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2013-02-19
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Mental Imagery and Reading Comprehension Proficiency in English Second Language Learners: An Exploratory Study

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2012

A research report submitted to the Faculty of Humanities, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements of the degree of Master in Research Psychology.

Abstract

Reading comprehension proficiency is vital for learners to be successful in their academic career, however, South African studies have revealed that reading comprehension skills are severely underdeveloped in secondary school learners. Local research has investigated many contributing factors such as multilingualism and deficits with the national curriculum standards. Far fewer studies have examined the cognitive underpinnings that differentiate between English second language (ESL) learners who are proficient in reading comprehension and those who are not. Certain multi-coding theories assert that the integration of visual mental imagery and verbal information is essential for the formation of a comprehensive mental model, which forms the basis of reading comprehension. This study explored the relationship between visual reasoning ability and the reading comprehension proficiency in a group of 83 ESL learners from two urban Gauteng schools. One school represented learners who are proficient readers whilst the second group represented learners who are developing readers. The Non-Verbal Reasoning and the 3D Spatial Manipulation subtests from the Differential Aptitude Test (DAT) battery were used to explore the learners' ability to reason using visual-object and visual-spatial mental imagery. The Verbal Reasoning test was used to establish a baseline for the learners' language skills. The items of the Reading Comprehension subtest of the Stanford Diagnostic Reading Test battery (SDRT-RC) were evaluated for textual factors that contribute toward word concreteness effects. The relationships between the DAT subtests and the SDRT-RC Mixed, Abstract and Concrete Items subtests were discussed in light of multi-coding models of reading comprehension.

Keywords: Mental Imagery, Reading Comprehension, ESL (English Second Language), Mental Models, Visual-Object, Visual-Spatial, Word Concreteness Effects

Declaration

I hereby declare that this Research Psychology Masters Thesis is my own independent effort and has not been presented for any other degree at an alternative academic institution. It is submitted in partial fulfillment for the degree of Master in Research Psychology at the University of the Witwatersrand, Johannesburg.

_____ _____

Aleksandra A. Ashton Date

Author Note

I would like to acknowledge the following people, who in various capacities and at different stages, have aided me during the development and writing process of this research paper.

I would like to thank Dr. Yvonne Broom, my supervisor, for all the invaluable guidance and insight she gave to me, especially in the last few months. Her direction was paramount in helping me focus and refine the core of the research.

Many thanks go to Ms. Enid Schutte and Prof. Kate Cockcroft, two of my past lectures who some time ago, ignited in me the sparks of inspiration which integrated and grew into the focus of my research.

A huge thank you goes to Ora, Nicole, Deanne and the friends that, at one time or another, served as sound boards, motivators, counselors, editors and even drivers, all in the goal to help me achieve this task. Thanks also go to Elsabe and Collin for lending me their knowledge of statistical analysis.

I would like to deeply thank my mother, father and sister for all their patience and for supporting me through my education financially, emotionally and nutritionally.

Most of all, I would like to thank my husband, Kevin who has put in countless hours discussing, editing and formatting my research. Your unbreakable faith in me has brought it to fruition. With all my love.

Contents

Abstract 2
Declaration 3
Author Note 4
Contents 5
List of Tables 7
Literature Review 8
Visual Mental Imagery, Cognitive Development and Cognitive Processing 11
Piaget's theory of cognitive development. 11
Memory and processing of visual mental imagery.....13
Reading Comprehension, Visual Mental Imagery and Mental Models.....18
Mental models and inference generation.....19
Multi-modal coding theories of reading comprehension.....20
Visual-Object and Visual-Spatial Mental Imagery.....29
International and South African studies of reading development intervention strategies using visual mental imagery. 33
Rationale 35
Differential Aptitude Test Battery and assessment of visual and verbal reasoning ability... 35
Stanford Diagnostic Reading Test Battery and assessment of reading and reading comprehension ability. 37
Research Questions and Hypotheses.....45
First research question. 46
Second research question. 47
Third research question. 48
Summary of research questions and hypotheses. 49
Methods 51
Research Design.....51

Sample Description 52

Instruments 54

Differential Aptitude Test-Form K. 55

The Reading Questionnaire. 56

Procedure 57

Ethics 58

Results 60

Data Analysis 60

Comparison and Amalgamation of the Two School Groups 62

Descriptive statistics. 62

Relationships between the Differential Aptitude Test subtests and the Stanford Diagnostic Reading Test -Reading Comprehension subtests 68

Predictive power of the Differential Aptitude Test subtests for each of the Stanford Diagnostic Reading Test-Reading Comprehension subtests 73

Discussion 76

Exploration of the relationship between the Differential Aptitude Test subtests and the total Stanford Diagnostic Reading Comprehension subtest 82

Exploration of word concreteness effects on the relationship between the Differential Aptitude Test subtests and the Stanford Diagnostic Reading Test Reading Comprehension subtest 88

Exploration of the predictive power of the Differential Aptitude Test subtests for each of the three Stanford Diagnostic Reading Test Reading Comprehension subtest 93

Limitations 97

Conclusion and Recommendations 99

Reference List 102

Appendices 113

Appendix A- Biographic Information, Reading Activity and English Exposure Questionnaire 113

Appendix B- Letter of Information for Learners 115

Appendix C - Consent Form 117

Appendix D – Ethical Clearance 118

List of Tables

Table 1 *M and SD for Demographic Variables and Academic Performance of all School Groups*.....62

Table 2 *M, SD and IQR for the Standard Diagnostic Reading Test-Reading Comprehension subtests (SDRT –RC) and for the Differential Aptitude Tests subtests (DAT) for all School Groups*.....63

Table 3 *ANOVA Comparison between the Lower Performance Group and the Higher Performance Group on Age, Academic Performance, Standard Diagnostic Reading Test-Reading Comprehension subtests (SDRT –RC) and the Differential Aptitude Tests subtests (DAT)*.....63

Table 4 χ^2 *Comparison of the Lower Performance Group and the Higher Performance Group results on selected Reading Questionnaire Items*.....65

Table 5 *Comparison of the Frequency with which the Participants in the Lower Performance Group and the Higher Performance Group use English to Communicate with Various Social Groups*.....66

Table 6 *Correlation matrix for the three Differential Aptitude Test subtests for all School Groups* ...68

Table 7 *Correlation Matrix between the Standard Diagnostic Reading Test-Reading Comprehension subtests and the Differential Aptitude Tests subtests for all School Groups* 69

Table 8 *Paired Sample T-Test comparing performance between Stanford Diagnostic Reading Test-Abstract Items and Concrete Items Subtests*.....72

Table 9 *Multiple Regression Models for the three Stanford Diagnostic Reading Test-Reading Comprehension subtests (SDRT-RC) with Differential Aptitude Test (DAT) subtests as predictors, for all School Groups* 73

Table 10 *Multiple regression Models for the Stanford Diagnostic Reading Test-Reading Comprehension Mixed Items Subtest and the Differential Aptitude Test subtests for the Combined Group*.....75

Literature Review

Learners in South Africa are not developing the literacy skills they need to cope with the demands of formal education. The Grade 6 Intermediate Phase Systemic Evaluation Report (Department of Education, 2005) indicated that 63% of the learners in the sample (total *n*=34015) did not meet the literacy assessment standards stipulated by the Department of Education. In addition, the Progress in the International Reading Literacy Study (PIRLS) indicated that South African learners' literacy skills were significantly below international literacy standards (Mullis, Martin, Kennedy & Foy, 2007).

Learners' performance on psychometric measures of reading ability has been found to be closely correlated with their academic performance (Khatpagam, 2009; Malope, 2009; Manyike, 2007; Van Rooyen & Jordaan, 2009). Poorly developed literacy has been a major factor in high university dropout rates because learners who pursue higher education are often unprepared for the level of reading that tertiary education demands (Kilfoil et al., 2005; Nel, Dreyer & Klopper, 2004). Poor literacy levels amongst the school going population may decrease the number of learners who find suitable employment after they matriculate. The problem is so severe that concerns have been raised by government officials regarding the economic consequences that low levels of literacy may have at a national level (Department of Education, 2009a, 2010).

Both South African and international researchers have identified a number of contextual and socio-economic factors which could impair learners language and reading comprehension development. Some contributing factors include limited educational resources such as text books for learners, particularly in African mother tongue languages and an insufficient number of qualified educators in many schools (Department of Education, 2009b; Macdonald, 2002). Arguably one of the core contributing factors was the misinterpretation of reading and multi-lingual education theory that formed the basis for the 1997 Language in

Education policy (LIEP). This policy was used to inform the language policies of the national education curriculum (Department of Education, 2010a; Heugh, 2005; Macdonald, 2002;).

Most South African learners are multilingual and almost two thirds of South African learners selected English as their preferred language of learning and teaching, despite English being the mother tongue for only 6.65% of the population. In addition 65.1% of schools use English as the medium of instruction (Department of Education, 2010a, p. 24). A large disparity exists between the literacy proficiency of learners for whom English is their first language (EFL) and those for who English is their second language (ESL). Local research into learners reading skills indicated that adolescent ESL learners can decode text (Khatpagam, 2009; Lathy, 2008) but they have a limited vocabulary (Bhorat, 2007; Catto, 2010; Khatpagam, 2009; Lathy, 2008; Ranchod, 2008; Winnett, 2009). A poor vocabulary represents the learners' inability to associate meaning with words so the learner has to divert cognitive resources to locate this meaning through translation or some other means, or they may ignore the word entirely. A number of studies have demonstrated that ESL learners' performance on reading comprehension measures was poorer than their EFL peers (Catto, 2010; Malope, 2009; Van Rooyen & Jordaan, 2009; Winnett, 2009). Poor English vocabulary contributes to poor comprehension; however, a broad vocabulary alone is not sufficient for reading comprehension to be successful (Ngwenya, 2004). A distinguishing factor between learners with poor and good comprehension skills is that learners with poor comprehension skills struggle to integrate different parts of a textual discourse with relevant prior knowledge in order to construct a coherent mental model of the text (Cain, Oakhill, Barnes & Bryant, 2001, Cain & Oakhill, 2003).

Learners who are not proficient in reading skills will depend on the use of rudimentary reading skills such as decoding when they encounter is very demanding on

cognitive resources (Cain et al., 2001; Cain & Oakhill, 2003). If too many resources are diverted to these processes then reading comprehension will be impaired.

Multi-lingual readers who struggle with reading comprehension do not necessarily have learning disorders but the additional complexities inherent to the development of multi-lingual verbal skills may require a greater dependence on rudimentary reading skills and thus result in cognitive demands in excess of what the learner is able to manage. If this is not suitably addressed it will inevitably hamper their developmental progress and may lead to the development of a serious learning disorder (Morishima, 2008; Nassaji, 2007; Oh, 2007).

There is an extensive source of information that is easily accessible to learners but is often underused in the educational context; learners' non-verbal prior knowledge. Visual mental imagery refers to prior knowledge that when activated, is experienced in a way that resembles visual sensory perception (Thomas, 2010a).Visual mental imagery based reading strategies can be tailored to support rudimentary reading skills as well as basic discourse level reading comprehension skills. Research has indicated that they are applicable to readers of all ages and levels of reading proficiency (Jenkins, 2009). They are also applicable for multilingual education contexts, including the South African context (Ngwenya, 2004, Ravenscroft, 2008). Even simple and brief instruction to learners to use visual mental imagery during reading has been shown to produce positive results for reading comprehension (Jenkins, 2009) and is thus an accessible and practical tool for teachers. The extent to which learners are exposed to instruction in using visual mental imagery strategies is subject to the preferences and experience of their teachers.

The disparity between the reading comprehension ability of EFL and ESL, particularly in the adolescent age group, has been well established in the local South African context. This research paper sought to explore the cognitive nuances specific to non-verbal processing ability and reading comprehension ability in ESL learners.

The text related factors which affect the spontaneous representation of visual mental imagery in the mind were also examined. It is the aim of this research to demonstrate that, even in the absence of instruction, learners already employ their non-verbal prior knowledge as a natural course of reading comprehension. This serves to promote visual mental imagery strategies as practical and widely applicable learning tools which can assist learners of all ages in developing the necessary reading skills they need to be successful in their academic career.

The next section of this chapter addresses the theoretical background of the role of visual mental imagery in cognitive development and day to day processing. The subsequent section explores three constructionist theories that provide insight into the construction of multi-modal mental models. The last section explores how visual mental imagery can be used in strategies which support a variety of reading and reading comprehension skills.

Visual Mental Imagery, Cognitive Development and Cognitive Processing

Piaget's theory of cognitive development.

Piaget (1970, as cited in Miller, 2007) stated that the knowledge that a child gains from various sensory motor experiences provides the basis for the development of basic thought, which in turn establishes the child's capacity to learn and to use language. The child will start to display the development of basic thought and language skills by using symbols, drawings, rudimentary speech and writing abilities, to represent concrete objects and experiences. Initially the child is dependent on cues to associate an object with an appropriate symbol. The child begins to make generalizations about objects which are informed by how they have categorised the object. These generalizations tend to be based on a single physical feature of an object and thus tend to be inaccurate. The accuracy of the child's categorisation ability is refined over time as the child begins to (a) develop *transitive inference* ability which

enables them to them to conceptualize and categorize concrete objects based on multiple features, (b) begins to understand the principles of cause and effect relationships and (c) develops the ability to understand sequences and changes in objects states and can understand the consequences of these changes.

As development proceeds, the child becomes less dependent on context based cues and is able to think about abstract concepts and develops the ability to reason about objects even if they are not present in the child's immediate environment. Abstract reasoning is dependent upon the child's ability to retrieve prior knowledge from memory and accurately apply it to current thought processes**.** Eventually, the child develops metacognition skills that allow him/her to reflect on and modify mental processes and prior knowledge. Abstract reasoning and metacognition skills form the foundation for skills such as problem solving, reasoning and critical thinking.

Piaget and Inhelder (1971) argued that education techniques that are predominantly verbal are insufficient for the child's developmental needs as a significant portion of the child's early prior knowledge is based on non-verbal information. Techniques that stimulate and integrate verbal and non-verbal information encourage the child to use their non-verbal knowledge to enhance language development. Units of non-verbal information that are brought into awareness are referred to as mental images. Mental imagery is typically experienced in a mode similar to the sensory modality it was originally perceived through. The visual modality is arguably the richest source of information, however other non-verbal modalities include: auditory, tactile, kinetic, hepatic and olfactory information. Multi-modal representation does not automatically result in the generation of meaning and learning. For learning to occur, the child must actively engage in the mental evaluation and manipulation of the non-verbal imagery. In addition, non-verbal imagery has to be actively integrated with verbal knowledge before it can be used to support language development.

Memory and processing of visual mental imagery.

The concept, nature and purpose of visual mental imagery has been the subject of philosophical debates and psychological investigation since the time of the great Greek philosophers and is still a subject of much contention in today's academic circles. The common coding versus dual/multi-modal coding debate is concerned with the nature of the information as it is used to form mental representations and the function these mental representations have in higher level cognition. Common coding theories argue that all information is processed in a unitary a-modal or propositional code. Dual and Multi-Modal coding theories propose that codes contain characteristics which correspond with different sensory modalities (Thomas, 2010a, 2010b).

There is no direct way to measure the perception of information in a human mind. The predominant sources of evidence for the presence of multi-modal coding emerged from neuroscience, dual task experiments and from participants' self-report about their perceptual experience.

Cognitive neuroscience has provided evidence which supports the hypothesis that the brain contains multiple areas that are specialized to perform particular processing functions and that some of these areas may be specialized to process a single sensory code, whilst other areas are associated with the processing of different types of codes. Many multi-coding theories propose that verbal information is represented by auditory codes and visual codes which represent the orthographic features of written language (Thomas, 2010a, 2010b). It follows that certain cognitive processes are used to process verbal and non-verbal information. For instance, auditory verbal cues were found to activate parts of the brain associated with visual-spatial processing (Mellet et al., 1996). The instruction to create mental images resulted in the activation of both visual and language related cortices (Mazoyer, Tzourio-Mazoyer, Mazard, Denis, & Mellet, 2002).

Dual task interference tests require a person to perform two tasks simultaneously. These tests have been used to assess the nature and mechanism of cognition such as attention, cognitive processing capacity and memory. Multi-modal coding theories have used these tests to assess performance on tasks that require processing different types of sensory information. Many studies have demonstrated that participants could perform tasks simultaneously if the information required for each task came from different sensory modalities, however, performance on the tasks suffered if both tasks required the processing of information from the same modality. This suggests that the tasks which involve the same modality may result in competition for the resources of similar cognitive processes (Baddeley & Repovs, 2006; Thomas, 2010b).

The common code / multi code debate has been applied to various cognitive processes and theories, however, one of the richest sources of research can be found in field of memory theory. Memory plays a vital role in many cognitive processes, including reading and reading comprehension. For reading comprehension to be successful, a person needs to be able to encode new information to memory, such as vocabulary and various reading skills, and to recall the relevant prior knowledge to construct mental representations (Smith, 2004).

Until the 1960s, memory was thought to be a unitary faculty that consisted of one processing component that processed a single code. These early models of memory, such as Atkinson and Shiffrin's model of human memory (Atkinson & Shiffrin, 1968) and Craik and Lockhart's levels-of-processing framework (1972, as cited in Craik & Lockhart, 1990), were not able account for the variation of recall when the sensory stimuli and context of the stimuli changed (Baddeley, 2003). Baddeley and Hitch's theory of Working Memory (1974, as cited in Baddeley & Repovs, 2006) proposed that the short term memory component of long term memory (LTM) is not a simple store for holding information temporarily, but also acts as a workspace to facilitate the complex mental functions related to processing of information.

This work space was called the working memory (WM).WM consists of a collection of executive processes and three code specific subsidiary systems. Executive processes are referred to collectively as the central executive. These processes are responsible for the distribution of attention control between the three subsidiary systems as well as the manipulation of information within the subsidiary systems (Baddeley, 2003; Baddeley & Repovs, 2006). The three code specific subsidiary systems are the visuo-spatial sketchpad, the phonological loop and the episodic buffer (Baddeley & Repovs, 2006). Each subsystem is composed of a passive store and a functional component. The passive store has a limited capacity to hold information temporarily. This information includes sensory information gained from a particular external stimulus and information retrieved from the person's prior knowledge store in the long term memory. The functional component is responsible for low level processing and maintenance of the store. The multi-modal nature of the three subsystems makes it possible for different sets of information to be processed simultaneously on condition that these sets of information are modally different.

The phonological loop is responsible for the storage and maintenance of sound and verbal information. Text is articulated sub-vocally into a phonological code and encoded in the phonological store and manipulated within the articulatory rehearsal process.

The visuo-spatial sketchpad is responsible for the storage, processing and integration of visual information. Evidence from various dual task interference tests and neurocognitive studies indicates that the visual-object and the visual-spatial components have their own storage and rehearsal processes (Baddeley, 2003; Baddeley & Repovs, 2006). Visual-object component includes visual information as details about an object's features while the visual-spatial component processes information about an object's location and its spatial relation to other objects.

The episodic buffer stores and processes multi-modal codes (Baddeley, 2000 as cited in Baddeley 2003). This system is able to integrate information from multiple modalities into one code to produce complex mental representations of a scene or, combined with temporal sequencing, of an episode. The episodic buffer also enables predictive mental modelling.

WM is an important component of the processes involved in most forms of cognition, including specialized skills such as reading comprehension, however traditional measures of WM span and capacity, particularly measures of visual and spatial WM, are poor predictors of variance in reading comprehension ability (Cain ,Oakhill & Bryant, 2004; Radvansky & Copeland, 2001). Reading comprehension is an on-going, sequential process that has an end product which reflects a large quantity of integrated multi-modal information, far more than can be represented in the WM at any one time. Standard tests of WM involve the processing of arbitrary and un-integrated information. In addition, the majority of the skills and cognitive processes which are involved in reading comprehension are not tapped by standard measures of WM (Ericsson & Kintsch, 1995; Long, Winograd & Bridge, 1989; Radvansky & Copeland, 2001).

Ericsson and Kintsch (1995) proposed the theory of Long term working memory (LTWM) to address the discrepancy between the WM capacity and the amount of information that is readily available to a reader during the reading process. LTWM represents highly practiced reading skills and frequently accessed knowledge that requires minimal cognitive effort to be used during reading comprehension. Ericsson and Kintsch (1995) used the term Short Term Working Memory (STWM) to describe Baddeley's WM in order to differentiate it from LTWM. Both STWM and LTWM represent a stable source of stored information that can be accessed reliably during reading comprehension, retrieval is slightly easier in the STWM storage since this represents the most recently activated prior knowledge. The transformation and simulation of information occurs within the STWM. The

primary function of LTWM is to facilitate easy retrieval of large amounts of information from long term memory thereby facilitating complex and information heavy processes such as reading comprehension.

The range of reading skills available in a reader's LTWM is dependent upon where they are in the development of their reading skills. Rudimentary reading skills, such as decoding, word identification and the acquisition and correct application of syntactic knowledge, are learnt in the initial stages of learning to read. Rudimentary reading skills exert a heavy load on the reader's cognitive resources, even after the skills have been mastered. Thus these skills are unlikely to form part of LTWM. Rudimentary reading skills become redundant and are replaced by more efficient, basic reading skills. Unlike rudimentary reading skills, the cognitive load of many of these skills is greatly reduced as the reader practices the skill. Eventually, the implementation of these skills during reading will become automatic and form part of LTWM. Advanced reading skills represent the reader's ability to automatically use basic reading skills and who can apply complex reading strategies to gain deep level comprehension of a text. Readers who have developed basic and even advanced reading skills may resort to rudimentary reading skills if they encounter unfamiliar words or a particularly difficult text (Cain et al., 2001; Cain & Oakhill, 2003).

LTWM also includes prior knowledge such as facts and general knowledge as well as knowledge that is domain specific. If a reader is very familiar with a particular topic it is easier for them to access relevant information when reading about something related to that topic. Reading related domain specific knowledge includes knowledge about text literary conventions such as genres and their implication for text structure, literary devices such as metaphors and analogies and various reading and reading comprehension strategies. The more general or domain specific knowledge is integrated with other information in LTM, the more likely it is to be activated during reading. Priming effects also play a major role in

LTWM. For declarative knowledge to be brought into WM a stimulus needs to activate the node or set of nodes associated with that knowledge which is stored in a dormant state. When the node is no longer stimulated enough to be maintained in WM it starts to revert to a dormant state. This process is a gradual and thus recently activated knowledge nodes retain a degree of activation for some time. As a consequence, less effort is needed to reactivate this information into WM (Kintsch & Ericsson, 1995; Reisberg, 2001).

The LTWM theory was developed as a companion to the Construction Integration Model of text comprehension proposed by Kintsch (1988).The following section explores the concept of Mental Models and different theories that conceptualize the construction of mental models during reading comprehension. The concluding section explores how visual-object and visual-spatial mental imagery, either as representations or as part of an integrated model, can be used to support reading and reading comprehension processes.

Reading Comprehension, Visual Mental Imagery and Mental Models

The constructivist paradigm purports that the knowledge contained in the human mind is not a concrete depiction of the physical world. Rather it is the product of an amalgamation of each person's experience and exposure to various aspects of the physical world (Hale-Hannif & Pasztor, 1999). Comprehension is the cognitive activity whereby a person exerts cognitive effort and applies higher cognitive processes such as logic and reasoning and elements from prior knowledge to create a mental model; an abstracted mental construct that represents some set of stimuli. Reading comprehension is a specialized form of comprehension that is constrained to the comprehension of a text-based stimulus. The mental model enables the person to consciously understand the meaning of a set of stimuli and to access the potential to make various inferences and predictions about the stimuli which are relevant but contain information beyond what is directly related to the stimuli and their immediate context. Mental

models are the result of the amalgamation of a number of different types of mental representations; mental constructs that contain information about a specific aspect of the physical world. Mental representations that are integrated into a mental model can represent different concepts or the same concepts albeit in unique ways through different sensory modalities (Johnson-Laird, 2004; Rapp, 2005).

Mental models and inference generation.

Successful reading comprehension depends on the learner's ability to reduce the semantic ambiguity of text and to construct, maintain and update a mental model of the text, to ensure it is coherent and contains information that is relevant to what is being read while it is being read (Smith, 2004).

Inference making is based on the process of using logical reasoning to draw conclusions based on the relationship between two or more premises which are believed to be true. The premises are not complete reflections of the world, but they can be used to make assumptions about the world when certain premises co-occur. Graesser, Singer and Trabasso (1994) proposed that the learner is an active participant in the reading process and will strive to satisfy his or her goals. The reader's goals influence the type of knowledge they will glean from a particular text and influences the way in which they process the text. The reader will strive to construct meaningful and coherent mental representations and situation models of the text through the use of inference. Generation of inferences varies in the degree of effort that is required and it is usually an active process that requires the reader to exert some degree of conscious cognitive effort (Graesser et al., 1994,; Graesser et al., 2007; Kintsch, 1998; Paivio & Sadoski, 2004, 2007).

Certain inferences are made using information from the syntactic structure of the text while other inferences are dependent upon declarative prior knowledge to construct meaning (Graesser et al., 1994).

The reader will also attempt to generate explanations for the presence of various explicit and implicit relationships that they were able to identify. Certain explanations are necessary to maintain coherence whilst other explanations can elaborate on relationships but may not be necessary for coherence (Graesser et al., 1994; Graesser et al., 2007).

The nature and quantity of inferences made by a reader is influenced by their prior knowledge of various rudimentary, basic and advanced reading skills, knowledge of language structure and meaning, and knowledge of literary conventions. In addition, the learner needs to be able to choose and apply the relevant knowledge and skills to comprehend a particular text.

If reading comprehension is interrupted there is a risk that the integrity of the mental model will be compromised (Cain et al., 2001). The acquisition of new knowledge and the development of reading skills at all levels are initially very demanding on cognitive resources. If the remaining resources are not sufficient to facilitate reading comprehension, then the process will be interrupted. The more the process is interrupted the more likely it is that the model created will be incomplete or erroneous (Cain et al., 2001). Developing readers may be able to comprehend the meaning of a sentence but they may not have sufficient cognitive capacity available to make the inferences necessary to maintain coherence of a text at discourse level, even if the reader is aware of inference making strategies (Cain et al., 2001; Cain & Oakhill, 2003; Cain et al., 2004).

Multi-modal coding theories of reading comprehension.

A number of theories that have emerged from this paradigm represent the cognitive complexities of reading comprehension related processes. All of the frameworks described in this section assert that reading comprehension involves the construction of mental representations and mental models that are thought to contain more information than is explicitly stated in the text and whilst each theory considers visual mental imagery to play a

vital role in reading comprehension, the underlying processes of comprehension are significantly different.

In Construction–Integration Model (CIM), Kintsch (1988, 1998) conceptualized the construction of the model as an iterative process through which a propositional text base activates multi-modal information at the model level. CIM uses the term situation model, as the models represent a complex situation that is represented in the text. In Dual-Coding Theory (DCT), Paivio (1974) argued that the verbal and non-verbal mental imagery are simultaneously created at the representational level and the mental model is the aggregate of links between these representations.

In isolation, neither theory provides a sufficiently comprehensive account of the role of visual information in the construction of mental models. In the Event Indexing Model (EIM), Zwaan and Radvansky (1998) examined the different modal and semantic domains which are commonly represented in models during reading comprehension, albeit that the domains are largely isolated from one another. Zwaan (2003) incorporated various aspects of CIM, DCT and EIM and developed the Immersed Experiencer Framework (IEF). IEF explores how different forms of modal information interact to represent a local level text. Here, the framework argues that the mental constructs formed at both the representation and the model level are perceptual in nature and contain properties of many different modalities.

Kintsch's Construction Integration Model.

Kintsch's Construction Integration Model (CIM) (1988, 1998) assumes that information is stored and processed using a single propositional code. This code is a symbolic abstraction of sensory information and spoken language. Sensory information is encoded in the propositional network in such a way that is retains the qualities of the sense it was first perceived in. Sensory information can be experienced as mental imagery however, this occurs

at the model level only. CIM has an iterative integrative perspective whereby mental representations and models are processed sequentially and reading comprehension is directed primarily by bottom up processes, the end products of which feedback to lower level processing.

In the construction phase, information is processed in two representational levels. The first level involves the construction of a surface representation of the text microstructure. This surface representation represents the linguistic text units. It contains the grammatical characteristics of the sentence as it is perceived and has little or no semantic qualities. The second level involves the creation of a text-based representation. Text based representations are created when the surface representation stimulates the activation of knowledge nodes in the learner's LTWM and LTM. Each node is thought to represent a proposition (Kintsch, 1988). The text base representation contains a representation of the text microstructure, which represent a small portion of local level text, such as a sentence. It also contains a representation of the text macrostructure, which represents a global summary of what has been read of a text discourse up to that point.

At the microstructure text level, propositions from the local level text are linked to each other to form micropropositions; small units of information that have semantic properties. Each microproposition's meaning can be ambiguous and hold much information that is not relevant to the meaning of what is read. The STWM can only hold between three and five activated micropropositions at any one time (Kintsch, Patel & Ericsson, 1999).

At the macrostructure level, the macropropositions are created partly as a result of further processing of micropropositions as well as various top down inferential processes (Ericsson & Kintsch, 1995). The macropropositions represent summarized sets of meaning which have been previously determined to be relevant to the maintenance of a coherent representation of the text. The macropropositions are held in the LTWM and not in the

STWM. As such a macrostructure representation can contain far more information than the microstructure representation without consuming STWM capacity. Since information in the LTWM has been encoded in LTM, it is more stable than the microstructure representations, which are often transient.

The macrostructure text base serves to limit the ambiguous meaning in a microstructure text base. The meanings of micropropositions are ignored if they are not coherent with the meaning held in the macropropositions, unless the reader actively attends to the inconsistency. Ignoring the inconsistency may lead to an error in the microstructure and macrostructure representations (Ericsson & Kintsch, 1995).

The remaining ambiguity in microstructure text base is eliminated in the integration phase of text comprehension. The integration phase is characterised by the formation of a situation model (Kintsch, 1988). A situational model is constructed for both the microstructure and macrostructure text based representations. The macrostructure situation model provides a contextual reference that is important for the comprehension of subsequent text. Situation models are generated through the integration of the propositions in a text based representation with propositions which are part of the learner's non-verbal prior knowledge. This knowledge can be consciously experienced as mental imagery (Ericsson & Kintsch, 1995; Kintsch, 1998). The manipulation and elaboration of information in situation models can provide the learner with access to information which exceeds the information that is communicated in a particular type of physical text. This information can be simulated and transformed to mentally explore the probable outcomes of cause and effect relationships, which enables the reader to make various predictions about physical text.

CIM proposes that readers who are less proficient in their second language have fewer reading processes encoded in LTWM in their second language than in their first language. Thus the execution of advanced reading comprehension processes, such as inference making,

in their second language requires the use of more cognitive resources (Kintsch, 1998; Morishima, 2008; Nassaji, 2007). It is likely that the reader's second language vocabulary is smaller than their vocabulary in their first language, so the reader may need to use even more cognitive resources for translation before they construct micropropositions in the text-based representation. As a result fewer cognitive resources are available for higher level cognitive processes such as the construction of a situational model and monitoring the consistency between text-based representations and situation models. Since reading comprehension is dependent on the construction of a coherent situation model, reading comprehension in a second language tends to be inferior to reading comprehension in the first language. Oh (2010) argued that bilingual learners construct the text-base in the second language, but the first language is used to then construct the situation model. Semantic knowledge in the first language can be used to support conceptual elaboration which cannot be achieved if proficiency in the second language is too low, however, this can only be successful if the learner is sufficiently proficient in their first language.

CIM focuses primarily on the constituents and processes of the propositional network and on the elaboration of the processes involved in the text-base and, while less attention has been given to the multi-modal nature of situational models (Dennis & Kintsch, 2007; Sadoski, 1999). Some theorists have attempted to elaborate upon the modality of situation models.

Paivio's Dual Coding Theory.

Paivio's Dual Coding Theory (DCT) (Paivio, 1974) is a multi-modal theory of general cognition. Paivio (1974) proposed that qualitatively different mental representations can be processed simultaneously in two specialized subsystems; namely the verbal and the non-verbal subsystems. The information in both subsystems is acquired through various sensory modalities. The non-verbal subsystem contains multi-modal sensory-motor information that

is not directly related to language. The verbal subsystem is specialized to represent and process auditory verbal information and orthographic depictions of words. It also includes sensory-motor kinaesthetic modes such as the physical mechanisms of speech and reading. When information is processed, it is processed in a format which is analogous with the sensory perception of the physical world it represents, rather than a propositional abstraction of the sensory information. This can occur at both the representational and the model level.

The basic code units in the verbal subsystem are called logogens and the basic code units in the non-verbal subsystem are called imagens. These units are dynamic and are enriched during the learning process. The two code subsystems are interconnected to some extent. Individual or groups of imagens can be linked with individual or groups of logogens as the different codes can refer to a single concept (Paivio & Sadoski, 2004, 2007). Information in one subsystem can be recoded into the code format of the other subsystem, to an extent. For instance a learner can read about an apple and learn about it through a verbal description even though they have never seen or eaten an apple. When information is encoded in both codes, information is more likely to be retained and is easier to retrieve because there are more pathways through which the learner can be access the information. Mental representations can thus be composed of both verbal and non-verbal codes.

Paivio and Sadoski (2004, 2007) applied DCT to explain reading comprehension. DCT proposes that text is processed at different levels. Processing at different levels occurs concurrently and results in the formation of a feedback loop between the levels.

The representational processing level is the first level text processing. Representational processing occurs when an orthographic textual feature stimulates the activation of a visual logogen or an auditory logogen.

The second processing level is called the associative processing level. At this level the logogens that were activated at the representational processing level, trigger a spread of activation within the verbal subsystem.

The third level, called the referential processing level, occurs when the activated logogens in turn cause the activation of imagens in the non-verbal subsystem. Typically this can only occur between logogens and imagens which are already connected.

Associative processing now also occurs in the non-verbal subsystem and is consciously experienced as visual mental imagery. This in turn leads to further referential processing between the imagens and the logogens.

The mental model is the "total verbal-non-verbal correspondence aggregate" which forms as a result of these various processing levels. Coherence is maintained as the spread of activation during associative and referential processing in one level is inhibited by the spread of activation in another level. In addition, spread and inhibition of activation between nodes of information within and between the two subsystems is influenced by the meaning which is generated from the construction and manipulation of a mental model (Paivio & Sadoski, 2004, 2007).

Paivio and Desrochers' (1980) used DCT to explain the cognitive process associated with bilingualism. Bilingual learners possess a single non-verbal subsystem and two separate verbal subsystems, one for each language they know. The information in these three subsystems is linked to varying degrees. Referential processing between two of the three subsystems can occur independently of the third system. When a learner is first learning a second language, its links to the information in the first language are very limited. A core feature of language learning is the association of verbal information to non-verbal information. Thus if the logogen in the second language is not linked to a logogen in the first language, but they are both linked to a mutual imagen, that imagen can be used to establish

the referential link between the logogens of the two verbal subsystems thereby facilitating translation (Ehlers-Zavlala, 2005; Paivio, Clark & Lambret, 1988; Paivio & Desrochers, 1980; Paivio & Sadoski, 2004).

A large body of research indicates that the different processes and characteristics of visual-object and visual-spatial mental imagery are processed in different ways (Baddeley, 2003; Baddeley & Repovs, 2006). Neither CIM nor DCT provided much insight into the implications of the role of visual-object and visual-spatial mental imagery on reading and reading comprehension processes.

Zwaan's Event Indexing Model and Immersed Experiencer Framework.

Zwaan's Event-Indexing Model (EIM) (Zwaan & Radvansky, 1998) proposed that the information that is present in a situation model can be divided into five domains including; causality, temporality, intentionality, spatiality and the domain of the story protagonist and objects. Readers automatically monitor the five domains as they read and update their situation model based on changes that occur in these domains. EIM presented the domains in isolation from one another, though some discussion on multi domain models was presented. It was observed that the more domains that are represented in the model, the more time that is needed for comprehension to take place. The spatial domain is thought to be experienced as spatial information. The protagonist and object domain represents the psychological traits, goals and physical characteristics of the protagonist in a narrative, as well as the physical characteristics of the objects that are related to the protagonist in the test. This domain could be related with visual-object mental imagery; however, its perceptual nature was not explained in the early model.

Zwaan (2003) reconceptualised the EIM and introduced the concept of embodied comprehension in the Immersed Experiencer Framework (IEF). The CIM view of the

activation of information in the LTWM has been integrated into the theory. Similarly to DCT, this model proposes that the representation level is fully perceptual and experienced as modal mental imagery. IEF assumes that, at the activation level, words are a represented as they are perceived when read, and this triggers the corresponding experiential representations of the words referents. The initial activation is believed to be very diffuse and in the absence of a context, textual cues are represented by the prior knowledge that is most routinely accessed.

The next level is called the constructural level. A constructural is a multi-modal mental representation that is constructed based on the information available in a small set of words called a clause. Unlike the CIM text base, constructural representations are not dependent on syntactic analysis and are constructed almost automatically. Constructurals contain information about multiple dimensions since cues in one modality, such as visual-object common nouns, can activate corresponding modal representations.

The integration level occurs when the reader's experience of one constructural is transferred to the construction and experience of the subsequent constructural. Previously formed constructurals that are in STWM and knowledge activated in LTWM strictly constrain the span of activation triggered by reading more text and thus they constrain the construction of subsequent constructurals. The aim of the constraint is to maintain continuity between the experiences of one constructural to another.

IEF does not expressly distinguish between microstructure and macrostructure mental models. Rather it seems to emphasize that the model is the aggregate of interactions between the text, the contents of STWM and LTWM and the product of these interactions results in the reading comprehension as a perceptual experience (Zwaan, 2003).

The content of the situation model is also restricted by the reader's prior knowledge as well as the reader's goal during reading. The reader's goal is assumed to act as a lens that

directs the reader to pay specific attention to certain information whilst information that is not immediately relevant is activated enough to form part of LTWM but not STWM**.**

The interruption of the integration process may result in ineffectively constrained spans of activation which results in the inclusion of irrelevant information into the experience constructural. The reader's ability to monitor the comprehension process for coherence and to recognise and attend to errors in the constructural and in their prior knowledge forms a vital part for the maintenance of a coherent situation model (Zwaan, 2003; Zwaan & Madden, 2005).

Visual-Object and Visual-Spatial Mental Imagery

Visual mental imagery is an integral part of the construction of comprehensive mental models and thus its effective use and manipulation is a vital component of reading comprehension (Kintsch, 1988, 1998; Paivio & Sadoski, 2004, 2007; Zwaan, 2004; Zwaan & Madden, 2005). Sadoski, (1983) highlighted the importance of the continual integration of visual mental imagery with verbal mental imagery by distinguishing visualization and imagination. Imagination occurs when both associative processing and referential processing between the non-verbal and verbal subsystems occurs. The maintenance of referential links between the verbal and the non-verbal subsystems can be used to direct the span of activation to visual mental imagery that is relevant to the text which ensures that the activated visual mental imagery is relevant and integrated into a coherent mental model and enables the learner to identify which aspects of visual mental imagery to suppress. Visualization occurs when little or no referential processing occurs and associative processing may lead to the introduction of irrelevant visual information into the mental model.

Ragni, Fangmeier, Webber and Knauff (2006) compared the effects of visual-spatial and visual-object mental imagery during comprehension of deductive text. They observed

that visual-object mental imagery tended to cause adverse effects similar to those Sadoski (1983) described as visualization. Visual-impedance-effects occur when the activation of visual-object words also activated details about the characteristics of the object that are not relevant for comprehension to occur. The subsequent processing of irrelevant visual-object mental imagery uses up cognitive resources and as a consequence, impedes higher level reasoning processes.

Visual-spatial mental imagery is believed to be relevant for higher order reasoning processes and may increase reasoning speed since it corresponds more closely with human perception of the physical world. In addition, visual-spatial mental imagery can represent a large number of causal relationships in a static system simultaneously and can be used to simulate dynamic properties of that system thus enabling the reader to make predictions (Knauff & Johnson-Laird, 2002; Schwartz & Heiser, 2006; Zwaan & Madden, 2005).

Visual-spatial mental imagery is less likely to cause visual impedance effects because the way in which it is maintained and updated makes it less likely for irrelevant spatial information to be integrated with the situation model. Spatial cues tend to refer to a broader spatial situation that is described within a textual discourse. Situation models will mainly contain and update spatial information that is relevant to a protagonist in a text unless the reader exerts effort to make them more comprehensive (Haenggi, Kintsch & Gernsbacher, 1995; Kintsch, 1998; Zwaan & Madden, 2005). The construction of detailed visual-spatial mental imagery is often not necessary or relevant to the comprehension of a text. In addition, the initial integration and transformation of spatial information requires a large amount of cognitive effort and thus it is not feasible to do on a regular basis (Haenggi et al., 1995, Kintsch 1998). If the text does not contain sufficient spatial cues, the reader will use the spatial information in the mental model and construct a generic spatial place holder if it’s needed to maintain the coherence of the model (Zwaan & Madden, 2005).

Spatial situation models (Zwaan & Madden, 2005) or spatial mental representations (Schwartz & Heiser, 2006) are particularly useful tools in the educational context because verbal descriptions are by necessity sequential, and thus cannot represent complex systems as effectively as spatial mental representations or models. Verbal information has to be processed sequentially before its meaning is clear. Visual mental images represent large quantities of information in a non-sequential manner and can lead to the identification of cause-effect relationships and processing of certain semantic concepts in a more efficient manner than if only verbal representation was used. Schwartz and Heiser (2006) argued that the consequences of certain relationships may only be evident once a number of other interactions are taken into consideration. It is much easier to identify certain causal relationships by reviewing the spatial construction than it is to identify in a textual discourse, whether it is explicitly or implicitly stated. In addition, the simultaneous representation might prevent errors which occur due to interpretation or because of an erroneous belief. On the other hand, the ability to simulate spatial systems could also lead to elaborative and innovative inferences on the part of the reader, and discovery through the construction of novel knowledge.

Visual-object mental imagery is an integral part of reading comprehension, but typically its use is determined by the extent to which it is integrated with spatial information in a coherent and relevant situation model (Zwaan & Madden, 2005). Visual-spatial mental imagery, whether at the representation or model level, is created to represent the orientation of an object or objects in space. Multiple objects can be present in a single spatial situational model; however the local level text must contain the relevant spatial cues which indicate that the objects are in the same location as the location that is depicted by the visual-spatial mental imagery in the situation model (Haenggi et al., 1995; Kintsch 1998).

Not all objects are automatically incorporated into a situational model. Under naturalistic reading conditions, visual-object mental imagery that represents the protagonist and objects that are explicitly related to the protagonist are represented in the situation model even if the reader did not read with a specific goal to do so (Zwaan & Madden, 2005). This relationship was first observed in experiments that limited the amount of spatial cues in a text (Haenggi et al., 1995; Therriault & Rinck, 2007; Zwaan & Oostendorp, 1993; Zwaan & Radvansky, 1998). Subsequent research revealed that is was more common for visual-object information that is related to the protagonist to be incorporated with spatial and temporal information to form a model of the event (Zwaan & Madden, 2005). When visual-object mental imagery, of various objects that are related to the protagonist, is integrated with visual-spatial mental imagery, the resultant situation model can be used for anaphor resolution processes. Anaphora is when words in the text refer to one character or object. Anaphor inference is the process where the reader infers which entity that was previously mentioned in the text is represented by an anaphor in a local level representation of text (Rinck & Bower, 1995).

Visual mental imagery can play a supportive role for developing readers since it can be used to facilitate and support the development of rudimentary and basic reading skills. This is not directly relevant to reading comprehension processes; however the mastery of basic reading skills has to occur before reading comprehension can be fluent. Visual-object mental imagery can assist learners in learning new concrete words. The formation of referential links between logogens and imagens usually makes the logogen easier to recall (Jenkins, 2009; Paivio & Sadoski, 2004; 2007). Visual mental imagery can act as the bridge between two verbal concepts that have no direct link in the mental lexicon, provided both verbal concepts are linked to a common imagen in the non-verbal subsystem (Paivio & Sadoski, 2004; 2007; Zwaan & Madden, 2005). In bilingual learners, logogens from two different

verbal subsystems can be linked in a similar fashion, in which case visual mental imagery facilitates translation (Paivio & Desrochers, 1980).

International and South African studies of reading development intervention strategies using visual mental imagery.

Jenkins (2009) reviewed 27 studies that explored the relationship between learners' use of visual mental imagery strategies during reading comprehension either with or without instruction to do so. This is just a small portion of the studies concerned with this subject over the past 40 years. Participants in these studies ranged from those who attended elementary school to university students. Most of the studies represented the use of visual mental imagery for the comprehension of discourse level text. About half of the studies did not have any form of instruction to form visual mental imagery. Out of these, 5 showed no positive gain on measures of reading comprehension. All 14 studies which had at least some basic form of instruction to form mental images showed positive gains on reading comprehension performance. The methods that were used, examined both direct benefits to reading comprehension as well as indirect benefits to reading comprehension through the scaffolding of basic reading skills. Thus even the brief instruction to construct visual mental imagery during reading had varying degrees of positive effects on reading comprehension performance.

The field of visual mental imagery and its relationship to reading development has received some attention in South Africa. Ngwenya (2004) investigated if visual mental imagery training can support the development of reading comprehension skills of secondary school learners from schools in a disadvantaged community. In this study 60 ESL learners from grade 9 were randomly assigned to three conditions; experimental, control and a non-treatment group. Random assignment resulted in the experimental group containing more weak readers than the other two groups. The experimental group was exposed to in-depth

visual imagery training in 20 single hour sessions which were held over three months. The participants in the control group were taught verbal techniques which support reading comprehension. The experimental group showed significant progress both in the post test and in the end of year English examinations. The control group also showed certain gains in the post test, however, the extent of the gains observed were lower than the gains made by the experimental group even though the control group had more proficient readers. Very little improvement was noticed in the non-treatment group. The significance of these differences could not be calculated due to the small sample sizes of all groups in the study. Lack of English vocabulary was seen as a particular barrier to the effectiveness of visual mental imagery training since learners need to be aware of the meaning of a word before they can imagine it.

The Targeted Revisualisation Programme (Ravenscroft, 2008) explored the potential of high visual mental imagery techniques as remediation alternatives for children with diagnosed verbal learning disabilities. The programme targeted different stages of reading skills development and culminated with literal and inferential text comprehension. 17 case studies were conducted to assess the impact of the programme which was run in a Gauteng school for children with learning disabilities. The studies included a wide range of assessment methods. The aggregate sample consisted of 93 children, 63 who underwent treatment with high visual mental imagery techniques and 30 were in the control group. They were aged between 6 and 13 years. The results indicated that children made progress in the development of their phonic skills irrespective of age, gender and the extent of their learning disability. Data for home language was not provided in this document.

Rationale

Visual mental imagery strategies can be tailored to support the development of reading comprehension at all ages and levels of reading proficiency in multilingual educational contexts. Even simple and brief instruction has shown positive improvements (Jenkins, 2009). Although there have been some studies into the effects of interventions that explored visual mental imagery strategy use in South Africa (Ngwenya, 2004; Ravenscroft, 2008), there has been little investigation of the relationship between visual mental imagery and reading comprehension in ESL adolescents. This study sought to contribute to this field by investigating the relationship between non-verbal reasoning abilities and reading comprehension proficiency of ESL learners in Grade 10.

Standard measures of STWM span and capacity do not predict reading comprehension ability largely because they do not tap into the cognitive processes that are related to text comprehension (Ericsson & Kintsch, 1995; Long, Winograd & Bridge, 1989; Radvansky & Copeland, 2001). Thus this study sought to explore whether measures of visual-object and visual-spatial reasoning aptitude have a stronger predictive faculty for reading comprehension than traditional STWM tests. The instruments used have commonly been used in the assessment of adolescent South African learners in the last decade. These include three subtests of the Differential Aptitude Test (Coetzee & Vosloo, 2000) and the reading comprehension subtest of the Stanford Diagnostic Reading Test battery.

Differential Aptitude Test Battery and assessment of visual and verbal reasoning ability.

The Differential Aptitude Test (DAT) battery was designed to measure the aptitude of learners on a wide range of cognitive skills and knowledge. The DAT is standardized for grade 10, 11 and 12 South African Participants however it was not used as a measure of

individual performance in relation to a norm group. Instead, the results of the tests were used to compare respective ability of the sample (Coetzee & Vosloo, 2000). The Non-Verbal Reasoning aptitude subtest (NVR) and the 3D Spatial Manipulation aptitude subtest (3DS) were used to assess the participants' ability to process visual mental imagery whilst the Verbal Reasoning aptitude subtest (VR) was used to assess the participants' ability to process verbal information.

The items in the VR require the learner to use reasoning skills to identify how certain words relate to each other. They also require the learner to generalize relationships onto other concepts by identifying the analogy which connects the different sets of words (Coetzee & Vosloo, 2000, p. 4). The purpose of the inclusion of the VR was to establish a reading skills baseline within the sample. The VR represents the learner's aptitude to work with decontextualized text. When a context is available, the reader can use the macrostructure situation model to supply additional information if the microstructure situation model does not contain sufficient textual cues. Thus the VR is much more sensitive to the quality and quantity of the reader's prior knowledge and their ability to use minimal textual cues to create a functional situation model.

The NVR measures the learners' ability to process two-dimensional visual-object mental imagery. The 3DS measures the learners' ability to process visual-spatial mental imagery. Visual-object metal imagery is qualitatively different from visual-spatial mental imagery in terms of the type of information they represent and in the way that they are cognitively processed. Visual-object mental imagery contains information that represents the physical characteristics of a single object and also contains information about the spatial relationship between these characteristics. Visual-spatial mental imagery contains basic information about the physical characteristics of these objects such as their shape and proportion in relation to other objects. The qualitative differences between these two types of visual

mental imagery have the potential to impact how information is processed and comprehended (Knauff & Johnson-Laird, 2002; Ragni et al, 2006; Schwartz & Heiser, 2006; Zwaan & Madden, 2005). The distinction between these two modes is far from complete. Visual-object and visual-spatial information can be integrated into a single multi-modal image in the episodic buffer (Baddeley & Repovs, 2006). This integration is an important part of the construction of situation or mental models and thus is an important part of reading comprehension (Paivio & Sadoski 2004, 2007; Zwaan & Madden, 2005).

During the development of the DAT battery, it was observed that the NVR and the 3DS are strongly correlated (Karlsen & Gardener, 1984). Thus it is possible to recognize that these two tests can test separate imagery constructs, however it is possible that both capacities may be employed in complex reasoning tasks.

Stanford Diagnostic Reading Test Battery and assessment of reading and reading comprehension ability.

Numerous studies have explored the state of reading comprehension in South African learners. The majority of these studies focused on learners in grades 6 to 10 who had been taught in the English language and, with few exceptions, explored the difference in reading ability between EFL and ESL learners. The general trend indicated that EFL learners tended to perform better on tests which measure reading comprehension and other related reading skills, however, this difference was not always significant. Since this trend has been well investigated, the current research explored variation in reading comprehension within a group of ESL learners.

The reading comprehension subtest of the Stanford Diagnostic Reading Test Battery (SDRT) 3rd edition has been frequently used in the South African context (Catto, 2010; Khatpagam, 2009; Lathy, 2008; Malope, 2009; Ranchod, 2008; Winnett, 2009). The observations in these studies have been corroborated by studies that used other measures of

reading skill including the Enriched Social Support Instrument (Bhorat, 2007), the Test Of Adolescent Language (Van Rooyen & Jordaan, 2009) and the Human Science and Research Councils Achievement Test for English second language learners (Manyike, 2007). The majority of the studies were performed with grade 8 learners. Manyike (2007) had learners from grade 7 and 8; Lathy (2008) included learners from Grade 5 to 10 and Winnett (2009) longitudinal study followed learners from Grade 8 to 10. The majority of the studies benefited from large samples that ranged from 80 to 347 participants, which provided a large population group to use as a reference for the comparison of results. However the ability to generalize the results of these studies in certain South African contexts may not be appropriate since all but one of the studies were conducted in urban schools in Gauteng province. Thus caution should be taken in applying the results of the reading comprehension test to the performance of learners in other more rural situations and other provinces.

The SDRT has been normed for grade 5-8 American participants who are proficient in English. This test is not standardized for the South African population (Karlsen & Gardener, 1984) however, the studies that used this test did not measure individual performance against the American norm group. Rather, the results were used to compare reading comprehension ability between groups of EFL and ESL.

The SDRT was designed as a diagnostic measure to assess the reading ability of participants who experience difficulty in reading at the expected level for their grade. It specifically assesses the participants' strengths and weaknesses across a wide range of reading skills (Karlsen & Gardner, 1984). The tests assess both basic reading skills and knowledge such as vocabulary and decoding skills as well as the more advanced skills used in reading comprehension.

The SDRT Reading comprehension (SDRT-RC) subtest is composed of 60 multiple choice items which are distributed across nine text based passages. These passages include standard paragraphs as well as two paragraphs where text is presented in the form a poster.

Catto (2010) and Winnett (2009) found a significant difference on the performance of EFL and ESL learners on the accumulative item SDRT-RC test. Winnett (2009) performed a longitudinal study where the difference between EFL and ESL Grade 8 learners' performance on English reading comprehension tests was monitored over a three year period. The difference between EFL and ESL performance remained significant but diminished over time as learners advanced to higher grades. The Van Rooyen and Jordaan (2009) study revealed that this trend of diminishing difference persisted in ESL learners whose mother tongue was African or European. Ranchod (2008) observed that where both EFL and ESL learners performed poorly on the English reading comprehension tests, the difference between EFL and ESL learners' performance was not significantly different. This result was also found in studies using other assessment measures (Bhorat, 2007; Van Rooyen & Jordaan, 2009).

The SDRT-RC items have been differentiated into two sets of categories. The first category set includes the structuring of passages to represent one of three different forms of textual discourse. The inferential Item and literal Item category set represents different levels of reading skill proficiency. The literal category is used to explore the learners' ability to use basic reading skills to deduce meaning from information that is explicitly stated in the text. In contrast, the inferential category explores the learners' ability to extrapolate the implicit meaning of the text through the process of inference. Lathy (2008) and Malope (2009) who provided results for the comparative data for both the inferential and literal category set and the discourse type category set. Both studies observed significant differences between the EFL and the ESL groups on all categories with the exception of the category set that represented textual discourse commonly used in school textbooks.

Assessment of the reading comprehension subtest of the Stanford Diagnostic Reading Test battery for concreteness effects.

The construction of the situation model is dependent on the explicitly stated visual-object or visual-spatial cues in a text (Kintsch, 1998; Sadoski, 2001; Zwaan & Madden, 2005). Concreteness effects refer to a phenomenon that has been frequently observed in studies which examined visual mental imagery and reading comprehension. Concreteness effects are typically associated with the imageability of specific words or of phrases in a text and how the word or phrase's textual context affects the construction of visual mental imagery. Concrete text triggers spontaneous representations of visual mental imagery in the mind and typically represents real objects or events in the physical world (Sadoski, 2001). Abstract texts, on the other hand cannot be easily imagined unless the reader relates the text to a real world situation through analogy and metaphor (Setti & Caramelli, 1997; Wiemer-Hastings, Krug & Xu, 2001).

Concrete words trigger visual mental imagery in the absence of instruction to visualise the text (Conroldi, De Beni & Baldi, 1989; Long et al., 1989). It is also generated when instruction is given to use specific reading strategies which did not specify the use of visual mental imagery (Truscott, 1995). Grambell and Bales (1986) demonstrated that when a group of sixty-two fourth-grade and 62 fifth-grade learners were given instructions to construct visual mental imagery, they were able to identify significantly more implicit and explicit textual inconsistencies than the control group. Word concreteness and the quantity of concrete details in a text are strongly associated with meaningful conceptual composition and comprehension (Wilcken, 2008) as well as improved recall (Sadoski, Goetz, Stricker & Burdenski, 2003; Wilcken, 2008). Truscott (1995) cautioned that word concreteness can improve immediate recall but not delayed recall. He argued that this could indicate be a result of lack of integration between the visual and verbal subsystems which compromises the

resultant mental model and may prevent the effective encoding of new information in LTWM. Word concreteness can thus be detrimental to reading comprehension if the activated visual mental imagery is not suppressed or correctly incorporated into a mental model (Knauff & Johnson-Laird, 2002; Sadoski, 1983).

A third category; the Concrete Item and Abstract Item category was added to the SDRT-RC. The standard way to assess the concreteness of a text is to examine the text as a whole and ask readers about the extent to which they experienced visual mental imagery when they read the text. The same process may not be applicable to the SDRT-RC. The SDRT-RC presents learners with a set of 9 passages, each of which is followed by 7 or 8 multiple choice questions each with four possible answers. The SDRT-RC passages are similar to those a learner is likely to encounter in day to day school life; however, it is not common for learners to answer multiple choice questions after each passage they read. During the reading of the passage, the learners will form a situation model for each passage macrostructure. Then the reader will create a microstructure situation model to represent each item. It is difficult to attribute concreteness effects in the passage to performance on a particular item. In order to control for this possible discrepancy a different approach was taken to examine concreteness effects in the SDRT-RC.

The purpose of the item situation model is to enable the learner to select the appropriate answer from a set of four. It was hypothesized that if the learner chooses the correct answer, and the answer contained a concrete word, then that word was integrated into the item situation model and formed part of comprehension.

Concrete words include concrete nouns (Sadoski, 2001; Sadoski et al., 2003) and concrete verbs (Richardson, Spivey, Barsalou & McRae, 2003) which represent movements that are easy to visualize. The review of both the passages and the multiple choice items revealed concrete common nouns were common to both the passage and the item questions

and answers. Concrete verbs were common in the passages but not in the item questions and answers. As such the analysis of the correct answers was restricted to common nouns which corresponded to visual-object mental imagery. It was hypothesised that the selection of the correct answer meant that the learner was able to navigate the multi-modal situation model based on the relationships between the spatial properties and the object represented by the common noun (Zwaan, 2003; Zwaan & Madden, 2005).

Common nouns were also present in the incorrect answers. The visual-object mental imagery triggered by these common nouns would be irrelevant to the item situation model. Failure to suppress the irrelevant visual-object mental imagery could result in visual impedance effects. The ability to select the correct answer indicates that the irrelevant visual information was adequately supressed (Knauff & Johnson-Laird, 2002; Ragni et al, 2006). Many of the item questions also contained a common noun; however these common nouns were a part of successful reading comprehension but did not represent its product. As such, these common nouns were not examined further. Items that had correct answers which contained a common noun were assigned to the Concrete Items Subtest (CIS) category, whilst items that had answers that did not contain a concrete common noun were assigned to the Abstract Items Subtest (AIS) category. The total SDRT RC subtest was referred to as the Mixed Items Subtest (MIS).

Assessment of the reading comprehension subtest of the Stanford Diagnostic Reading Test battery for effects of foreign vocabulary.

The range of a learner's vocabulary is directly related to a learner's ability to form situation (Kintsch, 1998; Oh, 2007) or mental models (Paivio & Sadoski, 2004, 2007). Since the SDRT has not been normed for the South African context, the vocabulary could be unfamiliar to the participants.

The following section explores results from assessments of decoding and vocabulary South African learners and the implications are discussed in light of the vocabulary of the SDRT-RC subtest.

Decoding is a rudimentary verbal reading skill that is used to identify the phonetic structure of words when learners are exposed to vocabulary that they do not automatically recognize. This may be used to further identify the words meaning, thus they are important for learners with a limited vocabulary. The results of the studies that assessed learners decoding ability are mixed. Lathy (2008) observed that whilst EFL learners performed better on the Phonetic analysis test than ESL learners, the difference was not significant. Khatpagam, (2009) showed a similar result, however, he did not assess the difference for significance. Bhorat, (2007) found a similar trend, however, both the EFL and the ESL decoding ability was poor. The participants in this research report come from an older age group (grade 10) than those observed in Bhorat's (2007) study (grade 8), and considering other studies have not found a problem with learners decoding skills, it is assumed that the participants of this research report have mastered their decoding skills and are able to employ them if necessary.

The SDRT Vocabulary subtest assesses the learners' knowledge of words which they are likely to encounter in educational and day to day texts. The results of the SDRT Vocabulary subtest from five separate studies revealed that ESL learners tended to have a significantly smaller English vocabulary than EFL learners. Participants with lower vocabularies tend to perform worse on reading comprehension tests than do participants with wider vocabularies (Catto, 2010; Khatpagam, 2009; Lathy, 2008; Ranchod, 2009; Winnett, 2009). A poor vocabulary represents the learners' inability to associate meaning with words and the learner will be forced to divert cognitive resources to locate this meaning through

translation or some other means or they may ignore the word entirely. This is likely to impede reading comprehension.

A concern about test validity was raised as low participant scores could be a result of a range of American-centred words that it is not possible to discern whether the participants have previously encountered through multimedia. Since the SDRT was developed for the American population, it contains a number of words which are not common in the South African English language and culture. For example one passage in the SDRT-RC subtest is about the 'Amish' community, a religious denomination localized in America, a second passage relates to snow sporting activities, snow is not a common phenomenon in South Africa (Catto, 2010).

The SDRT-RC items and answers were assessed for the number of potentially unfamiliar words they contained and their respective paragraphs were assessed to see if they contain sufficient information to provide an explanation for potentially unfamiliar words. This was compared to the total number of participants who correctly answered the item and more specifically if the correct answer was selected most frequently from all the multiple choice options. For an item to be excluded it had to have an correct answer rate of below 30%; the item and/or answer possess an unfamiliar word and the respective paragraph did not contain sufficient information to explain the unfamiliar word. Only one item met the exclusion criteria. Item 12, passage 2 required the participants to identify the sport of interest of Billy, the main character in the passage, based on the information provided in the passage. The answer options included; baseball, bicycling, football and ice-skating. The correct answer was '*baseball'*; however the majority of the sample chose the *'ice-skating'* answer. An examination of the passage revealed that the participants had to make an inference between the reference to a '*mitt'*, sports equipment used in *'baseball'* and the sport itself. This sport is not common in South Africa and thus it is unlikely the participants were familiar

with its details, however, the passage did state that '*his skateboard was old'*. It is assumed that the participants associated the word *'skateboard'* in the passage with the answer '*ice-skating'* due to similar orthographic content, namely the word '*skate'* and were unable to make the *'mitt-baseball'* inference. The other items also contained words that, in isolation, may be unfamiliar to the participants, but it was concluded that the passages contained sufficient additional information for the participants to deduce the meaning of these words.

Research Questions and Hypotheses

This research examined the extent to which measures of learner's ability to process visual information provide insight into the relationship between visual mental imagery and reading comprehension. In addition to testing cognitive ability, an attempt was made to examine certain variables which were believed to affect this relationship.

The first variable looked at word concreteness effects in the Reading Comprehension subtest of the Standard Diagnostic Reading Test battery (SDRT-RC). The SDRT-RC items were grouped according to whether or not the correct answer for the multiple choice items contained a common noun. Items that had correct answers which contained a common noun were assigned to the Concrete Items Subtest (CIS) category, whilst items that had correct answers which did not contain a concrete common noun were assigned to the Abstract Items Subtest (AIS) category. The term Mixed Items Subtest (MIS) was used to represent the combination of items from both categories.

The second variable examined the distinction of different types of visual metal imagery. Two subtests from the Differential Aptitude Test (DAT) battery were used to explore participants' ability to process different kinds of visual mental imagery. Visual-object mental imagery processing was assessed with the Non-Verbal Reasoning aptitude subset (NVR). Visual-spatial mental imagery processing was assessed with the 3D Spatial Manipulation

aptitude subtest (3DS). The DAT Verbal Reasoning aptitude subtest (VR) was also administered to provide a baseline for the comparison of participants' basic verbal skills.

First research question.

The first research question explored the relationship between the SDRT-RC MIS and the three DAT subtests.

It was hypothesized that low VR ability would be strongly correlated with the MIS and the strength of this relationship would decrease as VR ability increases. Learners with low VR ability are likely to be developing readers; small variations in VR ability may represent significant changes in reading comprehension. Learners with high VR ability are likely to have reached threshold for verbal reasoning ability and corresponding reading skills that are needed to cope with academic reading requirements relative to their age group. Once this threshold is reached occurs, further increases in VR ability are unlikely to contribute towards performance on the MIS.

NVR was expected to have a weak to moderate correlation with the MIS for learners with low and high VR abilities. NVR ability is associated with the processing of visual-object mental imagery. Visual-object mental imagery is an important component in situation models, however only certain visual-object mental imagery is relevant to the model (Haenggi et al., 1995; Therriault & Rinck, 2007; Zwaan & Oostendorp, 1993, Zwaan & Radvansky, 1998). Excessive processing of visual-object mental imagery can cause visual-impedance effects which are detrimental to reading comprehension (Knauff & Johnson-Laird, 2002; Ragni et al., 2006). Learners' ability to suppress irrelevant information is partially dependent on their NVR ability. The correlation was expected to be stronger for learners with low VR ability. VR ability also plays a role in the suppression of irrelevant visual-object mental imagery. If this faculty is faulty then the learner may depend more on their NVR ability. In addition, low VR ability is associated with a low vocabulary (Coetzee & Vosloo, 2000).

Visual-object mental imagery can be used as rudimentary reading skills particularly for learners with poor vocabulary (Paivio & Desrochers, 1980; Paivio & Sadoski, 2004, 2007; Zwaan & Madden, 2005).

It was hypothesized that the correlation between 3DS and MIS would be reasonably strong since 3DS ability is related to visual-spatial mental imagery. Visual-spatial mental imagery has an integral role in the construction of mental or situation models and thus in reading comprehension (Knauff & Johnson-Laird, 2002; Schwartz & Heiser, 2006; Zwaan & Madden, 2005). The relationship may be weaker in learners with low VR than learners with high VR because learners with low VR are less likely to have the available resources needed to successfully process spatial information for a situation model (Haenggi et al., 1995; Kintsch, 1998; Zwaan & Madden, 2005).

Second research question.

The second research question explored whether the differentiation of items in the MIS into the AIS and CIS categories, according to whether or not the answer to the correct item contained a common noun, was sufficient to demonstrate the influence of word concreteness effects upon the relationship between the SDRT-RC and the three DAT subtests.

Concrete words are thought to make text easier to understand (Sadoski, 2001; Wilcken, 2008), as such it's expected that learners will perform better on the CIS than with the AIS. Learners ability to comprehend abstract text is dependent on VR ability, thus learners with poor VR were expected to struggle more with the AIS than learners with high VR ability.

Since the comprehension of abstract text tends to be dependent on verbal skills so it was expected that VR scores would be correlated more strongly with Abstract Items than with Concrete Items, particularly in learners with low VR scores. In contrast, concrete words represent objects in the physical world, thus it was expected that NVR, which measures

visual-object reasoning ability, would be more strongly correlated with the CIS than with the AIS.

3DS measures the ability to process visual-spatial mental imagery that is represented by various spatial cues in the text passage. A successful item model requires the reader to integrate visual-object mental imagery with the visual-spatial mental imagery in the passage to form a macrostructure model so it indirectly represents successful modeling of spatial information. Relevant visual-object mental imagery may provide a cue to the relevant parts of the macrostructure mental model (Zwaan, 2003; Zwaan & Madden, 2005). Thus it was expected that 3DS score would be more strongly correlated with the CIS than with the AIS.

Third research question.

The last question explored the extent to which the three DAT tests can predict variance observed in MIS, AIS and CIS. It was hypothesized that VR ability would be a strong predictor for the learners with low VR but not for learners with good VR ability since learners with low VR ability are likely to be developing readers and thus more sensitive small variations in VR ability.

NVR ability could potentially contribute to the model for since NVR may have a role in preventing visual-impedance effects (Knauff & Johnson-Laird, 2002; Ragni et al., 2006), and it is involved in the construction of situation models (Haenggi et al., 1995; Therriault & Rinck, 2007; Zwaan & Oostendorp, 1993; Zwaan & Radvansky, 1998). The predictive strength of NVR was expected to be greater for CIS than AIS.

3DS ability may contribute to the model for learners with good VR ability but not for learners with poor VR ability due to limitation of cognitive resources (Haenggi et al., 1995; Kintsch, 1998; Zwaan & Madden, 2005). The integration of visual-object and visual-spatial mental imagery in the situation model may result in 3DS being a stronger predictor for the CIS than for the AIS (Zwaan, 2003; Zwaan & Madden, 2005).

Summary of research questions and hypotheses.

Research question 1 explored the relationship between the SDRT-RC MIS and the three DAT subtests. It was hypothesized that;

- Low VR ability would be strongly correlated with the MIS and the strength of this relationship would decrease for learners with stronger VR ability.
- NVR scores would have a weak to moderate correlation with the MIS for learners with low and high VR abilities.
- The correlation between 3DS scores and the MIS would be reasonably strong and the correlation will be relationship weaker in learners with low VR than learners with high VR.

Research question 2 explored whether the differentiation of items in the MIS into the AIS and CIS categories, according to whether or not the answer to the correct item contained a common noun, was sufficient to demonstrate the influence of word concreteness effects upon the relationship between the SDRT-RC and the three DAT subtests. It was hypothesized that;

- Learners would perform better on the CIS than with the AIS.
- Learners with poor VR scores were expected to struggle more with the AIS than learners with high VR ability.
- VR scores would be correlated more strongly with the AIS than with the CIS, particularly in learners with low VR scores.
- NVR scores would be more strongly correlated with the CIS than with the AIS.
- 3DS scores were likely to be more strongly correlated with the CIS than with the AIS.

Research question 3 explored the extent to which the three DAT tests can predict variance observed in MIS, AIS and CIS. It was hypothesized that;

- VR scores would be a strong predictor for the learners with low VR but not for learners with good VR ability.

- NVR scores would contribute minimally to the model and the predictive strength of NVR was expected to be greater for CIS than AIS.
- 3DS ability would contribute significantly to the model for learners with good VR ability but not for learners with poor VR ability.
- 3DS would be a stronger predictor for the CIS than for the AIS.

Methods

Research Design

The focus of this research project was to explore the relationship between the participants' reading comprehension skills and the participants' visually-based reasoning abilities. The research design was non-experimental and included the observation of trends for the two groups separately as well as for the Combined Group (Dematteo, Festinger & Marczyk, 2005).

The sample was composed of English second language (ESL) participants from two schools. Two groups were used to increase the number of participants in the overall sample and to provide a degree of compensation for the absence of randomization of the two separate sample groups. Initially, it was intended that the analysis would focus on identifying trends for the whole sample; however, trends in the participant's performance on the various measures necessitated a second level to the analysis.

The two groups were closely matched for demographic factors which are described in the Sample Description section; however subsequent analyses revealed that the one school performed significantly better than the other academically, as seen by a comparison of the two schools performance at mid-term on certain school subject as seen in Table 1 of the Results section and on the test measures as seen in Table 2 of the Results section. There was some degree of overlap between the ranges of performance in the two schools on most of the measures; however, it was only particularly high for the 3DS measure as seen in Table 2 of the Results section. When the measure results were ordered according to the learners' SDRT-RC scores, it was observed that the participants in the bottom 25% of the sample were from School A, the Lower Performance Group, whilst the majority of the top 25% was from School B, the Higher Performance Group. A concern was raised that the learners in the

bottom 25% may include learners with severe learning overall cognitive learning impairments rather than impairments which are specific to visual-spatial and visual-object reasoning since more than half of this selection of participants also received very low scores in 2 or 3 of the DAT subtests. Thus, rather than comparing the bottom and top quartiles, it was decided that the overall performance of the Lower Performance Group, which represented a group of learners with predominantly low to average scores on most of the measures would be compared to the Higher Performance Group, which represented a group of learners with predominantly average to high scores on most of the measures.

Thus analysis was performed on two levels. Firstly the two school groups were analysed separately to compare whether the trends identified over all varied when a group with a predominantly low to average was compared to a group with an average to high SDRT performance range. Certain contextual variables, such as the learners reading habits, were assessed to gain insight into why this distinction is present despite the similarity of demographic variables; however, this data was not incorporated into the actual statistical analysis as it was beyond the scope of this research.

Secondly, the analyses were performed on the Combined Group that resulted from the amalgamation of the participants from the two schools. This analysis provided insight into the trends which emerged from a broad rage o of performance on the SDRT-RC measure. The performance range of the Combined Group was much broader and would better reflect trends that may occur in the broader population.

Sample Description

Non-probability, convenience sampling was used as the sample was selected from a pool of participants that, were easily accessible to the researcher (Trochim, 2005). The sample was drawn from grade 10 learners from two Gauteng-based secondary schools. The

two schools were selected for this research because the learners who attended these schools resided in similar areas so all participants came from similar socio-economic backgrounds. The teachers were asked to describe the socio-economic background of learners in grade 10. The teachers communicated that the learners tended to reside in previously disadvantaged communities; learners in the Lower Performance Group lived in Soweto whilst learners in the Higher Performance Group lived in Soweto or Alexandra.

The inclusion criteria required that the participants' home language was not English, but the learners have been taught in English from grade 3. The teachers were consulted about the schooling background of their learners prior to administration to ensure that the participant met these criteria. The Lower Performance Group and the Higher Performance Group shared four subjects including English first language, a non-English second language, Mathematics and Life Orientation. Other Subjects for the Lower Performance Group learners were business related whilst the Higher Performance Group learners did either business or science related subjects.

Further analysis of the results of the two groups, as illustrated in the Results section in Table 1 for academic performance and Table 2 for test measure performance, the Lower Performance Group represented learners with a predominantly low to average overall performance range on test measures, whilst the Higher Performance Group represented learners with predominantly average to high overall performance across all measures. The same pattern was observed for the learner's academic performance.

A total of 104 questionnaires were administered, of which 21 were excluded from the analysis. Data analysis was performed on information gained from 83 participants. This included 42 participants from the Lower Performance Group and 41 participants from the Higher Performance Group.

Exclusion criteria post data capture included non-completion of large sections of tests and an analysis and removal of outlier variables. All participants spoke at least two languages and English was not their mother tongue. There were no significant differences in the two groups in terms of their age and gender distribution. The sample included 34 males and 49 females. The age of the participants ranged from 13.58 years to 20.00 years. The average age of the participants was 16.31 years (*SD*= 1.136), as seen on Table 1 of the Results section.

Instruments

Stanford Diagnostic Reading Test – Brown Level. The Stanford Diagnostic Reading Test Battery (SDRT), 3rd edition, was designed as a diagnostic measure to assess the reading ability of participants that experience difficulty in reading at the expected level for their grade. It specifically assesses participants' strengths and weaknesses across a wide range of reading skills. The SDRT Brown Level was created to assess participants in grades 5 through 8 as well as underperforming participants from higher grades (Karlsen & Gardner, 1984, p.5). The reading comprehension subtest (SDRT-RC) of the SDRT Brown Level was used to assess the participants' reading comprehension ability.

The SDRT-RC is composed of 60 multiple choice items which are distributed across nine text-based passages. One item was rejected due to the effects of foreign vocabulary on learners' performance on that item, as described in the rationale section of the literature review. The remaining 59 items were referred to as the Mixed Items Subtest (MIS). These items were differentiated into two categories. The Concrete Item subtest (CIS) represented the 27 items with correct answers that contained a concrete noun, while the Abstract Item subtest (AIS) represented the 32 items with correct answers that did not contain a concrete noun.

Differential Aptitude Test-Form K.

The Differential Aptitude Test – Form K test battery (DAT) is composed of 10 subtests, each of which measures the participants' potential to develop various cognitive processing skills. This test is standardized for grade 10, 11 and 12 South African Participants. The DAT was not used as a measure of individual performance in relation to a norm group. Instead, the results of the tests were used to compare respective ability of the sample (Coetzee & Vosloo, 2000). Three tests were selected from the DAT battery. The Non-Verbal Reasoning ability test (NVR) and the 3D Spatial Manipulation ability test (3DS) were used to assess the participants' ability to process visual-object and visual-spatial information, while the Verbal Reasoning ability test (VR) was used to assess the participants' ability to process verbal information.

The NVR assessed the participants' ability to identify potential relationships (patterns and sequences) between figures that were presented without direct verbal or numerical input. Each item included a sequence of four two-dimensional figures. Each figure in the sequence differed from the previous figure. The difference between the figures follows a pattern that corresponds to a change in one or more feature in the figure sequence. The features included figure size, shape, texture, presence/absence etc. The participants had to analyse each item's figure sequence and identify the pattern of the changes. Using this information, they had to select one image, from a set of five options that would, most likely, fit in with the pattern sequence presented by the original four figures.

The 3DS assessed the participants' ability to visualize and manipulate three-dimensional spatial images**.** In each item, the participants were required to construct mental representations of a three-dimensional figure and then mentally manipulate these figures according to instructions which were described in the introduction to the test. This included (a) mentally combining different shapes presented as separate entities in a figure and

predicting the properties of a new figure and (b) mentally controlling visualization based on a feature of the figure, such as a hinge, which restricted the range of movement of a figure's component parts. The participant had to choose one figure from a set of five that followed the initial instructions. Unlike the NVR, the learner is required to infer certain features of the figure since the figure is represented in two dimensions and from only one angle.

The VR was used to assess the participants' ability to process verbal information. The items in this test required the learner to make inferences based on word analogies and relationships, in order to determine which word did not fit in a particular word set or which word completed a word series. The textual cues in each item were limited to one sentence and a set of four single word answers. Thus, each learner's ability to make these inferences was heavily dependent upon their vocabulary and their prior knowledge about relationships between different word-based concepts (Coetzee & Vosloo, 2000).

The Reading Questionnaire.

The Reading Questionnaire (*Appendix A*) was constructed specifically for this research by the researcher and was used to assess the compatibility of the two groups. The first section sought biographical information regarding the participants' demographic information including age, gender, first language, other known languages, subjects and mid-year exam results. The second section aimed to provide a very brief insight into the amount of English the participant is exposed to on a daily basis, whether from the media or for communication with members in the community as well as the nature of the participants' reading context. The reading context included time spent on reading activities, access to reading material at home and the participants' perceptions about reading.

This questionnaire was used to provide general information which is pertinent to reading comprehension performance. This information was used to describe the different groups in the study but was not used as part of the inferential statistical analysis.

Procedure

The principals of four schools were contacted electronically via email and were invited to participate in the study. The principals were sent letters of information concerning the study (*Appendix B*) and were encouraged to ask questions related to the study. Two of the four schools agreed to participate. A suitable time for administration was arranged. Information and consent forms were distributed to all of the participants. Participants from the Lower Performance Group were gathered in the school hall. Participants from the Higher Performance Group were seated in two adjacent classrooms. A research assistant was present in both instances, thus either the researcher or the research assistant was present in the period during which the questionnaire and the tests was administered.

The letter of information, the consent form (*Appendix C*) and tests were discussed verbally with the participants prior to the test administration. The study was described in the same format and detail as was presented in the letter of Information. This included a brief introduction to visual mental imagery, however no direct instruction was given to the learners to use or construct visual mental imagery during the tests. The participants were informed that (a) participation in the study was voluntary; (b) they did not have to answer items on the questionnaire that they found to be inappropriate and (c) the individual test results would be kept completely confidential.

The participants were given the opportunity to ask questions regarding participation in the study. Once consent was given, the questionnaire and tests were administrated. The questionnaire and answer booklet were handed out at the beginning of the session. Two 15 minute breaks were given in between testing. The questionnaires and answer books were collected and placed in a box, which was sealed after the last answer book was collected and kept in a secure location during data capture and analysis.

Ethics

Ethical clearance was obtained from the University of the Witwatersrand (Clearance number MRES/09/001 IH *Appendix D*) after which a number of schools were approached and invited to participate in the study sample. The purpose of the research study, the consent form and the conditions of participation were discussed with the participants prior to the administration of the questionnaire and tests. The questionnaire and tests were administered only after the signed consent forms were collected. The participants were informed that participation in the study was voluntary and an accommodation was made to have a teacher available to supervise the small number of learners from the Lower Performance Group who chose not to participate in this research study.

To ensure the participants' confidentiality, all of the test material was kept in a secure location. It will be destroyed after the study is completed. The names of the participants were known only to the researcher during data capture and were used to enable the researcher to match mid-year marks with the participants' questionnaires. The participants' names were converted into a code and subsequently confidentiality was maintained.

Since the SDRT is not standardized for South Africa, the individual results were not used to reflect the participants' reading comprehension ability. The two schools will be provided with a general report of the results, the application of which will be discussed with all interested staff members as soon as possible.

As little time as possible was used for the testing and training so school time was not wasted. The educators decided on a day during which the minimal amount of academic time was used by the testing. Contact details were made available to both participants and staff members for any further queries.

Results

Data Analysis

This research sought to explore the extent of insight that can be generated about the relationship between reading comprehension and visual mental imagery, through the use of existing psychometric measures. These measures represented each learner's cognitive profile in a numerical format that corresponded with different levels of proficiency for a specific cognitive skill or skill set. Quantitative statistical analytical techniques allowed for the identification of explicit statistical relationships and trends that occurred between these numerical variables. Descriptive statistical analyses were used to determine the nature and spread of the dataset. Inferential statistical analysis was used to identify relationships within the dataset and to identify possible trends between the dataset and the larger population. Significance testing was used to determine the whether the differences that occurred between groups were due to the manipulation of the variable or if they occurred by chance (Howell, 2008).

Data analysis was first performed at the Lower Performance Group and the Higher Performance Group separately and later the analyses were run again for the amalgamated group, which was called the Combined Group. Descriptive statistical analyses were used to assess the distribution of the three groups' demographic variables and for their performance on the three Differential Aptitude Test (DAT) subtests and on the three Reading Comprehension subtests of the Stanford Diagnostic Reading Test (SDRT-RC) battery (Howell, 2008).

The DAT included the Verbal Reasoning aptitude subtest (VR), Non-Verbal Reasoning aptitude test (NVR) and the 3D Spatial Manipulation aptitude subtest (3DS). The three SDRT-RC subtests included; the Mixed Items Subtest (MIS) which represents the total

items of the SDRT-RC, the Concrete Items Subtest (CIS) and the Abstract Item Subtest (AIS).

The Shapiro-Wilk test for normality indicated that the distributions for all interval variables were normally distributed for the Lower Performance Group, the Higher Performance Group and for the Combined Group.

The Lower Performance Group and the Higher Performance Group were compared on multiple variables to establish the extent of similarities and differences between the two groups. The One-way Analysis of Variance test was used to compare the two groups on age, academic performance, DAT and SDRT-RC subtest performance.

Pearson's Chi squared test was used to compare the two groups on the items from the Reading Activity Questionnaire. Pearson's correlation coefficients were calculated to establish the strength of the correlation relationships within the three DAT subtests and between DAT subtests and SDRT-RC subtests for all three groups.

Lastly the three DAT subtests were entered into a Multiple Regression analysis for the three SDRT-RC subtests. The resultant models were discussed in light of the underpinning theory as well as the results of all the statistical analyses (Howell, 2008).

Comparison and Amalgamation of the Two School Groups

Descriptive statistics.

Table 1

M and SD for Demographic Variables and Academic Performance of all School Groups

		Gender				Academic performance				
Group	*n*	F	M	Statistic	Age	English	L2	Maths.	L.O.	Term
LPG	41	25	16	*M*	16.06	44.38	45.10	21.53	26.83	28.85
				SD	1.20	11.42	14.58	14.56	20.95	10.14
HPG	42	23	18	*M*	16.55	56.21	51.40	46.17	61.38	54.15
				SD	1.03	10.08	16.57	19.76	8.91	10.60
CG	83	49	34	*M*	16.31	50.44	48.33	34.15	44.52	41.81
				SD	1.14	12.24	15.86	21.29	23.53	16.38

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group.

Combined Group academic performance *n* = 82; The Lower Performance Group academic performance *n* = 40. L2 = Second language subject; L.O.= Life Orientation; Maths. = Mathematics; Term = Average marks for the second term.

The Higher Performance Group's academic performance *M* scores were higher than those obtained for the Lower Performance Group on all the subjects that were measured. Gender was similarly distributed in both groups and was not significantly different.

Table 2

M, SD and IQR for the Standard Diagnostic Reading Test-Reading Comprehension subtests (SDRT –RC) and for the Differential Aptitude Tests subtests (DAT) for all School Groups

		SDRT-RC			DAT		
Group	Statistic	MIS	AIS	CIS	VR	NVR	3DS
LPG	*M*	49.07	48.71	49.50	47.71	36.78	45.07
	SD	13.99	13.35	16.95	16.65	19.88	18.59
HPG	*M*	71.43	72.18	70.55	67.90	57.24	57.24
	SD	9.87	9.70	12.32	14.48	18.52	19.78
CG	*M*	60.38	60.58	60.15	57.93	47.13	51.23
	SD	16.45	16.54	18.11	18.53	21.69	20.04
Degree of overlap of IQR for the LPG and The HPG							
LPG	*Upper IQR*	57.63	56.25	62.96	60.00	44.00	60.00
HPG	*Lower IQR*	67.80	68.75	62.96	60.00	48.00	41.00
	Difference[a]	-10.17	-12.50	0	0	-4.00	19.00

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group. *MIS* = Mixed Items Subtest; AIS = Abstract Items subtest; CIS = Concrete Items Subtest; VR = Verbal Reasoning aptitude subtest; NVR = Non-Verbal Reasoning aptitude subtest; 3DS = 3D Spatial Manipulation aptitude subtest.

[a] The LPG performance range on the subtests was lower than the performance of HPG. The degree to which the performance of the LPG overlapped with the performance of range of HPG was examined. The range of overlap between the IQR of the two groups was examined since it provides more insight into the extent of the overlap. The upper performance range for LPG (IQR at the .75 percentile) was compared to the lower performance range for HPG (IQR at the .25 percentile). A negative value indicates a gap between the upper IQR for the LPG and the lower IQR for HPG, whilst a positive value indicates overlap.

p*< .05. ***p*< .01. * *p*< .001.

The Higher Performance Group's *M* score was much higher than the Lower Performance Group's *M* score for all of the subtests. The *M* score was between 20.19% and 23.47% higher for most tests with the exception of 3DS where the mean score was 12.17% higher for the Higher Performance Group. The was some overlap between the upper performance range in the Lower Performance Group and the lower performance range of the Higher Performance Group, however the overlap was minimal for most of the subtests. In most cases there was a gap between the Lower IOR for the Higher Performance Group and the Upper IQR for the Lower Performance Group. One exception on the 3DS measure which indicated a greater amount over overlap (*Upper* IQR_{LPG}= 60.00; *Lower* IQR_{HPG} = 41.00).

Table 3

ANOVA Comparison between the Lower Performance Group and the Higher Performance Group on Age, Academic Performance, Standard Diagnostic Reading Test-Reading Comprehension subtests (SDRT –RC) and the Differential Aptitude Tests subtests (DAT)

Measure	*F*
Age	3.95*
Academic performance	
English	24.83***
L2	3.33
Maths.	41.00***
L.O.	96.08***
Term	121.88***
SDRT-RC	
MIS	71.07***
AIS	84.20***
CIS	42.01***
DAT	
VR	34.84***
NVR	23.54***
3DS	8.33**

Note. $n = 83$. $df = 82$ for age, SDRT-RC and DAT; $df = 81$ for Academic Performance.
MIS = Mixed Items Subtest; AIS = Abstract Items Subtest; CIS=Concrete Items Subtest; VR = Verbal Reasoning aptitude subtest; NVR = Non-Verbal Reasoning aptitude subtest; 3DS = 3D Spatial Manipulation aptitude subtest.
L2 = Second language subject; Maths. = Mathematics; L.0. = Life Orientation; Term = Average marks for the second term.
*$p < .05$. **$p < .01$. *** $p < .001$

The difference in age between the two groups was not significant but it just bordered the .05 significance level. The two schools were significantly different from each other at $\alpha = .001$ for academic performance and performance on the SDRT-RC and DAT subtests. The Higher Performance Group was significantly different on all measures of academic performance except for the non-English second language.

Table 4

χ^2 Comparison of the Lower Performance Group and the Higher Performance Group results on selected Reading Questionnaire Items

Items	*n*	χ^2	LPG	HPG
Gender	83	.13		
Number of languages you can read and speak	80	23.32***	27.5% = two; 57.5% = three ; 10.0% = four languages	20.0% = three; 37.5% = four; 20.0% = five languages
Hours spent reading English text a day	79	6.68	47.6% read for four+ hours	56.1% read for one to two hours
Number of books at home	81	11.92**	87.8% had 15 or less	50% had 15 or more
Number of magazines or newspapers at home	82	9.68*	61.0% had 15 or less	59.5% had 15 or more
Perception of reading skill	82	5.53	43.9% found reading very easy 41.5% found reading easy	33.3% found reading very easy 64.3% found reading easy
Feelings towards reading	82	5.54	41.0% loved reading 50.6% liked reading	33.3% loved reading 59.5% liked reading

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group.

*p< .05. **p< .01. *** p< .001.

The distribution of the participants' gender in the Lower Performance Group and the Higher Performance Group was not significantly different. Participants in the Higher Performance Group spoke and read in significantly more languages than participants in the Lower Performance Group (p<.001) Participants in the Higher Performance Group tended to have more reading material at home including more books (p<.01) and magazines and newspapers (p<.05). More participants from the Higher Performance Group tended to read for longer each day than participants in the Lower Performance Group, however this difference was not significant (*p>.05)*. The participants' perception of reading difficulty and feelings towards reading were similar in both groups.

Table 5

Comparison of the Frequency with which the Participants in the Lower Performance Group and the Higher Performance Group use English to Communicate with Various Social Groups

Social group	n	χ^2	LPG %	HPG %
Friends	77	18.71***		
Almost always			14.3	50.0
Often			17.1	26.2
Sometimes			48.6	11.9
Rarely			2.9	4.8
Almost never			17.1	7.1
Family	75	4.29		
Almost always			11.4	2.5
Often			17.1	30.0
Sometimes			42.9	37.5
Rarely			14.3	20.0
Almost never			14.3	10.0
Educators	75	10.15**		
Almost always			58.8	87.8
Often			26.5	12.2
Sometimes			5.9	
Rarely			5.9	
Almost never			2.9	
Community	76	3.43		
Almost always			5.9	19.0
Often			11.8	14.3
Sometimes			44.1	38.1
Rarely			8.8	4.8
Almost never			29.4	23.8
Strangers	75	8.94		
Almost always			15.2	28.6
Often			15.2	23.8
Sometimes			12.1	16.7
Rarely			9.1	14.3
Almost never			48.5	16.7

Note: LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group.

*p < .05. **p < .01. *** p < .001 .

Participants in the Higher Performance Group tended to use English more frequently for communication purposes with friends (p<.001) and Educators (p<.01), than participants in

the Lower Performance Group. The frequency with which the participants in both schools used English to communicate with family members and members in their community varied in a similar way. Almost half of the participants in the Lower Performance Group and 16.7% of participants in the Higher Performance Group reported that they almost never used English to communicate with strangers; however, there was no significant difference in the frequency in which the two groups used English to communicate with strangers.

Relationships between the Differential Aptitude Test subtests and the Stanford Diagnostic Reading Test -Reading Comprehension subtests

Table 6

Correlation matrix for the three Differential Aptitude Test subtests for all School Groups

	LPG			LPG			CG		
Measure	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
1. VR	-			-			-		
2. NVR	.63***			.45**			.66***		
3. 3DS	.65***	.64***		.35*	.49**		.57***	.62***	

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group. VR = Verbal Reasoning aptitudesubtest; NVR = Non-Verbal Reasoning aptitude subtest 3DS = 3D Spatial Manipulation aptitude subtest
*p< *.05.* **p< *.01.* *** p< *.001.*

The correlations between the DAT subtests for the Lower Performance Group were moderately strong and significant at α=.001. The correlation strengths between the same subtests were weaker for the Higher Performance Group. Both VR and 3DS were moderately correlated with NVR and both correlations were significant at α=.01. The correlation between VR and 3DS was weak but significant at α=.05. The correlation strengths for the Combined Group were more like those observed in the Lower Performance Group than the Higher Performance Group and were all significant at α=.001.

Table 7

Correlation Matrix between the Standard Diagnostic Reading Test-Reading Comprehension subtests and the Differential Aptitude Tests subtests for all School Groups

Measure	LPG	HPG	CG
AIS			
VR	.75***	.24	.71***
NVR	.50**	.14	.56***
3DS	.40*	.37*	.47***
CIS			
VR	.79***	.34*	.74***
NVR	.43**	.18	.51***
3DS	.56***	.39*	.54***
MIS			
VR	.83***	.32*	.76***
NVR	.50**	.18	.56***
3DS	.52**	.42**	.53***

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group. MIS = *Mixed Items Subtest; AIS = Abstract Items Subtest; CIS=Concrete Items Subtest; VR = Verbal Reasoning aptitude test; NVR = Non-Verbal Reasoning aptitude test; 3DS = 3D Spatial Manipulation aptitude test.* *p< *.05.* **p< *.01.* *** p< *.001.*

The correlation strength and significance for the DAT subtests and the MIS varied greatly between the two schools.

VR was strongly correlated with the MIS for the Lower Performance Group (p<.001). VR was weakly correlated with the MIS for the Higher Performance Group (p<.05).

NVR was not significantly correlated with the MIS for the Higher Performance Group, but for the Lower Performance Group, NVR's correlation with the MIS was of a moderate strength and significant at α=.01

3DS correlation with the MIS was moderately strong and significant at α=.01 for both schools.In addition, for the Higher Performance Group, the correlation between 3DS and the

MIS was slightly stronger and had a higher significance level ($p<.01$) than the Higher Performance Group's correlation between VR and MIS ($p<.05$).

For the Combined Group the correlations between the DAT subtests and the MIS were all significant at α= .001 level. The correlations strength between NVR and 3DS with the MIS were stronger and at a higher significance level for the Combined Group than when the two correlations were observed for the Lower Performance Group and the Higher Performance Group independently.

The items in the MIS were divided into two categories, AIS and CIS. The correlations between the MIS and the DAT subtests were compared to the new correlations obtained for the CIS and the AIS with the DAT subtests. The correlations strengths were similar between the Lower Performance Group and the Combined Group, whilst the correlations for the Higher Performance Group were very different.

For the Lower Performance Group and for the Combined Group, the correlations between VR with the three SDRT-RC subtests were strong and significant at α=.001. These correlations were much stronger than observed those between NVR and 3DS with the three SDRT-RC subtests which were moderately strong and ranged from r=.40 to r=.56.

For the Combined Group, all the correlations for NVR and 3DS with the three SDRT-RC subtests were significant at α=.001. The correlation strength for both NVR and 3DS with the CIS and the MIS respectively were very similar. The largest difference in the correlation strength between 3DS and NVR for the Combined Group was between the AIS and 3DS was ($r(83)=.47$, $p<.001$) between the AIS and NVR was ($r(83)=.56$, $p<.001$).

For the Lower Performance Group, all the correlations between NVR and the three SDRT-RC subtests was significant at α=.01. The significance level for the correlations between 3DS and the three SDRT-RC subtests were varied; 3DS was significantly correlated with the AIS at α=.05. The MIS was significant at α=.01 and with the CIS was significant at

α=.001 for the Lower Performance Group, the correlation between the AIS and NVR was stronger and more significant than the correlation between the AIS and 3DS. The correlation between the CIS and 3DS was stronger and more significant than the correlation between the CIS and NVR. The correlation strength and size were similar for both NVR and 3DS with MIS.

For the Higher Performance Group, the correlation between NVR and the three SDRT-RC subtests were very week and not significant ($p>.05$). These correlations were all weaker than those observed for 3DS and VR with the three SDRT-RC subtests. The correlations between 3DS and the three SDRT-RC subtests were weak but slightly stronger that the corresponding correlations between VR and the three SDRT-RC subtests. 3DS was significantly correlated with the CIS and the AIS at α=.05 and with the MIS at α=.01. VR was significantly correlated with the CIS and the MIS at α=.05, but VR was not significantly correlated with the AIS.

Table 8

Paired Sample T-Test comparing performance between Stanford Diagnostic Reading Test-Abstract Items and Concrete Items Subtests

Groups	*M*	*SD*	*df*	*t*
LPG	-.80	11.41	40	-.45
HPG	1.63	9.68	41	1.09
CG	.43	10.58	82	.37

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group. No significant values

No significant difference was observed between the three group's performance on the AIS and the CIS.

Predictive power of the Differential Aptitude Test subtests for each of the Stanford Diagnostic Reading Test-Reading Comprehension subtests

Table 9

Multiple Regression Models for the three Stanford Diagnostic Reading Test-Reading Comprehension subtests (SDRT-RC) with Differential Aptitude Test (DAT) subtests as predictors, for all School Groups

SDRT-RC	DAT Predictors	R^2	*Adj.* R^2	*SEE*	*df2*	*F*
MIS						
LPG	VR	.68	.67	7.99	39	83.63***
HPG	3DS	.17	.15	9.09	40	8.34**
CG	VR	.58	.57	10.79	81	109.56***
AIS						
LPG	VR	.56	.54	9.02	39	48.63***
HPG	3DS	.13	.11	9.15	40	6.14*
CG	VR	.50	.51	11.71	81	82.55***
CIS						
LPG	VR	.63	.62	10.43	39	66.71***
HPG	3DS	.15	.13	11.51	40	7.00*
CG (Model 1)	3DS	.54	.54	12.34	81	95.88***
CG (Model 2)	VR and 3DS	.57	.56	12.08	80	52.15***

Note. LPG = Lower Performance Group; HPG = Higher Performance Group; CG = Combined Group. MIS = Mixed Items Subtest; AIS = Abstract Items Subtest; CIS = Concrete Items Subtest; VR = Verbal Reasoning aptitude subtest; 3DS = 3D Spatial Manipulation aptitude subtest.
*p< .05. **p< .01. *** p < .001.

The multiple regression analyses results varied between the three groups. In the majority of cases, the addition of a second variable to the regression did not add significantly to the predictive strength of the model.

For the Lower Performance Group, VR ability was a strong predictor for all three SDRT-RC subtests at the significance level of α=.001. VR ability explained 67.4% of the variance in the MIS (*Adj* R^2=.67, $F(1,39)=83.63$, $p<.001$). The division of the MIS into the

concrete or abstract category resulted in smaller adjusted R^2 values. VR ability explained 62.2% of variance for the CIS (*Adj* R^2=.62, $F(1,39)=66.71$, $p<.001$) and 54.4% of the variance for the AIS (*Adj* R^2=.54, $F(1,39)=48.63$, $p<.001$).

For the Higher Performance Group, 3DS was a weak predictor for all three SDRT-RC subtests with a significance level of α=.01 for the MIS and α=.05 for the CIS and the AIS. 3DS ability explained 15.2% of the variance in the MIS (*Adj* R^2=.15, $F(1,40)=8.34$, $p<.01$). The division of the MIS into the concrete or abstract category resulted in smaller *adjusted* R^2 values. 3DS explained 13.3% of the variability in the AIS (*Adj* R^2=.13, $F(1,40)=6.14$, $p<.05$) and 14.9% of variability in the CIS (*Adj* R^2=.15, $F(1,40)=7.00$, $p<.05$).

For the Combined Group, VR was a strong predictor for all three SDRT-RC subtests at α=.001. VR explained 57.0% of the variation in the MIS (*Adj* R^2=.57, $F(1,81)=109.56$, $p<.001$), 50.5% in the AIS (*Adj* R^2=.505, $F(1,81)=82.86$, $p<.001$) and 54.2% variation in the CIS (*Adj* R^2=.54, $F(1,81)=95.88$, $p<.001$).

Table 10

Multiple regression Models for the Stanford Diagnostic Reading Test-Reading Comprehension Mixed Items Subtest and the Differential Aptitude Test subtests for the Combined Group

					Change Statistics		
Predictors	*B*	*SE B*	ß	*t*	R^2 Change	*F* Change	*df2*
CG Model 1							
Constant	18.45	.47		4.13***	.54	95.88	81
VR	.72	.07	.74	9.79***			
CG Model 2							
Constant	15.78	4.56		3.46**	.02	4.39	80
VR	.62	.09	.63	7.06***			
3DS	.17	.08	.19	2.10*			

Note. CG = Combined Group. VR = Verbal Reasoning aptitude subtest; 3DS = 3D Spatial Manipulation aptitude subtest.
*p< .05. **p< .01. *** p< .001

The addition of 3DS to the model for the CIS increased the predictive power by 2.4% (*Adj* R^2=.57, $F(1,80)=52.15$, $p<.001$). This increase was significant at α=.05 (t=2.10, p<.05).

Discussion

Children use sensory information, particularly in the visual modality, for the development of fundamental reasoning and verbal skills (Piaget, 1974). Visual mental imagery is an important, if not a vital, facet of the formation of the mental models that facilitate the processes involved in reading comprehension, irrespective of the reader's age.

Many theories about visual mental imagery and reading comprehension, such as Dual Coding Theory (DCT) (Paivio, 1974; Paivio & Sadoski, 2004, 2007) and Construction Integration Model (CIM) (Kintsch, 1988, 1998) assert that it is necessary for readers to consciously exert effort to control the processing of visual mental imagery in order for the information to be kept relevant to the meaning of the text and to meet the reader's processing needs.

The assessment of the formation and application of visual mental imagery during reading and reading comprehension has been notoriously difficult. Part of the reason is because the construction of mental models (or situational models) involves many complex processes which draw upon and integrate verbal and non-verbal forms of prior knowledge (Kintsch, 1988, 1988; Paivio & Sadoski, 2004, 2007). It is possible to test the knowledge and skills involved in reading comprehension processes; however, it is more difficult to observe the interaction between the various skills, knowledge and processes.

This research examined the extent to which the results of measures that assess learners' ability to process and reason using visual information can provide insight into the role visual mental imagery plays during reading comprehension**.** There is compelling evidence that indicates that visual-object and visual-spatial mental imagery are processed via different neural pathways and represent different types of information (Baddeley, 2003; Baddeley & Repovs, 2006). As such, visual reasoning ability was assessed using two

measures from the Differential Aptitude Test (DAT) battery, including; the Non-Verbal Reasoning aptitude test (NVR), which measures learners' ability to mentally reason about and manipulate 2D figures, and the 3D Spatial Manipulation aptitude test (3DS) which requires learners to reason and mentally manipulate images on a 3D plane. These differences impact on the way visual mental imagery can be utilized for reading purposes.

Visual-object mental imagery plays various roles during the use and development of basic reading skills and it can play a supportive role in sentence level comprehension, especially in participants who have not yet become proficient in certain verbal reading skills. Readers need to become proficient in basic reading skills, such as decoding, before discourse level comprehension can be accomplished. Proficient readers can apply basic reading skills automatically, and thus are unlikely to make use of visual-object mental imagery skills that support basic reading skills, unless they encounter complex or unfamiliar text (Long et al., 1989; Paivio & Sadoski, 2004, 2007; Zwaan & Madden, 2005; Zwaan & Radvansky, 1998).

Visual-spatial mental imagery is more useful for proficient readers, as it can be used to aid reading comprehension at discourse level since visual-spatial mental imagery is a closer abstraction of physical reality than 2D visual or verbal information. It can simultaneously represent multiple relationships and interactions within complex systems or situations and can be manipulated to make predictions about a situation (Knauff & Johnson-Laird, 2002; Ragni et al., 2006; Rapp, 2005; Zwaan & Madden, 2005).

The integration of visual-spatial and visual-object mental imagery in a situation or mental model can also serve to support reading comprehension skills such as anaphor tracking (Rinck & Bower, 1995). Readers who are not proficient in verbal reading skills could make use of these strategies, if they are aware of them. However, the cognitive load that results from processing at sentence comprehension level may prevent readers from

expending resources in such a fashion (Haenggi et al., 1995; Rinck & Bower, 1995; Zwaan & Madden, 2005).

The differences in significance of visual-object and visual-spatial mental imagery to rudimentary and basic reading skills is related to the readers' level of proficiency with verbal reasoning. This includes the reading skills the reader has mastered and is still developing, as well as, their knowledge of literary mechanisms and vocabulary (Kintsch, 1998; Oh, 2010; Paivio & Sadoski, 2004). Thus the Verbal Reasoning subtest (VR) of the DAT was also administered to provide a baseline that could allow for the observation of such effects.

The differences in the nature of processing visual-object and visual-spatial mental imagery has a significant impact on text based phenomena known as word concreteness effects. Concrete words are words which have a referent in the physical world that is easy to visualize. Reading a concrete word automatically triggers a visual mental representation of that word (Paivio & Sadoski, 2004, 2007; Sadoski, 2001). Word concreteness has been associated with a number of benefits for reading comprehension (Long et al., 1989; Sadoski, 2001; Truscott, 1995). Word concreteness has also been associated with detrimental effects to reading comprehension processes. Uncontrolled visualization of the visual mental representation may lead to the diversion of cognitive resources away from the integration of verbal and visual information during the construction of the mental model. This may result in the inclusion of irrelevant or erroneous information in the mental model (Sadoski, 1983; Truscott, 1995). Uncontrolled visualization of visual-object mental imagery is particularly problematic since it is more likely to contain a large amount of detail that is irrelevant to the coherence of the mental model, whilst information in visual-spatial mental imagery is more likely to be relevant and useful for the maintenance of coherence, model elaboration and prediction (Knauff & Johnson-Laird, 2002; Schwartz & Heiser, 2006; Zwaan & Madden, 2005). Visual-spatial mental imagery constructed during the reading process is less likely to

contain irrelevant information since readers typically only construct partial visual-spatial mental representations or models using information that is directly relevant to the protagonist of a text, unless the reader exerts effort to construct a more detailed spatial representation (Haenggi et al., 1995; Kintsch, 1998; Zwaan & Madden, 2005).

An attempt was made to isolate text based variables in the items of the SDRT-RC that were believed to affect the processing of visual-object mental imagery**.** SDRT-RC items which had answers which contained a concrete noun that represented a visual-object were thought to be more likely to result in the construction of a mental model for the item with relevant visual-object mental imagery.

Cain et al., (2001) observed that readers who have poor reading comprehension abilities tended to be less successful in monitoring for intrusion of irrelevant information than readers who were proficient at reading comprehension, which resulted in the construction of inaccurate mental models. The Immersed Experiencer Framework (IEF) (Zwaan, 2003) provided insight on how this occurred specifically in terms of the processing of visual mental imagery. IEF proposed that the visual-spatial, visual-object and temporal information that is contained in small sets of words called constructurals, is automatically integrated at the representation level. IEF (Zwaan, 2003; Zwaan & Madden, 2005) argued that the diversion of cognitive resources to rudimentary and basic reading skills may displace a constructural present in working memory (WM) and replace it with other information. If the constructural is not properly recalled into WM afterwards, the constraining function of constructurals, whereby an existing constructural in WM constrains the content triggered in the subsequent constructural, may be interrupted and thus the relevance of the content of the new constructural is compromised.

Bilingual learners, particularly when they are not proficient in English, have to compensate for the high additional cognitive load that results from learning and integrating

two or more different languages, on top of the standard cognitive load associated with the development of reading skills (Kintsch, 1998; Morishima, 2008; Nassaji, 2007).

The sample for this research paper was drawn from participants whose home language was not English, but English had been their language of instruction since grade 3. The English second language (ESL) group was chosen since it reflects a large proportion of South Africa's school going population (Department of Education, 2010a). A large body of research exists that compares the performance of English first language (EFL) to ESL participants. Research indicates that ESL participants perform poorer than EFL participants on reading activities, even when the participants were matched for socio-cultural and demographic factors (Bhorat, 2007; Catto, 2010; Khatpagam, 2009; Lathy, 2008; Malope, 2009; Ranchod, 2008; Van Rooyen & Jordaan, 2009; Winnett, 2009). This difference decreases over time as ESL participants develop their English language skills and reach the threshold level for verbal skills required for academic language demands of their specific grade (Van Rooyen & Jordaan, 2009). The participants' ability to reach this threshold is subject to contextual factors such as quality of education, access to reading material, reading activity, as well as, exposure to and frequency of use of the English language (Department of Education, 2009b; Heugh, 2005; Macdonald, 2002). Far fewer South African studies have addressed the nature of cognitive processes used by ESL participants and the consequences of these processes with regard to their reading comprehension ability, particularly with regards to visual mental imagery (Ngwenya, 2004; Ravenscroft, 2009).

The two schools were selected for this research because the learners came from similar socio-economic backgrounds. Two groups were used to increase the number of participants in the overall sample and to provide a degree of compensation for the absence of randomization of the two separate sample groups. Initially, it was intended that the analysis would focus on identifying trends for the whole sample; however, trends in the participant's

performance on the various measures necessitated a second level to the analysis. The two groups of participants had similar age and gender distributions and similar academic results for their second language subject (Table 1). The participants in both schools had a positive perception of reading and considered reading to be easy or very easy (Table 4). Despite these similarities, the performance of the schools on academic subjects and on the test measures was very different. For the Higher Performance Group the overall performance on the DAT and SDRT-RC subtests, as well as the English, Maths, Life Orientation and their mid-year average mark, were significantly better than the performance of the Lower Performance Group. The Higher Performance Group performed better than the Lower Performance Group on all of the SDRT-RC and DAT subtests (Table 3). The results of the reading questionnaire revealed that the context and reading activities of participants in the Higher Performance Group were more conducive to the development of basic English language and reading skills. Participants in the Higher Performance Group (a) tended to use English as the primary language of communication with their peers and teachers more frequently and (Table 5) (b) spent more time reading every day and had access to more reading materials at home (Table 4). Participants in the Higher Performance Group reported being able to read and speak in more languages than participants in the Lower Performance Group (Table 4). Thus the Lower Performance Group represented participants with low to average visual and verbal reasoning aptitude and had underdeveloped reading and language skills, particularly when compared to the performance of participants in the Higher Performance Group, who tended to have average to good performance on the DAT and SDRT-RC subtests.

These two groups do not adequately represent learners with more extreme variation in their individual cognitive aptitudes. It is important to consider that the nature of the relationship between the DAT and SDRT-RC subtests may be very different for participants who, for instance, have low VR but high 3DS and/or NVR skills.

This research did not include an intervention or specific instruction to use visual mental imagery during the reading comprehension test, but during the discussion held with the participants prior to administration, the basic concept of visual mental imagery was introduced in line with the letter of information (*Appendix B*).Thus, if the learners employed visual mental imagery strategies when completing the SDRT-RC, it was more likely to have resulted from some form of instruction from teacher or other parties during their prior academic experience. This research may be interpreted as a review of the appropriateness of introducing visual mental imagery strategies for the support of reading and reading comprehension skills to secondary school learners with poor verbal and visual reasoning aptitudes.

Exploration of the relationship between the Differential Aptitude Test subtests and the total Stanford Diagnostic Reading Comprehension subtest

Research question 1 explored the relationship between the SDRT-RC Mixed Item Subtest (MIS) and the three DAT subtests. It was hypothesized that low VR ability would be strongly correlated with the MIS and the strength of this relationship would decrease for learners with stronger VR ability. The VR scores represented the extent of participants' vocabulary knowledge and their ability to make basic inferences based on a decontextualized text microstructure (sentence). Thus, it was not surprising to observe that in the Lower Performance Group, VR scores were very strongly correlated with the MIS ($r(41)=.83, p<.001$), whilst the corresponding correlation in the Higher Performance Group was weak and at a low level of significance ($r(42)=.32$, $p<.05$) (Table 7). These results support the hypothesis and suggest that the participants in the Higher Performance Group had achieved the minimum verbal reasoning skill threshold necessary for them to cope with the verbal components of the MIS. Since this threshold had been achieved, any further increase

in the participants' VR ability would not elicit similar changes in the MIS. The Lower Performance Group had not yet reached this threshold and thus differences in VR performance of individual participants corresponded more closely with changes in the MIS performance. Visual mental imagery use during reading comprehension differs between readers who have well developed verbal skills and readers who are still developing those skills, relative to their grade; as such, the Lower Performance Group's poor VR ability may indicate that the participants in that group were more inclined to resort to the use of rudimentary reading skills to cope with an unfamiliar or confusing text.

It was hypothesized that NVR scores would have a weak to moderate correlation with the MIS in learners with low and high VR abilities. The correlation between the MIS and the NVR for the Lower Performance Group, was of moderate strength ($r(42)=.51$, $p<.01$) , while the corresponding correlation for the Higher Performance Group was very weak and not significant (Table 7) which supports the hypothesis.

These results suggest that the Lower Performance Group may have used NVR and as such, visual-object mental imagery, during the reading process and they used it more than the Higher Performance Group. The Low Performance Group had a mixed range of performance levels from low to average on all their DAT scores. Since their VR was low, they would be more reliant on other sources of information to aid bridging the gaps in the VR ability during reading comprehension. Thus differences in NVR aptitude correlate moderately with the MIS. The manner in which this is accomplished is unclear. Visual object mental imagery can be used as basic reading skills as they facilitate access to additional verbal information and translation between languages. (Ehlers-Zavlala, 2005; Paivio, Clark & Lambret, 1988; Paivio & Desrochers, 1980; Paivio & Sadoski, 2004). This may be beneficial to the reading comprehension process as it assists in the development of the basic reading ability necessary to support reading comprehension. These strategies, however, may require significant

cognitive resources in order to be performed successfully, thereby interrupting the reading comprehension process and if the model is not properly reinstated this risks the inclusion of erroneous or irrelevant information in the mental model. In addition, for learners to employ these strategies, the participant would have to have learnt these strategies explicitly (Kintsch & Ericsson, 1995). The participants' knowledge of basic reading support strategies is unknown, but since their overall performance on verbal tasks is poor, it is unclear whether they had the requisite knowledge to readily apply visual mental imagery strategies.

An alternative benefit of NVR ability is that it may play a role in the suppression of irrelevant visual object mental imagery which, if left unchecked, can cause visual-impedance effects and thus can impede reading comprehension. The ability to identify what information is or is not relevant and the integration of this information into a coherent mental model requires the interplay of non-verbal imagery, specifically visual-spatial imagery and verbal information since visual-object mental imagery does not provide the type of information to describe a situation and various relationships between objects. This interplay is likely to involve other higher cognitive functions. Since the Low Performance Group's scores were in the lower range, NVR ability could play a more significant role in controlling visual impedance effects for learners who have the skills necessary to construct sound and reliable mental models. It follows that participants in the Higher Performance Group were proficient readers and thus were able to construct comprehensive mental models during reading comprehension. Thus they were less likely to make use of visual-object mental imagery as a basic reading skill to support gaps in VR ability, unless the imagery was already incorporated into a mental model.

It was hypothesized that both participants with low VR and those with high VR would show at least moderate correlations between 3DS and the MIS. The correlation observed for the Lower Performance Group ($r(42)=.50$, $p<.01$) was slightly higher than the correlation

observed for the Higher Performance Group ($r(42)=.42$, $p<.01$) (Table 7). The correlation for the Higher Performance Group between the 3DS and the MIS was stronger than the correlation between VR and the MIS ($r(42)=.32$, $p<.05$). These results support the hypothesis. It was also hypothesized that the correlation between 3DS and the MIS would be weaker in participants with low VR ability than participants with high VR ability since learners with low VR were not expected to have the cognitive resources available to successfully incorporate spatial information into a comprehensive mental model, however the results did not support this hypothesis.

A further finding emerged from the comparison of the correlation strengths for the two schools between MIS and VR and for MIS and 3DS. The results indicated that, for the Lower Performance Group, the correlation between VR and the MIS was much stronger than the correlation between 3DS and the MIS, whilst for the Higher Performance Group the correlation between VR and MIS was weaker than the correlation between 3DS and MIS (Table 7). This suggests that whilst learners with low VR ability may have had the minimum skills needed to manipulate visual-spatial mental imagery during reading comprehension, however the extent to which learners could successfully incorporate visual-spatial mental imagery into a mental model would be influenced by their VR proficiency. In addition, 3DS ability may impact the reading comprehension performance amongst learners who are proficient in VR.

The results from this analysis for research question 1 presented both expected and unexpected results, however, when the results were considered together, it was possible to generate an interpretation of these results which corresponded with the aforementioned visual metal imagery and reading comprehension theories. Visual-spatial mental imagery is unlikely to produce visual impedance effects like visual-object mental imagery and thus is less likely to drain cognitive resources unnecessarily (Haenggi et al., 1995; Kintsch, 1998;

Zwaan & Madden, 2005). Maintaining and updating spatial mental representations occurs naturally during reading but it does load on cognitive resources and it is interrupted if there are insufficient cognitive resources available (Haenggi et al., 1995; Kintsch, 1998; Zwaan & Madden, 2005). Participants with low VR were expected to be more likely to divert cognitive resources to rudimentary and basic reading skills, which could have affected the maintenance of the spatial mental representation or mental model. In addition, the 3DS score for the Lower Performance Group was much lower than the same score for the Higher Performance Group (Table 2); so theoretically participants in the Lower Performance Group would have to exert more cognitive effort to maintain and manipulate visual-spatial mental imagery. Despite these cognitive requirements, the correlation between 3DS and the MIS was slightly stronger for participants in the Lower Performance Group. Since visual-spatial mental imagery is unlikely to produce visual impedance effects like visual-object mental imagery (Haenggi et al., 1995; Kintsch, 1998; Zwaan & Madden, 2005), the results may suggest that the participants from the Lower Performance Group were able to utilize 3DS skills during reading comprehension to some extent, despite the overall low performance range on both VR and 3DS and despite the various constraints on those participants' cognitive resources. This suggests that visual-spatial mental imagery is particularly resilient despite the increased likelihood of interruption to the reading comprehension process. The Immersed Experiencer Framework (IEF) (Zwaan, 2003; Zwaan & Madden, 2005) proposed that when cognitive resources are diverted, from comprehension to rudimentary reading skills or for some other reason, then the constructural is displaced from WM. If it's not properly recalled this may lead to intrusion of irrelevant information in the subsequent constructural and thus the mental model of the text. The Lower Performance Group's poor overall performance (Table 2) may be related to an increased frequency in the interruption of the reading comprehension process and intrusion of irrelevant information. It is argued here that

visual-spatial mental imagery in the mental model may serve to reinstate a displaced constructural back into WM, however, the high frequency of intrusions make it more likely that an error will occur in the modelling process. Visual-spatial mental imagery in a mental model provides a situational and relational backdrop for large amounts of information from many dimensions. If spatial cues are not available in the text, the learner will naturally add a generic spatial component to the constructural based on what was read before (Zwaan, 2003; Zwaan & Madden, 2005). This generic component could serve to activate recently primed constructural information in other modes even if they were not adequately encoded into the mental model and provides a backdrop where this information can be fitted in. Visual-object mental imagery is integrated with specific information within a mental model and thus is less likely to be integrated into the model unless it is directly relevant to the constructural in question. The effectiveness of the constraining function of constructurals depends on the relevance and quality of the consecutive series of constructurals which are formed over a period of time spent reading. Thus errors which occur earlier on in the reading process may lead to the inclusion of irrelevant information, if they are not identified and corrected efficiently.

The correlations for the three DAT subtests and MIS were similar for the Combined Group and the Lower Performance Group, although the correlations between NVR and 3DS with the MIS were very significant at a higher level ($p<.001$) for the Combined Group (Table 7). The Higher Performance Group's correlations between VR and NVR with the MIS were comparatively much weaker. This suggests that VR ability is more closely associated with reading comprehension ability than 3DS and NVR when a broad range of performance on VR is assessed; however, the broad assessment obscures the different patterns in the correlations between 3DS and MIS the learners with low and high VR ability. Once learners have reached

a particular level of proficiency in reading comprehension ability, it is their 3DS ability that can serve to differentiate their performance from their peers with high VR ability.

Exploration of word concreteness effects on the relationship between the Differential Aptitude Test subtests and the Stanford Diagnostic Reading Test Reading Comprehension subtest

This research explored the influence of controlling items for concreteness effects of SDRT-RC item answers on the correlations observed for the first research question. The presence of a concrete noun in the correct answer was expected to indicate that visual-object mental imagery was a constituent of the mental modelling processes and product.

It was hypothesized that learners would perform better on the Concrete Items Subtest (CIS) and the Abstract Items Subtest (AIS) and this would be more pronounced in the Lower Performance Group. Abstract text was argued to be more difficult to comprehend than concrete text (Sadoski, 2001; Wilcken, 2008) and since the comprehension of abstract text is dependent on good VR proficiency, it was expected that the Lower Performance Group was likely to struggle with the AIS more than the CIS. The descriptive statistical analysis (Table 2) revealed that the mean and standard deviation for CIS and AIS results for the Lower Performance Group (M_{AIS} = 48.71, SD_{AIS} = 13.35; M_{CIS} = 49.50, SD_{CIS} = 16.95) and the Higher Performance Group (M_{AIS} = 72.18, SD_{AIS} = 9.70 ; M_{CIS} = 70.55, SD_{CIS} = 12.32) were respectively very similar. The *t* test analysis of the AIS and the CIS (Table 8) indicated that the difference between the groups was not significant for both groups separately or for the Combined Group. These results did not support the hypothesis that the Lower Performance Group's performance on AIS would be poorer than the group's performance on CIS.

These results may be a consequence of the way in which concreteness was determined for this research. This research considered items to be concrete if they contain a common

noun in the correct item answer, but the presence of concrete nouns in the other answer options or in the item question itself was not controlled. The previous section established that NVR ability in participants in the Lower Performance Group was likely to be used as a suppression mechanism for visual-object mental imagery and possibly as some form of basic reading skill to bridge gaps in VR ability. Thus, the use of NVR for suppression of irrelevant visual-object mental imagery could have been extended to imagery triggered by concrete nouns located in the incorrect answers or in the item questions of both concrete and abstract items (Knauff & Johnson-Laird, 2002; Ragni et al., 2006).

When the overall low performance of the Lower Performance Group on NVR (Table 2) was considered, a different explanation arose. Concrete text was found to be easier to understand than abstract text in previous research (Sadoski, 2001; Wilcken, 2008); however, this is less likely to be relevant for learners who are already proficient readers. Thus it is argued that the performance of the Lower Performance Group on the CIS, whilst slightly higher than the AIS score, was expected to be much higher still (Table 2). It is possible that the learner's did not have the NVR skills necessary to adequately control the visual-object mental imagery triggered by the common nouns in the CIS item. The correlations for the Lower Performance Group for NVR with CIS and with AIS were much stronger than the corresponding correlations observed for the Higher Performance Group, who had high overall performance on the NVR subtest (Table 2). Thus, for the Lower Performance Group, the learners NVR ability may have played a role in the suppression of irrelevant visual-object metal imagery but the ability not have been strong enough in the group for them to be able to fully prevent visual impendence effects of all concrete text.

An alternative observation can be made when interpreting the results from the position of Dual Coding Theory (Paivio & Sadoski, 2004, 2007). It is possible that the learners were not able to make all the necessary referential links between the visual-object

metal imagery with verbal and/or visual spatial mental imagery, thus they were not able to identify what visual object mental imagery was relevant to the model or they were not able judge what characteristics about the object were relevant to the model, both cases could result in excessive processing of irrelevant visual-object metal imagery. The mental articulation of information, i.e. the creation of the feedback loop between the visual-object mental imagery and the corresponding verbal representation is necessary if the learner used non-verbal information to get to the answer as they have to mentally articulate the information before they can match it to the verbal information presented in the item answer.

It follows that within the Low Performance Group, learners with better VR ability are more likely to create sound models and that these learners may have made sufficient referential links between verbal information and visual object mental imagery so that at least some irrelevant visual object mental imagery was supressed. This is demonstrated in the subsequent section; it was hypothesized that VR ability would correlate more strongly with the AIS than with the CIS, since abstract text is more difficult and thus relies more on VR ability**.** It was expected that VR ability would correlate more strongly with the AIS then with the CIS. The results, as seen in Table 7, revealed that the results for both schools did not support the hypothesis. For the Lower Performance Group, the correlation between VR and the CIS ($r(41)=.79$, $p<.001$) was slightly stronger than the correlation between VR and the AIS ($r(41)=.75$, $p<.001$). For the Higher Performance Group, the VR correlation with the CIS was weak but significant ($r(42)=.34$, $p<.05$) whilst the correlation between VR and the AIS was very weak and not significant ($r(42)=.24$, $p>.05$). The abstract items did not contain a common noun in the correct item answer, but they may have included a common noun in the item question or in the incorrect answers. Thus, the reader's ability to suppress irrelevant visual-object mental imagery is important so that the learner can identify the correct abstract answer. Since the information contained in a common noun can be represented both verbally

and as visual-object mental imagery, it is possible that learners utilized VR skills to control for irrelevant visual-object mental imagery triggered by the presence of a concrete noun in the correct answer of the items by comparing the visual-object mental imagery with the verbal information presented in each item. In this case VR ability may play a role in the suppression process by using verbal information and assessing the extent to which the verbal information is connected through referential links to the non-verbal information. In this way, the reader may be able to identify irrelevant visual-object mental imagery (Paivio & Sadoski, 2004, 2007).

Concrete words represent objects in the physical world, thus it was hypothesized that NVR score, which measures visual-object reasoning ability, would be more strongly correlated with CIS than with AIS, particularly for participants with poor VR ability. For the Lower Performance Group, the correlation between NVR and the CIS ($r(41)=.43$, $p<.01$) was slightly weaker than the correlation between NVR and the AIS ($r(41)=.51$. $p<.01$). These results did not support the hypothesis. As established in the previous section, NVR ability may be related to the suppression of irrelevant visual-object mental imagery, whilst the identification of relevant visual-object mental imagery is a function of a combination of NVR, VR, 3DS and other higher cognitive processes. The Lower Performance Group had low to average performances on VR (M=47,71, SD=16.65) and particularly on NVR (M = 36.78, SD = 19.88) (Table 2). Thus the results for the Lower Performance Group could reflect the consequence of low aptitudes on one or more sets of abilities and possibly the inability to successfully integrate the different processes necessary for the construction of a comprehensive mental model. For the Higher Performance Group, NVR was very weakly correlated at a non-significant level with all three SDRT-RC subtests, thus the differentiation of the MIS into the CIS and the AIS did not affect the correlation tests for participants with high VR ability.

It was hypothesised that 3DS would be more strongly correlated to the CIS items than the AIS items since the CIS items contain visual-object mental imagery that is relevant to the items mental model. 3DS is not involved in the processing of visual-object mental imagery, however, visual-object mental imagery is naturally integrated with spatial and temporal characteristics of a situation model (Kintsch, 1988, 1998) or potentially at the level of mental representation as constructurals (Zwaan, 2003; Zwaan & Madden, 2005). If the construction of the model is successful, spatial information can be used to relate objects to a particular location and/or to another object and 3DS ability may be used to make predictions about relationships between objects (Knauff & Johnson-Laird, 2002; Schwartz & Heiser, 2006; Zwaan & Madden, 2005). Visual-spatial mental imagery from the macro-structure situation model could be related to items where the product of comprehension is concrete or abstract; however, a concrete word cue has a more direct link to the model while more effort has to be exerted to relate an abstract cue to the same model (Setti & Caramelli, 1997; Wiemer-Hastings et al., 2001).

The results, as seen in Table 7, for the Lower Performance Group support the hypothesis since the correlation between the 3DS and the CIS ($r(41)=.56$, $p<.001$) was stronger and had a higher level of significance than the correlation between the 3DS and the AIS ($r(41)=.40$, $p<.05$). For the Higher Performance Group, however, the correlations between the 3DS and the CIS ($r(42)=.39$, $p<.05$) was only slightly stronger than the correlation observed between 3DS and the AIS ($r(42)=.37$, $p<.05$). The Lower Performance Group's overall performances on both NVR and 3DS were weaker than the Higher Performance Group (Table 7) and the Lower Performance Group participants tended to perform better on the 3DS ($M = 45.01$, $SD = 18.59$) than NVR ($M = 36.78$, $SD = 19.88$) (Table 2). In fact there was a greater degree of overlap in the range of performance between the two schools on the 3DS than on all other measures. This indicates that the Lower

Performance Group would be more dependent upon 3DS ability, because of their somewhat higher proficiency in it than on the NVR. The Higher Performance Group's NVR and VR ability was high overall, but since they were already proficient readers, they were less likely to be dependent on visual-object mental imagery for reading purposes and their high proficiency in VR (*M* = 67.90, *SD* = 14.48) and NVR (*M* = 57.24, *SD* = 18. 52) (Table 2), would likely enable them to effectively manage the concreteness effects of common nouns. The Higher Performance Group's performance on 3DS (*M* = 57.24, *SD* = 19. 78) was similar to that of NVR. It is possible that, due to the more relevant role 3DS plays during reading comprehension for proficient readers, the Higher Performance Group may have been able to engage with visual-spatial mental imagery and apply it to both the CIS and the AIS.

Exploration of the predictive power of the Differential Aptitude Test subtests for each of the three Stanford Diagnostic Reading Test Reading Comprehension subtest

The three DAT subtests were entered into a multiple regression for each of the SDRT-RC subtests and the results were compared across the three school groups. Regression Models with all three DAT subtests entered as predictor variables tended to favour models with one predictor variable

The natural and, to an extent, automatic construction of a multi-modal mental model during reading comprehension means that if the learner has sufficient cognitive resources available, they can use this information to make a variety of inferences about the text (Graesser et al., 2007; Graesser et al., 1994; Cain et al., 2001). The learner can use this information to make elaborate multi-modal simulations and predictive inferences about the situation described in the text. This process is cognitively demanding and typically requires the learner to do it offline, between sessions of reading, which interrupts the reading

comprehension process. Spread of activation in the neural network is constrained to include information that is directly relevant to the comprehension of a text. Thus the declarative information in the macrostructure situation model in the LTWM, represents a specific set of recently primed information (Kintsch & Ericsson, 1995; Kintsch, Patel & Ericsson, 1999). In this situation, if a reader chooses to go offline to perform extensive elaborative inferences, they are more likely to be able to use the macrostructure situation model to restart the reading comprehension process without compromising the integrity of the microstructure situation model.

Visual-object mental imagery does not facilitate the control of intrusion and may rather lead to intrusion errors caused by irrelevant visual information, also called visual impedance effects (Knauff & Johnson-Laird, 2002). NVR ability may be involved in suppressing irrelevant visual-object mental imagery. In this way NVR may have an indirect benefit for reading comprehension; however, it is only when visual-object mental imagery is integrated into a mental model through a combination of cognitive processes that it can be useful for reading comprehension purposes. As such, NVR ability was expected to be the least likely to contribute towards the predictive strength of the learners reading comprehension ability, particularly for learners with well-developed VR ability. The results of the multiple regression indicated that NVR ability did not contribute towards the model's predictive strength for any of the three school groups.

Poor VR ability is a chief cause of the failure to construct coherent and comprehensive mental models of text. It was hypothesized that VR would be a strong predictor for participants with weak VR ability but not for participants with good VR ability. VR did not contribute to the predictive strength of the Models for the Higher Performance Group, which was the stronger performing school. For the Lower Performance Group, VR explained 67.4% of variance in MIS (Table 9). The division of items according to word

concreteness resulted in a decrease predictive strength of VR. VR explained 62.2% of variance in the CIS and 54.4% in the AIS. VR was also the strongest predictor for the Combined Group and explained 57.0% of the variance in MIS, 50.5% of variance in the CIS and 54.2% in the AIS. Thus, VR was a strong predictor for both the Lower Performance Group and for the Combined Group at α=.001, however, a large amount of variation, almost 32,6% for the Lower Performance Group and 43.0% for the Combined Group, was not explained by VR. In addition, the categorization of the MIS items into the CIS and the AIS resulted in an increase in the unexplained variance.

Word concreteness effects were tested by isolating items that had correct answers which contained common noun words. Common nouns are associated with visual-object mental imagery. It was not possible to fully gauge the effects of words that reflected visual-spatial mental imagery. The IEF (Zwaan, 2003; Zwaan & Madden, 2005) argued that both visual -object and visual-spatial mental imagery are involved at both the representation and mental model level of construction. Thus, it was possible to derive a sense of the role 3DS ability may have played in the reading comprehension process since visual-object mental imagery is integrated into a visual-spatial mental imagery at model level.

It was hypothesized that 3DS would play a predictive role for participants with good VR ability but it was less likely that it would be a good predictor for learners with poor VR ability. The correlation between 3DS and the CIS was moderately strong ($r(41)=.56$, $p<.001$) (Table 7) despite the Lower Performance Group's low to average range of performance on 3DS; however, 3DS did not contribute to the predictive power of the model for the Lower Performance Group for MIS, AIS or CIS. This supports the hypothesis that 3DS would not be a good predictor for learners with poor VR because these learners were believed not to have the cognitive resources available to them to utilize visual-spatial mental imagery for reading comprehension purposes.

3DS was a weak predictor for reading comprehension ability of participants in the Higher Performance Group which supports the hypothesis. 3DS explained 15.2% of variance in the MIS which was significant at α=.01(Table 9). The division of items according to word concreteness resulted in a minor decrease in the predictive strength of 3DS. 3DS explained 13.3% of variance in the CIS and 14.9% in the AIS. This resulted in a decrease in the significance of the predictor to α=.05. In addition, 3DS explained an additional 2.4% of the variance for the CIS for the Combined Group (Table 10).These results suggest that 3DS played a role in the construction of mental models for reading comprehension, however, the role is only observable using aptitude measures it only becomes apparent once the learner has developed proficiency in VR and a certain degree of proficiency in 3DS. This proficiency results in the increased availability of cognitive resources for higher level processing involved when visual-spatial mental imagery is used to make various inferences about a text.

VR ability is more closely associated with reading comprehension ability than 3DS and NVR when a broad range of performance on VR is assessed; however, the broad assessment obscures the different patterns in the correlations between 3DS and MIS the learners with low and high VR ability. Once learners have reached a particular level of proficiency in reading comprehension ability, it is their 3DS ability that can serve to differentiate their performance from their peers with high VR ability. It is important to remember that the level of VR proficiency reached by the learners is relative to their grade and that the ceiling of VR proficiency is likely to be higher in subsequent grades and in formal tertiary education. Thus it is important to acknowledge the role of 3DS ability in reading comprehension, not as a skill possessed by proficient readers but as a milestone of reading comprehension proficiency in a learner's long term academic development.

Limitations

The sample chosen for this research paper was selected because it represented a general South African adolescent ESL learner population. The more specific characteristics of the sample's demographic profile limit the extent to which the finding can be generalized within the target population. Specific constraints included that the participants only represented Grade Ten learners; that the sample was selected from two Gauteng based Schools and that participants were reported to reside in previously disadvantaged communities.

The participants' performance on the three DAT subtests tended to be at a similar level within the two schools. It was not possible to clearly explore the effect on reading comprehension in cases where participants displayed significantly greater proficiency in one or two of the subtests over the others.

The NVR and 3DS measure the learners' ability to reason using visual mental imagery, however, the ability does not prescribe that the learner will use this skill as part of reading comprehension process. In addition, these measures do not facilitate the observation of the interaction between visual-object, visual-spatial, verbal and other cognitive faculties which may or may not become involved in reading comprehension. The assessment of the SDRT-RC focusing on word-concreteness-effects attempted to tap into these interactions. The parameters used to define word-concreteness-effects did account for the inclusion of visual-object mental imagery in the item situation models but it did not address the activation and suppression of irrelevant visual-object mental imagery, nor did it address the concreteness effects of spatial textual cues. Clarity could be gained in a number of ways including; (a) extending the word concreteness effects parameters in order to include the concreteness effects of the SDRT-RC passages and in all the text within the items (b) administrating a comprehensive visual mental imagery self-report assessment that will

correspond with the passages and items of the SDRT-RC, and (c) adding a questionnaire to explore whether or not the learner has received training in visual mental imagery reading strategies in their past.

The VR provides insight into learners' ability to reason using simple decontextualized verbal information and it is an indirect measure of a learner's vocabulary range. Vocabulary is particularly important for fluent reading comprehension and is a particular issue for ESL learners. The addition of a measure of vocabulary knowledge could have provided a clearer insight into whether the VR results were a result of inadequate VR skills specifically if it was also complicated by poor vocabulary knowledge.

In situation models, the visual-object mental imagery that is included is typically included only if it is relevant to the current protagonist. This relevance is constrained by the spatial characteristics of the object in the broader situational model. It was not possible to fully examine the effect that constraining function visual-spatial mental imagery may have had on visual impedance effects which in turn are caused by the activation of irrelevant visual-object mental imagery. A possible solution is the inclusion of an assessment of VR measure for word concreteness effects of visual-object and visual-spatial mental imagery. These results may be contrasted with the results of a more comprehensive assessment of concreteness of the SDRT-RC. The comparison may provide insight into the relationship between visual-object imagery and visual-spatial mental imagery with reading comprehension since the role of visual-spatial mental imagery in decontextualized sentence based items is likely to be very different from the role of visual-spatial mental imagery at discourse level reading comprehension.

Conclusion and Recommendations

A large number of learners in South African have underdeveloped literacy skills. Poor literacy skills have a detrimental effect on learners' academic performance from primary to tertiary level education and have been identified as a contributing factor to matriculant unemployment. A number of South Africa research studies have indicated that a large disparity exists between the reading skills of EFL and ESL learners. ESL learners' reading comprehension skills are often very under developed. Reading comprehension skills in learners is further compromised by inadequate English vocabulary among many ESL learners.

Many schools in South Africa have limited access to adequate resources and many teachers often do not have the tools or skills needed to institute successful literacy based interventions. There is an extensive source of information that is easily accessible to learners but is often underused in the educational context; this source is learners' non-verbal prior knowledge. Visual mental imagery plays a pivotal role in the construction of mental models that facilitate reading comprehension. Strategies which support reading comprehension are often based on the use of visual mental imagery. These strategies can be tailored to suit the needs of multilingual learners of all ages and levels of reading proficiency. Visual mental imagery reading comprehension support strategies have been found to be effective in the South African context. In addition, even simple instruction to construct visual metal imagery during reading can have positive effects for learners reading comprehension ability. Thus the use of visual mental imagery as part of reading comprehension support strategies is a practical option for teachers in South Africa.

Certain core principles in visual mental imagery theory must be taken into account prior to the use of visual mental imagery interventions. Visual mental imagery can be differentiated into visual-object and visual-spatial mental imagery. The characteristics of

these two types of visual mental imagery have different consequences for the effectiveness of visual mental imagery interventions. Visual-object mental imagery can be used to support vocabulary development and translation; however, excessive visualization of visual-object mental imagery and the visualization of irrelevant visual-object mental imagery can severely impede reading comprehension by causing visual impedance effects. These effects occur when limited cognitive resources are diverted to the processing of irrelevant information and as a result there are not sufficient cognitive resources to maintain the mental model simultaneously. If the model is not properly reinstated and the irrelevant information identified and rejected, this may lead to intrusion errors whereby erroneous or irrelevant information is incorporated into the mental model. The number of intrusion errors was found to be a key differentiating factor between poor and good comprehension since, if the intrusions are not rectified efficiently the comprehension process is unlikely to be successful. Thus coherent mental models can be used to reinstate reading comprehension processes with minimal or no damage to the models coherence and relevance.

Visual-spatial mental imagery best supports reading comprehension through (a) the facilitation of the integration of textual information, (b) the maintenance of coherence of the mental model, and (c) supporting certain kinds of inference made through the construction as well as simulation of situation based mental models. In addition, visual-spatial mental imagery contains a vast amount of information about the relationships between objects in dynamic and complex situations and this feature may serve to constrain visual-object mental imagery triggered by text thereby preventing visual impedance effects.

Visual-spatial mental imagery is unlikely to produce visual impedance effects such as visual-object mental imagery and thus is less likely to drain cognitive resources unnecessarily. Maintaining and updating spatial mental representations occurs naturally during reading but it increase the load on cognitive resources and it is interrupted if there are insufficient cognitive

resources available which may cause difficulty for developing readers, however, this research indicates that developing readers reading comprehension ability is related to the 3DS (3D Spatial Manipulation) ability. In addition, once learners have reached a particular level of proficiency in reading comprehension ability, it is their 3DS ability that can serve to differentiate their performance from their peers with high VR (Verbal Reasoning) ability. It is important to remember that the level of VR proficiency reached by the learners is relative to their grade and that the ceiling of VR proficiency is likely to be higher in subsequent grades and in formal tertiary education. Thus it is important to acknowledge the role of 3DS ability in reading comprehension, not as a skill possessed by proficient readers but as a milestone of reading comprehension proficiency in a learner's long term academic development and thus should be gradually introduced in the context of a reading skill some time before VR proficiency is achieved to support the control of irrelevant visual object mental imagery and to prepare the learners for their future education.

The evaluation and development of visual mental imagery reading support strategies that have been created to meet the needs of learners in the South African context is far from complete, and presents an opportunity for further study, particularly in the area of the development of psychometric assessments which are more sensitive to the effects of visual-object and visual-spatial concrete text on reading comprehension ability.

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Appendices

Appendix A- Biographic Information, Reading Activity and English Exposure Questionnaire

Date: _____

Name: _____

Gender: _____

Class: _____

Home Language:_____

1) What other languages can you speak and read in?

_____

2) How often do you speak English with your:

friends	almost always	often	sometimes	rarely	almost never
family	almost always	often	sometimes	rarely	almost never
educators	almost always	often	sometimes	rarely	almost never
people in your community	almost always	often	sometimes	rarely	almost never
strangers	almost always	often	sometimes	rarely	almost never

3) How many hours of English Television do you watch a day?

none	1 hour	2 hours	3 hours	4 hours +

4) How many hours of English radio or music do you listen to in a day?

none	1 hour	2 hours	3 hours	4 hours +

5) How many hours of English reading do you do in a day? (This includes text books, news papers, magazines etc)

none	1 hour	2 hours	3 hours	4 hours +

6) How many hours of *Non*-English reading do you a day? (This includes text books, news papers, magazines etc)

none	1 hour	2 hours	3 hours	4 hours +

7) How many books do you have at home?

less than 5	5-10	10-15	15-20	20 or more

8) How many newspapers and magazines do you have at home?

less than 5	5-10	10-15	15-20	20 or more

9) Why do you read? (you can tick more than one)

To do homework for school	
To learn more about something that interests me	
To learn how to fix or make something	
To relax or for fun	
Because I have to	
Because I have nothing else to do	
Because I enjoy reading	

10) How good are you at reading do you read?

Reading is very easy	Reading is easy	Reading is difficult for me	Reading is very difficult for me

11) How do you feel about reading?

I LOVE reading	I LIKE reading	I DISLIKE reading	I HATE reading

12) What career do you wish to pursue in the future?

_____

13) Explain in a short paragraph why reading is or is not important in this career.

_____

_____

Appendix B- Letter of Information for Learners

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

School of Human and Community Development
Private Bag 3, Wits 2050,
Johannesburg,
South Africa
Tel: (011) 717-4500
Fax: (011) 717-4559
Email: 018lucy@muse.wits.ac.za

Dear Learner,

My name is Aleksandra Wasiak and I am conducting research for the purposes of obtaining a Masters Degree at the University of the Witwatersrand. My research focuses on the English reading comprehension abilities of First and Second language learners who are being educated in English. Reading comprehension is the student's ability to understand what they read.

South Africa has twelve official languages. However, the majority of schooling is taught in English, even though this is often not the learner's home language. The impact of learning in a language that is not the learner's home language is not well understood in the South African context. However, research indicates that learners may be at risk of underachievement due to poorly developed reading comprehension abilities.

The Principle and the University of the Witwatersrand research ethics committee have given permission for this research to be conducted at the Secondary School. I would like to invite you/ your child to participate in this study.

Participation in the research will require you to complete a reading comprehension test, non-verbal reasoning test, a spatial visualization test and an Imagery Test, which will be administered during school time by myself at the School. In addition to these tests, you will be asked to complete a short biographical, reading interest and English exposure questionnaire giving details of your language experiences and exposure to the English language. In total, these tests will take about 3 hours to complete. One of the classes will be randomly chosen to undergo a short intervention. In this intervention, reading comprehension skills will be discussed and practised with the class. This intervention will take approximately 80 minutes. For the following six weeks I will visit the class once a week during the English or life orientation lesson and revise the intervention steps with the class.

Participation is **voluntary** and no learner will be advantaged or disadvantaged in any way for choosing to participate or not to participate in this study.You will be asked to fill in your name on the workbooks which contain the tests and the questionnaires so that their different results will be kept together. However ALL responses will be kept **confidential** and no information that could identify you will be discussed with any other people nor will they be included in the research report. The results of individual learners' performance on the reading tests will not be available to you or to the school. However, a general report of the results as

a whole will be made available to the educators and to the students if requested. This will contain the full Intervention and its application will be discussed.

If you choose to participate in this study, please complete the attached consent form. The consent form should be returned to the Class educator at the school as soon as possible. The first 30 returned consent forms from each grade will be asked to participate in this study. If you have any further queries about this research please contact my supervisor, Dr Yvonne Broom at xxx-xxx-xxxx or myself at xxx-xxx-xxxx.

Your participation in this study would be greatly appreciated. This research will contribute to a larger body of knowledge of English reading comprehension abilities of learners in South African schools. This will inform and help us develop appropriate educational practices in our schools.

Kind Regards

Aleksandra Wasiak.

Appendix C - Consent Form

I_____, understand that this is a consent form that will allow my Test results and , my Grade 10 mid year results and my biographical information used in a study conducted by Aleksandra Wasiak, a master's student in the Department of Psychology at the University of the Witwatersrand. The study is an exploration into issues that First and Second Language learners experience at secondary school. The aim of the research is gain insight into the student's reading comprehension ability and processes.

All information gathered in this study will be treated with the strictest confidentiality.

I _____, hereby give assent for all of my test results and my biographical information to be used in the above mentioned study. I understand that if I choose not to sign this form I will not be penalized in any way.

Name of Learner: _____

Date: _____

Address: _____

Signature: _____

Appendix D – Ethical Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (SCHOOL OF HUMAN & COMMUNITY DEVELOPMENT

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: MRES/09/001 IH**
PROJECT TITLE:	Does developing and focusing mental imagery improve reading comprehension of Secondary School Learners?
INVESTIGATORS	Aleksandra Wasiak
DEPARTMENT	Psychology
DATE CONSIDERED	24/03/09
DECISION OF COMMITTEE*	Approved

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

DATE: 25 March 2009

CHAIRPERSON
(Professor K. Cockcroft)

cc Supervisor:

Dr Yvonne Broom
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 2010

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES