions. The researcher was aided by a trained research assistant for several of the sessions.

In the sessions the participants were given the consent form (Refer to Appendix B: Consent Form), demographic questionnaire (Refer to Appendix E: Demographic Questionnaire) and the answer sheet for the RAPM, as well as the students letter (Refer to Appendix A: Student's Information Letter) which all participants were encouraged to read and take with them after the data collection session. The participants were each given an anonymous code that linked their RAPM and MQT performance to their demographic questionnaires.

When the participants had completed the demographic questionnaire and signed the consent, the researcher or research assistant gave a set of standard instructions to the participants before they began the MQT. While busy with the MQT, the researcher or research assistant ensured that the noise levels in the computer laboratory did not become distracting to any of the participants. Participants were also instructed not to use any writing materials during the test as it is a memory test. After the participants completed the MQT, the researcher or research assistant would close the MQT window on the computer and provide a standardised set of instructions before administering the RAPM. Again, while the participants were completing the RAPM, the researcher or research assistant would ensure that the laboratory stayed quiet so as to ensure that the participants could concentrate on the task at hand. The RAPM was not timed as this would have been difficult with multiple participants, and due to the fact that the study did not aim to compare the participants to a standardised population, but rather aimed to compare the participants' RAPM scores to one another. The lack of timing was the only deviation from normal administration of the RAPM.

The study was conducted ethically and all participants were guaranteed anonymity and all results were confidential. Participants had the right to withdraw without consequence and feedback was offered to those participants who requested it.

Data Analysis

The data was analysed according to the research questions in the results section. As the study is quantitative in nature, correlations and *t*-tests have been used to identify relationships and compare groups respectively. Based on the nature of the data many of the variables used in the study were dichotomised in order to aid the analyses. Due to the small sample size the researcher had to be aware of the limitations that were then placed on the power of the statistical analyses.

All statistical analyses were run using the statistical program SAS Enterprise Guide 9, a statistical program freely available for use at the university at which the research was conducted.

Threats to validity

A number of threats to the validity are present in the current study and although the extent to which they will affect the results cannot be ascertained, these threats must be outlined.

Firstly, despite the fact that the current study aimed to investigate the role of various non-verbal intelligence measures in relation to tertiary academic success, the use of university students as a sample is problematic as this sample can be said to be fairly homogenous and highly specific. At the same time, the small sample size (n=51) is problematic as it would affect the power of the statistical results.

A further problem with sampling is that only Psychology students, registered at one urban university in Gauteng formed the sample. This would undoubtedly affect the generalisability of the findings from the study which would be limited to similar groups only.

Chapter 3: Results

In order to answer the research questions, data was collected by using the instruments outlined in the methods section above. The data obtained were i) Five working memory scores namely – Number Score (NS), Letter Score (LS), Letter Processing (LP), Shape Score (SS) and Shape Processing (SP), ii) Raven's Advanced Progressive Matrices Results which were grouped into Set I total, Set II total and a combined total score (referred to as Raven's total score) iii) Demographic data, such as race and gender as well as data that related to language and socioeconomic status, iv) Academic results, namely – Psychology aggregate scores and Matric scores. As some of the categorical variables in the study were dichotomised for analysis, it is necessary to understand the divisions of these variables and group sizes. The descriptive statistics based on the demographic variables are presented in the table below.

Table 1
Descriptive Statistics for Dichotomised Variables

	n	%	N	Missing data
Gender			51	0
Male	15	29.41		
Female	36	70.59		
Home Language			51	0
English	28	54.90		
Other	23	45.10		
Ethnic Group			51	0
Black	26	50.10		
Non-Black	25	49.9		
Self reported Neighbourhood Wealth			45	6
Average and Below	28	62.22		
Above average	17	37.78		
Self reported perceived neighbourhood wealth			51	0
Average and Below	28	54.90		
Above Average	23	45.10		
Mark Groups			51	0
Below Average (0-49%)	14	27.45		
Average (50-64%)	26	50.98		
Above Average (65%+)	11	21.57		

As can be seen in table 1 above, the sample represents a fairly homogenous group of students. It can also be seen that the sample is not representative of the population of South Africa, as a whole as the ethnic and gender ratios are skewed. This, as well as the fact that university students represent a specific population group must be taken into consideration when examining the results of the analyses.

For the analyses certain variables were dichotomised or trichotomised to allow for comparisons to be made. Gender was a natural divide based on each participant's self report, however other variables were divided by the researcher. Home language was based on each participant's self reported home language and it was decided to divide home language into English and non-English as English is the language of instruction at the university at which the research was conducted. The non-English group represents the students that reported either Zulu, Sotho, Tswana or several other languages were their home language. This divide resulted in English first language (EL1) and English second language (EL2) groups.

Ethnicity was also dichotomised based on participants' self report and it was decided that Black and non-Black would form the two groups (refer to Table 1). The non-Black group consisted of participants that were Caucasian, Asian or Coloured. Other studies in South Africa have divided ethnicity either by individual ethnic groups (e.g. Owen, 1992) or have chosen to only compare Black and White ethnic groups while excluding others (e.g. Rushton & Skuy, 2000), however due to the small sample size in the current study all ethnic groups were included and the division was such that it would give the most even divide. This division was then based on practical rather than theoretical reasons.

The classification of socioeconomic status (SES) was based on the participants' self report of their perception of their own neighbourhood's wealth, as well as how they rated others would perceive their neighbourhood's wealth. The rating was in the form of a five point likert scale from 1 (very poor) to 3 (average) to 5 (very wealthy). As Table 1 shows, the number of participants that perceived their neighbourhood to be of average or below average wealth is identical to the number of participants that rated that others would perceive their neighbourhood to be of average or below average wealth. Thus, there congruence between what the participants perceive and what they rate others as

perceiving. The division between average and below average wealth in one group and above average wealth in the other group was decided upon as students from urban universities typically come from medium to high SES backgrounds and thus this division represents the typical and atypical socioeconomic statuses of the students in the sample.

The grouping of the marks for the analyses was decided upon based on certain criteria at the university at which the research was conducted. The below average group represents the participants whose Psychology aggregates were below 50%. This then represents the participants who failed their Psychology course as 50% represents a pass. As the university requires a minimum Psychology aggregate of 65% for students to qualify for post graduate Psychology courses, it was decided that all Psychology aggregates above 65% would be deemed above average and as a result the scores between 50 and 64% would then represent the average range. The Psychology aggregate score represents each participant's performance across all essays, tests and exams in the first semester of the academic year. The Matric score is a representation of the participants' secondary level academic performance as it is a composite score of each participant's final Matric marks. This then made exploring the role of working memory and non-verbal intelligence at secondary level academic success possible.

In order to understand the analysis variables in the study the distribution statistics have been provided in the table below (See Table 2). Table 2 also contains the values that the MQT and the RAPM subscales were out of.

When looking at the table below (see Table 2) a few factors are worth noting. Firstly, on a number of the working memory measures it can be seen that some participants reached the maximum score on that particular subtest (e.g. Letter Score – 5 participants, 9%; Letter Processing – 7 participants, 13.73%; Shape Score – 2 participants, 3.92% and Shape Processing – 3 participants, 5.88%). These ceiling effects would have reduced the variability between individuals. The variance within the variables also reveals that the scores fall at the higher end of the potential scores and in relation to Letter Score (M=18.39, SD=6.65) it can be seen that the sample's score range (11.75-25.04) falls outside the range of possible scores at the upper end of the range. Thus, it can be seen that the sample as a

whole scored towards the upper end of the possible scores and that this may be a limiting factor, as well as the fact that this resulted in skewed distributions.

Table 2
Distribution Statistics for Analysis Variables

Variable	N	Mean	Standard Deviation	Minimum	Maximum	Maximum Result
Ravens' Set I total	51	9.65	2.70	1	12	12
Ravens' Set II total	51	18.45	8.10	0	34	36
Ravens' Total Score	51	28.10	10.15	3	45	48
Number Score	51	14.59	5.33	0	23	24
Letter Score	51	18.39	6.65	0	24	24
Letter Processing	51	77.04	36.87	0	112	112
Shape Score	51	16.78	5.32	0	24	24
Shape Processing	51	75.63	30.77	0	112	112
Psychology Overall Mark	49	57.10	13.19	30	85	100
Matric Score	47	28.09	7.30	4	47	50

Data sets were checked to determine whether they met the assumptions necessary for parametric analyses. The data from the RAPM, the MQT as well as the Psychology marks are all interval due to the fact that the data is either in the form of percentages or a whole number score from standardised tests. However, the demographic data used in the analyses is not interval due to the discrete nature of the numerical data and the fact that the variables (e.g. Ethnicity and gender) cannot be said to exist on a continuum. Thus the parametric assumption of interval scale data was not met (Huck, 2005). Due to the convenience sampling that was used, the assumption of random independent sampling was also not met (De Vos, Strydom, Fouche & Delport, 2006). The third parametric assumption that would need to be investigated would be normally distributed data (De Vos *et al*., 2006). To ascertain whether the data met the requirement of being normally distributed the Kolmogorov-Smirnov tests of normality was run. The results are presented in Table 3 below.

Table 3
Kolmogorov-Smirnov tests for normality on the variables of the study

	Variable	Statistic
RAPM sub scores	Raven's Set I Total	0.24*
	Raven's Set II Total	0.13*
	Raven's Total Score	0.16*
MQT subtests	Number Score	0.09
	Letter Score	0.28*
	Letter Processing	0.17*
	Shape Score	0.15*
	Shape Processing	0.15*
Academic success	Psychology Aggregate	0.09

*$p < 0.05$

As can be seen from the above table, only the variables of Number Score and Psychology aggregate score were normally distributed. Considering this as well as the lack of random independent sampling, non-parametric tests were run to answer the research questions that follow. However, the parametric equivalents of the tests were also run to confirm whether or not the obtained results were significant using a stricter set of tests.

In order to ascertain the reliability of the instruments used, Cronbach's Alphas were calculated where possible. Due to copyright and the availability of the results from the MQT, only subscale total scores were provided and thus Cronbach's Alpha's could not be calculated. The data obtained from the RAPM was sufficient to calculate Cronbach's Alphas and the results are presented in the table below.

Table 4
Cronbach's Alphas for Raven's Set I, Raven's Set II and Raven's Total Score

Variable	Raw Score α	Standardised Score α
Raven's Set I	0.83	0.86
Raven's Set II	0.92	0.92
Raven's Total	0.93	0.93

As the data in Table 4 shows, the RAPM showed good reliability.

Having presented the descriptive statistics, ascertained the parametric nature of the data and discussed the reliability of the instruments the research questions are addressed in order using the relevant statistical analyses. Non-parametric results will be used in the answering of the research questions, but parametric analyses were also run and were included for further reference. Where the results of the two analyses differed, the non-parametric results were considered over the parametric results.

The first research question investigated whether the subscales of the MQT correlated significantly with academic success as determined by each participant's Psychology Aggregate mark. Pearson's product moment correlations and Spearman's correlations were calculated between all of the key variables in the investigation and the results are presented in the table below (see Table 5).

None of the correlations (see Table 5) revealed a significant relationship between any of the working memory subscales and the participants' Psychology overall mark, or their Matric results. Thus it would appear that no relationship exists between working memory as assessed by the MQT and academic success.

The second research question explored the possible relationships between the RAPM results and academic success. The correlations between the RAPM results and each participant's Psychology aggregate are presented in Table 5 above. As the table shows, there appear to be no significant correlations between the RAPM results, performance in Psychology or performance in Matric. This is similar to the correlations between the MQT subtests and academic success. Tables 5 shows a number of moderate correlations between the MQT subscales and the three RAPM scores. Further, the Spearman's and Pearson's correlation analyses yield similar results. Thus, the RAPM and working memory measures appear to be measuring similar skills which would explain why neither the RAPM or the MQT was significantly correlated with the participants' Psychology aggregate mark or Matric score.

Table 5
Correlation Matrix for Main Variables in the study

Variable	Ravens' Set I Score	Ravens' Set II Score	Ravens' Total Score	Number Score	Letter Score	Letter Processing	Shape Score	Shape Processing	Psychology Aggregate	Matric Score
Ravens' Set I Score	-	**.69****	**.81****	**.28**	**.35***	**.30***	**.36***	**.30***	**.24**	**-.01**
Ravens' Set II Score	.63**	-	**.98****	**.41***	**.40***	**.31***	**.43***	**.40***	**.04**	**.04**
Ravens' Total Score	.74**	.98**	-	**.40***	**.41***	**.33***	**.44***	**.40***	**.09**	**.03**
Number Score	.18	.40*	.36*	-	**.30***	**.40***	**.52****	**.54****	**-.02**	**.19**
Letter Score	.28*	.44*	.42*	.34*	-	**.87****	**.60****	**.51***	**-.03**	**.14**
Letter Processing	.10	.26	.24	.50*	.67**	-	**.62****	**.60****	**.08**	**.19**
Shape Score	.21	.35*	.33*	.47*	.41*	.60**	-	**.93****	**.08**	**.25**
Shape Processing	.20	.37*	.36*	.51*	.40*	.58**	.91**	-	**.10**	**.16**
Psychology Aggregate	.27	.04	.08	-.02	<-.01	.09	.04	.07	-	**.25**
Matric Scores	.07	<.01	.04	.12	.07	.15	.15	.64	.26	-

*p<0.05, **p<0.0001

Note: The correlations above the diagonal and in bold are Pearson's Product Moment Correlations, while the correlations below the diagonal are Spearman's Correlations

In order to answer the third research question the participants were grouped into three groups based on their final score for Psychology for the first term of the academic year. The groupings were below average (0-49%), average (50-65%) and above average (>65%). A non-parametric ANOVA was used to investigate if any significant differences between the three groups exists based on their working memory scores, because the data sets were not normally distributed. The results of this analysis are presented in Table 6 below.

Table 6
Differences in Working Memory performance between three groups of students

Working Memory Variable	*p*-Value	Chi^{2-} Value
Number Score	0.85	0.32
Letter Score	0.21	3.10
Letter Processing	0.46	1.57
Shape Score	0.92	0.16
Shape Processing	0.99	0.01

As the above table shows, no significant differences can be seen between the three mark groups' performance on the working memory subscales of MQT. Thus, in relation to the correlations in question 1 and the results it would appear that working memory is not related to academic performance in Psychology. An ANOVA was run, but due to the fact that this procedure is stricter the results were similarly non-significant. Mann-Whitney U, post hoc comparisons of the various pairings, also revealed no significant differences. The results of these analyses is shown in the table below (see Table 7).

Table 7
Differences in Working Memory Variables between three mark groups, group analyses in pairs.

Group Comparison	Number Score *p*-value	Letter Score *p*-value	Letter Processing *p*-value	Shape Score *p*-value	Shape Processing *p*-value
1 & 2	0.65	0.14	0.30	0.68	0.93
2 & 3	0.73	0.19	0.34	0.88	0.89
1 & 3	0.74	0.88	0.94	0.90	1.00

Note: 1= below average group, 2= average group, 3= above average group.

As the above table shows, when comparing the groups in pairs, the results still indicate no significant statistical differences between the three mark groups. A parametric two way *t*-test was also run and the results were all non-significant.

The fourth research question considered differences in RAPM performance between the three mark groups. To answer this research question a similar approach was taken to that employed in question three. However, here the variables being compared by a non-parametric ANOVA between the three mark groups were the three Raven's results, namely – Ravens Set I, Ravens Set II and Ravens total score. The results are presented in the table below.

Table 8
Kruskal-Wallis results for the differences in Raven's Scores between three mark groups

Raven's Variable	*p*-Value	Chi^{2-} Value
Raven's Set I	0.07	5.29
Raven's Set II	0.75	0.56
Raven's Total	0.63	0.91

As the table above shows, there was no significant difference in the RAPM scores between the three mark groups for Psychology. A one way ANOVA was also run and also yielded no significant results. Thus, in relation to the correlations in question 2, it can be inferred that there is no relationship between non-verbal intelligence and performance in

Psychology. To examine the variable more closely it was decided that the individual groups should be paired and compared by means of a Mann-Whitney U to see if significant difference existed between any of the mark groups. The results of these analyses are shown in the tables below.

Table 9.1

Differences in Raven's Advanced Progressive Matrices Variables between three mark groups, group analyses in pairs.

Group Comparison	Raven's Set I *p*-value	Raven's Set II *p*-value	Raven's Total *p*-value
1 & 2	0.59	0.98	0.89
2 & 3	0.08	0.43	0.37
1 & 3	0.04*	0.70	0.50

Note: 1= below average group, 2= average group, 3= above average group.

Table 9.2

Differences in Raven's Advanced Progressive Matrices Variables between three mark groups, group analyses in pairs as per a 2 sample *t*-test

Group Comparison	Raven's Set I *p*-value	Raven's Set II *p*-value	Raven's Total *p*-value
1 & 2	0.77	0.87	0.97
2 & 3	<0.05[1]	0.76	0.54
1 & 3	<0.05[1]	0.86	0.54

[1] = Analyses with unequal variance

Note: 1= below average group, 2= average group, 3= above average group.

As the results of the above table show, when the individual groups were compared with each other, the Below Average and the Above Average groups differed significantly in terms of their Ravens Set I performance, with the Above Average scoring higher. The parametric analyses (see Table 9.2) also yielded significant differences the Below Average and Above Average groups.

The fifth research question explored the roles that demographic factors had in relation to working memory, non-verbal intelligence and academic success. To analyse the differences in performance on these measures the demographic variables were dichotomised or trichotomised to create groups that could be compared. All data was then compared using non-parametric and parametric *t*-tests. The results are presented in the tables below.

Table 10.1
Wilcoxon Two Sample test comparisons for the Ethnic groups

Variable	*p*-Value	Variable	*p*-Value
Raven's Set I	0.02	Number Score	0.03
Raven's Set II	0.14	Letter Score	0.47
Raven's Total Score	0.08	Letter Processing	0.14
Psychology Overall Mark	0.08	Shape Score	0.07
Matric Score	0.99	Shape Processing	0.01

Table 10.2
Two sample *t*-test results for the Ethnic groups.

Variable	*t*-Value	Variable	*t*-Value
Raven's Set I	2.01*	Number Score	2.33*
Raven's Set II	1.42	Letter Score	0.92
Raven's Total Score	1.67	Letter Processing	1.27
Psychology Overall Mark	1.98	Shape Score	2.14*
Matric Score	0.12	Shape Processing	2.88*

*$p < 0.05$

As the above tables show, there were significant differences between the black and non-black groups on Raven's Set I, Number Score and Shape Processing results, with the difference being in favour of the non-black group for all three measures. These results were concurrent between the parametric and non-parametric analyses but the two sample t-test also revealed a significant difference between the two groups in their Shape Scores with this difference favouring the non-black group.

The sample was also dichotomised based on self report home language and the comparisons between the English first and second language groups can be seen in the tables below.

Table 11.1
Wilcoxon Two Sample test comparisons for the English first and second language groups

Variable	*p*-Value	Variable	*p*-Value
Raven's Set I	0.04	Number Score	0.12
Raven's Set II	0.19	Letter Score	0.30
Raven's Total Score	0.10	Letter Processing	0.06
Psychology Overall Mark	0.25	Shape Score	0.08
Matric Score	0.23	Shape Processing	0.02

Table 11.2
Two sample *t*-test results for the English first and second language groups.

Variable	*t*-Value	Variable	*t*-Value
Raven's Set I	1.80	Number Score	1.66
Raven's Set II	1.27	Letter Score	1.19
Raven's Total Score	1.50	Letter Processing	1.65
Psychology Overall Mark	1.44	Shape Score	2.20*
Matric Score	1.13[1]	Shape Processing	2.85*

*p = 0.05
[1]Analyses with unequal variance

As Table 11.1 shows, the English first and second language groups showed significant difference on the Raven's Set I and Shape Processing measures. When looking at the two groups results the English first language group is shown to have outperformed the English second language group on both of these measures.

Worth noting is the fact that the Raven's Set I and the Shape Processing differences are common between the race and language analyses most likely because English second language is a proxy for a Black ethnic group.

In order to explore differences based on socioeconomic status, the group that reported that their neighbourhood would be perceived by others as being Average or Below Average in terms of wealth was compared to the group that reported that their neighbourhood would be perceived by others as being Above Average in terms of wealth. The results of these analyses are presented in the tables below.

Table 12.1
Wilcoxon Two Sample test comparisons for the Average and Below Average and the Above Average Other perception of neighbourhood socioeconomic status groups.

Variable	*p*-Value	Variable	*p*-Value
Raven's Set I	0.45	Number Score	<0.05
Raven's Set II	0.98	Letter Score	0.58
Raven's Total Score	0.99	Letter Processing	0.13
Psychology Overall Mark	0.45	Shape Score	0.79
Matric Score	0.12	Shape Processing	0.37

Table 12.2
2 sample *t*-test results for the Average and Below Average and the Above Average Other perception of neighbourhood socioeconomic status groups.

Variable	*t*-Value	Variable	*t*-Value
Raven's Set I	0.33	Number Score	-1.91
Raven's Set II	0.00	Letter Score	0.41
Raven's Total Score	0.09	Letter Processing	-0.89
Psychology Overall Mark	0.38	Shape Score	-0.10
Matric Score	1.60[1]	Shape Processing	-0.68

*p = 0.05
[1]Analyses with unequal variance

As Tables 12.1 shows, the only difference found was between the two groups Number Score results and this was in favour of the group that reported that their neighbourhood is perceived as being above average in terms of wealth.

Gender was dichotomised based on the participants' self report, the results of the analyses are presented in the tables below.

Table 13.1
Wilcoxon Two Sample test comparisons for gender groups

Variable	*p*-Value	Variable	*p*-Value
Raven's Set I	0.56	Number Score	0.98
Raven's Set II	0.11	Letter Score	0.85
Raven's Total Score	0.13	Letter Processing	0.97
Psychology Overall Mark	0.31	Shape Score	0.29
Matric Score	0.95	Shape Processing	0.63

*p = 0.05

Table 13.2
2 sample *t*-test results for gender groups

Variable	*t*-Value	Variable	*t*-Value
Raven's Set I	1.32[1]	Number Score	0.11
Raven's Set II	2.04	Letter Score	0.63
Raven's Total Score	1.91	Letter Processing	0.31
Psychology Overall Mark	-0.92	Shape Score	0.91
Matric Score	0.39	Shape Processing	0.49

*p = 0.05
[1]Analyses with unequal variance

As the results in the above tables show, no significant differences were found between the males and females in the sample.

As the results section has shown, the data was analysed in a number of ways in order to gain a full understanding of the variables in the study. The results will be interpreted and discussed in the next chapter.

Chapter 4: Discussion

The research aimed to investigate any possible relationships between working memory, non-verbal intelligence and academic success at university level, particularly in the field of psychology. The overarching reason for these analyses was to uncover some of the cognitive factors that are related to academic success. The results obtained from the study will now be discussed in relation to existing research.

Working Memory and Academic Performance

As the key variable in the study, working memory will be explored first. Working memory, despite its relatively short history in the field of cognitive psychology, is already seen as a prominent skill in cognitive functioning. This is evident in the Working Memory index in the Wechsler Adult Intelligence Scale (WAIS-III), which tests working memory as a unitary concept underlying general intelligence or the Full Scale IQ score (Kaufman & Lichtenberger, 1999). Working memory also relates to cognitive skills such as long term memory and the ability to switch attention between tasks (Baddeley, 2007). Thus, working memory is an aspect of cognition.

Working memory has also been found to have strong links to various aspects of academic success. However, despite research indicating a strong positive relationship between working memory and academic success in primary school aged children (Aarnoudse-Moens *et al*., 2009; Berninger *et al*,, 2010; Chiappe *et al*., 2000; Gathercole *et al*., 2003; Siegel & Ryan, 1989; Swanson *et al*., 2010 & Swanson & O Connor, 2009), no such significant relationship was found in the current study. When examining group differences between the three academic groups (see Table 6) it was found that no significant differences existed between the three groups in terms of their working memory skills. These results are surprising when considering literature that suggests that working memory is not only a vital factor in academic success, but also that working memory scores in fact have great predictive value in relation to academic success (Gathercole *et al*., 2003).

The lack of significant results can however be explained through exploring the sample that was used in the current study. In the study by Gathercole *et al*. (2003) the sample consisted of children between the ages of four and seven, where in the current study a

much older sample was used. Thus, the differences between the groups may explain the inconsistent results. Firstly, as a younger group was used in the Gathercole *et al*. (2003) study, this sample may have possessed limited acquired knowledge and thus the predictive value between working memory and academic success was in fact related to the acquisition of knowledge in the children's early school performance. Indeed, that is what the study was testing and the results indicate that working memory predicted literacy attainment, but not mathematical performance. In the current study, it can be assumed that the entire sample is literate due to the fact that they were university students. Thus, working memory may then validly be seen as necessary for the prediction of language acquisition, but less closely related to the higher order abstract cognitive functioning necessary to succeed at tertiary education. Working memory has been proposed as a better measure of learning ability rather than a measure of crystallised skills (Alloway *et al*., 2010; Dollaghan, Campbell, Needleman, Dunlowsky, 1997; Weismer *et al*., 2000). This learning ability has in the abovementioned studies been shown to represent the attainment of skills (Gathercole *et al*., 2003), which in early education is perhaps the measure of academic success. However, the sample in the current study consisted of Psychology students and the measure of academic success (such as tests and exams) would thus draw on the students' long term memory abilities (Gazzaniga *et al*., 2009). Thus, the sample in the current study may rely more on long term memory than working memory for their academic success. This offers some explanation for the lack of significant results between working memory and academic success in the current study.

Another possible reason for the lack of significance is that the sample used represents students that have already achieved a level of academic success that has enabled them to enter in tertiary education. Therefore, the sample in the current study would potentially not have any learning disabled students where the learning disability is severe enough to prevent their entrance to tertiary education. Not only does this limit the sample and make it homogenous (see methods section) but in relation to the study by McNamara and Wong (2003) the lack of learning disabled students in the sample would remove the working memory deficits and variability in working memory performance seen in children with learning disabilities.

Also linked to the nature of the sample used is the fact that the sample represents members of the population that have not only achieved a degree of academic success already, but also have a range of working memory and RAPM scores that are skewed to the higher end of the possible range (refer to table 2). Of particular importance is the fact that the subtests of the MQT yielded scores that similarly fell at the upper end of the range of scores. When considering this in relation to the study by Alloway *et al*. (2010) this would imply that the students in the sample have adequate working memory and potentially would not need cognitive styles as compensatory mechanisms in order to achieve academic success. The above two arguments indicate a lack of variance in terms of working memory performance where a lack of variance and ceiling effects limited the ability to find statistically significant differences between the groups.

As the above discussions have highlighted, qualities specific to the sample might have for a number of reasons accounted for the lack of significant results. Had the current study been carried out on a more representative, randomly selected population it is possible that the results may have shown some significance. Despite the lack of significance, the results are still valid and then might indicate a smaller role for working memory in tertiary level academic success, or a role that is not apparent due to the lack of variance in the sample.

Thus, from the results on working memory it would appear that although the current sample showed no significant associations between working memory and tertiary level academic success, this may be due to the fact that the students in the sample are possibly not as dependent on working memory as lower functioning students would be. It is also be possible that working memory only correlates with lower level and developing academic skills and thus will show significance in primary school years. This then makes the results of these analyses inconclusive at best but provides some avenues for future working memory research.

Non-verbal intelligence and Academic Performance

Similar to the working memory analyses, non-verbal intelligence showed no significant correlation with academic success (see Table 5). What the results do however show is that

significant differences were found academic groups on the Raven's set I scores. These differences were between the above average and the below average mark groups (see Table 9), between the black and the non-black students (see Table 10) and between the English and non-English first language groups (see Table 11). The above average group, the non-Black group and the English first language groups showed the highest performance in each case. These findings will be discussed in relation to non-verbal intelligence and other demographic factors.

The first set of the RAPM provides an indication of eductive ability as the participants are required in this set to understand the concept of the test and identify the patterns so as to complete the entire test (Necka & Orzechowski, 2005). This can then be said to be an indication of the participant's ability to learn. The finding that a significant difference exists between the above average and the below average groups is thus logical. The RAPM Set II also has an eductive component and thus it is possible that if the rules governing the RAPM are not acquired during Set I, then a further degree of eduction can occur during Set II (Raven, 1994). This may then explain the lack of significance difference between any of the groups on both the Raven's Set II and the Raven's total results. It is possible that much of the eduction that did not occur during Set I occurred during Set II, making the results more similar between the groups.

The above discussion then explains the findings of the RAPM analyses to some degree. Theoretically, the eductive ability differences found between the above and below average groups can be seen as indicative of a general ability that relates to both non-verbal intelligence and academic functioning.

Race and Language results

The next finding to be explored is that of the pattern of significant results found in the analyses that explored the differences between the black and non-black students (see Table 10), and the English first (EL1) and English second language (EL2) students (see Table 12). This finding as a whole is interesting as the pattern of significance across the variables is similar between the two analyses, with both showing significant differences on the Raven's Set I scores and the Shape Processing Scores from the MQT. In addition, significant differences were found on the variable of Number Score (from the MQT) between the black

and non-black students (see Table 10). In relation to the significant differences, the non-black group outperformed the black group and the EL1 group outperformed the EL2 group. These results in isolation are interesting, but when the two sets of analyses are looked at in relation to one another, a relationship between the two is evident. These results would also be expected due to the sociohistorical disadvantages that continue to effect these populations (Robbins, 2001).

As home language is a proxy for race in a South African sample, the same construct is essentially being investigated (Foxcroft, 1997; Nell, 1999). Thus, the racial and language significance patterns found in the two respective analyses would be similar if the abovementioned racial-linguistic link is correct. The variables of race and language must then be considered together when trying to explain why one group would then outperform the other group on those specific subtests. These results can also be considered in relation to previous studies conducted in the same context in which racial differences were also found in performance on the RAPM (Rushton & Skuy, 2000; Rushton *et al*., 2003). What these studies hypothesised is that the differences represent cultural bias in the Raven's Matrices, particularly in relation to the analytical style of thought needed to complete the Raven's Matrices (Rushton *et al*., 2003), and that the differences may be due to differences in general intelligence between the various ethnic groups (Rushton & Skuy, 2000). The explanation for the current results as well as the results of the previous studies can be considered under this discussion.

Socioeconomic status must then too be considered in this discussion and of note is the fact that there was a significant difference found in the Number Score subscale of the MQT between the groups of students that reported that their residential area was perceived to be average or low in terms of wealth and those students that reported that their residential area is perceived as high in terms of wealth (see Table 13). This difference was found to be in favour of the group that lives in the above average area, which can thus be said to be the high socioeconomic status area. On its own this finding is interesting and informative, but in relation to the significance found in the racial groups it is interesting to note that there was significant difference between race groups on the Number Score subscale of the MQT (see Table 10). This is contradictory to findings in the Engel *et al*. (2008) study as that study showed that working memory measures are free of the effects of socioeconomic status. This

inconsistency in research findings between the current study and the Engel *et al*. (2008) study could represent the differences between the samples (a South African adult sample in the current study and Brazilian school children in the Engel *et al*. study).

So, it would appear that race, language and socioeconomic status may in some way be linked in the sample of students used in the study.

Academic success results

With the exception of the findings that eductive reasoning differed between high and low academic success groups, the results of the study indicate no significant difference between the academic groups, while the Psychology Aggregate and Matric Score values did not correlate significantly with the MQT or RAPM scores (see Table 5). This lack of significance can perhaps be explained by the multitude of factors that will affect academic success at both tertiary and secondary school levels. Examples of such factors would be access to resources, home environment, distance to university or school etc (CHE, 2010). These factors potentially have great effects on the academic success of all learners and thus might account for the lack of significant results as academic success then is not merely a reflection of underlying cognitive skills.

Working Memory and Non-Verbal Intelligence

In relation to working memory and non-verbal intelligence, Table 5 shows that subscores of these constructs correlate positively with one another. This is interesting as it provides evidence for the link between the two cognitive constructs that has been proposed in the literature (Williams *et al*., 2008).

Gender Differences

In relation to previous findings it is worth noting that no gender differences were found in the current study (table 14). This is interesting although does not add clarity to the body of research that indicates gender differences in the RAPM (e.g. Abad *et al*., 2004; Lynn, 2002 and Rushton & Skuy, 2000) but supports the research that indicates that no gender differences exists (e.g. Israel, 2006; Rushton *et al*., 2003). However, the current study at best

provides some clarity to the gender differences issue but because of the limitations of the current research these results must also be considered cautiously.

Limitations of the current study

In order to understand the current study and its applicability, the limitations the study must be acknowledged.

The first and perhaps most important limitation of the current study is the sample. The sample size of 51 is problematic due to the fact that it not only limited the statistical analyses that could be run, but also limited the power of the analyses. Another problem with the sample is the fact that, despite racial and socioeconomic differences in the sample, the sample is relatively homogenous, partially due to the samples' performance on the measurement of working memory. As the current study aimed to investigate non-verbal intelligence, working memory and academic success in university students, the sample's lack of generalisability to the population of South Africa as a whole is not problematic. However, the sample was not representative due to the fact that only Psychology students were used and students from other Faculties were not included. The voluntary nature of the study is also problematic as potential differences exist between the types of students that would volunteer to participate in research and those that would not. This is known as volunteer bias, and studies into this phenomenon state that the specificity of the sample that volunteers limits the generalisability of findings (e.g. Gaither, Sellbom & Meier, 2003). Due to the above mentioned homogeneity of the sample in the current study had obvious methodological flaws when considering the comparative nature of the analyses run.

The study also did not account for other variables that would have impacted on the students' performance either academically or on the non-verbal intelligence scales that were used. Such factors that could have been explored would be attributions, motivation and cognitive styles, to name a few.

The study also used three different levels of performance in Psychology (Psychology I, II and III) as a measure of academic success. This construct of academic success is essentially then not a unitary concept as the different levels could then actually represent academic success in different forms. For instance, at Psychology I level, the assessments are in the

form of Multiple Choice Questions, whereas Psychology II and III requires written assessments. This the represents a difference in what is required of the students as multiple choice questions theoretically require recognition whereas written assessments that require the students to answer questions would then require recall and long term memory functioning (Gazzaniga *et al*., 2009). Thus this variable, a key variable in the study, was then not well constructed. However, due to the necessity to increase the sample size it was necessary to include the different Psychology courses.

Directions for future research

The roles of working memory and non-verbal intelligence in academic success at university are still unclear and despite the knowledge gains from this study, recommendations can be made for future research. In order to more effectively study the nature of the relationships between non-verbal intelligence and tertiary level academic success future studies could improve on the current one in a number of ways.

Firstly, future studies could use students from multiple Faculties as part of their sample. This would give greater insight into the roles that non-verbal intelligence play in different students and give a more representative understanding of the role that non-verbal intelligence plays in tertiary level academic success as a whole.

Future research could also explore other cognitive abilities in relation working memory and non-verbal intelligence, such studies could (for example) time the RAPM and simultaneously investigate processing speed. The behavioural factors relating to academic success could also be explored, with examples of these being motivation, locus of control, attributional styles and learning styles.

Similarly, future research could attempt to identify factors that would promote or impair academic success in order to consider these effects in relation to the findings of the study. Examples of these factors could be accessibility to resources (such as textbooks and internet) as well as distance from the university. This information could be obtained through carefully constructed questions in the demographic questionnaire.

Future research could include a more qualitative approach in order to understand the strategies used to complete the RAPM and the MQT. This could give insight into the factors contributing to the success that the participants would have on these tasks.

Conclusion

The current study explored the potential relationship that working memory and non-verbal intelligence have to tertiary level academic success in the hopes of identifying cognitive variables that could help to improve the throughput rates at universities in South Africa. The results of the analyses indicated differences between high and low academic achievers in terms of eductive ability. However, the working memory analyses provided little evidence for a possible link with tertiary level academic success, but add to a body of research that has previously focused largely on younger populations.

Reference List

Aarnoude-Moens, C.S.H., Smidts, D.P., Oosterlaan, J., Duivenvoorden, H.J., Weisglas-Kuperus, N. (2009). Executive Function in Very Preterm Children at Early School Age. *Journal of Abnormal Child Psychology, 37.* 981-994.

Abad, F.J., Colom, R., Rebollo, I. & Escorial, S. (2004). Sex differential item functioning in the Raven's Advanced Progressive Matrices: evidence for bias. *Personality and Individual Differences, 36.* 1459-1470.

Allen, R., Baddeley, A.D. & Hitch, G.J. (2006). Is the binding of features in working memory resource-demanding? *Journal of Experimental Psychology: General,135.* 298-313.

Alloway, T. P. (2007). *Automated Working Memory Assessment.* Pearson Assessment, London.

Alloway T.P. (2009). Working memory but not IQ predicts subsequent learning in children with learning difficulties. *European Journal of Psychological Assessment, 25*. 92-100.

Alloway, T.P. & Alloway, R.G. (2010). It is better than you think: Fluid Intelligence across the lifespan. Unpublished research article.

Alloway, T.P., Banner, G.E. & Smith, P. (2010). Working memory and cognitive styles in adolescents' attainment. *British Journal of Education,*

Alloway, T.P., Gathercole, S.E. & Elliott, J. (2010). Examining the link between working memory behaviour and academic attainment in children with ADHD. *Developmental Medicine and Child Neurology, 52.* 632-637.

Anderson, J.R., Reder, L.M. & Lebiere, C. (1996). Working Memory: Activation Limits on Retrieval. *Cognitive Psychology, 30.* 221-256.

Baddeley, A. (1986). *Working Memory (1st Ed.).*Oxford: Claredon Press.

Baddeley, A. (1998). *Human Memory: Theory and Practice (Revised Edition).* United States of America: Allyn & Bacon.

Baddeley, A. (2000). The Episodic Buffer: A new component of Working Memory? *Trends in Cognitive Sciences, 4.* 417-423.

Baddeley, A. (2003). Working Memory: Looking back and looking forward. *Nature Reviews. Neuroscience, 4.* 829-839.

Baddeley, A. (2007). *Working Memory, Thought, and Action (1st Ed.).* United States: Oxford University Press, Inc.

Berninger, V.W., Abbott, R.D., Swanson, H.L. & Lovitt, D (2010). Relationship of Word- and Sentence-Level Working Memory to Reading and Writing in Second, Fourth and Sixth Grade. *Language, Speech and Hearing in Schools, 41.* 179-194.

Bickman, L., Rog, D.J. & Hedrick, T.E. (1998). Applied Research Design: A Practical Approach. In Bickman, L. & Rog, D.J. (Eds.), *Handbook of Applied Social Research Methods* (pp.5-39). United States of America: Sage Publications.

Carroll, J.B. (1976). Psychometric Tests as Cognitive Tasks: A new structure in Intellect. In L.B. Resnick (Ed.) *The Nature of Intelligence (1st Ed).* New Jersey: Lawrence Erlbaum Associates, Inc.

Chiappe, P., Hasher, L. & Siegel, S. (2000). Working Memory, inhibitory control, and reading disability. *Memory and Cognition, 28.* 8-17.

Conway, A.R.A., Cowan, N., Bunting, M.F., Therriault, D.J. & Minkoff, S.R.B. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30.* 163-183.

Cook, P. & Wilson, M. (2010). Do young chimpanzees have extraordinary working memory? *Psychonomic Bulletin & Review, 17.* 599-601

Council on Higher Education 2007-2008 Annual Report (2008). Retrieved 19 February 2010 from http://www.che.ac.za/documents/d000185/CHE_Annual_Report_2007-2008.pdf

Council on Higher Education Higher Education Monitor – Post Graduate Studies in South Africa: A Statistical Profile (2009). Retrieved 19 February 2010 from http://www.che.ac.za/documents/d000196/CHE_MonitorProjectV7.pdf

Council on Higher Education (2010) *Higher Education Monitor: Access and throughput in South African Higher Education: Three Case Studies*. Pretoria: Council on Higher Education

Cowan, N (2005). *Working Memory Capacity (1st Ed).* New York: Psychology Press

Dollaghan, C., Campbell, T., Needleman, H. & Dunlosky, G. (1997). Reducing bias in language assessment: A processing-dependent measure. *Journal of Speech, Language and Hearing Research, 40*, 519-525.

De Vos, A., Strydom, H., Fouche, C. & Delport, R. (2006). Research at Grass roots for the Social Sciences and Human Service Professions (3rd Ed.). Pretoria: Van Schaik Publishers.

Engel, P.M.J., Santos, F.H. & Gathercole, S.E. (2008). Are Working Memory Measures Free of Socioeconomic Influence? Journal of Speech, Language, and Hearing Research, 51. 1580-1587.

Ericsson, K.A. & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102.* 211-245.

Foxcroft, C.D. (1997). Psychological Testing in South Africa: Perspectives Regarding Ethical and Fair

Practices. *European Journal of Psychological Assessment*, *13* (3), 229-235.

Fougnie, D. & Marois, R. (2007). Executive working memory load induces inattentional blindness. *Psychonomic Bulletin and Review, 14.* 142-148.

Freeman, F.S. (1962). *Theory and Practice of Psychological Testing (3rd Ed).* New York: Holt, Rinehart and Winston.

Gaither, G.A., Sellbom, M. & Meier,B.P. (2003). The effect of stimulus content on volunteering for sexual interest research among college students. *The Journal of Sex Research, 40.* 240.

Gathercole, S. E., Brown, L., & Pickering, S. J. (2003). Working memory assessments at school entry as longitudinal predictors of National Curriculum attainment levels. *Educational and Child Psychology, 20.* 109–122.

Gazzaniga, M.S., Ivry,R.B. & Mangun, G.R. (2009). *Cognitive Neuroscience: The Biology of the Mind (3rd Ed.).*United States of America: W.W. Norton and Company.

Halpern, D. F. (1986). *Sex Differences in Cognitive Abilities (1st Ed.).* New Jersey: Lawrence Erlbaum Associates, Publishers.

Harrison, B. (1990). Culture, Literature and the Language Classroom. In B. Harrison (Ed.) *Culture and the Language Classroom (1st Ed.).* Britain: Modern English Publications

Henson, R.N.A., Norris, D.G., Page, M.P.A. & Baddeley, A.D. (1996). Unchained Memory: Error patterns rule out chaining models of immediate serial recall. *Quarterly Journal of Experimental Psychology, 49*. 80-115.

Hitch, G.J & de Ribaupierre, A. (1994). Preface. In A, de Ribaupierre and G.J. Hitch (Eds.), *The Development of Working Memory (1st Ed).* East Essex: Laurence Erlbaum and Associates.

Hunt, E.B (1980). Intelligence as an information-processing concept. *British Journal of Psychology, 71.* 449-474.

Holly, D. (1990). The Unspoken Curriculum, or how language teaching carries cultural and ideological messages. In B. Harrison (Ed.), *Culture and the Language Classroom (1st Ed.).* Britain: Modern English Publications.

Huck, S.W. (2008). *Reading Statistics and Research (5th Ed.).* Tennesee: Pearson Education, Inc.

Israel, N. (2006). *Raven's Advanced Progressive Matrices within a South African context*. Unpublished Masters Research Report, University of the Witwatersrand, Johannesburg.

Jensen, A. R. (1998). *The g factor: The science of mental ability*. Westport, CN: Praeger.

Jensen, A.R. (2005). Mental Chronometry and the Unification of Differential Psychology. In R.J. Sternberg and J.E. Pretz (Eds.). *Cognition & Intelligence: Identifying the Mechanisms of the Mind (1st Ed).* United Kingdom: Cambridge University Press.

Kamin, L.J. (2006). African I.Q. and Mental Retardation. *South African Journal of Psychology, 36.* 1-9.

Kaufman, A.S. & Lichtenberger, E.O. (1999). *Essentials of WAIS-III Assessment (1st Ed.).* U.S.A.: John Wiley & Sons, Inc.

Klauer, K.J. & Phye, G.D. (2008). Inductive Reasoning: A Training Approach. *Review of Educational Research, 78.* 85-124

Lockwood, J.R., McCombs, J.S. & Marsh, J. (2010). Linking Reading Coaches and Student Achievement: Evidence From Florida Middle Schools. Educational Evaluation and Policy Analysis, 32. 372.

Logie, R.H. (1995). Essays in Cognitive Psychology: Visuo-Spatial Working Memory (1st Ed). United Kingdom: Lawrence Erlbaum Associates, Publishers.

Lohman, D.F. (2005). Reasoning Abilities. In R.J. Sternebrg and J.E. Pretz (Eds.). *Cognition & Intelligence: Identifying the Mechanisms of the Mind (1st Ed).* United Kingdom: Cambridge University Press.

Lopez-Higes, R.S., Valdehita, S.R. Aragoneses, M.T.M. & Del Rio, D. (2010). Interindividual Variability in Vocabulary, Sentence Comprehension and Working Memory in the Elderly: Effects of Cognitive Deterioration. *The Spanish Journal of Psychology, 13*. 75-88.

Lubinski, D. (2009). Exceptional Cognitive Ability: The Phenotype. *Behavioural Genetics, 39.* 350-358.

Lynn, R. (2002). Sex differences on the progressive matrices among 15-16 year olds: some data from South Africa. *Personality and Individual Differences, 33.* 669-673.

Lynn, R., Allik, J. & Irwing, P. (2004). Sex differences on three factors identified in Raven's Standard Progressive Matrices. *Intelligence, 32.* 411-424.

McNamara, J.K. & Wong, B. (2003). Memory for Everyday Information in Students with Learning Disabilities. *Journal of Learning Disabilities, 36.* 394-407.

Necka, E. & Orzechowski, J. (2005). Higher-Order Cognition and Intelligence. In R.J. Sternberg and J.E. Pretz (Eds.). *Cognition & Intelligence: Identifying the Mechanisms of the Mind (1st Ed).* United Kingdom: Cambridge University Press.

Nell, V. (1999). Standardising the WAIS-III and the WMS-III for South Africa: Legislative, Psychometric, and Policy Issues. *South African Journal of Psychology*, *29* (3), 128-137.

Oppenheimer, N. (1966). *Questionnaire Design and Attitude Measurement (1st Ed.).* London: Heinemann Educational Books.

Owen, K. (1992). The Suitability of Raven's Standard Progressive Matrices for various groups in South Africa. *Personality and Individual Differences, 13.* 149-159.

Philips, D.C. & Burbules, N.C. (2000): *Postpositivism and Educational Research.* Lanham & Boulder: Rowman & Littlefield Publishers.

Raab, M & Gigerenzer, G. (2005). Intelligence as smart Heuristics. In R.J. Sternberg and J.E. Pretz (Eds.). *Cognition & Intelligence: Identifying the Mechanisms of the Mind (1st Ed).* United Kingdom: Cambridge University Press.

Raven, J. (2004). *Raven's Advanced Progressive Matrices –Occupational User's Guide.* Oxford: Oxford Psychologists Press.

Reid, E. (1990) Culture and Language Teaching: ESL in England. In B. Harrison (Ed.), *Culture and the Language Classroom (1st Ed.).* Britain: Modern English Publications.

Robbins, D. (2001). *Education Pathfinders: A short history of the Joint Education Trust (1st Ed).* Johannesburg: Joint Education Trust.

Rosnow, R & Rosenthal, R. (1996). *Beginning Behavioural Research (1st Ed.).* New Jersey: Prentice Hall.

Rushton, J.P. & Skuy, M. (2000). Performance on Raven's Matrices by African and White University Students in South Africa. *Intelligence, 28.* 251-265.

Rushton, J.P., Skuy, M. & Bons, T.A. (2004). Construct Validity of Raven's Advanced Progressive Matrices for African and Non-African Engineering Students in South Africa. *International Journal of Selection and Assessment, 12.* 220-229.

Rushton, J.P., Skuy, M. & Fridjhon, P. (2003). Performance on Raven's Advanced Progressive Matrices by African, East Indian, and White engineering students in South Africa. *Intelligence, 31.* 123-137.

Scheurich, J.J. (1997). *Research Method in the Post Modern (1st Ed).* Great Britain: Falmer Press.

Siegel, L. S., & Ryan, E. B. (1989). The development of working memory in normally achieving and subtypes of learning disabled children. *Child Development, 60,* 973–980.

Shipman, M. (1997). *The limitations of social research (4th Ed.).* UK: Longman Group.

Skuy, M.A. (2003). *The Contribution of Intelligence, Learning Strategies, and Personal Development to Engineering Students' Academic Performance*. Unpublished Research Report submitted for the Degree of M.Ed. Johannesburg: University of the Witwatersrand.

Skuy, M., Gewer, A., Osrin, Y., Khunou, D., Fridjhon, P. & Rushton, J.P. (2002). Effects of mediated learning experience on Raven's matrices scores of African and non-African university students in South Africa. *Intelligence, 30.* 1-12.

Spearmans, C. (1904). General Intelligence: Objectively Determined and Measured. *The American Journal of Psychology, 15.* 201-292.

Spector, P.E. (1986). *Research Designs (1st Ed.).* United States of America: Sage Publications

Sternberg, R.J. (1977). *Intelligence, information processing, and analogical reasoning: The componential analysis of human abilities.* New Jersey: Lawrence Erlbaum and Associates, Inc.

Swanson, H.L., Kehler, P., & Jerman, O. (2010). Working Memory, Strategy Knowledge, and Strategy Instruction in Children with Reading Disabilities. *Journal of Learning Disabilities, 43.* 24-48.

Swanson, H.L. & O'Connor, R. (2009). The role of Working Memory and Fluency Practice on the Reading Comprehension of Students who are dysfluent readers. Journal of Learning Disabilities, 42. 548-576.

Swanson, H. L., & Siegel, L. (2001). Learning disabilities as a working memory deficit. *Issues in Education: Contributions From Educational Psychology, 7,* 1–48.

Valdes, J. (1990). The Inevitability of Teaching and Learning Culture in a Foreign Language Course. In B. Harrison (Ed.), *Culture and the Language Classroom (1st Ed.).* Britain: Modern English Publications.

Weismer, S.E., Tomblin, J.B., Zhang, X., Buckwalter, P., Chynoweth, J. G. & Jones, M. (2000). Nonword repetition performance in school-age children with and without language impairment. J*ournal of Speech, Language, and Hearing Research, 43*, 865-878.

Williams, B., Myerson, J. & Hale, S. (2008). Individual differences, Intelligence, and Behaviour Analysis. Journal of the Experimental Analysis of Behaviour, 90. 219-232.

APPENDIX A: STUDENT'S INFORMATION LETTER

Dear Student

Hello, my name is Tristan Paton and I am a Master's student at the University of the Witwatersrand. As part of my completion of my Masters degree in Educational Psychology I am researching the relationship between Working Memory and tertiary level academic success. Working memory has been found to be a better predictor of academic success than conventional I.Q. scales in children and thus seeing whether the same is true in an older academic population will be invaluable to the development of curricula and careers development programs.

Today I would like to invite you to participate in my study. Participation in the study is voluntary and will involve two aspects. Firstly, each student would be asked to complete a demographic questionnaire, an assessment that measures non-verbal intelligence and then finally an assessment that measures Working Memory. The entire process should take no longer than two hours. This will take place during the free time allocated for the afternoon lecture slot for Psychology that is reserved for make up lectures, should there be no need for these lecture slots to be used. The second part of the study would involve accessing each student's test, essay and exam results for the first half of the year, as well as each student's High School M-Score. All of the results and responses from the questionnaires will be kept anonymous and no raw scores will appear anywhere in the research. This is because the data will be captured under each participant's participant number (this will be linked to the student number by an external research aid not from Wits University). Only myself and my supervisor will have access to the raw scores and these will be kept in a secure location (a locked safe at my house) so as to ensure all participants confidentiality and anonymity. As such participation in this study will have no impact (negative or positive) on the participant's academic success and choosing to participate in the study or not will also not advantage or disadvantage any students. Any participants in the study may also ask to withdraw from the study at any time.

After the completion of the project group feedback can be given should any of the participants wish to know the findings of the project, however no individual feedback can be given. Please note that the results of this study may also be published in a scientific journal in the form of a journal article.

If you choose to participate in the study, your permission would also be asked to allow your data to be made archival, thus allowing future research to be carried out on the data. Anonymity will again be guaranteed in this case.

Kind Regards,

Tristan Paton

For any queries, please feel free to email me at tristanpaton@gmail.com or alternatively you can contact my supervisor (Prof. Kate Cockcroft) at kate.cockcroft@wits.ac.za.

APPENDIX B: CONSENT FORM

Student's Consent Form

I,_____, consent to participate in this study. I have read and understand the information letter and am aware of what participation in the study entails.

By participating in the study I give consent to the researcher to access my Psychology I results as well as my High School M-Score for use in the study.

Furthermore, I DO/ DO NOT (please circle the appropriate response) give permission for my data to become archival and thus be used in future studies at the University of the Witwatersrand.

Signature_____

Date_____

Student Number

APPENDIX C: DEMOGRAPHIC QUESTIONNAIRE

All responses are confidential. Please answer all questions as truthfully as possible.

Demographic Questionnaire

1) Student Code :

W	I	T	S			

2) Date of Birth (DD/MM/YYYY)_____

3) Age (years)_____

4) Gender 1☐ Male 2☐ Female

5) How many years have you been at University?_____

6) What degree are you currently registered for? (E.g. BA, BCom, BSc)_____

7) What other courses are you currently taking and at what level? (E.g. Philosophy I)?

_____

_____

_____

_____

_____

8) What High School did you attend (if more than one school, which was the last school)?

_____

9) Is the school a Government or Private School?

1☐ Government 2☐ Private 3☐ Semi Private 4☐Don't Know

10) What year did you matriculate?_____

11) What is your home or first language?* (please choose one)

1☐ English 2☐IsiZulu 3☐ IsiXhosa 4☐ Sepedi (North Sotho)

5☐ Sesotho 6☐ Setswana 7☐ Xitsonga 8☐ Tshivenda

9☐ IsiNdebele 10☐ Afrikaans 11☐ SiSwati

12☐ Other(s) _____

12) What is your ethnic group?*

1☐ White (Caucasian) 2☐ Black (African)

3☐ Indian 4☐ Coloured (mixed race)

5☐ Other (please specify) _____

*For statistical purposes

13) Have you ever suffered a traumatic brain injury?

1☐ Yes 2☐ No

If you answered "Yes", please explain the injury

_____

_____

14) Have you ever been diagnosed as having ADD (Attention Deficit Disorder) or ADHD (Attention Deficit Hyperactivity Disorder)?

1☐ Yes 2☐ No 3☐ Don't Know

If you answered "Yes", were you previously on any medication for ADD/ADHD?

15) Are you currently diagnosed as having ADD or ADHD?

1☐ Yes 2☐ No

If you answered "Yes", are you currently on any medication for ADD/ADHD?

1☐ Yes 2☐ No

16) Have you ever been diagnosed as having a learning disability? (E.g. Dyslexia, Dyscalculia)

1☐ Yes 2☐ No

If you answered "Yes", please explain the nature of the learning disability

_____

_____

17) Are you thinking of taking Psychology II next year?

1☐ Yes 2☐ No

18) If "Yes", are you thinking of taking Psychology as one of your majors?

1☐ Yes 2☐ No 3☐ Not Applicable

19) If “Yes”, do you want to pursue postgraduate studies in Psychology (i.e. Honours, Masters or Doctorate)?

1☐ Yes 2☐ No 3☐ Not Applicable

20) Would you like to pursue a career in the field of Psychology?

1☐ Yes 2☐ No

21) What is your handedness?

1☐ Right 2☐ Left 3☐ Ambidextrous

Standard of Living Questionnaire

The following questions relate to the Standard of Living in your neighbourhood, this is the area approximately 20 minutes walk or 2km from your house.

22) How do you describe your neighbourhood in terms of wealth?

1☐ Very poor 2☐ Poor 3☐ Average

4☐ Wealthy 5☐ Very Wealthy

23) Do you think people living outside your neighbourhood see your neighbourhood as being:

1☐ Very poor 2☐ Poor 3☐ Average

4☐ Wealthy 5☐ Very Wealthy

24) Which of the following statements do you think is true about your neighbourhood?

1☐ There is a **big** mix of living standards

2☐ There is **some** mix of living standards

3☐ **Most** households have the same living standards

4☐ **All** households have the same living standards

The next few questions are about the main type of housing in your neighbourhood. Please don’t talk about **your** house, but rather the houses that are **most common** in your **neighbourhood**.

25) What type of housing is most common in your neighbourhood?

1☐ Shacks

2☐ Government housing/ Flats (e.g. Municipal/ RDP housing)

3☐ Improved government housing/ flats (e.g. Extended Municipal/ RDP Housing)

4☐ Bond housing/ flats/ townhouses (need a bank loan to buy)

5☐ Other (Please specify in detail – housing type and ownership)

_____

26) How would you describe the general condition of most of the houses in your neighbourhood?

1☐ Very bad condition 2☐ Bad condition 3☐ Average condition

4☐ Good condition 5☐ Very good condition

27) Do most of the houses in your neighbourhood have gardens?

1☐ No 2☐ Yes

28) Do most of the people in your neighbourhood have a place to park their car near to their house, either in the garden or on the street?

1☐ No 2☐ Yes

29) Do most of the houses in your neighbourhood have fences or walls around their property?

1☐ No 2☐ Yes

30) If YES, which of the following are the fences/ walls mainly used for in your neighbourhood?

1☐ Status 2☐ Noise Prevention 3☐ Security

4☐ Privacy 5☐ Boundary 6☐ Don't Know

999☐ N/A (answered 'no' to previous question)

7☐ Other (please specify)_____

Thank you for your participation!

APPENDIX D: ETHICS APPLICATION

University of the Witwatersrand, Johannesburg

Application to the Human Research Ethics Committee (HREC Non-Medical)

Use this form in applying for clearance of research involving human participants ('human subjects'[1]).

Instructions

1. Completed applications must be submitted to the Research Office by the last day of the month for consideration at the meeting during the following month.
2. Incomplete applications will NOT be considered.
3. Applications will NOT be processed without signatures from supervisors (where relevant) and the Head of School/Unit.
4. Photocopying should be done 'back to back' to save paper.
5. All submissions and materials must be typed. Handwritten submissions are NOT acceptable. Glossy and fancy binding NOT necessary.
6. All appendixes, if any, must stapled to the ethics form and collated

The following documents must be included with your application as numbered appendices:

☑	**Check list**	**No. of copies required**
For all research:		
	Completed Ethics Application Form	**10**
	Copies of the research proposal	**4**
	Copies of proposed questionnaires/interview schedules	**4**
	Participant Information sheet	**4**
Where applicable (Attach to this form):		
	Acknowledgement of Informed Consent form (for participant's signature)	**4**
	Relevant permissions (from, e.g. company's HR department, National authorities such as Education, Correctional Services, etc.) or other legally required consent	**4**
	Any other required/appropriate release or consent forms (e.g.: Focus group participant consent form, consent to record (audio), model release (for video or photography), etc.	**4**
	Guardian consent form (for participants under the age of 14)	**4**
	Minor assent form	**4**
	Other (Please specify)	**4**

Declaration:

I recognise that it is my responsibility to conduct my research in an ethical manner according to Guidelines of the University of the Witwatersrand, according to any laws and/or legal frameworks that may apply, and according to the norms and expectations of my discipline.

In preparing this Application for Ethics Clearance from the University of the Witwatersrand, I have consulted the **Guidelines for Human Research Ethics Clearance Application /non-medical** (a separate document

[1] In place of the term 'human subjects', University of Witwatersrand prefers to use the term '(research) participants' in order to reflect the difference between the bio-medical sciences—where 'research subjects' is more appropriate—and the humanities and social sciences.

available on this web site http://web.wits.ac.za/Academic/Research/Applications.htm and have familiarised myself with the ethical guidelines specific to my discipline.

Signature	
Name of Researcher/Applicant	Tristan Khyall Paton

Researcher's personal data

Surname	**Paton**			**Name:**	**Tristan Khyall**				
Title (circle one):		**Prof**		**Dr**	**X**	**Mr**		**Ms**		**Other:**
Department/discipline	**Psychology**								
School	School of Human and Community Development								
University address	**1 Jan Smuts Street, Braamfontein**								
Staff / Student number	**0609510G**	**X**	**Full time**		**Part time**		**Staff**		
Your telephone(s)	**(011) 431-0328/ 083-380-2446**								
Your Email:	**tristanpaton@gmail.com**								
Name of Supervisor	**Professor Kate Cockcroft**								
Supervisor's email address	**kate.cockcroft@wits.ac.za**								
Supervisor's tel. number(s)	**011 717 4511**								

TITLE OF RESEARCH PROJECT
CAN WORKING MEMORY WORK FOR UNIVERSITY STUDENTS? THE RELATIONSHIP BETWEEN WORKING MEMORY AND ACADEMIC SUCCESS.

Is this research for degree purposes?					**X**	**Yes**		**No**	
If so, for what degree?		**Honours**	**X**	**MA**		**PhD**		**Other (specify):**	
Has it been approved by the relevant higher degrees committee or other relevant unit?		**Yes**		**No**	**X**	**Submitted & pending**			

Where will the research be carried out?
The University of the Witwatersrand, Johannesburg, South Africa.

What are the aims & objectives of the research relevant to human research participants (Please list; be brief)
This research project aims to investigate the predictive value of working memory scores on tertiary level academic success. The rationale behind this project is that in previous studies working memory has been found to be a better predictor of academic success than conventional I.Q. scales, as well as the fact that studies have shown that South African universities show below average pass rates. Thus, working memory assessments may help greatly in the formation of educational interventions and screening procedures. The study will be a quantitative study using first year Psychology students. All participants will be asked to complete questionnaires that will give demographic and socioeconomic information. An assessment of non-verbal intelligence will also be administered to enable the researcher to compare the results from the working memory assessment to more conventional I.Q. measures. Following that each participant will complete a computerized working memory assessment that will give data on each participant's phonological and visuospatial working memory. This data will be analyzed by running correlations and multiple regressions.

List the names and affiliations of any *additional* researchers who will be covered by this ethics protocol
Emma O'Toole and Viktoria Gunkel (Supervised by Dr. Yvonne Broom) as well as Nicole Israel (supervised by Prof. Kate Cockcroft) may potentially help with data collection as part of a broader project combining data sets. However, each researcher would apply for separate ethical clearance for their project.

Has appropriate formal permission been obtained, if required (e.g. employer, government department, land owner, etc.)?					
	Yes (attached)		Not required	X	Pending (must be supplied before permission is granted)

Do you have any financial or material interest associated with your research participants or with the organisations that you will work with during your research?					
	Yes, current	**X**	**No**		**Potential conflicts of interest may exist**
If yes, please explain how you will manage any existing or potential conflicts of interest. **N/A**					

Protocols submitted to the Committee must have sufficient information to enable the committee to judge the ethical implication of the proposed research. Please be brief and concise but also as specific and informative as possible.

How will data on human research participants be collected (techniques, methods, procedures)? Be brief but specific	
X	Formal interviews using questionnaires, schedule/list of questions, or formal protocol (**Attach all questionnaires, schedules, etc.**)
	Informal interviews, semi-structured or open ended interviews (**Attach interview protocol, or guidelines**)
	Ethnographic observation, participant observation, other informal descriptive and / or interactive methods
	'Focus group', seminar/discussion group, or other group-orientated research
	Community-based, participant, or 'action research' methods or technique such as drama workshops, community theatre, training workshops, participant rural appraisal (PRA), rapid rural appraisal (RRA), etc.
	Research on/in therapeutic or counselling contexts
	Observation of public performance, and/or public behaviour observation
	Photography, video and/or audio recording (**specific separate consent forms may be required**)
	Mapping or other techniques that involve direct interaction with participants (otherwise exempt)
X	Other research methods or techniques—explain below.
Details: The study will use a computerised working memory assessment (the AWMA), a nonverbal I.Q. measure (the Raven's Advanced Progressive Matrices) as well a Demographic questionnaire that will cover general demographic information as well as information relating to socioeconomic status and any medical complications that may effect academic performance.	

How will informed consent be obtained?	X	Formal (Signed form)		Informal or Verbal		Other (e.g. public speech)
Explain your strategy for ensuring informed consent						
All potential participants in the research project will be approached and told briefly the nature of the project, what participation will require of them, the time that the data collection process will take, that participation is voluntary and that any participant can withdraw at any time, that participation will not result in any positive or negative effects. Participants will also be given all of the above in the form of a letter from the researcher. On this letter the researchers contact details will be given should any participant wish to contact the researcher to ask any further questions. A consent letter will be given to each participant to sign before starting data collection with this again highlighting some of the important information regarding the research. Once signatures have been obtained only then data collection will begin. Should any of the participants be under the age of 18, then parental consent forms will also be sent out to be signed.						
Attach participant's information sheets, informed consent forms, and/or other related materials						

NB*: informed consent* in the social science and humanities research involving human participants
Where informal ethnographic or participant observation methods are used, or where signed Informed Consent forms are not possible, or for research involving group contexts (focus group, Participant Rapid Assessment,

Rapid Rural Appraisal, public performance, workshops) **state how the quality of informed consent will be assured**. It is essential that direct participants in research be fully informed and agree on this basis to participate in research.

Who will the research participants be?					
Age range?	+/- 18 years old and above.				
Does this research expose either the participant or the researcher to any potential risks or harm that they would not otherwise be exposed to?			Yes	X	No
Will research involve vulnerable categories?			Yes	X	No
If so, state which ones:	N/A				
How will participants be selected and approached?	Participants doing only the Psychology I Course at the University of the Witwatersrand will be selected and approached by the researcher during class time in a time that is least disruptive for the lecture (such as at the end of the lecture)				
How will any existing vulnerabilities among research participants be addressed?	N/A				

NB: The term 'Vulnerable categories' includes, among others, children under 14, orphans, prisoners, persons with cognitive or communication disorders, people who are traumatised or currently in traumatic situations.

Can **confidentiality** be guaranteed?	X	Yes		No
Can **anonymity** be guaranteed in resulting reports, theses and/or publications?	X	Yes		No
Explain how this will be done? What will participants be told in this regard?				
Confidentiality can be guaranteed by the secure storage of the raw data by the researcher. Also, each participant's student number will be linked to participant numbers, with all of the data being captured only under the participant numbers. Access to the information linking the participant numbers to the student numbers will only be given to a research assistant (external to Wits) who will capture all of the data. As only the results of statistical analyses will appear in any reports, theses and/or publications the participant's results will not appear and thus anonymity will be guaranteed in this regard.				

NB: While confidentiality may be desirable, it cannot be guaranteed in, for example, focus groups, or ethnographic observation. Similarly anonymity should be preserved in questionnaires, but cannot be offered in workshop methodologies, focus group research, etc. All data however should be kept confidential and safe from unauthorised access once it has been collected. Informants should have the right to remain anonymous in the final report, and this must be respected in handling of all data relating to them.

What is to be **done with the research data** after completion of the project?
As the researcher would like the data to be made archival and thus possible to be used in future research by the university the data would be stored in a secure location (a locked cupboard in my supervisor's office) by the university after the completion of the project. However, whether the data will be allowed to be used archivally or not it will be kept in a secure location should it be needed for reanalysis or reinvestigation at a later stage (i.e. Should the researcher decide to publish the research). For purposes of the research project, the raw data will be correlated with first year and Matric scores.

NB: 'Raw' or unprocessed data, especially **where the identity or personal data of research participants is included, must be safeguarded** and preserved from unauthorised access. Data may be destroyed after use, but **preservation in an archive or personal collection** may also be appropriate, desirable or even essential. For instance, data sets that contain **historically important information** or information that relates to **national heritage** must be preserved and should be placed in a public archive where possible and appropriate.
All data should be preserved in a way that **respects the nature of the original participants' consent**.

10. How will the results be **reported**, and who will have access to this/these?
The end results of the research will be reported in the researcher's research report. Should any of the participants in the study request feedback from the study a summary can be emailed to them once the study has been completed. The summary will only show the statistical calculations and results of the

study and no feedback in terms of raw scores will be given to any participants. Following the completion of the project the results may be reported in a journal article should the research be published and thus readers of either the research or any subsequent publications will have access to the results.

SIGNATURES (REQUIRED)

In signing this form, the researcher and supervisor (if any) of this project undertake to ensure that any amendments to this project that are required by the Human Research Ethics Committee are made before the project commences.

Declaration: We, the signatories, declare that all information on this form is correct and that we will strive to maintain the highest ethical standards in this research, according to disciplinary and university expectations at all time, recognising that ethical practice in research is always a continuing process.

	Date	Name	Signature
Applicant			
Research **Supervisor**'s name & signature (for students)			
Dept/**Unit Head**'s name & signature			

APPENDIX E: ETHICAL CLEARANCE CERTIFICATE