TITLE: WORKING MEMORY AND DIVERGENT THINKING AS PREDICTORS OF ACADEMIC ACHIEVEMENT: EXPLORATORY STUDY

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by
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Declaration

I, Jaime Abrahams hereby declare that this research is my own work entitled: "Working Memory and Divergent Thinking as predictors of Academic Achievement: Exploratory study". I declare that this research report is purely my own work. It has not been submitted before for any other degree or study that may be related to it at this university or any other institution. This research is submitted in partial fulfilment of the requirements for the degree of Masters in Education (Educational Psychology) at the University of the Witwatersrand, Johannesburg.

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Jaime Abrahams

Date: 07 December 2018

Dedication

This thesis is dedicated to my beloved father, Pastor Neil Abrahams. May your sweet soul rest in peace as you rest in the arms of your Saviour, Yeshua. You will be missed and loved always.

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I would like to acknowledge and give thanks to the following:

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Abstract

This study explored the relationship between working memory, divergent thinking and academic achievement. The aim was to determine which variable (working memory or divergent thinking) better predicts academic outcomes within the context of Johannesburg, South Africa. In addition to this, the study explored the relationship of gender, types of schooling (public and private) as well as socioeconomic status with the aforementioned variables. Participants were 65 school learners across three schools (2 public and 1 private). Participants included were English first and second-language speakers, all however being educated in English. Results showed that (1) divergent thinking had a greater impact on academic achievement than working memory, it was found that as divergent thinking abilities increased academic achievement scores decreased; (2) no significant relationship between working memory and academic achievement was found; (3) gender had an influence on academic achievement, in favour of females; and (4) socioeconomic status and academic achievement were negatively correlated. The researcher then split the sample into two groups, one being participants from public schools and the other being participants from private schools. When split it was found that (1) divergent thinking significantly correlated with academic achievement in the private school; (2) socioeconomic status had a significant relationship with working memory in the government schools; and (3) gender had a significant relationship within the private schooling system with working memory and academic achievement. The findings provide a theoretical contribution in understanding the relationship between these variables and thereby potentially impacting on how academic achievement is understood.

Key Words: working memory; divergent thinking; academic achievement; socioeconomic status; gender; types of schooling; South Africa

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CHAPTER 1

Working Memory and Divergent Thinking as predictors of Academic Achievement: Exploratory Study

Academic achievement is essential as it is predictive of many variables that have an impact on an individual's personal life (Bissonnette, 2000) such as further educational and occupational success (Flashman, 2011). Due to the importance of academic achievement as it has prolonged effects on one's future, it is essential to investigate factors which contribute to its success in order to facilitate optimal performance of learners. Previous research has suggested that academic achievement is influenced by both working memory (Alloway & Alloway, 2010; Alloway, Gathercole, Willis & Adams, 2004; Baddeley, 1992; Gropper & Tannock, 2009; La Lopa & Hollich, 2014; Swanson & Sachse-Lee, 2001) and divergent thinking (Cohen, 1975; Plucker, Beghetto, & Dow, 2004; Runco & Acar, 2012).

Working memory refers to one's ability to mentally hold information and then use and handle this information in a short period of time (Alloway, 2011). This construct has been found to correlate with academic achievement (Alloway & Alloway, 2010) and is responsible for complex cognition as well as reasoning (Baddeley, 2007). Working memory is indicative of a child's ability to learn, fluid intelligence (Berk, 2009), rather than what they have learned already, crystallized intelligence (Berk, 2009). Thus, could be argued to be relatively unbiased as it is not dependent on previous education or socioeconomic status (Cockcroft, 2015), which makes it particularly applicable in the South African context as children's environments vary significantly.

Divergent thinking on the other hand refers to the construction of numerous solutions to a single stimulus or problem (Yamada & Nagai, 2015). In a study conducted it was found that

cognitive flexibility is an underlying mechanism which contributes to the production of divergent thinking (Ritter & Mostert, 2016). According to Guilford (1967) flexibility enables an individual to re-explain and regroup information thus facilitating divergent thinking. Divergent thinking has been related to the concept of creativity and is argued to be the main ingredient of it (Runco & Acar, 2012; Southard, 2014; Vincent, Decker & Mumford; 2002). Creativity has also been associated with academic achievement (Anwar, Aness, Khizar, Naseer & Muhammad, 2012; Cohen, 1975; Runco & Acar, 2012). Measures used to assess divergent thinking and creativity seem to explore the same constructs such as fluency, flexibility, originality and elaboration (Kim, 2006), therefore these terms tend to be used interchangeably. Thus, one could argue that if creativity has been found to correlate with academic performance then so should divergent thinking.

It is clear that working memory and divergent thinking are both associated with academic achievement, however seen that these constructs seem to differ conceptually, it is important to ask which construct is the most important contributor to academic achievement. This study intends to find out the potential contributions of working memory versus divergent thinking into academic achievement. In order to achieve this aim this manuscript follows the outline described below.

This study looked at the different models concerned with divergent thinking and working memory as well as how these variables are associated with academic achievement in South African schools in Johannesburg, Gauteng. The effects of socio-economic status as well as types of school, such as private verses government schooling will be explored in more detail.

This report is divided into seven chapters. Chapter two will cover the theoretical background of working memory and divergent thinking, it also explores academic achievement

as well as socio-economic status, gender and the effects thereof. Thereafter the rationale of the study as well as the research questions will be introduced. The third chapter covers the methodology which describes the design used, which is non-experimental, cross sectional, correlational and quantitative in nature. It also provides a brief description of the measurements used to assess the variables involved in this study, which includes Guilford's Alternate Uses Test, school reports, working memory subtests of the Wechsler Intelligence Scale for Children as well as a biographical questionnaire used to measure socioeconomic status. It also describes the population sample used to perform this study. The fourth chapter provides a detailed summary of the results obtained using statistical analysis. Chapter five offers a detailed discussion of the findings. Chapter six and seven describes limitations, recommendations as well as the conclusion of the study.

CHAPTER TWO

LITERATURE REVIEW

This research looked at predictors of academic achievement namely working memory and divergent thinking. It also aimed to explore demographic variables such as socioeconomic status and gender. In order to accomplish this task, one must have a good understanding of the various variables included in this study specifically looking at the South African context. Thus, the first area of the literature review covers working memory followed by divergent thinking. Following from this it is important to conceptualise the term academic achievement. In addition to these the literature review will explore socioeconomic status and gender.

2.1. WORKING MEMORY

Working memory is the capability of an individual to take in information, hold the information and then to control, direct and use the information (Baddeley, 1992). Working memory requires the synchronized storage and processing of information and is necessary for learning, reasoning as well as for understanding information (Baddeley, 1992). It is believed to be a transient storage facility which regulates and promotes complex cognition all of which is under attentional control (Baddeley, 2007). Working memory is considered to form part of what is referred to as 'executive functioning' which refers to higher order cognitive processes which manage and control cognition (Ilkowska & Engle, 2010).

Several working memory models have been proposed by various theorists (Miller, Galanter & Pribram, 1960; Atkinson & Shiffrin, 1968; Baddeley, 1992). Atkinson and Shiffrin (1971) proposed a model in which they described the working of a unitary 'short term store', which was described as a mechanism in which information is stored and

controlled temporarily. Baddeley and Hitch expanded on this idea in 1974 and proposed the idea of working memory instead of what Atkinson and Shiffrin called the 'short-term store', due to their somewhat limited understanding of this component of memory (Baddeley & Hitch, 1974; Baddeley, 1992). For the purposes of this study Baddeley and Hitch's model will be used as it has become the most influential model to date (Baddeley & Hitch, 1974; Baddeley, 1992).

Baddeley and Hitch proposed a three-component system to describe working memory which include the central executive component and the two subsidiary systems namely, the visuospatial sketchpad component and the phonological loop (Baddeley & Hitch, 1974; Baddeley, 1992). The central executive component controls the entire system by directing attention, the visuospatial sketch pad component is presumed to influence visual and spatial information and the phonological loop holds and reviews speech based information (Baddeley, 1992). The main task of the central executive component is that of control and coordination of the visuospatial sketch pad and the phonological loop and in addition to this it has been found to play a role in selective attention and inhibition as well (Baddeley, 1992; Alloway, Gathercole, Willis & Adams, 2004).

The visuospatial sketchpad is divided into two components, that being the spatial component which involves the occipital lobe and visual component which involves the parietal lobe (Baddeley, 1992). The two components of the visuospatial sketchpad are supported by neuropsychological evidence in which patients have presented with varying difficulties such as being unable to recognise visual aspects (visual component) such as shape and colour but are able to describe locations and routes (spatial component) (Baddeley, 1992).

The phonological loop is made up of two sections namely a phonological store and an articulatory control process (Baddeley, 1992). The phonological store holds verbal data and the articulatory control process acts as an internal voice that repeats sounds (Baddeley, 1992). The phonological loop undertakes two functions, stores auditory information as well as material which has been presented visually such as the written word, is associated with speech perception and production systems and in addition to this has been found to play a role in language acquisition (Baddeley, 1992; Alloway, Gathercole, Willis & Adams, 2004).

Later, Baddeley added another element to his model which he named the episodic buffer (Baddeley, 2000) (see figure 1). Controlled by the central executive, the episodic buffer executes multiple tasks such as holding, binding and incorporating data in addition to linking long term memory (Baddeley, Allen, & Hitch, 2011).

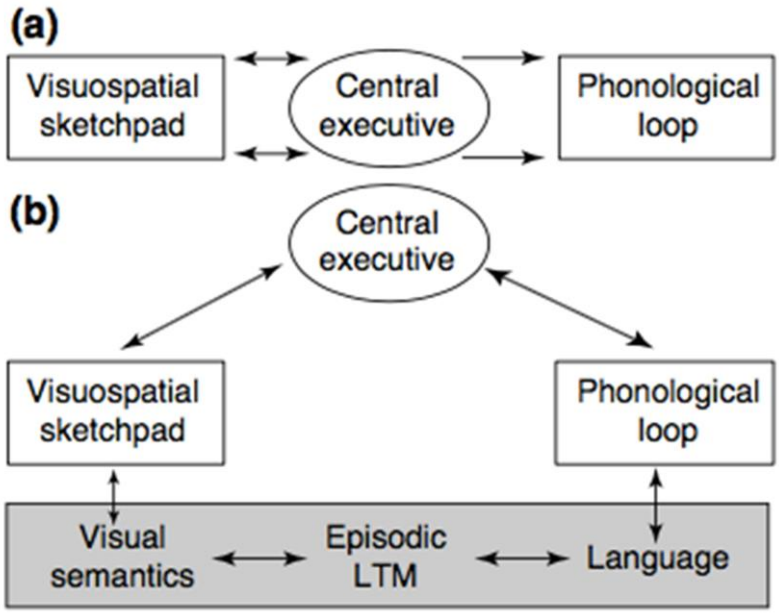

Figure 1: Working Memory Model (Baddeley, 2000).

Baddeley and Hitch's model has been criticised and it has been suggested that there is not sufficient evidence available to claim that the central executive function of working memory exists (Parkin, 1998), however brain imaging studies support Baddeley's model of working memory (Smith & Jonides, 1998; Collette & Linden, 2002; Baddeley, 2007).

Working memory plays an essential role in various aspects of one's life including assisting in maintaining attention, mathematical and language skills and, therefore, is fundamental to academic achievement (Baddeley, 1992; Swanson & Sachse-Lee, 2001; Gropper & Tannock, 2009; Alloway & Alloway, 2010; Alloway, Gathercole, Willis & Adams, 2004). Working memory is fundamental in the classroom as it is required for storage and mental manoeuvring of information which is needed for the attainment of multifaceted abilities and knowledge (Cockcroft & Dhana-Dullabh, 2013).

Working memory abilities can predict academic attainment, more specifically links between working memory, reading, comprehension and mathematics abilities have been identified (Alloway & Alloway, 2010; Gropper & Tannock, 2009; Alloway, Gathercole, Willis & Adams, 2004). A study has confirmed that scholastic achievement can be better predicted by working memory than IQ, as learners with an average IQ may still underperform, therefore learning potential is associated with working memory (Cockcroft & Dhana-Dullabh, 2013). In places with great diversity (eg. linguistic, socioeconomic status etc.) where IQ tests are considered to be biased (Lucas, 2013), the measurement of working memory could therefore be argued to be fairer. According to Cockcroft (2015) working memory is an unbiased measure of a child's ability as it is not influenced by previously learned material or environments in which the child is growing up in. However, opposing

the idea of the fairness of working memory, there has been evidence which suggest that working memory measures are not as culturally fair as suggested. Crawford, Gray and Allan (1995) have explored the results of different individuals when measuring working memory abilities utilising the Digit Span subtest in the Wechsler measures. They suggest that Digit Span achievement is affected by one's articulation and accent (Crawford, Gray & Allan, 1995) thereby implying that measures used to assess working memory is not as culture fair as thought. In a study conducted it was found that in languages which digits take longer to pronounce the amount of digits retained reduced, thereby negatively affecting the working memory totals (Ellis & Hennelly, 1980), thus variances can be ascribed to average pronunciation rates for digits (Crawford, Gray & Allan, 1995).

Working memory is necessary in the schoolroom as it is required for a variety of tasks (Alloway, Gathercole, Kirkwood, & Elliott, 2009) such as mathematical abilities (Swanson & Sachse-Lee, 2001; Gropper & Tannock, 2009, Bull & Scerif, 2001) and reading comprehension (Daneman & Carpenter, 1980). Links have been made between working memory and mathematical skills and in studies it was found that poor results on calculation and word problems was related to poor working memory abilities (Swanson & Sachse-Lee, 2001; Gropper & Tannock, 2009, Bull & Scerif, 2001). Daneman and Carpenter (1980) found that working memory plays a vital part in gaining meaning from written text and reported that individuals with a higher working memory span were better at reasoning and finding meaning from written language.

In this section the researcher has presented the concept of working memory which included the definition of working memory, models of working memory as well as how working memory impacts on learning. The section to follow will present divergent thinking

and will be presented in a similar way, presenting a definition as well as links between divergent thinking and creativity and lastly the effects of divergent thinking on learning.

2.2. DIVERGENT THINKING

The structure of the intellect was articulated in the 1950's by Guilford and later refined to a three-way organisation of intellectual abilities proposed and structured to incorporate and categorize intellectual aptitude features (Guilford & Hoepfner, 1966). These three areas proposed by Guilford included operation, content and product dimensions (Guilford & Hoepfner, 1966). Each of these dimensions include subcategories (Guildford, 1960).

The operations dimension deals with process or, in other words, activities, which the individual does with raw materials or how the individual categorises (Guilford & Hoepfner, 1966). The operations dimension includes five processes which are cognition, memory, evaluation and convergent and divergent operations (Guilford & Hoepfner, 1966). The content dimension includes, "broad classes or types of information discriminable by the organism" (Guilford & Hoepfner, 1966, p.3). The content dimension includes four areas of information which are figural, symbolic, semantic behavioural to which the human intellect applies the above mentioned 5 processes (Guilford & Hoepfner, 1966). The third dimension of the human intellect is referred to as the product dimension and it is described as "forms that information takes in the organism's processing of it" (Guilford & Hoepfner, 1966, p.4). This dimension is made up of products which increase in complexity and includes "units, classes, relations, systems, transformations and implications" (Guilford & Hoepfner, 1966, p.4).

Divergent thinking falls under the operations dimension and is highly involved with creative abilities (Guilford & Hoepfner, 1966). Divergent thinking involves much examining

which allows thinking going off in a number of directions resulting in a variety of conclusions (Guilford, 1956). In contrast to this, convergent thinking results in a unique solution or assumption, in other words one possible answer such as multiple-choice questions (Guilford, 1956). Divergent thinking contributes to the generation of remote associations, and in contrast convergent thinking, enables one to choose an answer therefore it is argued that both are needed for idea production (Yamada & Nagai, 2015).

Cropley and Cropley (2010) propose that there are various stages to the production of ideas and that both divergent and convergent thinking are necessary at different phases in the process. They suggest a seven-phase model where convergent thinking is utilised during a preparation phase, which is concerned with crystallised knowledge and pertinent task oriented information, as well as a stage of validation, which is concerned with evaluating the ideas generated from divergent thinking (Cropley & Cropley, 2010). Another perspective proposed suggests that the generation of many ideas requires divergent thinking, however when narrowing these ideas to find a conclusion then requires convergent thinking, in other words divergent thinking is the generation of ideas and convergent thinking is the evaluation and criticism of these ideas (Yamada & Nagai, 2015).

Divergent thinking is often used interchangeably with creativity, however there is a slight difference between these concepts. Researchers have found that creativity and divergent thinking are linked with each other, more specifically that divergent thinking is the main ingredient of creativity and that it results in creative problem solving (Runco & Acar, 2012; Southard, 2014; Vincent, Decker & Mumford; 2010). Divergent thinking has been found to be associated with creative thinking as well as problem solving (Gilhooly, Fioratou, Anthony & Wynn, 2007), however, creativity itself requires “redefinition abilities which include transformations of thought, reinterpretations, and freedom of functional fixedness in

driving unique solutions" (Kim, 2006, p. 4). Divergent thinking abilities provide an estimate of creative potential of individuals (Runco & Yoruk, 2014). Measures which assess both creativity and divergent thinking evaluate the same constructs which include fluency, flexibility, originality and elaboration (Kim, 2006) all of which contribute to an individuals' productive abilities (Nusbaum & Silvia, 2010) and therefore these terms tend to be synonymous.

Convergent and divergent thinking is believed to be led by parallel attributes, however in a study conducted it was found that divergent thinking was related to linking aspects of the intellect and that convergent thinking was related to executive functioning (Nusbaum & Silvia, 2010). The linking aspects imply that when an individual who is relying on their divergent thinking abilities is given a particular task, this task will link to previously learned ideas which will then connect to other ideas thus creating associations (Nusbaun & Silvia, 2010). Research however has suggested that divergent thinking is related to executive tasks which rely on controlling interference (Nusbaun & Silvia, 2010). For example in order to generate an idea in the Guilford Alternate Uses Test an individual has to control interference such as; the knowledge of what the particular item is specifically used for, getting stuck on what exactly the object looks like, and one's own previous answer, all of which may prevent abstract thought; and therefore the argument arises that in order to successfully complete a divergent thinking task executive control, inhibition and switching, is fundamental (Gilhooly, Fioratou, Anthony & Wynn, 2007).

In a study conducted utilizing the Alternate Uses Test, various strategies were identified to be related to divergent thinking. These included memory responses, which were pre-existing ideas which did not require creative thought, once these resources were exhausted additional strategies were needed in order to produce more novel ideas (Gilhooly, Fioratou,

Anthony & Wynn, 2007). Property use production is an additional strategy which involves the evaluation of particular properties of an item and then the search for uses applicable to these specific properties identified, for example using a tissue box as a pillow purely based on its dimensions (Gilhooly, Fioratou, Anthony & Wynn, 2007). Property use production involves two stages, the first stage evaluating properties of the target object and the second involving searching one's memory for uses and functions of the properties observed (Gilhooly, Fioratou, Anthony & Wynn, 2007). The disassembly strategy involves breaking the item up into its individual parts and then evaluating these, for example a flower may be broken up onto a stem, leaf and petal and then each of these may utilised as an idea for property use (Gilhooly, Fioratou, Anthony & Wynn, 2007). The last strategy identified was that of broad use production which assessed general categories of usage, for example modes of communication (Gilhooly, Fioratou, Anthony & Wynn, 2007).

Creativity was found to be associated with scholastic success (Plucker, Beghetto, & Dow, 2004). Therefore, as mentioned above that divergent thinking is the main ingredient of creativity (Runco and Acar, 2012; Southard, 2014; Vincent, Decker & Mumford; 2010), one could argue that if creativity is dependent on divergent thinking and is associated with the same cognitive processes then divergent thinking should also be associated with scholastic success. However, contrary to this, Fugate, Zental and Gentry (2013) found that divergent thinking was associated with inattention, distractibility and results in obstacles to learning therefore there is no consensus with regard to the relationship between creativity and academic achievement as this relationship is a complex one (Ai, 1999).

One could argue that if working memory is part of executive functioning (Ilkowska & Engle, 2010) and divergent thinking is also reliant on executive cognition (Nusbaum & Silvia, 2010) such as inhibition and switching (Gilhooly, Fioratou, Anthony & Wynn, 2007),

then one might assume that these concepts tap into similar cognitive functions and therefore should correlate and should both then affect academic achievement which will be explored next.

Both working memory and divergent thinking have been explored, in the following section the researcher will discuss academic achievement, commencing with the definition of academic achievement, followed by the ways in which academic achievement is measured. Thereafter variables which have an effect on academic achievement will be explored.

2.3. ACADEMIC ACHIEVEMENT

Academic Achievement speaks to the results obtained that show the level to which an individual has attained particular outcomes that were the focal point of tasks in situations such as places of learning, particularly in school and college (Steinmayr, Meibner, Weidinger, & Wirthwein, 2014). Standardised tests, academic tests and observations by teachers are ways in which academic achievement is measured (Tomporowski, Davis, Miller, & Naglieri, 2008).

There are cognitive and non-cognitive factors which have an impact on academic achievement. Non-cognitive factors which affect academic achievement include motivation (von Stumm, Hell, & Chamorro-Premuzic, 2011), socioeconomic status, parental education (Magnuson, 2007), and gender (Hubbard, 2005). Another factor is that of the parental relationship. A study found that the relationship status of parents affected academic outcomes in such that children with parents who were separated or divorced performed significantly lower than their peers from intact families regardless of socioeconomic status (Cherian, 1989).

There has been an ongoing debate with regards to differences observed as a result of gender, studies have been conducted to establish why these differences occur such as investigating hormonal influences, neuroanatomical functions and environmental aspects (Muglia Wechsler et al., 2014). A study found that females' academic achievement as well as class attendance surpassed that of their male counterparts (Hubbard, 2005). In another study exploring the relationship between gender and academic achievement it was found that males performed much better on tasks such as multiple choices questions whereas females performed better of questions requiring free responses (Bolger & Kellaghan, 1990). According to Klein (2004) various factors contribute to gender differences in achievement such as socialisation and biological factors. In a study to explore the differences in achievement it found that it was not the students gender which contributed to the differences but that the gender of the educator accounted for the differences observed (Klein, 2004), thereby challenging the argument of gender differences in academic achievement. It has been argued that if gender differences exist it is unknown the cause of these variations and further studies need to be conducted (Muglia Wechsler et al., 2014).

Another factor found to impact on academic achievement is the type of school learners attend (Mburu, 2013). A study conducted in Kenya found that students in private schools yielded better results than those in a government school (Rong'uno, 2017), and that students attending same-gender schools (as opposed to co-ed) had better results (Mburu, 2013). The author argued that in mixed gender schools' boys tend to dominate discussions, appear to receive more encouragement with regards to work and teachers tend to perpetuate gender stereotypes that males are superior to females Mburu (2013).

Cognition, which is a term used to describe one's ability to learn, is made up of various processes which impact on academic achievement (Tomporowski et al., 2007). With regard

to cognitive factors which affect academic achievement they include cognitive flexibility (Kercood, Lineweaver, Frank & Fromm, 2017), attention (Steinmayr, Ziegler & Träuble, 2010), reasoning (Nnorom, 2015), and working memory (La Lopa & Hollich, 2014). There has been much research done exploring the relationship between academic achievement and working memory (Alloway & Alloway, 2010; Alloway, Gathercole, Willis & Adams, 2004; Baddeley, 1992; Gropper & Tannock, 2009; La Lopa & Hollich, 2014; Swanson & Sachse-Lee, 2001), and minimal research done exploring the links between academic achievement and divergent thinking (Cohen, 1975; Plucker, Beghetto, & Dow, 2004; Runco & Acar, 2012).

Working memory, divergent thinking and academic achievement have been explored. It is important to view these variables within a specific context, as individual contexts might impact on them, thus socioeconomic status and the impact thereof will be explored.

2.4. SOCIOECONOMIC STATUS

Socioeconomic status (SES) refers to an individual's place in society based on various aspects such as work, income and education. SES takes into account one's education level as well as position of work and the economic standing which refers to the amount of money one earns (Berk, 2009). SES in some definitions also include the material objects which are present in a household such as the access to books or computers (Sirin, 2005).

In the United States of America, individuals of colour largely made up the lower SES groups, whereas Caucasians made up the middle and upper classed groups. The results obtained from these studies gave rise to the nature/nurture debate of intelligences. It postulated that if differences were found, it could mean that either genetic hereditary characteristics differ with SES groups and colour groups or it could indicate that certain

groups lacked resources which gave rise to achievement (Berk, 2009). Brooks-Gunn and Duncan (1997) argue that families from higher SES standings were able to offer better opportunities which benefited their children greatly and that children from lower SES communities did not have the same access to the same types of resources and therefore are at risk developmentally.

There are various factors of SES influencing educational achievement one of which is home support, this construct is impacted by parental level of education and allows for parents to help their child with his or her homework. Having a high level of education possibly results in the ability to provide better schooling opportunities for their children as well as provide their children with the opportunity to live in neighbourhoods which are safe and conducive to optimal development (Taylor & Yu, 2009). In a study conducted it was found that maternal level of education had a greater impact on children's achievement than that of paternal level of education (Bradeley & Corwyn, 2002).

In a report conducted by James Coleman (1966) it was found that when individuals from a lower SES were concentrated in the same institution, attitudes which were not conducive to achievement at school as well as disruptive behaviour arose, therefore it was proposed that social configuration of schools affected outcomes. Schools generally located in areas which were found in lower SES communities were under resourced thus impacted on achievement (Taylor & Yu, 2009). In South Africa research suggested that in the year 2000 socioeconomic differences in educational achievement were still prevalent (van der Berg, 2008) and sadly still seems to be the case even two decades after the abolishment of apartheid (Bayat, Louw & Rena, 2014). Taylor and Yu (2009) argued that in South Africa SES served as a determining factor of reading abilities, they also found the lower SES

learners experienced great difficulty in overcoming disadvantages which were inflicted on them as a result of the previous regime.

The level of scholastic success attained is highly affected by the quality of education received which is directly influenced by one's socioeconomic status (Shuttleworth-Edwards et al., 2004). In South Africa which is a highly unequal society, the hierarchical arrangement of society due to historical events was based purely on the colour of one's skin, these arrangements included the access to wealth, services as well as quality education. Therefore, in South Africa as a result the effects which still are experienced today is that SES is scattered along racial lines (Taylor & Yu, 2009). However, since apartheid has been abolished there have been vastly different scholastic opportunities available pending on one's economic status which is not always determined by colour (Shuttleworth-Edwards et al., 2004). Therefore, one could argue that quality of education differs both throughout and within ethnic groups which have huge impacts on both scholastic and cognitive attainment (Shuttleworth-Edwards et al., 2004). In a study conducted in the Western Cape, South Africa it was found that the majority of under-resourced leaners were from local black and coloured households (Bayat, Louw & Rena, 2014). These learners not only attended schools which lacked important resources but also came from households which were more likely to be overcrowded, have a lowered parental/caregiver level of education, lack parental involvement, have inadequate access to basic services, lack sufficient nourishment, have a lowered attendance rate and reside in unsafe neighbourhoods all of which have negative consequences on academic achievement (Bayat, Louw & Rena, 2014).

During apartheid, the Department of Education and Training (DET schooling) organised schooling for black learners which had minimal resources and its own syllabus, their white counterparts on the other hand had access to private schooling which followed the British

curriculum (Shuttleworth-Edwards et al., 2004). During this time, the schools provided for the black students had to endure high teacher-to-pupil numbers, reduced wages, unqualified educators, insignificant extra mural events, inadequate space, desks and reading and writing supplies (Shuttleworth-Edwards et al., 2004). Subsequently, black south Africans have now been integrated into the private schooling system as a result of increased economic statuses, however the majority remain in the schools previously known as the DET schools which are still under resourced (Shuttleworth-Edwards et al., 2004). The discrepancies in access to quality education affects the achievement of the learners, it is expected that learners who are enrolled in private schools have better knowledge of English and improved reading abilities as well as test taking skills (Shuttleworth-Edwards et al., 2004). Thus, this study aims to establish whether quality of education, which is referred to types of schooling in this study, has an impact on cognitive abilities such as working memory and divergent thinking.

2.5. RATIONALE

Academic achievement is a determining factor when decisions need to be made such as progressing to the next grade, gaining entry into tertiary institutions and even decisions about future careers, therefore could be argued to be very important in one's life (Bissonnette, 2000).

Over the past few decades many cognitive psychologists have looked into the various factors which contribute to poor academic achievement (Gathercole, Lamont & Alloway, 2006). Consistent findings in research suggest that academic achievement has been linked to IQ and Working Memory (Gathercole, Lamont & Alloway, 2006; Alloway & Alloway, 2010). Working memory abilities are predictive of academic attainment (Alloway & Alloway, 2010) and is suggested to be unbiased (Cockcroft, 2015) which is significant in the

context of Southern Africa due to the fact that it is a country in which there are varying cultures and languages. Working memory is proposed to be the mechanism which allows learners to track directives for activities, understand written language and complete complicated mathematical tasks (La Lopa & Hollich, 2014) all of which is essential in the classroom environment.

Divergent thinking has been linked to creativity (Runco & Acar, 2012; Reese, Lee, Cohen, & Puckett Jr, 2001), in that divergent thinking seems to be the main ingredient of and results in creative outcomes (Runco and Acar, 2012; Southard, 2014; Vincent, Decker & Mumford; 2010). Measures which assess both creativity and divergent thinking evaluate the same constructs which include fluency, flexibility, originality and elaboration (Kim, 2006) all of which contribute to an individuals' productive abilities (Nusbaum & Silvia, 2010) and therefore these terms tend to be synonymous. Intellectual abilities, emotional and social health as well as academic achievement all seem to be impacted on by creativity (Plucker, Beghetto, & Dow, 2004). Thus, it could be proposed that if both divergent thinking and creativity involve similar processes, then both of these constructs should be associated with scholastic success. It was also found that divergent thinking abilities were associated with inattention and distractibility and could result in academic difficulties (Fugate, Zentall & Gentry, 2013). Therefore, there seems to be conflictual understandings of the connection between divergent thinking and academic achievement (Ai, 1999).

Therefore, this research study will seek to investigate the correlation between working memory, divergent thinking and academic achievement. It will also explore the impact of ones' socioeconomic status and gender on academic achievement. It also sought to investigate the impact of types of schooling on academic achievement. Implications of this study are that it could potentially provide contributions of a theoretical nature in

understanding the relationship between working memory and divergent thinking as well as understanding their impact on academic achievement. By understanding the impact of these variables, it could potentially affect how academic achievement is understood and how it could be better promoted.

2.6. RESEARCH QUESTIONS

a. Is Working Memory associated to Academic Achievement?

b. Is Divergent Thinking associated to Academic Achievement?

c. Is there a relationship between demographic variables (socio-economic status and gender) and divergent thinking?

d. Is there a relationship between demographic variables (socio-economic status and gender) and working memory?

e. Can academic achievement be better predicted by working memory or by divergent thinking?

CHAPTER THREE

METHODS

3.1. Research Aim

3.1.1. General aim

The general aim of this study is to explore whether working memory and divergent thinking have any relation with academic achievement and to establish which variable is a better predictor of academic achievement.

3.1.2. Specific Aims

1. To explore the relationship between working memory and academic achievement.
2. To explore the relationship between divergent thinking and academic achievement.
3. To explore the relationship between demographic variables such as socio-economic status and gender on academic achievement.
4. To explore the relationship between demographic variables such as socio-economic status and gender on divergent thinking.
5. To explore the relationship between demographic variables such as socio-economic status and gender on working memory.

3.2. Research Design

3.2.1. Research Description

This research did not involve the manipulation of variables. Data was collected at one point in time. Participants were assessed using neuropsychological tests, which yielded numeric outcomes that was interpreted as performance. The research was non-experimental, cross sectional, correlational and quantitative in nature (Terre Blanche, Durrheim, & Painter, 2006).

3.2.2. Research Variables

3.2.2.1. Academic Achievement

Conceptual Definition: Academic achievement refers to results which an individual obtains when examined to establish the extent to which knowledge which was formally taught has been acquired at institutions such as schools and universities (Steinmayr, Meißner, Weidinger, & Wirthwein, 2014).

Operational Definition: Academic achievement levels were obtained by requesting school reports of the learners looking specifically at English and Mathematics. The English and Mathematics percentage results were combined to get an overall academic achievement score. Therefore 200 points would be the best possible outcome for a learner with 0 points being the worst outcome.

3.2.2.2. Working Memory

Conceptual Definition: Working memory is the ability to grasp information, hold it and then manipulate it and then to use it (Baddeley, 1992).

Operational Definition: Abilities in working memory was ascertained by administering subtests in the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V) which contribute to the Working Memory Index. The subtests which were used included Digit Span, Picture Span and Letter-Number Sequencing. With regard to the Digit Span subtest one point was rewarded for each correct number sequence, the highest possible outcome was 54 with the lowest possible outcome 0. Picture Span was made up of 26 questions each question having a highest total of one or two points each, the highest possible outcome was 49 and the lowest 0. The Letter-Number Sequencing subtest had a total of 10 questions each worth 3 points, therefore the highest outcome possible was 30 and the lowest 0. These

subtests were combined to calculate an overall working memory score with the highest possible outcome being 110 and the lowest 0.

3.2.2.3. Divergent Thinking

Conceptual Definition: Divergent thinking refers to the ability to produce numerous thoughts from a single stimulus (Yamada & Nagai, 2015).

Operational Definition: Divergent thinking was tested by administering Guilford's Alternate Uses Test. The Alternate Uses Test is divided into two parts consisting of three questions each. Each question allows for six possible answers. The best possible outcome for this test would be a result of 36 and the lowest being 0.

3.2.2.4. Socio-Economic Status

Conceptual Definition: Socio-Economic Status refers to the access that one has to certain commodities (Sirin, 2005).

Operational Definition: Socioeconomic status was measured using the biographical questionnaire (See appendix G). Access to certain resources resulted in particular points received, the totals were tallied and then placed into groups resulting in a particular rank. The highest rank received a total of 10 with the lowest possible rank receiving a total of 1.

3.2.1.5. Type of schooling

Conceptual Definition: Types of schooling refers to the quality of education one has access to and in South Africa a distinguish can be made between prior DET schools (under resourced schools) and the private/Model C schooling (highly resourced schools) (Shuttleworth-Edwards et al., 2004).

Operational Definition: Two types of schooling was utilised for this study. Public schools were identified as those which operate under the Gauteng Department of education and therefore special clearance was obtained for this particular reason (Appendix C). Ex model

C schools were not considered to be part of the study. Private schools where identified as those which fall under the Independent Schools Association.

3.3. Sample and Sampling

Non-probability, purposive sampling was utilised for this study (Terre Blanche, Durrheim, & Painter, 2006). The sample consisted of children enrolled in school between the ages of 12 to 15 which were in their senior phase (grades 7 – 9) of schooling. The study consisted of 65 students (38 learners from a public school and 27 learners from a private school).

Learners who had previously failed a grade were excluded from the study. If a formal diagnosis of any form of learning disability, visual or hearing impairments were made pertaining to a particular learner they were excluded. Participants had to be capable of communicating in English in order to be included in the study. Participants who had a neurological, metabolic, psychiatric illness or who had a traumatic brain injury were excluded from the study. The list of exclusionary criteria was included in the parental consent form and by signing they were stating that their child did not have any of the above illnesses or traumas (see Appendix F).

Table 1 indicates that females made up the majority of the sample, 30.8% males and 69.2%. With regard to the age categories the majority of the sample were 13 years of age. The majority of the sample were in grade 7 making up 46.2%. Learners from both government and private schools took part in the study, more learners from the government school participated making up 58.5% of the total sample which is representative of the total population being that more children attend government schools as opposed to private schools.

Table 1
Demographic Information

Variable	N (65)	Frequency				Total	
		Government		Private			
		N	%	N	%	N	%
Gender							
Male		11	18	9	14	20	31
Female		27	9	18	28	45	69
Years of Age							
12		9	14	2	3	11	17
13		18	28	12	18	30	46
14		8	12	6	9	14	22
15		3	4	7	11	10	15
Grade							
7		22	34	8	12	30	46
8		7	11	12	18	19	29
9		9	14	7	11	16	25

3.4. Measurement Instruments

3.4.1. Demographic questionnaire

Information about the participants were gathered by asking them to complete a demographic questionnaire. The questionnaire consisted of items pertaining to current age and grade, gender and also socio-economic status (See appendix G).

3.4.2. School reports

School reports were required in order to ascertain academic achievement utilising results from the third school term and looking specifically at their English and Mathematic results.

3.4.3. Alternate Uses Test

The Alternate Uses Test, designed by J.P. Guilford in 1967, was utilised to measure divergent thinking. This task assessed originality, fluency, flexibility and elaboration. The learner was required to list as many possible purposes for which a given item may be used. High scores obtained on this test indicate good divergent thinking abilities. The Alternate

Uses test is reliable with a reliability coefficient ranging from 0.75 to 0.86 for the ninth grade (Guilford, Christensen, Merrifield & Wilson, 1978). Factor analysis was used in a number of studies to ascertain the validity of the Alternate Uses Test, the Alternate Uses test has been found to be valid (Guilford et al., 1978). No psychometric data was found on the with regards to the South African population specifically.

3.4.4. Working Memory Index from the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V)

Sub-tests composing the Working Memory Index of the of the Wechsler Intelligence Scale for Children were utilised to ascertain working memory scores, the latest edition was used which is the WISC-V (Wechsler, 2014). High scores obtained on these subtests indicate a good working memory.

The Working Memory Index in the WISC-V has been found to be reliable. The subtests mentioned below contribute to this index which include Digit Span, Picture Span and Letter-Number Sequencing. The reliability coefficient of the Working Memory Index for the age group 12 to 14 years ranges from 0.92 to 0.93 (Wechsler, 2014).

The validity score of the working memory index (WMI) is excellent. The correlation coefficients are as follows; between Digit Span and the WMI it is 0.87, Picture span and WMI it is 0.87 and lastly between the Letter-Number Sequencing and the WMI it is 0.66 (Wechsler, 2014).

The WISC-V has not been specifically standardised within the South African context, previous versions of the WISC have not been standardised for the South African context either (Shuttleworth-Edwards, van der Merwe, van Tonder & Radloff, 2013). However, working memory is suggested to be unbiased as it is not influenced by previously learned material or environments in which the child lives (Cockcroft, 2015).

The subtests included in the study were:

Digit Span

Participants were administered numbers verbally which they in turn had to repeat. There were three sections which are as follows:

Forward: Numbers were given verbally which the participant had to repeat verbatim.

Backward: Numbers were given verbally by the examiner which then had to be repeated in the reverse order.

Sequencing: Numbers were given verbally which then had to be repeated by the participant in numerical order.

In this subtest one point was awarded for each correct number sequence, the highest possible outcome was 54 with the lowest possible outcome 0.

Picture Span

In picture span the participant was required to remember pictures and identify them in order on the following page. As the subtest progressed items increased in number. This subtest was made up of 26 questions each question having a highest total of one or two points each, the highest possible outcome was 49 and the lowest 0.

Letter-Number sequencing

The Letter-Number Sequencing Subtest required the participant to repeat a series of numbers and letters. The examiner read out a list of letters and numbers, when the participant recalled the series they had to mention the numbers in ascending order first and then the letters in alphabetical order. This subtest had a total of 10 questions each worth 3 points, therefore the highest outcome possible was 30 and the lowest 0.

These subtests were combined to calculate an overall working memory score with the highest possible outcome being 110 and the lowest 0. The scores obtained from the Picture

Span subtest were then utilised to explore visual working memory, and the scores obtained from the Digit Span and Letter-Number Sequencing subtests were combined to explore auditory working memory abilities.

3.5. Procedure

Approval of the research proposal was obtained from the Faculty of Humanities at the University of the Witwatersrand (See appendix A). The University of the Witwatersrand Human Research Ethics Committee Non-Medical then provided ethical Clearance (MEDP/17/001 IH) (See appendix B). Permission was received from the Gauteng Department of Education (GDE) (See appendix C) to perform assessments in governmental schools in the Johannesburg area. The School Principals were then contacted and the researcher then delivered all the essential information concerning the purpose of the study (See appendix D). Parents were approached and invited to give permission for their children to be invited to participate in the study once permission was granted by all the appropriate bodies. Parents were then offered information with regards to the nature and purpose of the proposed study, they were also assured of confidentiality which was provided in the form of a letter (See appendix E and F). The demographic questionnaire and consent form was given to parents/guardians to be completed and returned of those who granted permission (See appendix G). Information such as the exclusion criteria where included in the information sheet. Parents were informed that by signing the consent form they were confirming that their child did not possess any of the conditions stipulated under the exclusion criteria.

The researcher discussed appropriate times with the principal concerning when best to assess the learners as important class time was not to be missed. The participant was accompanied to a quiet room on the school's grounds in order to begin with the assessments

once an appropriate time was agreed upon. Although the best assessment conditions were intended, in some cases the environmental noise was high and could not be controlled. The noise levels were not always appropriate for testing and the session had to be paused until it was quiet.

Once the participant joined the assessor, the purpose of the assessment was reviewed as well as what was needed. The participant was invited to give their assent in order to continue with the study (See appendix H). Once the participant gave their assent, assessments commenced. Each participant was required to attend one individual assessment session which lasted for approximately 30 to 40 minutes in a quiet environment. The test battery was conducted in the following order:

1. The Language Experience and Proficiency Questionnaire[1]
2. Wechsler Individual Achievement Test – Second Edition (Oral Expression)[1]
3. Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V)
    a. Digit Span
    b. Picture Span
    c. Letter-Number Sequencing
4. The Alternate Uses Test

Once the assessment sessions were completed, assessments were marked and then moderated. Once scoring was completed analysis of the data commenced and then the final research report was compiled.

It is important to note that this research is part of a bigger project that included Kirstin Anthony, data collection was identical for both researchers however the data used differed.

[1] It is important to note that the Wechsler Individual Achievement and the Language Experience and Proficiency test does not fall part of this study and was administered to be used for Kirstin Anthony's research. Therefore, the description of this measure is not included under the instruments in this research but appears in Miss Anthony's research project.

For this research data gathered from the Wechsler Individual Achievement Test – Second Edition was not utilised, it was however included in Kirstin Anthony's research. Kirstin Anthony did not utilise academic records as academic achievement did not fall part of her investigation.

3.6. Ethical Considerations

The University of the Witwatersrand Human Research Ethics Committee Non-Medical provided ethical clearance (MEDP/17/001 IH) (See appendix B). Once ethical clearance was received approval for conducting assessments at government funded schools in the Johannesburg area was sought from the Gauteng Department of Education (GDE) (See appendix C). Thereafter schools were approached and the principals were contacted, providing them with information pertaining to the study (See appendix D).

As the participants from this study was under the age of 18 and in South Africa are regarded as minors and fall part of the vulnerable population the following specific ethical considerations were upheld.

Learners were informed that participation in this study was voluntary, and had the participant wished to withdraw no negative consequences would have been incurred. Parents/guardians of the children which partook in the study were provided with consent forms as well as an information sheet (See Appendix E and F). Information sheets which outlined the purposes of the study as well as assent forms were provided for all participants (See Appendix H).

Assurance was made to all participants that no harm physically or emotionally would be incurred should they partake in the. The assessors tried their utmost to keep testing times minimal, however if at any moment the participant felt that a break was required it was

granted. Appropriate administration times for the assessments was reviewed with the principal prior to the assessment to guarantee that important class time was not lost. No participant experienced any risks or harm.

Assessments were conducted face to face with the researcher and therefore anonymity could not be guaranteed. Participant's names appeared on the demographic questionnaire as well as school reports. However, only the research team and their supervisor viewed the data collected, and the identifying details of the participants were not included in the final research report thus assuring confidentiality.

CHAPTER FOUR

RESULTS

4.1. Overview of Data Analysis

An overview of the statistical analysis conducted in this study and the outcomes thereof will be presented in this chapter. Descriptive statistics describe the data set in terms of gender, age, grade (displayed in table 1) and socioeconomic status and language (displayed in table 3 and 4). Inferential statistics, in the form of correlational analysis, are then explored which is necessary in order to draw conclusions based on the data collected.

The results were calculated by running a statistical analysis using the SPSS software. The analysis will look at measures of variation (used to describe the distribution of data) such as the mean, minimum, maximum, standard deviations as well as skewness and kurtosis.

The predictor variables being working memory and divergent thinking consisted of the following measures; specific subtests of the Wechsler Intelligence Scale for Children (WISC-V) which included Digit Span, Picture Span and Letter-Number Sequencing. The measure used to assess divergent thinking was Guilford's Alternate Uses Test. Additional predictor variables included types of schooling, gender and socioeconomic status which were measured using a demographic questionnaire.

The outcome variable of this study being academic achievement was established by exploring the participants school reports, looking specifically at their overall results for English and Mathematics.

This section is comprised of three parts. Part one explores the descriptive statistics of the sample which includes the frequencies of both the predictor variables and the outcome variables

as well as descriptions of the sample. Part two discusses the testing of assumptions. Part three will look at the correlations between variables including multiple regression.

Table 2

Descriptive statistics for language variables

		FREQUENCY		
Variable	**(N=65)**	**GOVERNMENT**	**PRIVATE**	**TOTAL**
Number of Languages spoken				
2		4	4	8
3		15	11	26
4		8	11	19
5		11	1	12

4.2. Description of language and socio-economic variables

The statistics (displayed in table 2) show the distribution of language variables among the participants. The sample was asked to identify the language which they felt was their dominant language. All of the participants spoke 2 or more languages. All of the participants attended schools which had English as the language of instruction. It is important to note that as a result 66% of the participants were taught in a second language.

Table 3

Socioeconomic status – categories

		Frequency					
		Government		Private		Total	
Variable	**(N=65)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Socioeconomic Status							
4		1	3	0	0	1	1
5		3	8	0	0	3	5
6		8	21	0	0	8	12
7		11	29	1	4	12	18
8		4	10	1	4	5	8
9		9	24	13	48	22	34
10		2	5	12	44	14	22

Table 3 summarises the distribution of socioeconomic status among the participants. A demographic questionnaire was provided in which the participants had to identify which resources they had access to. Each item was allocated a total, these totals were added together which resulted in a final socioeconomic score. These totals were then allocated into specific groups ranging from 1 to 10. One being the group with the least access to resources and 10 being the group having the most access to resources. The results were divided into two groups namely participants from the government school and those who attend private schools. No participants from either type of school fell within the groups 1 to 3. It is evident from the data presented in table 3 that learners in the private school have access to more resources as 92% of the learners fell in the 9^{th} and 10^{th} socioeconomic groups. Whereas 61% of the participants in the government school fell in the groups 7 and below.

4.3. Testing of Assumptions

In order to use parametric tests the data utilized should have met certain requirements which include normal distribution of the data, homogeneity of variance, interval data as well as independence (Field, 2009).

Normally distributed data is characterized by a bell-shaped curve when viewed using a histogram, this implies that most of the results lie close to the mean. Important values to bear in mind when discussing normality is skewness and kurtosis. The value of skewness in normally distributed data should be between -1 and 1 and the value of kurtosis should be between -2 and 2 in order to be described as data which is normally distributed (Field, 2009). Independence means that participants did not influence each other (Field, 2009). Participants were assessed individually and their participation in the study was confidential as to avoid participants

conferring with each other thereby limiting opportunities of influencing results. Interval data yields numeric results and the difference between each value is the same (Field, 2009).

Table 4

Descriptive Statistics for Variables

Variable (N=65)	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Academic Achievement	60	170	133.35	26.725	-0.923	0.472
Mathematics Results	30	98	67.91	16.301	-.646	-.159
English Results	20	87	65.45	12.843	-.941	1.742
Working Memory	51	108	74.77	11.19	0.375	0.443
Digit Span	18	42	27.32	4.483	0.494	0.788
Picture Span	17	45	29.32	6.548	0.452	-0.304
Letter-Number Sequencing	12	26	18.12	2.678	0.433	0.492
Divergent Thinking	0.00	2.94	1.68	0.27087	-0.644	0.507
Socio-Economic Status	4	10	8.14	0.88691	-0.61	-0.65

Table 4 represents the descriptive statistics such as the minimum, maximum, mean, standard deviation, skewness and kurtosis of the outcome variable academic achievement as well as the predictor variables working memory, divergent thinking and socioeconomic status. The table indicates that the results are symmetrical, meaning that the results are normally distributed. Initially the variable divergent thinking was asymmetrically distributed, a log transformation was performed using the SPSS software in order to normalize the data collected for the divergent thinking variable. The initial results for skewness and kurtosis were 1.318 and 2.569 respectively. Once the log transformation was performed, the result for skewness was -0.644 and for kurtosis 0.507. Log transformations corrects positively skewed data by taking the logarithm of a set numbers, in doing so flattens the right tail of the distribution (Field, 2009). The idea

behind a transformation is to alter all the items to correct distributional issues (Field, 2009). Once this transformation was performed all variables were considered to be normally distributed and as a result parametric tests could be used in order to analyse data.

4.4. Correlation Analysis

Table 5
Correlations between variables – Overall Results

Variable (N=65)		AA	WM	DT	SES	G
1	**Academic Achievement**					
	Pearson's correlation	1				
	Sig. (two-tailed)					
2	**Working Memory (WM)**					
	Pearson's correlation	.135	1			
	Sig. (two-tailed)	.285				
3	**Divergent Thinking (DT)**					
	Pearson's correlation	-.293*	.040	1		
	Sig. (two-tailed)	.018	.750			
4	**Socio-Economic Status**					
	Pearson's correlation	-.284*	.075	.188	1	
	Sig. (two-tailed)	.022	.553	.133		
5	**Gender (G)**					
	Pearson's correlation	.290*	.079	-.167	-.139	1
	Sig. (two-tailed)	.019	.530	.185	.269	

* Correlation is significant at the 0.05 level (2-tailed)

Table 5 indicated that there were significant but weak correlations between divergent thinking (DT) and academic achievement (AA) (r = -0.293, p = 0.018) as well as between socioeconomic status (SES) and academic achievement (AA) (r = -0.284, p = *0.022)* and also between academic achievement (AA) and gender *(*r = 0.290, p = *0.019*).

This suggests that there is an inverse correlation between divergent thinking, socioeconomic status and academic achievement, suggesting that lower levels of divergent

thinking and socioeconomic status are linked to higher academic achievement. The results indicate that the gender of the participant significantly related to the academic achievement of the individual. This relationship was found to be weak and was in favour of females.

No significant relationship was found between gender and working memory or between gender and divergent thinking. No significant relationship was found between socioeconomic status and working memory or between socioeconomic status and divergent thinking. No significant relationship was found between academic achievement and working memory.

Since academic achievement seems to negatively correlate with divergent thinking and not with working memory a new question emerges: Is this the case for both types of schooling? It has been found that quality of education is an important indicator of performance therefore the decision was made to do a separate analysis based on types of schooling (Shuttleworth-Edwards, 2016). To address this, correlational analysis was conducted between these variables looking specifically at types of schooling (table 6). The researcher included SES and gender as well. The researcher was also interested in splitting working memory into auditory and visual working memory.

Table 6

Correlations between variables – School Specific

Variable	DT		WM		AWM		VWM		AA		SES		G	
	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)	GOV (n=38)	PVT (n=27)
Divergent Thinking	1	1												
Sig. (two-tailed)														
Working memory	.21	-.18	1	1										
Sig. (two-tailed)	.195	.382												
Auditory working memory	.10	-.23	.87*	.83*	1	1								
Sig. (two-tailed)	.565	.241	<.0001	<.0001										
Visual working memory	.28	-.07	.85*	.87*	.49*	.45*	1	1						
Sig. (two-tailed)	.086	.716	<.0001	<.0001	.002	.019								
Academic achievement	-.02	-.41*	.00	.26	.026	-.333	-.02	-.363	1	1				
Sig. (two-tailed)	.913	.034	.977	.199	.875	.089	.906	.063						
Socioeconomic status	.088	.086	.348*	-.294	.50*	-.31	.12	-.16	-.15	.02	1	1		
Sig. (two-tailed)	.598	.669	.033	.136	.001	.112	.455	.422	.370	.939				
Gender	.053	-.295	-.187	.418*	.17	.17	-.16	.52*	-.18	.64*	-.19	.00	1	1
Sig. (two-tailed)	.750	.135	.260	.030	.321	.392	.347	.005	.273	<.0001	.258	1.000		

Note. Gov = Government School. Pvt = Private School. DT = Divergent Thinking. WM = Working Memory. AWM = Auditory Working Memory. VWM = Visual Working Memory. AA = Academic Achievement. SES – Socioeconomic Status. G = Gender

* Correlation is significant at the 0.05 level (2-tailed)

According to the results yielded from the Pearson's Product Moment Correlation there appears to be no significant relationship between divergent thinking, socioeconomic status, and gender when reviewing both the overall results as well as the results in which the data in categorized according to type of schooling.

The data indicated by table 5, which explored the overall results of all the participants, suggest that there was no significant relationship between working memory, socioeconomic status and gender. However, when the sample was divided into two groups, namely government schooling and private schooling, the results suggested that significant relationships existed. There was a positive weak relationship between working memory and socioeconomic status in the group which attended government schools, ($r = .348$, $p < 0.05$), which proposes that as socioeconomic status increased as did working memory abilities. With regard to gender and working memory the results suggest that there is a moderate positive correlation between these variables in the group that attend private schools, ($r = .418$, $p < 0.05$), implying that gender accounts for 17.4% of the variability in scores for academic achievement within private schools. There was a significant positive relationship between visual working memory and gender within the private school, ($r = .52$, $p = 0.05$), suggesting that females performed better on the visual working memory tasks within the private school environment.

Table 6 presents the relationship between auditory and visual working memory and overall academic achievement as well as the relationship between gender and academic achievement looking specifically at the different types of schooling was explored. No significant relationships were found between auditory and visual working memory and academic achievement. There was however a moderate positive relationship between gender and academic achievement in the private school environment, ($r = .64$, $p = .000$), favouring females.

Since academic achievement seemed to correlate with divergent thinking but not working memory another question emerged: Would this be the case if analysis was performed looking specifically at English and Mathematics results instead of an overall academic result. To answer this question a correlational analysis was conducted between divergent thinking and working memory looking specifically at Mathematics and English results (table 7). A significant weak negative correlation was found between Mathematics scores and divergent thinking, ($r = -.32$, $p = 0.10$). Indicating that when divergent thinking abilities increase mathematics scores decrease. A strong positive correlation was found between Mathematics and English, suggesting that as proficiency in the English language increases so did Mathematics performance.

Table 7

Correlations between Mathematic results, English results, Divergent Thinking and Working Memory

Variable (N = 65)	Mathematics	English	DT	WM
1 Mathematics results				
Pearson's correlation	1			
Sig. (two-tailed)				
2 English results				
Pearson's correlation	.68*	1		
Sig. (two-tailed)	.000			
3 Divergent Thinking				
Pearson's correlation	-.32*	-.21	1	
Sig. (two-tailed)	.010	.096		
4 Working Memory				
Pearson's correlation	.22	.01	.040	1
Sig. (two-tailed)	.085	.956	.750	

Note. DT = Divergent Thinking. WM = Working Memory.
* Correlation is significant at the 0.05 level (two-tailed)

4.4.1. Multiple Regression

4.4.1.1. Multiple Regression exploring the effects of Working Memory and Divergent Thinking on Academic Achievement

The variables that went into this model included the predictor variables, working memory and divergent thinking as well as the outcome variable, academic achievement. It was thought that working memory would be a better predictor but found that divergent thinking was in fact the best predictor of academic achievement. A multiple linear regression was carried out to predict academic achievement based on working memory and divergent thinking. Table 8, 9 and 10 reflect the results of the regression which indicated that the model explained 10.7% of the variance and that the model was a significant predictor of academic achievement, ($F(2,62) = 3.729$, $p = .030$, R^2 of .107) (see table 8 and 9). While Divergent thinking contributed significantly to the model ($\beta = -12.800$, $p = .015$), Working Memory did not ($\beta = .351$, $p = .226$) (see table 10). The final predictive model was:

Academic achievement = 128.661 + (.351*Working Memory) + (-12.800*Divergent Thinking) (see table 10)

This indicates that when divergent thinking scores decrease by 12.8 points academic achievement increases by 1 point and when working memory increases by 0.351 points academic achievement increases by 1 point.

Table 8

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.328[a]	.107	.079	25.65

Table 9

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4907.8	2	2453.9	3.729	.030[b]
	Residual	40803.06	62	658.11		
	Total	45710.86	64			

a. Outcome Variable: Academic Achievement
b. Predictors: (Constant), Divergent Thinking, Working Memory

Table 10

Coefficients[a]

		Unstandardized Coefficients		Standardised Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	128.661	23.022		5.589	.000
	Working Memory	.351	.287	.147	1.223	.226
	Divergent Thinking	-12.800	5.142	-.299	-2.489	.015

a. Outcome Variable: Academic Achievement

Based on these findings the researcher thought that it would be interesting to explore the variance in the two subjects which made up academic achievement. It was thought that if divergent thinking was a better predictor of academic achievement, then is should be the case for both English and mathematics results as well, however it was found that divergent thinking only significantly predicted mathematics scores.

4.3.1.2. Multiple Regression exploring the effects of Working Memory and Divergent Thinking on Mathematics results.

The variables that went into this model included the predictor variables, working memory and divergent thinking as well as the outcome variable, mathematics results. In order to ascertain whether working memory and divergent thinking could significantly predict Mathematics scores a multiple regression was performed. Table 11, 12 and 13 reflect the results of the regression which indicated that the model explained 15.2% of the variance and that the model was a significant predictor of Mathematics results, ($F(2,62) = 5.569$, $p = .006$). While Divergent thinking contributed significantly to the model ($\beta = -8.506$, $p = .007$), Working Memory did not ($\beta = .333$, $p = .055$). The final predictive model was:

Mathematics results = 57.312 + (.333*Working Memory) + (-8.506*Divergent Thinking)

This indicates that when divergent thinking scores decrease by 8.506 points Mathematics results increases by 1 point and when working memory increases by 0.333 points academic achievement increases by 1 point.

Table 11
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.390[a]	.152	.125	15.248

Table 12

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2589.747	2	1294.873	5.569	.006[b]
	Residual	14415.699	62	232.511		
	Total	17005.446	64			

a. Outcome Variable: Mathematics results
b. Predictors: (Constant), Divergent Thinking, Working Memory

Table 13

Coefficients[a]

Model		Unstandardized Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	57.312	13.684		4.188	.000
	Working Memory	.333	.171	.229	1.953	.055
	Divergent Thinking	-8.506	3.056	-.326	-2.783	.007

a. Outcome Variable: Mathematics results

4.3.1.3. Multiple Regression exploring the effects of Working Memory and Divergent Thinking on English results.

The variables that went into this model included the predictor variables, working memory and divergent thinking as well as the outcome variable, English results. In order to establish whether working memory and divergent thinking could significantly predict English scores a multiple regression was performed. Table 14, 15 and 16 reflect the results of the regression which suggested that the model described 4.4% of the variance and that the model was not a significant predictor of English results, ($F(2,62) = 1.411$, $p = .252$).

Table 14
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.209[a]	.044	.013	12.761

Table 15
ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	456.574	2	229.787	1.411	.252[b]
	Residual	10096.488	62	162.847		
	Total	10556.062	64			

a. Outcome Variable: English results
b. Predictors: (Constant), Divergent Thinking, Working Memory

Table 16
Coefficients[a]

		Unstandardized Coefficients		Standardised Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	71.349	11.452		6.230	.000
	Working Memory	.018	.143	.015	.124	.902
	Divergent Thinking	-4.295	2.558	-.206	-1.679	.098

b. Outcome Variable: English results

In summary, the results suggest that working memory did not have an influence on Mathematics or English results. Divergent thinking abilities on the other hand seems to have an impact on Mathematics results but not English. As divergent thinking abilities increased Mathematics results decreased significantly.

CHAPTER FIVE

DISCUSSION

The aim of this study was to explore the relationship between working memory, divergent thinking and academic achievement. The research also sought to examine the effects gender, socioeconomic status and types of schooling have on academic achievement, working memory and divergent thinking in the South African context. The literature reviewed in chapter two is utilised as the context in which the results, as summarised in chapter four, will be explored. The general aim was to explore which variable, namely working memory or divergent thinking would better predict academic achievement. Descriptive statistics were utilised in order to understand the sample which was used for this research which provide valuable insight into the sample.

One of the criteria that needed to be met in order to be part of the study was that each participant needed to be proficient in English. A language questionnaire was completed by each of the participants to explore which and how many languages each participant could speak. Out of the 65 participants only 33% of the sample noted English as a home language, however every participant was deemed to be proficient enough to participate in the study. When exploring the number of languages spoken 18,4% spoke 5 languages, 29,2% spoke 4 languages, 40% spoke 3 languages and 12,3% spoke 2 languages. There were no monolingual participants in this study. It was interesting to note that 16,9% of participants from the government could speak 5 languages whereas in the private school only 1,5% percent could. Language diversity in South African schools is a multifaceted issue. Language is of utmost importance as it is necessary for the transmission of knowledge in order to facilitate learning (Nel & Müller, 2010) as well as the mechanism used to make sense of this knowledge, thus language difficulties poses a threat on

academic achievement (Botes & Mji, 2010). When being educated in an additional language not only does the learner have to learn new jargon but also the new language of tuition (Botes & Mji, 2010). Research has found that second language speakers tend to have a lower level of knowledge acquisition than their home language speaking counterparts (Barton & Neville-Barton, 2003). All participants attended schools where they were taught in English and as a result only 33% of the population was being taught in their Home Language. Therefore, if the transmission of knowledge is hindered due to either the teacher or the learner having limited English abilities acquisition of important concepts will not be effective (Nel & Müller, 2010), thereby having a negative effect of academic achievement.

The results obtained from the descriptive statistics revealed that 69.2% of the sample were female and 30.8% were male. According to Stats SA (2017) there is a slightly higher percentage of females than males in primary and high school. Therefore, the distribution of males to females is slightly disproportionate when compared to the total population of South Africa, however is actually showing the national trend although accentuated. Stats SA (2017) have suggested that in primary school the proportion of male to female is 49,4% to 50,6% and in high school it is 49,1% to 50,9%. Therefore, this research has an over representation of females to male ratio. It is possible that the skewed distribution in gender might have influenced the results of the gender correlations, therefore this must be interpreted cautiously and it is recommended that future research explores these findings with equal representation between gender.

This study indicated that the gender of the participant significantly related to the academic achievement of the individual. This relationship was found to be weak and was in favour of females. Literature has shown that there are conflicting findings with regard to gender

differences in academic achievement, and if gender differences exist, the cause of these variations is unknown and further studies need to be conducted (Muglia Wechsler et al., 2014). A study has found that females tend to surpass males in class attendance and academic achievement (Hubbard, 2005), however in contrast to this, another study revealed that males tend to outperform females on certain tasks such as multiple-choice questions, whereas females excel in tasks requiring free responses (Bolger & Kellaghan, 1990). In another study, it was found that the gender of the learners do not play a role in differences observed in academic achievement scores rather the gender of the teachers seems to have an impact on the results of the students (Klein, 2004).

This study also aimed to look at gender differences in working memory. This research indicated no significant relationship between working memory and gender when reviewing the overall results; however, a significant relationship was found when reviewing the data collected from the private school. Literature suggests that there are differences in working memory when comparing genders and has suggested the differences occur due to different areas of the brain being activated during tasks associated with working memory (Hill, Laird and Robinson, 2014; Speck et al., 2000). In contrast, another study found that there are similar working memory networks among both male and females, however the same research revealed that there are gender specific neural networks which are activated during specific tasks (Hill, Laird & Robinson, 2014). Factors such as being tested in ones' home language may have had an impact on these results. Twenty six percent of the participants from the government school were assessed in their home language whereas 44% of the participants from the private school was assessed in their home language English. It is important to take into account the under representation of English first language speakers in the public school which may have impacted

on these results. When individuals are assessed in their second or third language on the WISC, it was found that they tend to score significantly lower (Kopelman, 2016; Lucas, 2013). Working memory results have also be found to be influenced by articulation and accent (Crawford, Gray & Allan, 1995) and may negatively influence the number of digits being retained (Ellis & Hennelly, 1980).

An additional aim of the study was to explore the relationship between gender and divergent thinking. Sayed and Mohamed (2013) found that there were no gender differences with regard to divergent thinking, this study corroborated these results.

Working memory has been linked to academic achievement (Alloway & Alloway, 2010), however this study did not support this relationship. Auditory working memory has been linked to academic achievement as well (Gropper & Tannock, 2009), however again this study did not support these findings, in addition to this no significant relationship was found between visual working memory and academic achievement. The researcher explored the relationship between working memory, English and Mathematics scores and no statistical relationships were found. These results are contrary to the research available which argues that working memory plays a vital role in mathematical skills as well as reading (Baddeley, 1992; Swanson & Sachse-Lee, 2001; Gropper & Tannock, 2009; Alloway & Alloway, 2010; Alloway, Gathercole, Willis & Adams, 2004).

These results may have been affected by various factors which could have had an adverse effect on working memory abilities such as the assessment environment not being conducive to optimal performance. It has been found that learner distractibility affects working memory performance (Gathercole, Lamont & Alloway, 2006). Factors such as the majority of the participants being individuals who use English as a second or third language yet being assessed

by exclusively English measures could have impacted on these results. It has been found that when students are assessed in a second language and are not proficient enough in English they score significantly lower on cognitive measures such as the WISC-IV (Kopelman, 2016). Although working memory is understood to be an unbiased measure if a child's ability (Cockcroft, 2015) being assessed in one's second language might influence the results negatively. Of the studies included in the literature review which argued that working memory abilities improved academic achievement, the participants which were assessed were from the United States (Swanson & Sachsa-Lee, 2001) and Scotland (Bull & Scerif, 2001), which suggests that the participants were English first language speakers. Many of the participants in this study were second language English speakers which may account for the inconsistent findings and perhaps English proficiency was not controlled appropriately in this study.

According to Plucker, Beghetto and Dow (2004) there are links between divergent thinking and scholastic success, however this research did not support this argument. As it found that there was a significant negative weak relationship (r = -0.293, p = 0.018) between divergent thinking and academic achievement. These results indicate that as academic achievement results went up, divergent thinking abilities reduced. One could argue that schooling is geared towards the development and refinement of convergent thinking as assessment usually require one correct answer, and as result divergent thinking could indirectly be discouraged. Beghetto (2006) found that teachers favoured relevant answers over uniqueness and found unique responses distracting, thus discouraging divergent thinking. As a child progresses through the schooling years it appears as though divergent thinking abilities become less utilised. Fugate, Zental and Gentry (2013) found that divergent thinking abilities were closely related to inattention and distractibility and found that individuals which possess these characteristics often experience

obstacles with academic achievement which validate the findings of this study which were that as divergent thinking abilities increased academic achievement decreased.

This research found that when looking at the overall results no significant relationship between working memory and socioeconomic status were identified. However, when looking specifically at type of schooling which is directly affected by socio-economic status the researcher found a significant positive relationship between socioeconomic status and working memory in the government schooling sample. Indicating that as the socioeconomic status increased so did the working memory abilities. The relationship between working memory and academic achievement has been contradictory in the literature for example Leonard et al. (2015) found a significant difference in working memory when comparing groups from a higher and a lower socio-economic standing. Leonard et al. (2015) found that individuals from a lower socio-economic standing performed significantly lower on working memory tasks when compared to individuals from a higher socioeconomic standing. Opposing these findings in another study conducted it was found that socioeconomic status did not affect working memory (Engel, Santos & Gathercole, 2008).

No significant relationship was found between socioeconomic status and divergent thinking in this study. These findings corroborate with literature in which it was found that there is no significant relationship between divergent thinking and socio-economic status (Warden & Prawat, 1975).

A significant negative correlation was found between academic achievement and socioeconomic status when reviewing the overall results. Thus, implying that learners from a higher socioeconomic status had lowered academic achievement. This possibly implies that academic achievement appears to decrease within the private schooling system or it could be an

indication that the level of learning and achieving within the private schooling system requires more effort to achieve high marks. Thus, implying that it is easier to obtain higher results within the public sector as the requirements differ in level of difficulty. This discrepancy might also be due to an assessment bias (Popham, 2009).

Predictors of Academic Achievement

A regression analysis was performed to ascertain whether working memory or divergent thinking better predicts academic achievement. It was found that divergent thinking was a better predictor. Results revealed that higher divergent thinking abilities resulted in poor academic achievement. This corresponds with Beghetto's (2006) findings in which it was revealed that teachers tended to favour relevant answers over unique responses, thus discouraging divergent thinking. These findings also support the argument of Fugate, Zental and Gentry (2013) that divergent thinking abilities were closely related to academic difficulties, thereby confirming that as divergent thinking abilities increase academic achievement decreases.

A regression analysis was performed to ascertain whether working memory or divergent thinking better predicts Mathematics achievement. It was found that high scores in divergent thinking tests predicted lower scores on Mathematics ($F(2,62) = 5.569$, $p = .006$). This could be a result of Mathematics encouraging learners to think in a more convergent manner as the curriculum is set out in a way to expect one correct answer, in other words methodical/procedural learning instead of creative learning. In a study conducted it was found that teachers favoured convergence over divergence (Beghetto, 2006) with regard to thinking thus causing divergent thinking to decrease as a child progresses through school.

CHAPTER SIX

LIMITATIONS OF STUDY AND SUGGESTIONS FOR FUTURE RESEARCH

The general aim of this research was to investigate which variable namely, divergent thinking or working memory were better predictors of academic achievement. The methods used to investigate this aim have several limitations that affect the power of generalisation.

Firstly, the selection of schools and participants were based on convenience and availability which could have resulted in selection bias. According to Terre Blanche, Durrheim and Painter (2014) when selecting a sample, it needs to be representative of the population one wishes to generalise findings to. An additional element which should be considered is that of sample size, in that the size of the sample should be large enough to allow for inferences (Terre Blanche, Durrheim and Painter, 2014). The sampling procedure utilised for this research was convenience sampling which is a type of sampling where the researcher selects participants based on availability and could at times lead to the sample being nonrepresentative (Terre Blanche, Durrheim and Painter, 2014). As convenience sampling was utilised it was found that not all of the racial populations were accounted for within the government schools, for example no white participants were assessed within the government schools. It was also found that not all of the national language groups were represented. The sample size could have been larger had participants been selected from more schools. Due to time constraints and due to the lengthy assessment period, it took to test one participant it made increasing the sample size difficult. It

would have been more ideal had a larger sample been possible as well as including schools from the different provinces to allow for generalization of results.

Secondly, there was some concern about Guilford's Alternate Uses Test with regards to its applicability in the South African context as well as time constraints. Although it was used recently in research to establish its usefulness in identifying creative potential (Dippo & Kudrowitz, 2013), the psychometric properties of the test have not yet been explored in the context of Southern Africa. Foxcroft and Roodt (2013) argue that in order for assessment to be valid and reliable in a context like Southern Africa there needs to be a process such as adaptation that needs to take place. This ensures that participants from different languages, cultural and socio-economic backgrounds stand the same of chance of achievement in any given test (Foxcroft & Roodt, 2013). The Alternate Uses Test required participants to produce written examples in English which could have been limited as 67% of the participants were second language English speakers. However, during administration no issues of note were experienced and raw scores were utilised. Another limitation with regard to testing of divergent thinking abilities, it was found that participants should not be timed as this limits the amount of original ideas being produced (Yoruk & Runco, 2014). The Alternate Uses Test was however utilised as it has been found to be a simple way of evaluating divergent thinking abilities (Dippo & Kudrowitz, 2013).

Thirdly, the researcher evaluated the assessment conditions. According to Foxcroft and Roodt (2013) one of the key elements of administering psychological assessments is that of ensuring that the assessment conditions are satisfactory. Some of these conditions include having a well-lit, ventilated, relatively quiet area free of any disturbances as conditions of the physical environment might have an impact on results (Foxcroft & Roodt, 2013). The assessment

environment was not standardised for all participants and differed between the private and government school. As the researcher relied on the schools to provide venues for assessment, these venues varied from day to day depending on the availability of rooms at the school. The researcher was forced to assess in the school hall, available classrooms as well as in a hallway when rooms were not obtainable. The researcher attempted to ensure that the room was appropriate to assess in, such as the room being ventilated and well lit, however, the researcher was not able to regulate the noise or particular distractions in the surrounding areas. Future studies would benefit by having one standard venue available for all participants to be assessed in to limit extraneous variables which could have affected the results obtained.

Fourthly, the identification of specific exclusion criteria could not be properly verified. There were certain criteria each participant had to meet in order to be part of the study. Criteria which could have led to a participant being excluded included being diagnosed with any learning disorder, traumatic brain injuries, a history of illnesses such as meningitis and epilepsy as well as any identified behavioural concerns. There was no way to test for these variables and as a result had to trust that parents would be forthcoming with the aforementioned conditions. However, there was a possibility that learners could have had learning disorders which had not been identified as yet or may have experienced a TBI. Due to this the results may have been impacted by conditions not identified by parents.

Lastly, the use of two assessors to collect data may have had an impact on the results yielded. According to Foxcroft and Roodt (2013) the assessor has an influence on the results yielded by each participant. There are various factors which should be taken into account when evaluating the assessors' skills such as the ability to establish rapport, the use of non-verbal cues as well as the capacity to adapt to different participants according to their needs (Foxcroft &

Roodt, 2013). The research consisted of two researchers who collected data and perhaps results were influenced differently based on each assessors' own individual characteristics.

CHAPTER SEVEN

CONCLUSION

This study aimed to explore if working memory and divergent thinking could possibly predict academic achievement. Limited research had been done in the South African context around divergent thinking and academic achievement and therefore this research provided an introduction to this area. It also aimed to look at the relationship between working memory and divergent thinking as well as socioeconomic status and gender. A total of 65 participants were part of the study, 27 from private schools and 38 from government schools. Participants had to be in grades 7 to 9 and proficient in English in order to be part of the study. Participants had to complete the LEAP-Q questionnaire to ascertain language proficiency. They then completed a working memory task which involved the administration of specific subtests of the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V) namely Digit Span, Picture Span and Letter-Number sequencing. These subtests yielded results for both auditory as well as visual working memory abilities. In order to measure divergent thinking abilities participants had to complete Guilford's Alternate Uses Test. School reports specifically results yielded during the third term of 2017 were used to ascertain level of academic achievement.

The results revealed that there were no significant relationships between working memory and academic achievement which was in contradiction to existing studies (Alloway & Alloway, 2010; Gropper & Tannock, 2009; Alloway, Gathercole, Willis & Adams, 2004; Cockcroft & Dhana-Dullabh,2013). A negative correlation was found between divergent thinking and academic achievement which implied that as divergent thinking abilities increased academic achievement decreased. This could be a result of formal schooling

encouraging learners to think in a more convergent manner as the curriculum is set out in a way to expect one correct answer. A significant positive correlation was found between gender and academic achievement and a significant negative relationship was found between socioeconomic status and academic achievement.

The researcher then looked at private schooling and government schooling separately and found that within the private schooling sample a significant positive correlation was found between gender and working memory. The results yielded from the government schooling sample found a positive correlation between socioeconomic status and working memory.

Finally, a regression analysis was performed to establish whether working memory or divergent thinking was a better predicted academic achievement. The results obtained suggested that divergent thinking was ultimately the better predictor of academic achievement in that as divergent thinking abilities increased academic performance decreased.

Further research into this topic should be embarked on within the South African context specifically to understand and help promote academic achievement for all.

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Appendix A: Faculty Approval

University of the Witwatersrand, Johannesburg

Faculty of Humanities – Postgraduate Office

Private Bag 3, Wits 2050, South Africa • **Tel:** +27 11 717 4007• **Fax:** +27 11 717 4037• **Email:** madile.moeketsi@wits.ac.za

Student Number: 848097

Miss Jaime Joy Abrahams
30 Walnut Road
Lansdowne
Cape Town 7780
Western Cape South Africa

18 May 2017

Dear Miss Abrahams

APPROVAL OF PROPOSAL FOR THE DEGREE OF MASTER OF EDUCATION IN EDUCATIONAL PSYCHOLOGY

I am pleased to be able to advise you that the readers of the Graduate Studies Committee have approved your proposal entitled "***Working memory and divergent thinking as predictors of academic achievement: Exploratory study***". I confirm that Mrs Aline Ferreira Correia has been appointed as your supervisor in the School of SHCD.

The research report is normally submitted to the Faculty Office by 15 February, if you have started the beginning of the year, and for mid-year the deadline is 31 July. All students are required to RE-REGISTER at the beginning of each year.

You are required to submit 2 bound copies and one unbound copy plus 1 CD in pdf (Adobe) format of your research report to the Faculty Office. The 2 bound copies go to the examiners and are retained by them and the unbound copy is retained by the Faculty Office as back up.

Please note that should you miss the deadline of 15 February or 31 July you will be required to submit an application for extension of time and register for the research report extension. Any candidate who misses the deadline of 15 February will be charged fees for the research report extension.

Kindly keep us informed of any changes of address during the year.

Note: All MA and PhD candidates who intend graduating shortly must meet your ETD requirements at least 6 weeks after your supervisor has received the examiners reports. **A student must remain registered at the Faculty Office until graduation.**

Yours Sincerely

MM Moeketsi

Madile Moeketsi (Ms)
Postgraduate Division
Faculty of Humanities
Private Bag X 3
Wits, 2050

Appendix B: Ethics Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (SCHOOL OF HUMAN & COMMUNITY DEVELOPMENT

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: MEDP/17/001 IH**
PROJECT TITLE:	Working Memory and Divergent Thinking as Predictors of Academic Achievement: Exploratory Study
INVESTIGATORS **DEPARTMENT**	Abrahams Jaime Joy Psychology
DATE CONSIDERED	05/06/17
DECISION OF COMMITTEE*	Approved

This ethical clearance is valid for 2 years and may be renewed upon application

DATE: 10 May 2017

CHAIRPERSON
(Prof. Joseph Seabi)

cc Supervisor: Ms Aline Ferreira-Correia
Psychology

DECLARATION OF INVESTIGATOR (S)

To be completed in duplicate and **one copy** returned to the Secretary, Room 100015, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure, as approved, I/we undertake to submit a revised protocol to the Committee.

This ethical clearance will expire on 31 December 2019

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: GDE Clearance

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	08 May 2017
Validity of Research Approval:	06 February 2017 – 29 September 2017 2017/91
Name of Researcher:	Abrahams J.J
Address of Researcher:	26 205 Wits Junction
	Junction Avenue, Parktown
	Johannesburg, 2193
Telephone Number:	011 717 0959 060 528 6356
Email address:	jaimejoy007@yahoo.com
Research Topic:	Working Memory and Divergent thinking as predictors of Academic Performance: Exploratory study
Number and type of schools:	One Primary School and Three Secondary Schools
District/s/HO	Johannesburg Central, Johannesburg North and Johannesburg South

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

08/05/2017

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....

Ms Faith Tshabalala
CES: Education Research and Knowledge Management

DATE: 08/05/2017

2

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix D: Information Letters and Consent Forms from Schools

PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 · Tel: 011 717 4541 · Fax: 011 717 4559 · E-mail: psych.SHCD@wits.ac.za

Letter seeking access and permission for school research
Dear Principal,

Good day. My name is Jaime Abrahams and I am currently completing my Master of Education (Educational Psychology) at the University of the Witwatersrand. For the purpose of my studies, I am required to undertake research. My research is entitled; Working Memory and Divergent Thinking as Predictors of Academic Performance: Exploratory Study. This project falls within a bigger research study that also seeks to explore the relationship between these variables and language experience (such as monolingualism, bilingualism and multilingualism) in which Kirstin Anthony (Masters Student in the field of Psychology by Coursework and Research Report) is part of the research team and is also under the supervision of Ms Aline Ferreira-Correia.

For the purposes of ethical clearance permission to collect data from the school and the Gauteng Department of Education is required. I will forward the ethical clearance letter to you prior to data collection.

I will be conducting a short cognitive evaluation of school students in the 7th to 9th grades (ages 12 – 14 years). Standardized assessments will be used to measure working memory (ability to mentally hold and process information) and divergent thinking (ability to think about many ideas related to one concept). This evaluation involves tests such as the Alternate Uses Test and the Digit Span, Picture Span and the Letter-Number Sequencing subtests from the Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V) as well as language questionnaires. There will also be a demographic questionnaire which will be completed by the parents/guardians. As Academic Achievement is one of the core variables of my study, access to academic records in the form of the learners' school reports of the current year will be required as we are looking specifically at results obtained in English and Mathematics. The entire assessment takes approximately 30 to 40 minutes for each participant.

I am requesting that you invite potential participants in grades 7 to 9 from your school by sending the information sheet, consent form and demographic questionnaire attached to all parents/guardians. All the letters and envelopes will be provided. Consent to participate will be requested from the parents or legal guardians. Information letters, consent forms and assent forms have been prepared for these purposes and have been attached for your perusal.

I am contacting you in order to respectfully request your permission to conduct data collection in your School. This permission and the help I require involves:

- Getting in touch with the 7th to 9th grades teachers in order to organise with them the best moment for the student that has been granted consent to be invited to participate and be assessed.
- Having a quiet and well-lit space in the school premises, with a desk and two chairs, in which I can conduct the assessments

Data collection will take place in August 2017 according to times that are most convenient to the school, participants and parents/legal guardians.

This research will adhere to all the Ethical Principles and protocols endorsed by the University of the Witwatersrand's Human Research Ethics Committee (HREC Non-Medical). This involves no-harm, voluntary participation, confidentiality, and right to withdraw at any stage during the data collection. Although there are no individual benefits to participating in the study, the information gained will however contribute to the broader understanding of academic achievement in the South African context.

The report resulting from this research will be available in the library of the University of the Witwatersrand, which offers access to material on the world-wide web. The findings will also potentially be published in scientific journals. I will send a digital copy of the results of the study to you by June 2018.

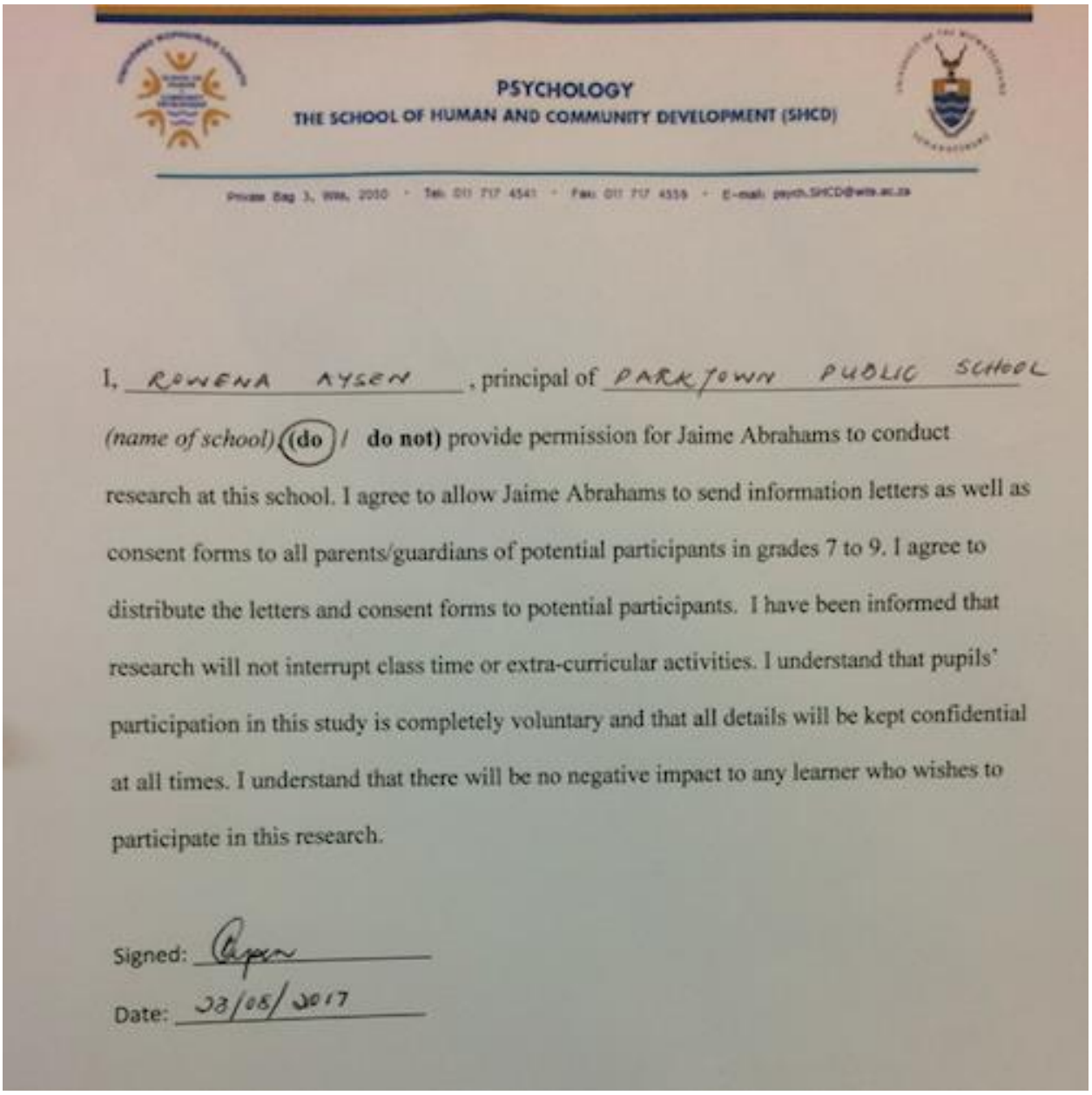
If you do grant me permission to conduct research at your institution, would you please be so kind as to complete the attached consent form. You may either email the letter to me or I can collect it directly from you. My details as well as my supervisors' details appear below should you need any further information.

I look forward to hearing from you.

Yours sincerely

Jaime Abrahams
Cell: 060 528 6356
Email: jaimejoy007@yahoo.com

Aline Ferreira-Correia
Tel: (011) 011 717 4527
Email: Aline.FerreiraCorreia@wits.ac.za



PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

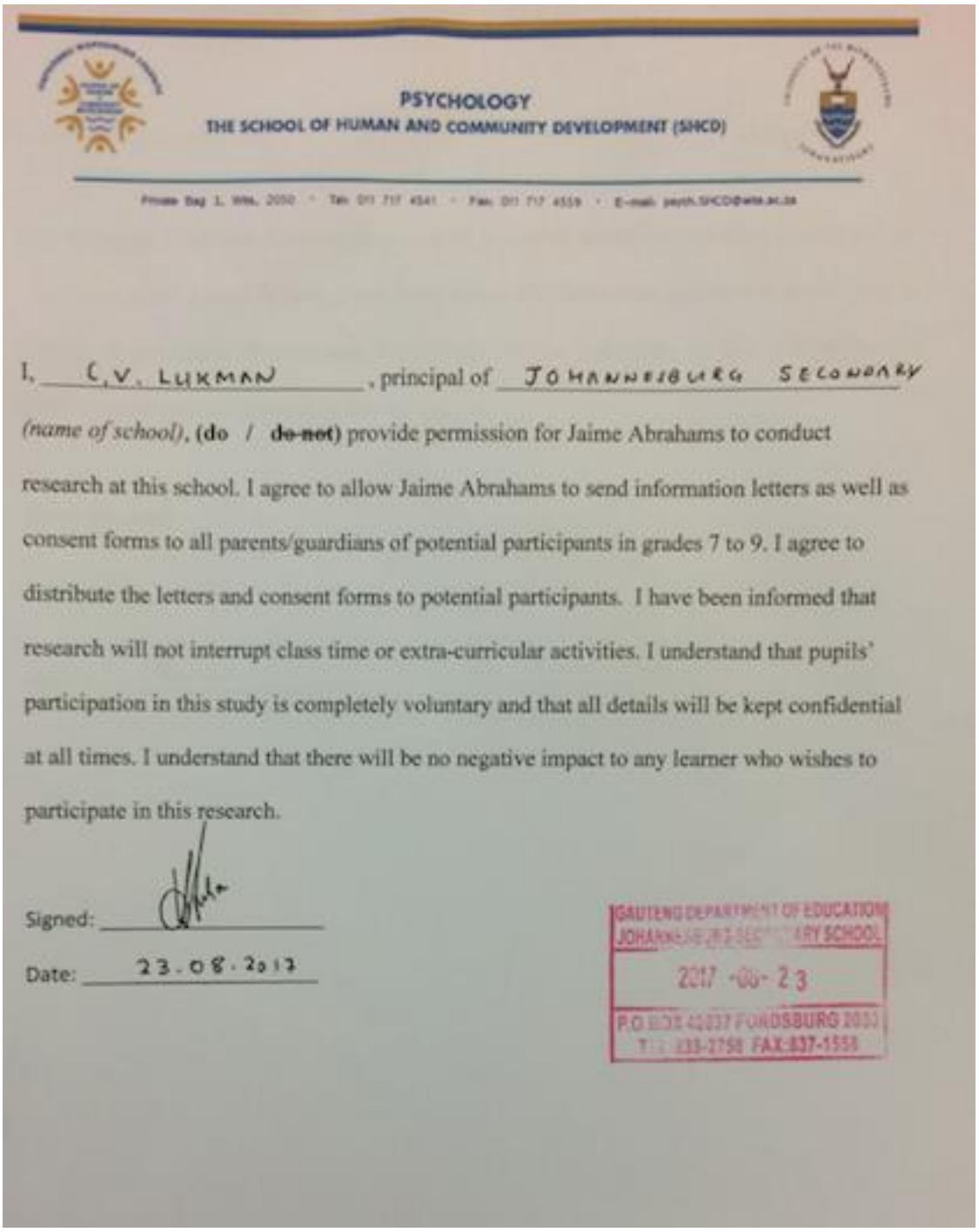
Private Bag 3, Wits, 2050 · Tel: 011 717 4541 · Fax: 011 717 4559 · E-mail: psych.SHCD@wits.ac.za

I, RONENA AYSEN, principal of PARKTOWN PUBLIC SCHOOL

(name of school) **(do / do not)** provide permission for Jaime Abrahams to conduct research at this school. I agree to allow Jaime Abrahams to send information letters as well as consent forms to all parents/guardians of potential participants in grades 7 to 9. I agree to distribute the letters and consent forms to potential participants. I have been informed that research will not interrupt class time or extra-curricular activities. I understand that pupils' participation in this study is completely voluntary and that all details will be kept confidential at all times. I understand that there will be no negative impact to any learner who wishes to participate in this research.

Signed: _____

Date: 23/05/2017



PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, WITS, 2050 · Tel: 011 717 4541 · Fax: 011 717 4559 · E-mail: psych.SHCD@wits.ac.za

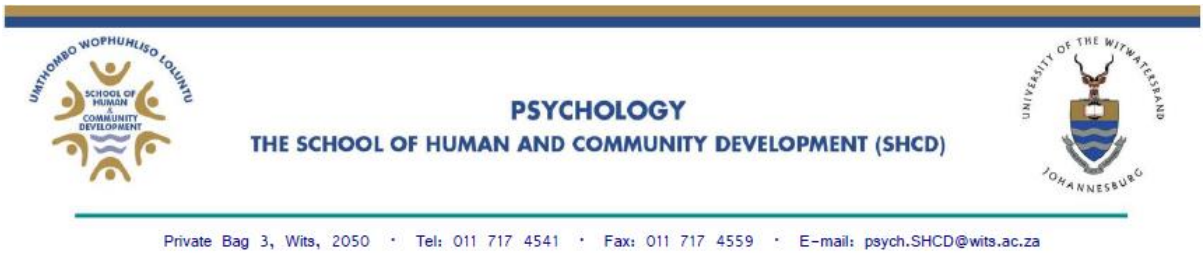
I, C.V. LUKMAN, principal of JOHANNESBURG SECONDARY *(name of school)*, **(do / ~~do not~~)** provide permission for Jaime Abrahams to conduct research at this school. I agree to allow Jaime Abrahams to send information letters as well as consent forms to all parents/guardians of potential participants in grades 7 to 9. I agree to distribute the letters and consent forms to potential participants. I have been informed that research will not interrupt class time or extra-curricular activities. I understand that pupils' participation in this study is completely voluntary and that all details will be kept confidential at all times. I understand that there will be no negative impact to any learner who wishes to participate in this research.

Signed: _____

Date: 23.08.2017

GAUTENG DEPARTMENT OF EDUCATION
JOHANNESBURG SECONDARY SCHOOL
2017 -08- 23
P.O BOX 42037 FORDSBURG 2033
T: 833-2758 FAX: 837-1558

Appendix E: Information Letters For Parents



Parent/Legal Guardian Information Sheet

Dear Parent/Guardian

My name is Jaime Abrahams, I am completing my Master of Education (Educational Psychology) at the University of the Witwatersrand. For the purpose of my studies, I am required to undertake research. I would like to invite your child to participate in my research.

My research aims to examine the interactions between the following:

- Divergent thinking (a component of creativity)
- Working Memory (ability to mentally hold and process information)
- Language acquisition and proficiency (information about the number of languages each participant knows and uses)
- Academic Performance (Specifically looking at English and Mathematics)

It is important to note that this research falls part of a bigger study including co-researcher Kirstin Anthony (Masters Student in the field of Psychology by Coursework and Research Report). The larger study also involves investigating the relationship between divergent thinking and working memory as well as language and academic performance. The results obtained from this research will be shared with Kirstin Anthony. This research and the larger study are under the supervision of clinical psychologist, Ms. Aline Ferreira-Correia.

Specifically, I am looking for voluntary participants between the ages of 12 and 14, with no history of neurological illnesses or head injuries. I have gained permission from the School's Principal in order to conduct the study at their school.

This research aims to make a significant contribution to the understanding of how speaking one or more languages have an impact on particular cognitive functions (such as working memory and divergent thinking), and how this can potentially contribute to the academic performance of children in the 7^{th} to 9^{th} grades. There is very limited research regarding these important variables in the South African context. The findings may be of particular interest to psychologists and educators.

If you agree to allow your child to participate, he/she will be invited to meet with me for an assessment session that involves different types of activities, from answering questions, remembering information and solving different types of cognitive problems. The tests of this protocol tools are frequently used by psychologists all over the world when conducting psychological research. This process will take approximately 30 to 40 minutes. This testing will take place at your child's school in a time that does not affect academic or sport attendance. As

Academic Achievement is one of the core variables of my study, access to your child's academic records in the form of the learners' school reports of current year will be required as we are looking specifically at results obtained in English and Mathematics.

Your child will not receive any compensation, monetary or otherwise, for participating in the study and no negative consequences for withdrawing.

I would therefore like to stress that your child's participation in this research is entirely voluntary and may withdraw from it at any point, your child may also refrain from answering any particular question.

Your child's identity as a participant will be only known to me, my fellow researcher and our supervisor. The test protocols will be stored in a locked file cabinet (at my supervisors' office) and the results stored in a password protected computer. Only we and our supervisor will have access to these files. To protect confidentiality, the name or other personal identification data will not be used. Instead, an identification number will be used in each protocol. The school or teachers will not have access to any of the results obtained during testing. These results will not affect your child's academic results.

If you agree to allow your child to participate in the study it is required that you complete the attached consent form and demographic questionnaire on behalf of your child. The consent form, demographic questionnaire and school reports will be kept separately from the rest of the data for the purpose of confidentiality.

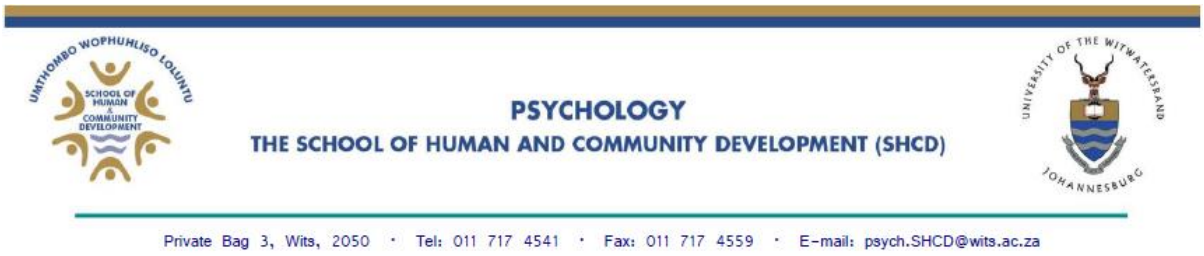
The report resulting from this research will be available in the library of the University of the Witwatersrand, which offers access to material on the world-wide web. The findings will also potentially be published in scientific journals. If you wish to have access to the results, you may request so by contacting me. The results are expected to be ready by June 2018.

Should any matters require further clarification please do not hesitate to call me at 0605286356, or email me at or jaimejoy007@yahoo.com.

You may also contact my research supervisor, Ms. Aline Ferreira-Correia telephonically at 011 717 4527 or via email at Aline.FerreiraCorreia@wits.ac.za.

Thank you and Kind Regards,
Jaime Abrahams

Appendix F: Parental Consent Form



Consent Form

Dear Jaime Abrahams

I, Mother/Father/Legal Guardian of _____
give consent for my child to participate in this study.

I understand:

- The aims and procedures of the research are provided in the information sheet.
- There is no risk or harm that could come to my child from participating in this study.
- Participation is completely voluntary
- My child may choose to withdraw from the study at any time, for any reason, with no negative consequences.
- My child's identity and results will be confidential and the information will be kept in a password secure file in a password secure computer and the protocols of the tests will be kept in a locked cabinet, both only accessible to the researchers and the supervisor.
- No rewards will be offered or provided for my child's participation.
- I have received the contact details of the researcher (Jaime Abrahams) and the supervisor (Mrs Aline Ferreira Correia)
- The research will be conducted at my child's school, for approximately 30 minutes, during a period that would not involve missing class or sports.
- I can request a summary of the results on June 2018 to the researcher via email.

By allowing my child to participate I state that my child:

- Has not repeated any grade
- Has not been diagnosed with any form of learning disability
- Has no visual or hearing impairments
- Is proficient in English
- Has no history of epilepsy, meningitis, or has suffered a head injury.
- Is not on chronic medication
- Has no behavioural difficulties

Signed: _____ Date:_____

Appendix G: Demographic Form

Demographic Questionnaire

Full Name of child:

_____

Gender: | M | F | Date of Birth: | D | D | M | M | Y | Y | Y | Y |

Home Language: _____ School Language: _____

Current Grade:_____

Did your child ever fail a grade at school? If so, which one?_____

Did your child attend pre-primary school? _____

Living Amenities & Caregiving

Educational and occupational status of parents or primary caregivers:

Mother: Level of Education		Father: Level of Education	
No schooling		No schooling	
Less than primary school completed		Less than primary school completed	
Primary school completed		Primary school completed	
Secondary school not completed		Secondary school not completed	
Secondary school completed		Secondary school completed	
Tertiary education completed		Tertiary education completed	
Other		Other	
Current occupation:		Current occupation:	

Marital status of primary caregivers:

Married	
Living together as husband and wife	
Widow/widower	
Divorced/separated	
Never married	

Number of caregivers in the household (please tick):

0	
1	
2	
>2	

Living Standards Measure:

Please answer the following questions according to your child's circumstances.

Question	Answer	
1. I have the following in my household:		
TV set	TRUE	FALSE
Video game consoles (e.g. Xbox or Play Station)	TRUE	FALSE
DVD player	TRUE	FALSE
M-Net/DStv subscription	TRUE	FALSE
Hi-fi/music centre	TRUE	FALSE
Computer / Laptop	TRUE	FALSE
Vacuum cleaner/floor polisher	TRUE	FALSE
Dishwashing machine	TRUE	FALSE
Washing machine	TRUE	FALSE
Tumble dryer	TRUE	FALSE
Home telephone (excluding a cell)	TRUE	FALSE
Deep freezer	TRUE	FALSE
Fridge/freezer (combination)	TRUE	FALSE
Microwave oven	TRUE	FALSE
Built-in kitchen sink	TRUE	FALSE
Home security service	TRUE	FALSE
3 or more cell phones in household	TRUE	FALSE
2 cell phones in household	TRUE	FALSE
Home theatre system	TRUE	FALSE
2. I have the following amenities in my home or on the plot:		
Tap water in house/on plot	TRUE	FALSE
Hot running water from a geyser	TRUE	FALSE
Flush toilet in/outside house	TRUE	FALSE
3. There is a motor vehicle in our household	TRUE	FALSE
4. I am a city dweller	TRUE	FALSE
5. I live in a house, cluster or town house	TRUE	FALSE
6. I live in a rural area outside Gauteng and the Western Cape	TRUE	FALSE
7. There are no radios, or only one radio (excluding car radios) in my household	TRUE	FALSE
8. There is no domestic workers or household helpers in household (both live-in & part time)	TRUE	FALSE

Appendix H: Participant Information Sheet and Assent Form

PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)
Private Bag 3, Wits, 2050 · Tel: 011 717 4541 · Fax: 011 717 4559 · E-mail: psych.SHCD@wits.ac.za

Participant Information Sheet
Dear Student,

My name is Jaime Abrahams and I am completing my Master of Education (Educational Psychology) at the University of the Witwatersrand. For me to become an Educational Psychologist I need to do research about how speaking one or more languages can change the way you solve problems in your mind and use your creativity, and how those can have an impact on your marks. Because I am looking at your school results I will need to access your current school year report, as I will be looking at your English and Mathematics marks.

I have contacted your parent/guardian and he/she has given me permission to invite you to participate in this research. It will take 30 to 40 minutes and I will ask you to remember information, think about new ideas and solve a few problems in your mind. Participating in the research will not interfere with any of your academic lessons or extramural activities. Your answers are confidential, which means that no one will have access to them, and they will not be shared with the school and your teachers. These results will not affect your school academic results. Instead of using your name in your answers, we will use a number.

If you are willing to take part in the study please write your name or sign the attached assent form. You will not receive any reward for participating. If you decide not to participate you can let me know at any stage and we will stop with no negative consequences.

If you have any questions after the assessment you may ask your parent/guardian to contact me at 0605286356, or email me at or jaimejoy007@yahoo.com.

You may also contact my research supervisor, Ms. Aline Ferreira-Correia telephonically at 011 717 4527 or via email at Aline.FerreiraCorreia@wits.ac.za.

Thank you and regards

_____
Jaime Abrahams

PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 · Tel: 011 717 4541 · Fax: 011 717 4559 · E-mail: psych.SHCD@wits.ac.za

Participant Assent Form

I, _____ understand:

- I have been invited to participate in this study.
- Jaime Abrahams has explained what the study is about.
- That there are no rewards that will be given if I say yes.
- That there are no negative consequences if I choose not to participate.
- I can stop the activities at any time that I want.
- That my name will not be used in any materials or reports as the information will be confidential and anonymous.
- I can ask questions at any time.

Would you like to participate? Please tick one of the boxes below.

☐ Yes, I am willing to participate in the study

☐ No, I am not willing to participate in the study

(Signing the form will indicate that you will participate in the study)

_____ _____

Name/Signature Date