MEASURING GROUP DIFFERENCES USING A MODEL OF *TEST ANXIETY*, *FLUID INTELLIGENCE* AND *ATTENTIONAL RESOURCES*.

by

ANELLE BOSCH

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SUPERVISOR: DR HC JANEKE

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I declare that ***Measuring group differences using a model of test anxiety, fluid intelligence and attentional resources***. is my own work and that all the sources that I have used or quoted have been
indicated and acknowledged by means of complete references.

Sign: _____

Date: _____

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First and most importantly, sincere thanks to my Saviour Jesus Christ, without His strength I am capable of nothing.

To my parents, thank you for your never-ending encouragement, love and support.

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Dedication

To Marietjie, Rudy and Frans: you are the wind beneath my wings.

"For I know the plans I have for you," declares the LORD, "plans to prosper you and not to harm you, plans to give you hope and a future."

- *Jeremiah 29:11* -

Abstract

Literature reports that *test anxiety* may have an influence on aptitude test performance for some racial groups and therefore serves as a source of bias (Zeidner, 1998). Testing organisations have also found that individuals from African groups perform poorly on measures of *fluid intelligence*, putting them at a disadvantage when these scores are used for selection and training purposes. The current study examines a model defining the relationship between *test anxiety*, *attentional resources* and *fluid intelligence* in the following manner: an increase in *test anxiety* will result in a decrease of *attentional resources* as well as a decrease in *fluid intelligence*. With a decrease in *attentional resources* we will see a negative influence on *fluid intelligence* and test performance for different racial groups.

Twenty-five African individuals and twenty-five individuals from Caucasian racial groups have set the stage to answer the question if certain groups experience higher *test anxiety* and thus perform poorly on *fluid intelligence* measures. Significant relationships were found, within and between groups, for *attentional resources* and *fluid intelligence*. Meanwhile, other factors, such as *test anxiety*, were not strongly associated with *fluid intelligence* performance. Future research into reasons why certain racial groups display lower overall attention in testing situations is suggested in order to ensure that tests for selection and training and aptitude tests are fair to all racial groups.

CHAPTER 1: INTRODUCTION

Today's competitive marketplace demands innovative individuals who can continuously acquire new skills, conquer new technologies and who can be flexible in applying new strategies. Individuals, however, differ from one another in their ability to adapt effectively to the work environment and to achieve success in their careers (Willner, 1999). A way of predicting future success of an individual in the corporate sector is usually done by measuring intellectual ability. The purpose of such a test would be to gather information regarding an individual's intellectual functioning, on which selection and training can be based. The higher the score on such a measure, the better the individual is likely to be at performing mental tasks accurately and quickly. The scores obtained on these types of tests are usually a measure of *fluid intelligence*.

When measuring possible work success, a heavy load is placed upon an individual's cognitive ability, especially *fluid intelligence* ability. *Fluid intelligence* can be seen as the mechanics of cognition and is involved in basic processing of information (Kay, 2005). It can be used to predict important life outcomes such as academic performance and social status (Higgins, Pihl, Peterson & Lee, 2007). Apart from that, fluid and simultaneously executive processes deal with higher-level functioning concerning abstract action and goal selection under conditions of novelty, making *fluid intelligence* appropriate to the corporate context.

Crystallised abilities are set aside when it comes to measuring individuals for performance in the business world. The reason for this is the fact that crystallised abilities are generally developed by schooling, based on memories and learning which have been acquired; it is also closely aligned with advanced education and life experiences (Sternberg & Grigorenko, 2002). To avoid erroneous decisions based on concepts varying among individuals, *fluid intelligence* ability is a better performance predictor. *Fluid*

intelligence ability can be defined as a general ability to acquire and reason with information (Sternberg & Grigorenko, 2002).

One would think that measures of *fluid intelligence* give an accurate account of a person's future and current functioning. This however cannot be considered as the truth. Testing of *fluid intelligence* has proved to be problematic as research indicates that factors such as attention and anxiety may influence these scores. The impact of stress on higher-order cognitive functions is of prime practical and clinical importance in this context (Kaufman, 2006). Attention is an executive process within a limited capacity system (Sternberg, 2000). Evidence exists of a relationship between resistance to interference (attention) and *fluid intelligence* scores.

Attention therefore is a predictor of higher-order cognitive task performance (gf)[1] (Konig, Buhner & Murling, 2005). Anxiety on the other hand reduces task performance and efficiency. It absorbs some of the limited capacity of processing and intentional resources of the working memory, of which *fluid intelligence* forms a part (Zeidner, 1998).

A commonly held contention states that *test anxiety* may have an influence on aptitude test performance of some racial groups and therefore serves as a source of bias (Zeidner, 1998). There is an important need for equivalence in measures. This is achieved when a measure assesses the same underlying concept in two separate groups of individuals (Bernal, Trimble, Burlew & Leong, 2003). This is especially the case in South Africa with its cultural diversity. Various language groups complicate the matter of measurement even further, with differences observed between these groups. English-speaking South Africans were more closely related to international (western) norms than was the case for African language speakers. For example Tests for Selection and Training (TST), an independently validated battery of

[1] gf denotes the fluid component of general intelligence

normative ability tests, show very poor[2] performance on certain subtests (measuring *fluid intelligence*) by members belonging to African language groups. Any biases in the use of such a measure must therefore be eliminated to avoid detraction from the goal of gathering accurate information on racial groups (Bernal, Trimble, Burlew & Leong, 2003). However, Tests of Selection and Training (TST) are constructed in such a way as to minimise the effects of educational disadvantages associated with achievement, test performance and racial group status.

If observed differences between racial groups cannot be attributed to un-equivalence in tests, explanations could lie with individual differences between groups. Psychology in an African context, unlike univocal[3] science, accepts differences between races resulting from different influences such as social oppression or cultural heritage. By adopting the belief that racial differences do play a role in assessment, the proposed research will avoid cultural[4] malpractice and by so doing investigate what these differences are and to what extent they influence scores obtained. Therefore, the aim of the research is to explore whether or not race moderates the relationship between attention, anxiety and *fluid intelligence*.

1.1 The mechanics and model: attentional resources and fluid intelligence

Working memory capacity tasks are related to general *fluid intelligence* and executive attention (Engle, 2002). Individual differences in working memory capacity are also related to those in attentional control (Unsworth & Engle, 2005). Although working memory and *fluid intelligence* are not isomorphic constructs, working memory is a crucial determinant of performance on tests of *fluid intelligence* (Fry & Hale, 1996). Reasoning tasks, ascribed to *fluid intelligence*, place demands on the management of *attentional resources* in

[2] Performance below the 10th and 15th percentile
[3] European American Psychological concepts and methods, seen as universal, denying racial and ethnic differences in psychology.
[4] Tendency to formulate theories and applications of Psychology based on European and American studies.

working memory (Wesley, 2006). Thus people with high susceptibility to interference have a lower working memory capacity. Zeaman and House (1963) also conducted research that found a correlation between individual differences in intelligence and attention (Sternberg, 2000).

Shifting attention to anxiety, research found that choking[5] under pressure was not confined to tasks involving acquired skills and knowledge. It encompassed those tasks that call for fluid reasoning abilities (Grimmig, Huguet, Caverni & Cury, 2006). Logically, if the system gives precedence to the demands of anxiety avoidance, more effort and spare capacity is allocated to the solution of the anxiety problem at the expense of solving the primary cognitive task at hand (Zeidner, 1998). *Test anxiety* (worry) influences filtering, perceiving, interpreting and attending to new information. Given the fact that affect has a selective influence on each stage of information processing, it also modulates the availability of *attentional resources* (Kramer, Wiegmann & Kirlik, 2007). Through previous research such as a study done by Meijer (2001), it has been proved that *test anxiety* does influence *attentional resources* and *fluid intelligence*. Hembree (1988) also made the discovery that there is an association between high-*test anxiety* and IQ test performance. This can be explained partly by the fact that the main effects of worry are on the central executive and thus impair central executive processing (Eysenck, Santos, Derakshan & Calvo, 2007). Based on existing theory and findings, a model depicting the interrelationships among these constructs can be formulated. This model assists in the aim of the research and in answering the problem statement: is there a relationship between *test anxiety*, *attentional resources* and poor test performance in certain racial groups?

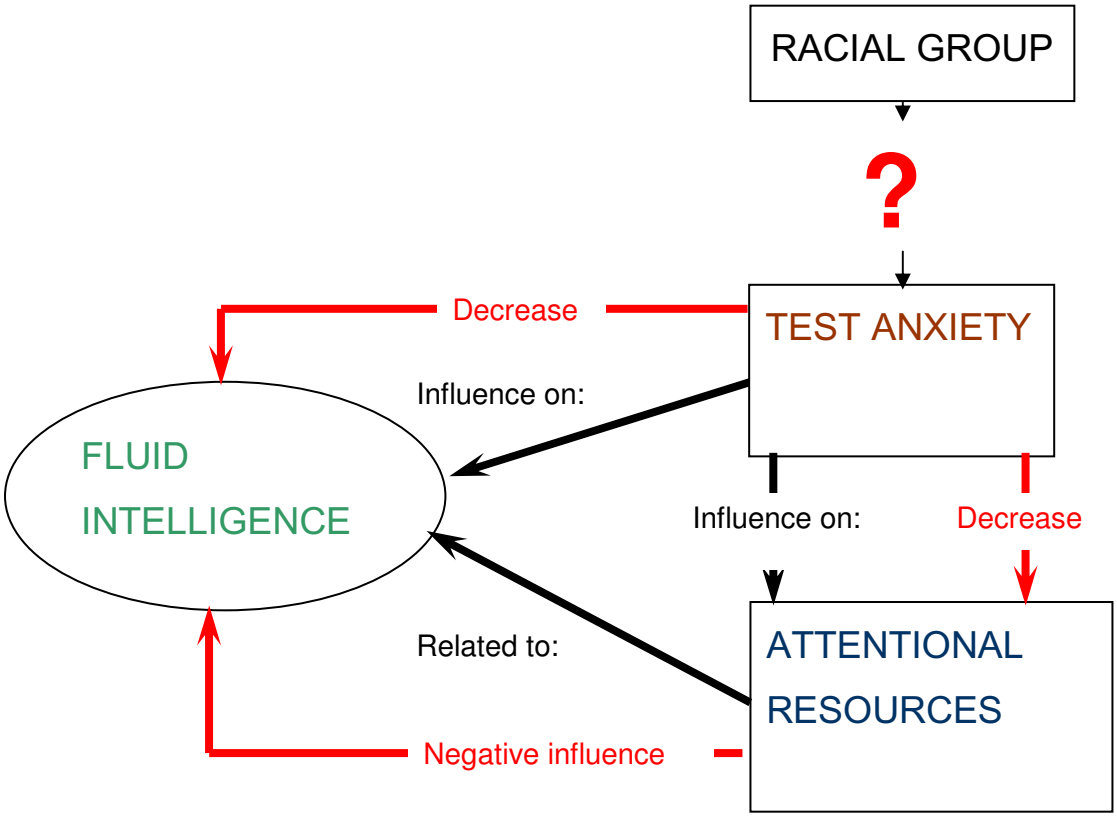
The model forming the base for the problem statement includes *fluid intelligence*, *attentional resources* and *test anxiety*. *Test anxiety* is proved through previous research, done by Meijer (2001), to have an influence on *fluid intelligence* and *attentional resources*. *Attentional resources* also form an

[5] An effective state caused by test anxiety

integral part of performance on *fluid intelligence* measures. Thus, the model defines the relationship in the following manner: an increase in *test anxiety* will result in a decrease of *attentional resources* as well as a decrease in *fluid intelligence* (as proved by Meijer, 2001). With a decrease in *attentional resources* we will see a negative influence on *fluid intelligence* and test performance. The model links up with Sternberg's theory by showing an interaction between the three constructs *(fluid intelligence, attentional resources and test anxiety)* and their connection to the three components (meta-components, performance components and knowledge acquisition components).

Fluid intelligence and *attentional resources* can be linked to meta-components, while *test anxiety* will influence performance components. The following is a graphical presentation of the aforementioned model:

Figure 1.1 The model of attentional resources, test anxiety and fluid intelligence:



1.2 Research objectives

The aim of the research dissertation is to confirm the model. In order to do this the following objectives can be stated:

1.2.1 To establish if a relationship exists between *test anxiety* levels, *attentional resources* in individuals and *fluid intelligence* measurement scores.

In an attempt to answer the above-stated research objective, the researcher will conduct measurements of *test anxiety*, *attentional resources* as well as *fluid intelligence* measures. This will enable one to explore the relationship between *test anxiety* and *fluid intelligence* scores.

Thus meaning, if an increase in *test anxiety* exerts an influence on *attentional resources*, it will result in lower scores on *fluid intelligence* measures.

1.2.2 To investigate if differences exist between individuals belonging to different racial groups in terms of *test anxiety* levels.

A model depicting the inter-relationships among test anxiety, *attentional resources* and *fluid intelligence* will be utilised in order to explore if differences in levels of *test anxiety* do exist for different racial groups. This will give insight onto how levels of *test anxiety* vary for different groups and the impact of this on scores obtained from *fluid intelligence* measurements.

In light of the above, the aim of this work is to investigate if African groups experience higher levels of *test anxiety* than their Caucasian counterparts. This will then explain low scores on subtests of the TST test measuring *fluid intelligence*. The research focus is exclusively looking into Tests for Selection and Training, the reason being that the subtests included in the TST have shown to measure aspects of *fluid intelligence* such as perceptual speed, reasoning and working memory. Group differences have been found to exist on these measures, establishing the need for an investigation.

Research has found differences in performance related to test anxiety by comparing middle-class racial majority with lower-class racial minority groups (Zeidner, 1998). However, few studies have examined the effects of *test anxiety* on test performance by comparing different racial groups[6] with the same educational level and social status. According to Zeidner (1998), empirical findings bearing upon racial group differences in test anxiety amongst adolescents (Zeidner, 1998) and college populations (Jensen 1980) are neither consistent nor sufficiently well established; this identifies a gap for investigation.

[6] Race entails difference in culture and being from African or Caucasian descent

1.3 The model of intelligence scores

In an attempt to answer the above-stated research question, the researcher will make use of two groups of participants. Group A will consist only of African respondents while group B will comprise only Caucasian respondents, all participants being South African citizens. To establish the functionality of the previously mentioned model, it will be applied to both groups to investigate differences in scores on *test anxiety*, *attentional resources* and *fluid intelligence* measures and to test whether inter-correlations between the constructs are as predicted by the model.

1.4 Delineations and limitations

This research study will not deal with investigations into how language influences test scores. Respondents participating in the research were selected, controlling for language. All respondents are fluent in English; this was controlled by an English proficiency test. Research results will only be generalisible to the South African context. Previous research done on attention and aptitude tests with Israeli (Zeidner, 1998) and US participants showed conflicting results. Israeli's showed no differences in *test anxiety* while US individuals compared to African American respondents showed significant differences in *test anxiety* measures. The reason for this was contributed to possible cultural and political differences between the two countries. It is of utmost importance to investigate this issue within the South African context.

1.5 Definition of terms and concepts

The following definitions provide a guide to better understand the concepts used throughout the study. This will also aid in understanding human intelligence and the proposed model:

1. Fluid intelligence

When giving a definition of *fluid intelligence* it is essential to start with the origin, namely intelligence[7]. Research done from the Information Processing paradigm yielded explanations which differentiate between two types of intelligence namely *fluid intelligence (gf)* and crystallised intelligence (gc) within working memory (Dennis & Tapsfield, 1996). *Fluid intelligence* is seen as a basic capacity to adapt to new situations.

Fluid intelligence is an inherent capacity for learning and problem solving that is independent of education and cultural influences (Samuda, Feuerstein & Kaufman, 1998). Crystallised intelligence emerges from a person's use of *fluid intelligence* to interact with society and is a product of formal education. The research focuses on *fluid intelligence* because of its close relationship with Spearman's general ability factor (intelligence) (Wesley, 2006).

Previous research as well as literature however indicates that intelligence, more specifically *fluid intelligence*, is such a complex factor that one cannot be certain that intelligence does indeed provide a valid measure of intelligence. The notion of fluid abilities as some basic genetic potential one brings into the world, which development is expressed in crystallised abilities, does not ring true. *Fluid intelligence* abilities are likely to be more susceptible to environmental influences than other abilities (Sternberg & Grigorenko, 2002). Such influences could for instance be cultural[8] tools internalised as psychological tools or intellectual stimulation (Richardson, 2002).

It is important to bear in mind that *fluid intelligence* does not exist on its own**.** It is a component within the system of working memory. The two components (working memory and *fluid intelligence*) share similarities to such an extent that previously they were construed to be identical structures. Measurements of working memory capacity will yield results based on *fluid intelligence*, but

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[7] The ability to meet and adapt to novel situations quickly and effectively (Chaplin, 1968)
[8] Intellectual skills acquired by living in a certain culture.

these results should be viewed with caution. According to Konig, Buhner and Murling (2005), constructs of working memory also capture abilities that are not part of *fluid intelligence*. Therefore working memory and *fluid intelligence*, although similar, cannot be seen as identical structures. Research by Borella, Carreti and Mammarella (2006) has shown that the point of conjunction between working memory and complex cognitive processes and fluid abilities is the management of *attentional resources*. This was proven by the observation that the biggest individual differences in *fluid intelligence* emerged exclusively in working memory trials where interference was introduced, because *fluid intelligence* is related to attentional control. *Attentional resources* are therefore strongly associated with *fluid intelligence*.

2. Attentional resources

Attention as described by Naglieri and Das (1997) is a mental process by which the individual selectively focuses on particular stimuli presented over time.

Attentional resources are therefore the ability to shut out other activities or information so that more mental resources can be invested in the object at hand. Successful performance on attention tasks requires the effort applied to be focused, selective and sustained (Sternberg, 2000).

Under focused attention it is understood that it involves directed concentration towards a particular activity. Selective attention requires the inhibition of responses to some stimuli over others, which may be hard to ignore. Lastly, sustained attention refers to performance over time, which is susceptible to influences that vary in the amounts of effort required for a task (Sternberg, 2000). *Attentional resources* are a component within the working memory system. It exerts an influence over reasoning ability and can therefore be linked to *fluid intelligence*. Zeaman and House (1963) found that individual differences in intelligence were related to attention while Sternberg (2000) has hypothesised that working memory (executive processes) is an essential feature of intelligence in support of the above-mentioned relationship between

attention and intelligence. All three above-mentioned concepts (attention, *fluid intelligence* and executive processes) are incorporated into a central system called working memory.

This is the unit that directs the temporary storage of incoming information in any range of tasks (Zillmer & Spiers, 2001).

3. Test anxiety

"We live in a test-conscious, test-giving culture in which the lives of people are in part determined by their test performance" (Sarason, 1959).

Tests and evaluative situations emerge as a class of potent anxiety-evoking stimuli in our society, which determines many important decisions relating to an individual's status at work and their future based on tests and other assessment devices (Zeidner, 1998). By looking at the ways in which tests determine the lives of individuals, it is evident that testing situations can evoke anxiety. Liebert and Morris (1967) made a theoretical distinction between two distinguishable components of *test anxiety*. These components are the cognitive component and the emotional component.

The cognitive component is synonymous to worry. Worry is a cognitive concern about one's performance and it entails thinking about the consequences of failure. Autonomic or physiological reactions that occur in the test situation are the effects of the emotional component.

Research has shown worry scores to be consistent with negative relationships to performance expectations, as well as to actual performance on cognitive tasks (Krohne & Laux, 1982).
No relationship, however, was observed between emotionality scores and the subjects' performance.

The *cognitive component's* contribution to poor performance can be explained by cognitive interference. Interference is caused by thoughts that intrude during tests with no functional value in solving the cognitive task at hand. Test-anxious subjects tend to spend 60% of their available time on the task and 40% on non-task cognitive activities (Zeidner, 1998). It is important to consider situational factors and individual differences playing a role in test anxiety. Individuals may also be distracted by task-generated thoughts such as the time left to complete the exam or test and the inability to leave unsolved problems. These individual differences explain why low- and high-anxious individuals can have comparable performance effectiveness[9] but differ greatly in efficiency[10] inferred from differences in response time (Eyensenc, Santos, Derakshan & Calvo, 2007).

Thus *test anxiety* can be defined as referring to the set of phenomenological, physiological and behavioural responses that accompany the concern about possible negative consequences or failure in an exam or similar evaluative situation, according to Zeidner (1998). Test-anxious individuals can be seen to be easily distracted, experience difficulty in comprehending relatively simple instructions, and they also find it hard to organise and recall relevant information during the test procedure (Zeidner, 1998). The issue of *test anxiety* can lead to jeopardised assessment validity when looking at the cognitive domain. It also constitutes a major source of "test bias" as concluded by Zeidner (1998).

1.6 Assumptions

An assumption made in the research is that all respondents have similar levels of education, meaning that all individuals have completed high school and are in the process of, or have already obtained, an additional qualification. These individuals are representative of individuals who are usually tested for inclusion into high-level positions within organisations.

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[9] Accuracy and number of correct completed items.
[10] The speed of correct completed items.

1.7 Significance

The research provides theoretical significance by investigating differences between races in the South African context. It tries to explain the influence of *test anxiety* and *attentional resources* on the measurement of *fluid intelligence*, and how these factors must be taken into consideration when testing individuals. This may have an influence on future psychometric test development.

The practical significance of the research may be to indicate ways in which the TST (Tests for Selection and Training) and similar measures can be adapted to be a more valid measurement for all racial groups.

1.8 Chapter overviews

The following will provide an indication of the topics to be discussed in each of the following chapters:

The dissertation commences with the literature review defining concepts and discussing theories. Thereafter the methods used for data collection are discussed including the research design, objectives, sampling as well as data collection methods and ethical aspects. The results chapter follows, explaining the data profile and statistical methods used to obtain the results that are also discussed.

The discussion provides a summary of the findings with regards to theory and how this contributes to knowledge. Directions for further research are also given. The study ends with the conclusion.

CHAPTER 2: LITERATURE REVIEW

This chapter explains how individual differences pertaining to *test anxiety (trait anxiety)* and *attentional resources* can contribute to poor performance on some measures of *fluid intelligence (gf)* by establishing a goodness of fit between different racial groups and a model depicting the interrelationships between performance on *fluid intelligence* tasks, *test anxiety* and *attentional resources*. The model as well as the validating theory is discussed in the following sections.

2.1 Defining working memory and working memory capacity

"Working memory involves the simultaneous storage and manipulation of material" (Baddeley & Hitch, 1974).

According to Baddeley (1974), *working memory* consists of three parts namely the *phonological loop, visual-spatial sketchpad* and the *central executive*. The executive component is the most important component in terms of its general impact on cognition through coordinating information presented in the subsystems: the *phonological loop* using language and the *visuo-spatial sketchpad* using imagery. The important role of the *central executive* is also to act as an attentional controller, selecting certain streams of incoming information and rejecting others (Hitch & Lagie, 1996). Another theory named the *multi-component working memory model* was also postulated by Baddeley (1974) in which he introduces a fourth component to the model namely the *episodic buffer* as a general integrated storage system.

Fluid intelligence measures reflect the operation of a *central cognitive processor*, which could be identified as the *central executive* of *working memory* (Hitch & Lagie, 1996).

Duncan (1993) supported this view through findings indicating that performance on intelligence tests is an index of *executive function* and depends upon the operation of the frontal lobes; frontal lobe damage is

connected to disturbances in *executive functioning* (disturbed attention, increased distractibility, difficulty in grasping the whole of the complicated state of affairs). Working memory can be referred to as a limited capacity (as explained by limited attention) temporary storage system that underpins complex human thought through its functional role, comprising multiple components such as the *central executive* (Baddeley, 1974). Working memory resources are also essential in explaining individual differences in higher cognitive functions (Ackerman, Kyllonen & Roberts, 2002).

A fundamental characteristic of *working memory* is that it has a limited capacity which constraints cognitive performance in such a way that individuals with greater capacity typically perform better than individuals with lesser capacity on a range of cognitive tasks. These tasks include complex learning, reading and listening, comprehension and reasoning (Conway et al, 2007). By definition, *working memory capacity* is one of the general features of the cognitive architecture that could function as a limiting factor for a wide range of abilities, foremost of which is *reasoning* (Herrmann, Yoder, Gruneberg & Payne, 2006). Several researchers have found strong relationships between *working memory capacity* and *reasoning* (Fry & Hale, 1996). Working memory capacity, as discussed, reflects a general *executive capacity*; it is considered an important aspect of intelligence. However, there is also an overlap between the two concepts (Conway et al, 2007) because working memory is closely related to the *central executive function* (Ackerman, Beier & Boyle, 2005). Working memory capacity predicts performance on a wide range of cognitive tasks, including measures of general intelligence and practical cognitive skills (Daneman & Carpenter, 1980).

Working memory capacity and the variance that exists within this capacity is important to everyday cognitive performance (Conway et al, 2007).

2.2 Defining test anxiety

> *"We live in a test-conscious, test-giving culture in which the lives of people are in part determined by their test performance" (Sarason, 1959).*

Tests and evaluative situations emerge as a class of potent anxiety-evoking stimuli in our society, which determines many important decisions relating to an individual's status at work as well as their future, determined by tests and other assessment devices (Zeidner, 1998). By looking at the ways in which psychometric tests determine the lives of individuals, it is evident that testing situations can evoke anxiety. In all achievement domains, the ability to identify, attend to, and process task relevant cues is the key to optimal performance. Factors, such as anxiety, which interferes with concentration will almost invariably result in a performance decline. Michael Eysenck's *processing efficiency theory* explains the mechanism whereby emotion interferes with cognition. This theory assumes a limited capacity *working memory system* which, under conditions of threat, becomes preoccupied with irrelevant thoughts, leaving less capacity for processing and executing actions (Baddeley, 2007). Interference is caused by intruding thoughts with no functional value in solving the cognitive task at hand. It has been found that test-anxious individuals (individuals with high-trait anxiety levels) tend to spend 60% of their available time on the task and 40% on non-task related cognitive activities (Zeidner, 1998). It is important to consider aspects such as situational factors and individual differences in test anxiety. Distractions can also be caused by task-generated thoughts such as the time left to complete the exam or test and the inability to leave unsolved problems. More irrelevant thoughts in testing situations include cognitive appraisals of the situation as threatening and seeing oneself as incapable of coping successfully within the situation (Blankstein, Toner & Flett, 1989a). These thoughts as well as cognitions concerning the terrible consequences that might follow and the negative personal implications of failure all demand attention (Blankstein, Toner & Flett, 1989b). Eysenck (1992) states that task efficiency may be maintained during these conditions provided more effort is invested.

This explains why low- and high-anxious individuals (high or low on trait anxiety) can have comparable performance effectiveness but differ greatly in efficiency (Eysenck, Santos, Derakshan & Calvo, 2007). Highly anxious individuals (high-trait anxiety) are likely to be more challenged by distraction from potential threats and show more cognitive deficits under stress referred to as Eysenck's (1992) *worry hypothesis*.

Liebert and Morris (1967) made a theoretical distinction between two distinguishable components of *test anxiety*. These components are the *cognitive component* and the *emotional component*. The *cognitive component* is a synonym for worry. Worry is a cognitive concern about one's performance and it entails thinking about the consequences of failure. Autonomic or physiological reactions that occur in the test situation are the effects of the *emotional component*. Research has shown worry scores to be consistent with negative relationships to performance expectations, as well as with actual performance on cognitive tasks (Krohne & Laux, 1982). No relationship, however, was observed between individuals' emotionality scores and their performance. The cognitive component's contribution to poor performance can be explained by earlier mentioned cognitive interference.

In accordance to Eysenck's *processing efficiency theory*, Williams (1988), Mogg and Bradley (1998) also support the view that *working memory* is disrupted by anxiety-provoking stimuli. Williams (1988) gives an account of the relationship between emotion and cognition in order to explain test anxiety, by describing the existence of a pre-conscious detection system followed by an evaluation system. Depending on the degree of threat signalled by the evaluation system, the stimulus is either paid attention to or inhibited. Individual differences occur in the evaluation process where people high on trait anxiety tend to focus on the potential threat, while those low on this trait ignore the threat (Baddeley, 2007). Mogg and Bradley (1998) modified the Williams model with their *cognitive-motivational hypothesis*. According to the hypothesis, stimuli have both a valence, positive or negative and motivational component.

Anxiety is assumed to be motivationally aversive, leading to a heightened level of attention, a rapid response to threat and increased automatic activation. Anxious individuals will tend to have a lower threshold beyond which a potential threat will attract attention (Baddeley, 2007). All of the above mentioned findings fit into a multi-component model of *working memory* which explains the influence of *test anxiety* on cognitive task performance.

Thus *test anxiety* can be defined as referring to the set of phenomenological, physiological and behavioural responses that accompany concern about possible negative consequences or failure in an exam or similar evaluative situation, according to Zeidner (1998). Test-anxious individuals can be seen to be easily distracted, experience difficulty in comprehending relatively simple instructions, while they find it hard to organise and recall relevant information during the test procedure (Zeidner, 1998). The issue of *test anxiety* may jeopardise the assessment of cognitive functions due to test-takers performing sub-optimally when they experience high levels of *test anxiety*.

2.3 Defining *attentional resources*

"Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which is called distraction" (Benjafield, 2007).

Attention as described by Naglieri and Das (1997) is a mental process by which the individual selectively focuses on particular stimuli presented over time. *Attentional resources* are therefore the ability to shut out other activities or information so that more mental resources can be invested in the object at hand. Successful performance on attention tasks requires the effort applied to be focused, selective and sustained (Sternberg, 2000).

It is generally assumed that focused attention involves directed concentration on a particular activity (LaBerge, 1995). Focussing attention depends on our ability to be sufficiently aroused to attend to certain stimuli while blocking out others (LaBerge, 1995). The number of items that can be attended to at one time is referred to as the *span of attention* (Herrmann et al, 2006). The likelihood that information in *working memory* will be encoded and will be available for retrieval from stored memory depends on how carefully we attend to the information that is being processed. In order to encode information, *selective attention* is needed for the inhibition of responses to some stimuli over others, which may be hard to ignore. *Sustained attention* refers to performance over time, which is susceptible to influences that vary with the amounts of effort required for a task (Sternberg, 2000). Attention is crucial to successful reasoning, problem solving and decision making (Herrmann et al, 2006). Measures of *attentional resources* also give the best account of individual differences in general mental ability, such as individual differences in the ability to understand concepts, plan one's actions, solve problems and perform other important cognitive functions (Ackerman, Kyllonen & Roberts, 2002).

With the world confronting us with an amazing amount of information, attentional mechanisms must filter and limit the information that reaches higher levels of thought (Holyoak & Thagard, 1994). The limitation and filtering of information is necessary due to the limited amount of attention available to us (Kahneman, 1973); attending to one event takes away from the capacity to attend to something else (Broadbent, 1958). Studies investigating the attentional bases of intelligence (Necka et.al., 1996) supported the *limited-resource theory of attention* proposed by Kahneman (1973), and further elaborated on others (Hunt & Landsman, 1982). 'Paying attention' comes at the cost of consuming mental ability. This limitation in capacity can be ascribed to *attentional resources* being a component within the limited capacity *working memory system*. Within the *three component working memory system,* attentional control forms part of the *central executive*, which

comprises a limited pool of general processing capacity (Baddeley & Hitch, 1974).

The *central executive* is the most important subsystem of *working memory* due to its capacity to direct and focus attention, although this capacity is limited in nature. Although it is exceptionally difficult to characterise and understand *executive functions* and its *components*, many have given their theories. Prominent theories of *working memory* state a singular view of *executive functions*, however, a great deal of debate exists around the topic with the argument in favour of a separation of different components (Wesley, 2006). Researchers such as Baddeley (1986), Shallice (1988) and Burgess (1997) all agree that *executive functions* include higher-level motor programming, cognitive flexibility in shifting, planning and self-monitoring. More recent research by Cowen (2005) suggests a *four component model of working memory.* The four *executive components* include the capacity to focus attention, dividing attention, switching attention and creating a link between *working memory* and long-term memory. This theory corresponds with research done by Shapiro, Arnell and Raymond (1997) where they investigated the relationship between attention focus, division and ultimately intelligence. Heim (1975) also found that in cases where the *central executive* was impaired, a greater degree of impairment was found on tests demanding measures of *fluid intelligence* in which attention plays a major role. It is interesting to note that attention, as part of the *central executive,* is also strongly related to *fluid intelligence*. Engle (2002) conducted a study which indicated a strong correlation between *working memory span* and measures of *fluid intelligence*.

Zeaman and House (1963) found that individual differences in intelligence were related to attention, and Sternberg (2000) hypothesised that *working memory (executive processes)* is an essential feature of intelligence. All three abovementioned concepts (attention*, fluid intelligence (gf)* and *executive processes*) are thus incorporated into one central system called *working memory.*

2.4 Defining fluid intelligence

"Fluid intelligence (gf) is the ability to think flexibly and may increase when you are young but levels off as you mature" (Baddeley, 2007).

When giving a definition of *fluid intelligence (gf),* it is essential to start with the origin, namely intelligence. Research done from the *information processing paradigm* yielded explanations which differentiate between two types of intelligence, namely *fluid intelligence (gf)* and *crystallised intelligence (gc)* within *working memory* (Dennis & Tapsfield, 1996). The distinction between the two types of intelligence is the difference between cognitive processes that manipulate information, but are themselves unchanged by learning (*fluid intelligence*), and cognitive systems capable of accumulating long-term knowledge (*crystallised intelligence*) (Baddeley, 2007).

Fluid intelligence (gf) is seen as a basic capacity to adapt to new situations. It is an inherent capacity for learning, problem solving and reasoning that is independent of education and cultural influences (Samuda, Feuerstein & Kaufman, 1998). *Fluid intelligence (gf)* and general intelligence are often thought to be very similar, if not identical, as general intelligence is typically assessed by testing the ability to grasp unfamiliar relationships, rather than testing the content of knowledge (Lubinsky, 2004). *Crystallised intelligence* emerges from a person's use of *fluid intelligence (gf)* to interact with society and is a product of formal education. This study focuses on *fluid intelligence (gf)* because it fulfils a similar function as the *central executive* (Benjafield, 2007). The *central executive* selects and integrates information, constituting a workspace within which solutions to problems are formulated (Baars, 2002). Within the framework of Baddeley's (1986) theory, the *central executive's* capacity is the most natural candidate to account for the relationship between *working memory capacity* and *reasoning ability* (Bayliss, Jarrold, Baddeley & Gun, 2003). *Fluid intelligence (gf)* is responsible for reasoning ability; therefore a strong association between the *central executive, working memory capacity* and *fluid intelligence (gf)* can be postulated (Conway, et.al., 2007).

Previous research indicates that intelligence, more specifically *fluid intelligence (gf),* is such a complex factor that one cannot be certain that intelligence does indeed provide a valid measure of *fluid intelligence (gf)*. Research literature comprising hundreds of empirical studies conducted over nearly three decades has established that people's responses often deviate from the performance considered normative on many reasoning tasks (*fluid intelligence (gf)* tasks) (Stanovich & West, 2002). *Fluid intelligence (gf)* abilities are likely to be more susceptible than other abilities to environmental influences (Sternberg & Grigorenko, 2002). Numerous investigators have argued that there were reasons why instances of *fluid intelligence (gf)* performance were not in line with the norm (Cowan, 2005). Performance may depart from normative standards because of performance errors such as temporary lapses in attention and other sporadic information processing mishaps (Oaksford & Chater, 1993).

It is important to bear in mind that *fluid intelligence (gf)* does not exist on its own, and that it is a component within the system of *working memory*. The two components (working memory and *fluid intelligence*) share similarities to such an extent that they were previously construed to be identical structures. However, although measurements of *working memory capacity* will yield results similar to those obtained using tests of *fluid intelligence (gf),* these results should be viewed with caution. The three functions of *fluid intelligence* under the control of *working memory* include the capacity to maintain, transform and coordinate information (Wesley, 2006). *Working memory*, however, contains a multitude of other functions which do not form part of *fluid intelligence*. Therefore, *working memory* and *fluid intelligence (gf)*, although similar, cannot be seen as identical structures - they are only two sides of the same coin. Research by Borella, Caretti and Mammarella (2006) showed that the point of conjunction between working memory, complex cognitive processes and fluid abilities is the management of *attentional resources* within the *central executive*. In their research they found that the biggest individual differences in *fluid intelligence (gf)* emerged exclusively in *working memory* trials where interference was introduced. Their study supports the previously

mentioned research suggesting that *fluid intelligence (gf)* is related to *attentional control* (Braver et.al., 2003).

2.5 Theories explaining the relationship between *test anxiety*, *attentional resources* and *fluid intelligence*

Many theories have been postulated to explain the interaction and relationship between *attentional resources* and *fluid intelligence (gf)* in cognitive processes. These theories also suggest that factors such as *test anxiety* influence cognitive processes within the working memory system. The following theories will be discussed briefly to validate the model depicting *test anxiety* as having an influence on *attentional resources* and ultimately *fluid intelligence (gf)* scores.

Baddeley and Hitch's (1986) three component model of working memory:

The concept of *working memory* was introduced to contemporary cognitive psychology by Baddeley and Hitch (1974) who argued that a short-duration, capacity-limited *working memory system* was used in a variety of cognitive tasks. This system which both maintained representations and performed computations on them was thought to be responsible, at least in part, for limitations on human performance in a wide range of cognitive tasks (Conway et al., 2007).

Baddeley and Hitch proposed a *multi-component working memory model* that consisted of domain-specific storage buffers (slave systems), such as the *articulary rehearsal loop* and the *visuo-spatial sketch pad*, as well as a *central executive* (Conway et al., 2007). They provided empirical evidence from dual-task studies showing that the mental juggling required by complex cognitive behaviours such as reasoning, can be achieved by coordinated storage and processing between the slave systems and the central executive.

How activated memory and cognition are when used for tasks such as reading, listening, problem solving and reasoning, relies on these three elements according to Baddeley's (1986) *three component model of working*

memory. These three elements draw from a central area of *attentional resources* for carrying out tasks and operations. Therefore, working memory directs attention, initiates decisions, and handles learning tasks as well as the comprehension of language and reasoning. All of these processes are limited without the power of attention (Kelogg, 1995).

Kahneman's (1973) capacity models - the multiple resource capacity theory:
Kahneman's (1973) *capacity models* depict attention as a capacity-limited system (Murray et.al., 1999) within which various dimensions of structural interference exist. There are two basic assumptions made by the *capacity model of attention;* firstly, in attentional systems, there are one or more pools of attentional or processing resources (quantitatively limited energy or effort). Secondly, flexibility exists with which available resources can be deployed to one or more activity. However, the amount of attention invested in a specific cognitive task depends on the task demand (processing of resources). Therefore, the allocation of attention to a task is regulated by the novelty of the task, the intent to attend to the specific channel or input, and the arousal level where low (fatigue) and high arousal (time and pressure) have detrimental effects to completing a task (Murray et.al., 1999). The failure to complete a task could then be ascribed to either the demands of the task exceeding available capacity, or the inappropriate or ineffective allocation of resources. Dual tasks may also lead to a failure in task completion should one or both tasks compete for the same pool of resources.

Capacity theory goes further to explain that various mental activities require different amounts of attention. The notion that attention is limited can be conceptualised as a power supply; task performance has a limit given by the capacity of the fuel tank that powers attention (Kahneman, 1973). When the attention supply does not satisfy the demand, the level of performance declines. Activity can fail entirely if there is not enough capacity to meet attentional demands (Reed, 1996). This can also be the case in a testing environment where there are *fluid intelligence (gf)* tasks needing attention, as well as anxious thoughts due to *test anxiety* or time constraints demanding

attention, and this could lead to a decrease in attentional capacity for the task at hand.

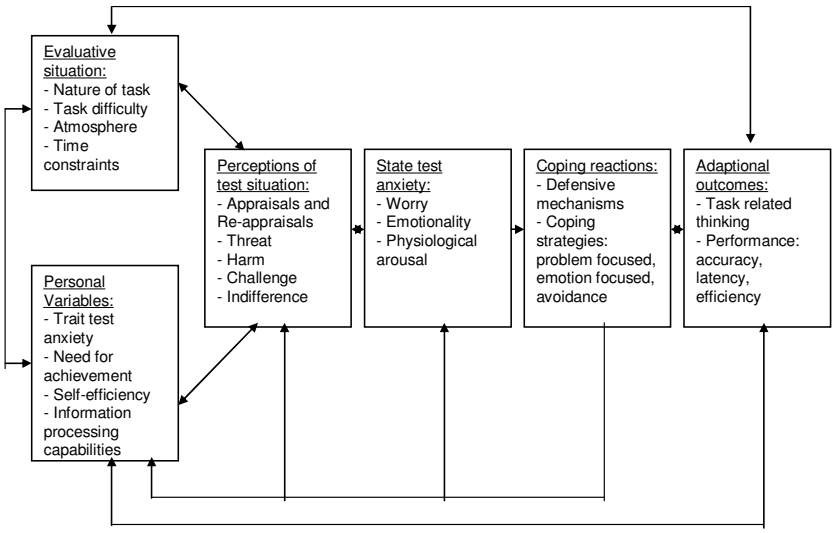
Research conducted by Bursill (1958) demonstrates that high arousal causes attention to be concentrated on the dominant aspects of the situation at the expense of other aspects.

Complex tasks often require attention to various cues and are therefore performed poorly when arousal is high. High arousal has been found to result in an increased tendency to focus on only a few relevant cues. Individuals spontaneously become more selective due to limited attention capacity when they are highly aroused, but the effectiveness of their selections is likely to deteriorate.

Another experiment by Broadbent (1971) indicated that the ability to select relevant stimuli is impaired by arousal. Individuals were briefly shown an array of red and white digits and were then asked to report as many digits of one specific colour as they could. Performance in this task deteriorated under loud noise (arousal) (Kahneman, 1973).

Spielberger and Vagg's (1995) transactional model of test anxiety:

Figure 2.5 The transactional model of test anxiety



The theoretical framework conceptualises the phenomenon of *test anxiety* as a dynamic process involving the reciprocal interaction of a number of distinct elements at play in a stressful encounter between the person and an evaluative situation. The key elements include the *evaluative context, individual differences in vulnerability (trait anxiety), threat perceptions, appraisals* and *re-appraisals, state anxiety, coping patterns and adaptive outcomes* (Zeidner, 1998).

The *transactional model of test anxiety* proposed by Spielberger and Vagg (1995) established that the importance of the assessment situation interacts with individual differences in trait anxiety. Persons who are high in evaluative trait anxiety are predisposed to see test or evaluative situations as more threatening or dangerous than low trait-anxious individuals. If a person is able

to respond to the assessment's demands, the situation may be re-appraised as less threatening, thus leading to a decrease in state anxiety and worry cognitions. If the assessment is seen as threatening, it will be followed by increased state anxiety which places additional demands on *working memory,* thereby influencing the *attentional* system.

The attentional system is influenced by task irrelevant cognitions which reduce the amount of attention available for *fluid intelligence (gf)* tasks and ultimately lead to a reduction in task efficiency (Ashcraft, 1989). Research by Meyers and Martin (1974) found that highly-anxious students maintained effectiveness on tasks requiring low working memory demands (simple tasks). A decline in processing effectiveness was only predicted on assessment tasks that placed heavy demands on working memory resources (complex tasks), and only for such tasks was a decline in task performance manifested (Journal of Educational Psychology, 1974). The bulk of current research evidence suggests that both stressful test conditions and *test anxiety* interact with the task complexity to impact upon the *test anxiety* and performance of individuals (Zeidner, 1998). It is therefore evident that *working memory* and *attentional resources* are influenced by an individual's susceptibility to *test anxiety*. The more *test anxiety* an individual experiences, the less attention will be available to direct to the task at hand, and the effectiveness of completing the task will suffer accordingly.

2.6 Individual differences in *fluid intelligence*, *attentional resources* and *test anxiety*

"Emotional experience is an essential aspect of the process of cognition and must be considered in any adequate description of it" (Blumenthal, 1977).

The focus of *intelligence* should be on specific mental abilities which can be actively defined and measured, and which are influenced by various internal and external factors. The number of mental abilities of individuals is large, but the variance (individual differences) among abilities is relatively small. The reason for this is that abilities are not independent but have sources of

variance in common (Jensen, 1998). "The term *intelligence* applies to the whole class of processes or operating principles of the nervous system that make possible the behavioural functions that mediate an organism's adaptation to the environment, such as stimulus apprehension, perception, attention, discrimination, stimulus generalisation, learning, remembering, thinking and problem solving" (Jensen, 1998, p. 46).

Individual differences contributing to different performances on cognitive tasks include high and low *working memory capacity, processing speed, trait anxiety* and the *inhibition of task-irrelevant thoughts* to name a few. These all contribute to differences in scores obtained on measures of *fluid intelligence (gf)*. As previously discussed, the *attentional control system (central executive)* within *working memory* directs the capacity to attend selectively to one stream of information while discarding others, this is also known as *selective attention* (Hitch & Lagie, 1996). Working memory capacity can therefore be seen as an agent causing differences between individuals through the use of attention. Such differences were found on *fluid intelligence (gf)* tasks, reading comprehension, and on the acquisition of various skills (Sarason, Pierce & Sarason, 1996). Studies done by Alan Baddeley (2007) also show that low working memory capacity individuals are more susceptible to proactive interference, while high capacity individuals are more successful at inhibiting unwanted messages and keeping them from conscious awareness.

Similar studies by Kane and Engle (2000) show a greater tendency of high capacity individuals to inhibit unwanted information on the Stroop Task. Barett, Tugade and Engle (2004) went so far as to argue that *working memory capacity* should be conceptualised in terms of the ability to regulate attention due to the close relationship it has to attention.

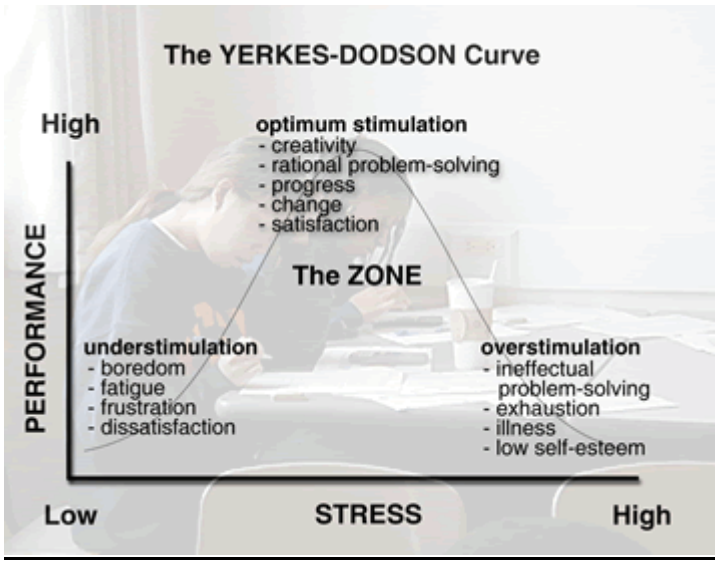
A wide range of cognitive activity therefore depends on the capacity to inhibit competing or unwanted streams of information or response habits, whilst inhibiting requires active attention (Baddeley, 2007). Factors influencing

attention will ultimately limit the capacity available as well as reduce processing speed.

The conclusion follows that due to *working memory capacity* and *processing speed*, individuals differ in their powers of attentiveness. However, these differences should not always be ascribed to an individual's genetic endowment or cognitive abilities. Situations that fatigue or upset a person can adversely affect one's ability to focus and, accordingly, also limit working memory capacity and processing speed (Herrmann, Yoder, Gruneberg and Payne, 2006). Anxiety is likely to be triggered environmentally, either externally through the person's surroundings or internally as a result of thoughts, feelings and memories (Baddeley, 2007). Cognitive processes are sometimes subtly, and other times powerfully, affected by our psychological conditions (Herrmann et.al., 1992).

The Yerkes-Dodson law is usually taken to apply in the case of fear and anxiety. The law states that an inverted U-shaped relationship exists between performance and level of arousal (Yerkes & Dodson 1908), and that high arousal causes a narrowing of the field of attention (Baddeley, 2007). However, this theory also states that low arousal due to boredom or fatigue can result in poor performance. The Yerkes-Dodson law should be considered descriptive rather than explanatory due to its failure to explain the reason for the curvilinear relationship (Baddeley, 2007).

Figure 2.6: The Yerkes-Dodson Model:



The Yerkes-Dodson law was proven by Mcleod and Donnellan who used two groups of individuals selected as being high or low on *trait anxiety (the self-rated tendency to be an anxious person)*. The anxious individuals performed poorly on these measures and, when anxiety was induced, attentional capacity was further diminished (Meyers and Martin, 1974). One explanation offered for this finding is that negative or irrelevant thoughts caused by anxiety place a strain on *working memory*; these thoughts influence the operation of the *central executive* and hence disrupt the performance of other cognitive tasks such as those requiring attention (Baddeley, 2007).

Individual differences in cognition are assessed today using a variety of self-report, behavioural performance and neurological methods depending on the kind of information sought (Herrmann, Yoder, Gruneberg & Payne, 2006). Psychometric intelligence is related to increased efficiency of cognitive control. In general, cognitive control permits the suppression of unnecessary responses, as well as the execution of consecutive actions in their appropriate order. Increased strength of cognitive control possibly results in the enhanced proficiency of various cognitive tasks, and the performance of individuals being labelled as bright or intelligent is characterised by such proficiency (Ackerman, Kyllonen & Roberts, 2002). However, the previous explanation

does not take into account that individuals experience situations in various manners and react to stimuli in different ways. People are not mere processors of information; they bring unique emotions into the evaluative situation which must be taken into consideration when interpreting research results. As indicated in the Yerkes-Dodson curve, a variety of factors could disrupt performance such as fatigue, frustration, exhaustion, illness or even low self-esteem.

For the purpose of this research, individual differences will include differences between racial groups on assessments measuring *fluid intelligence*. Unfounded assumptions are often made when applying psychometric instruments to such groups, such as:

- Tests are measuring general intelligence (g factor);
- Individuals taking the test from different racial groups are sufficiently comparable to permit valid inferences to be drawn as to the quality of their intelligence or abilities;
- What tests measure is to the largest extent intelligence determined by genes (Montagu & Biesheuvel, 1999).

Montagu & Biesheuvel (1999) maintains that it is false to claim that there has been any success in distinguishing genetic from environmental contributions in the development of intelligence. We can only deal with behaviour which is the outcome of an interaction between genetic endowment and the environmental factors influencing its development (Montagu & Biesheuvel, 1999).

Therefore, what has been asserted is that it is impossible to separate and measure the non-environmental determinants of ability with a behavioural test only, since these interact with the environment in such a way as to ensure that any test of ability will inevitably involve both aspects. Even when tests make minimal use of acquired educational skills, performance on the test will always be influenced in a profound and complex way by the experiences of a lifetime

(Richardson, Spiers & Richards, 1972). In a South African context, these 'experiences' include discrimination in previous years and, therefore, a lack of experience in taking tests.

This situation has changed with all races now enjoying equality; but what are the implications of past experiences on present behaviour and abilities? It could be that individuals from previously-disadvantaged backgrounds might perform poorly on certain measures due to feelings of inadequacy or the anxiety created by inexperience in test taking. According to Erikson, the test situation should be seen as a microcosm of society and that the particular face-to-face contact in this situation, especially when the tester and the person taking the test belong to different racial groups and have different backgrounds, will be affected by the prevailing relations between their two groups in the wider society (Richardson, Spears & Richards, 1972). This means that the race of the tester and societal issues influence how well someone does in a test; for example, if individuals believe that the administrator holds negative stereotypes about them they will perform at the level expected by the administrator (Weiner, Graham, Schinka & Naglieri, 2003).

The Tests for Selection and Training (TST) developed by Thomas International found that African races performed under the norm on certain subtests included in the measure. Out of a sample of 782 individuals belonging to Caucasian and African groups, African individuals tend to score lower on the Reasoning Test (collective effect 21.3%), the Number Speed and Accuracy Test (collective effect 6.5%), the Working Memory Test (collective effect 7.6%) and the Spatial Visualisation Test (collective effect 9.3%). African females tend to score the lowest of all groups. Language was controlled and therefore did not cause these differences. It is therefore unclear what caused these group differences. This finding is the impetus for this research project.

2.7 Research questions

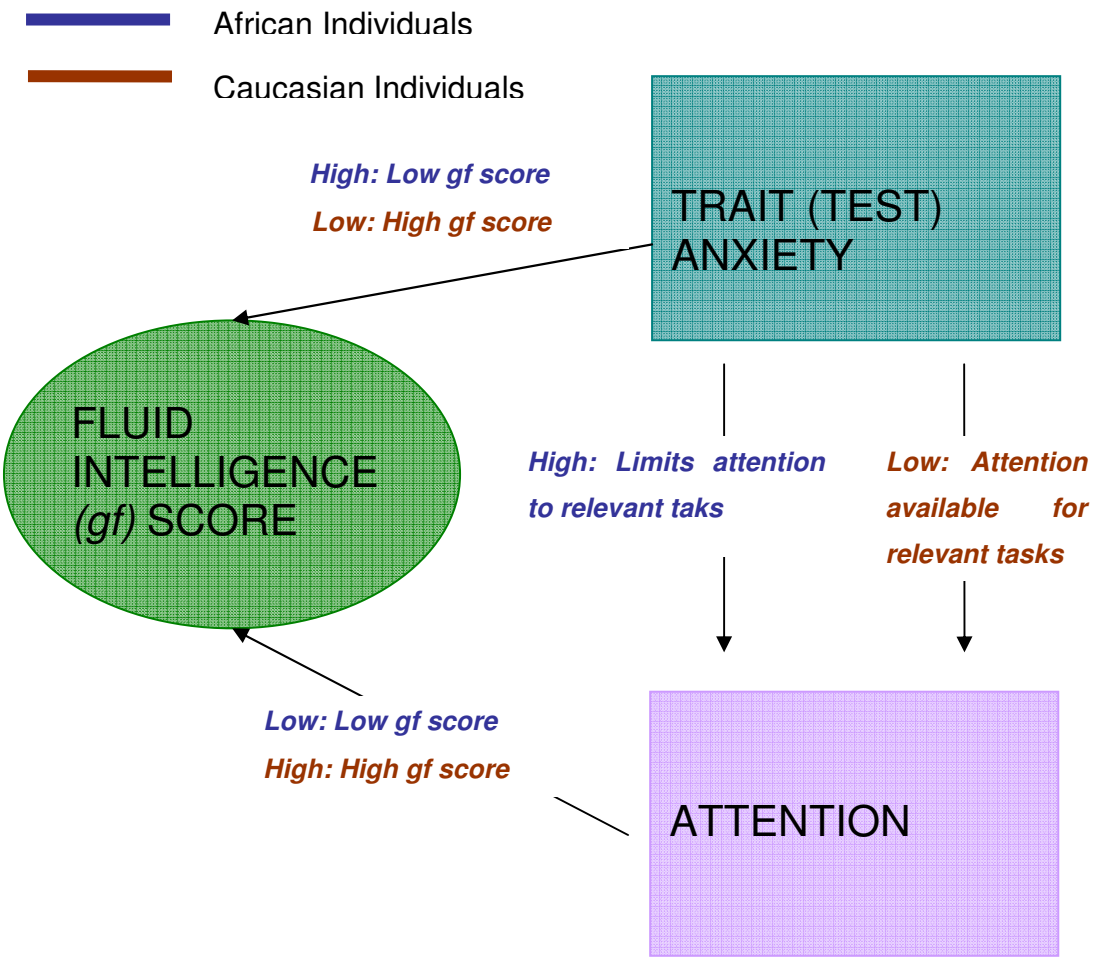
From the previous discussion, a number of research questions can now be derived:

- Higher levels of *test anxiety* could negatively influence the performance of individuals on measures of *fluid intelligence (gf)* and the subtests of the TST, due to some individuals being previously disadvantaged.
- A number of research studies suggest that stress (anxiety) actually improves performance on relatively simple tasks but hampers it on difficult ones (Richardson, Spears & Richards, 1972). As mentioned previously, individuals from African races perform poorly on the more taxing subtests (Reasoning Test). This could be due to higher anxiety meaning that they were acting under more stress in relation to the other group.
- What is the role that attention plays in performance on *fluid intelligence* measures?
- What are the differences in scores obtained on subtests of the TST and what do these scores reflect in terms of differences between groups?

2.8 The model: *test anxiety*, *fluid intelligence (gf)* and *attentional resources*

Earlier mention has been made of the interaction between *test anxiety* and *attentional resources*. The importance of attention was also emphasised as the capacity to inhibit irrelevant material caused by emotions such as anxiety and other factors (Engle, 2002), and the individual differences pertaining to this. Now the question can be asked as to how all of these variables (*test anxiety* (trait anxiety), *attentional resources* and *fluid intelligence*) fit together in a model.

Figure 2.8. The model of attentional resources, test anxiety and fluid intelligence:



The majority of Caucasian individuals score according to the norm on the TST, therefore we can hypothesise that they are low in trait anxiety (the tendency to experience *test anxiety*) and high in attention span, and that they will obtain high to moderate scores on the TST (*fluid intelligence (gf)* score) according to the norm. For African individuals, we hypothesise that they are higher in trait anxiety than their Caucasian counterparts, and therefore lower in attention span. This is due to high anxiety levels having an effect on attention span as previously mentioned, and, as a result, they will obtain lower scores on the TST. These findings thus indicate that African individuals' poor performance can be attributed to higher *test anxiety* levels during the test procedure.

By finding support for the hypothesis, interpretations of scores on measures of ability such as the TST will be more cautiously done. This will result in fair and valid testing practices for all racial groups. Alternatively, it could be found that poor performance is attributable to other factors which need to be explored through future research.

CHAPTER 3: METHODS

The purpose of this study is to investigate if *test anxiety* has an influence on *attentional resources* and ultimately the TST's *fluid intelligence scores*. The experience of *test anxiety* and the influence this has on scores are explored, especially within different racial groups, in order to ensure fair and valid testing of all individuals. This chapter will explain in more detail how this research was conducted from a methodological perspective.

3.1 Research design

3.1.1 Research objectives

The aim of the research is to investigate how different racial groups fit into a model in which an increase in *test anxiety* for certain racial groups will lead to a decrease in *attentional resources*. It is further postulated that such a decrease in *attentional resources* will result in poorer scores on *fluid intelligence* measures relative to groups not suffering from similar levels of *test anxiety*. The model tries to account for the influence that *test anxiety* has on *attentional resources* and *fluid intelligence* scores, and a quantitative research procedure was chosen for collecting and analysing data. The data were collected using four different tests, namely an attention test (d2 Test of Attention), an English ability test (LACS English Fluency Test), TST, as well as a self-completion anxiety questionnaire (EMAS-T and EMAS-P). From these measures, data were gathered to test the previously-mentioned model. In doing this, the research aims to model the relationship between *test anxiety*, *attentional resources* and *fluid intelligence*, as well as to explore racial differences in *test anxiety*. From the main objectives, more specific research questions were formulated.

The following research questions guided the research:

1. Are there racial differences in trait anxiety as reported by individuals assigned to different groups?

2. Does trait anxiety play a role in poor performance on the TST for different racial groups?
3. What is the influence of attention on performance on the TST for the different groups?
4. What is reflected by subtest scores obtained on the *fluid intelligence* measure between different individuals and groups?

3.1.2 Sampling

The purpose of the research is to identify if African race groups experience *test anxiety* to a larger extent than their Caucasian counterparts, and thus achieve lower scores on subtests contained in the TST. The TST is usually administered to individuals working within the corporate sector. Therefore, it was important to ensure that the population consisted of individuals from corporate companies or self-employed individuals within the corporate sector. The accessible population encompassed employees from corporate companies and professional self-employed individuals.

A convenience sample procedure was used comprising consent-giving individuals from the following companies: Terrapin (1), Jasco Electronics Holdings (1), Eskom (3), Millward Brown (1), Sakile Procurement (2), Liberty Life (12), TransUnion (8), Aurecon (1), Complete Clarity (1), UCS-Solutions (1), Mintek (1), Van Sitters (1), Ask Afrika (1), Tshwane North College (1), MegChem (1), University of Johannesburg (2), Sisima AST (1), Inscape College (1), Christian Revival Church (2), Healing Hands (1), NECSA (1), Minerals and Energy (1), Trac - Trans African Concession (2), as well as self-employed individuals (5).

Convenience sampling was used to form two subgroups with 25 individuals each. Group A consisted of individuals from the African race group, whilst Group B was assigned individuals from Caucasian descent. These two groups were homogeneous in terms of aspects such as educational levels and had comparable English language ability in terms of conducting work related tasks. English language ability was assessed through the use of an online

English ability test provided by the LACS (Language and Communication Skills) Centre. This particular measure was used as it is quick to complete (10 minutes), a thorough measure of English ability, and was sponsored by the LACS Centre for the purpose of this research project.

This English assessment gives the participant a score which can be plotted on a scale ranging from 'Native speaker' to 'Limited ability'.

Following are the scale descriptors that were used:
0 = No practical ability.
2 = Has very limited functional ability in using English.
4 = Can exchange simple information. Can conduct simple/routine work-related tasks. Conversational ability in using English.
6 = Can conduct work-related tasks that can be anticipated. Has conversational ability.
8 = Should be able to handle a wide range of work-related tasks and act independently in most situations. Should be reasonably comfortable in conversation.
9.5 = English should not be a hindrance when conducting work-related tasks. Should be able to actively participate in most social situations.
9.5 – 10 = Indicates native speaker equivalence.

All participants received scores indicating English competency, ranging between 6.0 and 10.0 - group A: African individuals (M:8.2, SD:1.17) and group B: Caucasian individuals (M:9.4, SD:0.51). Although the two groups differed in terms of the mean scores obtained, the test results show that both groups are proficient enough to complete the assessments successfully (see Figure 3.2 on page 61).

In determining how many participants were needed, a balance of cost and information needs was done. A sample of 50 individuals was selected; reasons for the small sample size included poor availability of professional

and corporate individuals as not many of them had the time to attend measurement groups, and the high costs involved in the purchasing and scoring of the psychometric tests and other measurements used in this research.

3.1.3 Data collection

Data collection was done by administering the measures between the two groups. The sample consisted of individuals from both groups A and B. Participants were from diverse corporate sectors such as business and media (16), financial institutions (20), IT services (2), law firms (1), educational institutions (3) and engineering companies (8). Individuals were between the ages of 21 and 47, with a 28% male and 72% female gender split. The group times and dates were scheduled according to the availability of participants, and were therefore not held on similar dates, times or even at the same venue.

Four assessment sessions with the groups were held in Johannesburg and six groups in Pretoria. The reason for the two locations, and the different times on which the assessments were carried out, is because the groups consisted of individuals from different companies. The groups were conducted at different venues that were selected according to the participants' locations. Groups conducted in Pretoria made use of TransUnion Credit Bureau's boardroom, while the Johannesburg groups used a private venue room as well as Standard Bank's boardroom in some instances. The venues were made available by the relevant parties purely on good will. Between four and eight participants took part in each group. The groups were conducted by one assessment administrator at a venue convenient to the participants in that group. The venue included comfortable seating and tables, adequate lighting, two pencils per respondent, sharpeners and test material, and the venues were free from any disturbances. Safe and secure parking was also arranged and refreshments were available to participants during the break.

The testing session was approximately two hours in duration, and three tests were administered (the English ability test was an online assessment which was completed by the respondent prior to other measurements), these included the TST, d2 Test of Attention and the EMAS-T/EMAS-P. Participants were assessed over a period of two months. The measures were administered to all participants in the same manner and under very similar physical conditions.

3.1.4 Recruitment procedure

"Recruitment procedures refer to the process of screening and selecting relevant individuals to participate in certain research projects" (Wikipedia, 2009).

The contact details of the respondents were provided by management, human resource divisions within selected companies, or via church groups. Respondents from both groups had to meet certain requirements in terms of demographics, such as age (22 to 47 years), race (sampling was done to fill quotas for the two groups), occupation (working within the corporate sector), English ability (must be fluent in the English language), as well as educational level (some form of tertiary qualification). No distinction was made on the basis of gender, which resulted in mixed groups participating in the research.

Potential participants were contacted via e-mail or telephone to invite them to partake in the research. The reason for the research was briefly explained and participants were informed about the procedures involved. Individuals who gave their consent to participate were given possible group dates, times and venues from which they could choose the most suitable. They were also informed that the measurements would take approximately two hours to complete. Each participant received a monetary incentive to the value of R150 to thank them for their time and participation.

3.1.5 Data collection methods

Psychometric tests and other types of measurements and assessments, such as questionnaires, are usually used in quantitative research designs to generate numerical data that can be used to answer research questions as well as to confirm or refute hypotheses. What follows is a description of the four data collection methods used:

Tests for Selection and Training (TST)
Development and Distributors: Thomas International

TST is a battery of tests originally developed for Navy personnel selection. It has undergone a comprehensive and exhaustive research validation programme consisting of 16 separate and detailed technical reports authored over a three-year period. The series was first constructed at two levels, the initial and advanced entry levels.

Initial entry level tests were suited to school-leavers who were entering employment for the first time. Advanced entry level items were constructed at a level more suited for college entrance or individuals pursuing further education. A single mid-range version was devised to cover the entire spectrum from standard school-leaving to executive level candidates. It underwent standardisation for two years before being released and is called the *combined version*. Currently, it is used as an aptitude test for selection and placement purposes in the corporate environment.

The TST is a suite of ability tests, and each test demands that the respondent complete one type of task in that particular test for a relatively short period of time (Thomas International USA Inc., 2003). The content of the TST has been dictated by three principles, namely:

1. All tests have to be defined clearly in the literature by published work that reveals those aspects of human mental performance captured by the test items.

2. They have a long history as types of mental tests that measure known mental abilities used in work, training and educational contexts.

3. The tests have an equal opportunity knowledge requirement or threshold.

The tests may be among very few test series designed to satisfy the more obvious needs of employers who pursue equal opportunity policies in selection and training.

The test indicates an individual's trainability in:

- ***Perceptual speed (a perceptual speed measure)***
  This test assesses how quickly and accurately an individual can check for error/accuracy and then describe the data. In addition, it is a general literacy assessment.
- ***Reasoning (deductive reasoning measure)***
  This test assesses the ability of an individual to hold information in memory and solve problems after receiving either verbal or written instructions. A high score suggests quick reasoning skills.
- ***Number speed and accuracy (mental agility and general memory assessment)***
  This is a numerical test. It is relevant to all roles that emphasise a need for numerical aptitude.
- ***Working memory (information retention and deductive logic)***
  This is a deductive problem-solving measure for roles with a high mental work load and where there is a requirement for a substantial attention span and concentration over long periods.
- ***Spatial visualisation (a spatial orientation measure)***
  This measure examines an individual's ability to deal with mechanical and technical logic problem solving.

Subtests of the TST provide a good measure of *fluid intelligence* and working memory. The theory behind the TST enables them to function reliably and

validly within the limits of difficulty determined for them. Scores have also been described in technical publications as a measure of *fluid intelligence*. The higher the score, the better the individual is likely to be at performing mental tasks accurately and quickly. Focus is placed on subtests of Perceptual Speed (PS), Reasoning (REA), Working Memory (WM), Number Speed and Accuracy (NSA), Spatial Visualisation (SV), as well as measurements of accuracy and speed. The Reasoning (REA) subtest tests the power to make inferences and the ability to reason from information provided. Research conducted on working memory (Christal, 1985; Thurstone, 1938) suggests that performance on reasoning problems is a function of individual differences in the power to allocate *attentional resources*. It is also a measure of *fluid intelligence*. Working Memory (WM) subtests include tasks that place a heavy load on working memory. It measures general memory capacity, which is central to problem solving. The Number Speed and Accuracy (NSA) subtest includes tasks where attention and concentration are required. It measures how well a person can work with quantitative concepts as well as general memory capacity (all subtests are non-verbal in nature). Accuracy is given by a numerical indicator represented as a percentage and calculated by dividing the number of test responses performed correctly (accuracy) by the number of test responses completed within the given timeframe (speed). Speed is given by results that serve as an indicator of how fast the individual worked in certain tasks (Thomas International USA Inc., 2007). Results from the TST are given as percentile ratings. An overall measure of the TST test will thus provide a measure of *fluid intelligence*. (Thomas International USA Inc., 2003)

Validity, reliability, standardisation and norms

Verbal, mathematical and spatial tests correlate highly with other tests in the same domain (convergent) and correlate weakly with tests testing very different types of performance (discriminant). Therefore, there is evidence of convergent validity with like tests and divergent or discriminate validity with unlike tests. All forms of validity have been demonstrated within the TST: construct validity, concurrent, predictive and incremental validity (Thomas

International, 2007). Validity of the TST is therefore shown by results and labelled as fully acceptable to excellent, depending on the type of validity that was tested for.

Reliability is measured through *split-half reliability* and *test-retest reliability*. *Split-half reliability* aims at checking the internal consistency of the TST. There are five different subtests, each measuring a different component of learning potential from the other. Together, they seek to measure *fluid intelligence*, thus internal consistency is very important because the assumption made in this study is that when administered together these subtests give an adequate measure of *fluid intelligence*. For the five subtests the results for *internal consistency* as established by previous research was PS=.81, REA=.90, NSA=.93, WM=.88 and SV=.94 (Thomas International, 2007). Provided that careful attention is given to administrative procedures, the *internal consistency* will remain high. Three interval periods (immediate retest, six-week intervals and longer than six weeks) were used, and the correlations analysed.

Previous research found the *test-retest reliability* to be PS=.74, RE=.78, NSA=.86, WM=.84, SV=.73 (Thomas International, 2007). On the whole, interval reliabilities are very consistent across delivery options and across cohorts where literacy levels are constant across time. In terms of *parallelism* (if the parallel form of the original test gives the same results), analysis of variance did not show any significant differences. Therefore, results for reliability trials show that the series has very good internal consistency in a single trial, satisfactory test-retest reliability and parallelism. This aptitude test is an independently validated battery of normative tests. The TST has also been constructed to incorporate maximum equal opportunity knowledge levels. Knowledge requirements for the completion of the battery are no more than that of the normal grade 12 school level. It is the unique design of the tests that gives them their superior flexibility and allows uncompromised extra fit to different levels. It has been developed specifically for the workplace.

Time taken to administer

The TST consists of five subtests, each with a different time constraint ranging from 3 to 5 minutes.

- Perceptual Speed (PS) must be completed within 3 minutes.
- Reasoning (REA) must be completed within 4 minutes.
- Number, Speed and Accuracy (NSA) must be completed within 4 minutes.
- Working Memory (WM) must be completed within 4 minutes.
- Spatial Visualisation (SV) must be completed within 5 minutes.

Whether there are small or large groups, the tests are easy to administer, score and interpret.

Suitable age groups

There are six basic entry level requirements to ensure an equal opportunity threshold. These include knowledge of the alphabet, knowledge of the order of letters in the alphabet, recognition of differences between upper case and lower case letters, reading simple English sentences and understanding simple adjectives, using the negative form to change the meaning of a sentence, as well as counting up to thirty and doing simple subtractions. The TST is designed for use on working adults; therefore the suitable age group can be set at 18 years and older.

The TST can also be described as minority-conscious. These tests are constructed in such as way as to minimise the effects of educational disadvantages and are almost invariably shown to be associated with achievement test performance and minority group status (Thomas International, 2007).

D2 Test of Attention

Distributors: Jopie van Rooyen

The d2 Test was originally developed at the Institute for Safety in Mining, Industry and Transportation for the Technical Control Commission in Essen, Germany. The primary objective was to have an instrument for evaluating driver proficiency (Brickenkamp & Zillmer, 2003). It is useful in psychological assessment to have tests for general abilities (intelligence and comprehension), but instruments for investigating certain prerequisites of achievement, such as those suggested by terms like 'attention', 'mental concentration', 'effort', 'mental exertion' and 'attentional control', are also very important. The d2 Test belongs to the category of prerequisite related instruments and is a test of attention span, selective attention and sustained attention (Lezak, 1995). Often referred to as concentration, selective attention can be defined as the capacity to focus on one or two important stimuli, while suppressing awareness of competing distractions (Zillmer & Spiers, 2001).

In short, the d2 Test is a timed test of selective attention. The test focuses on aspects such as:

- ***The speed of work***: the number of stimuli which are processed within a specific unit of time (an aspect of drive).
- ***The quality of work:*** the degree of accuracy which is inversely related to the error rate (an aspect of attentional control).
- ***The relationship of speed and accuracy of performance:*** gives insights into stability, consistency, fatigue, attentional and inhibitory efficiency.

Amongst other scores, scores such as TN (Total Number of Items Processed), E% (Percentage of errors), TN-E (Total Performance) and CP (Concentration Performance) are measures of overall performance on the test, and the Fluctuation Rate (FR) assessing the stability and consistency of performance across trials can also be calculated.

Validity, reliability, standardisation and norms

The validity of the technique is documented by a large volume of research. Among them are research studies in the areas of clinical psychology and psychiatry, educational psychology, vocational counselling, industrial psychology and sport psychology. The research supports the multiple clinical and empirical applications of the d2 Test (Brickenkamp & Zillmer, 2003). A preliminary psychological indication of the validity of the d2 Test can be seen during the administration of the test.

There is apparent prima facie evidence for assuming that speed and accuracy in distinguishing between various but similar characters in print requires selective attention. The d2 Test has *psychological validity* as well as *construct validity*.

The reliability was tested on different scoring indices and with a variety of methods. The internal stability of test indices TN, TN-E and CP proved to be very high (r>.90). Reliability coefficients of E% are expected to be somewhat lower. The stability of E% is less affected by test-retest experiments, and thus can be improved with retesting. In a series of test-retests, and intervals of up to 40 months, d2 Test indices TN, TN-E and CP demonstrated satisfactory to good reliability (r>.70).

Internal consistency, one of the major measures of reliability, concerns the equivalence of parts of the test for measurement purposes (Brickenkamp & Zillmer, 2003). There have been a number of investigations estimating internal consistency of the d2 Test, conducted on various samples of subjects. The procedures included the frequently used split-half methods (correlation between the first and second half and correlation between odd and even lines) with correction by either the Spearman-Brown formula (S-B) or the Guttman method (Gutt.) to estimate the reliability of the entire test.

There is general agreement that split-half methods of estimating reliability should be applied to power tests only, but the d2 Test, a speed test, is divided into 14 separately timed parallel parts (lines). Using this approach reduces the

specific problems of the reliability of speed tests (Anastasi & Drake, 1954; Guilford, 1956; Cronbach & Warrington, 1951). Current data also support the notion that the d2 Test is a reliable test regardless of cultural bias. In almost all studies, the scores of the d2 Test are very reliable (r>.90), independent of the statistical method used for reliability analysis or the sample size (Brickenkamp & Zillmer, 2003).

Standardised instructions and scoring ensure the objectivity of this procedure. These standardised instructions, with 20 seconds of working time allotted for each of the lines, make it possible to administer the test to a broad spectrum of age groups with various levels of performance ability (Brickenkamp & Zillmer, 2003).

The selection of subjects for the standardisation group was designed to obtain a very broad representative sample of the general population. Norms for adults cover the age groups 19-39, 40-49 and 50-59 years.

Time taken to administer

The procedures, including instructions, can be administered within 8 minutes. Individuals have 20 seconds of working time for each line, and there are 14 lines altogether that need to be completed.

Suitable age groups

The age range is from 9 to 60 years.

Endler Multidimensional Anxiety Scales (EMAS)

Distributors: Jopie van Rooyen

The Endler Multidimensional Anxiety Scales (EMAS) are based on the interactional model of personality (Endler, 1983) and consist of three related self-report measures that allow greater precision in assessing and predicting anxiety across situations and in measuring treatment response. The first scale, EMAS-State (EMAS-S), which measures state anxiety, measures the

individual's actual transitory anxiety response. It assesses both physiological and cognitive responses. The research will however not include EMAS-S.

The second scale, EMAS-Trait (EMAS-T), measures the individual's predisposition to experience anxiety in four different types of situations: *socially evaluative, physically dangerous, new or ambiguous* and *routine*. The third scale, EMAS-Perception (EMAS-P), evaluates the individual's perception of the type and intensity of threat in the immediate situation. These scales can be given separately or as a set and provide a multidimensional assessment of anxiety (Endler, Edwards & Vitelli, 2009).

EMAS-T

This scale measures four dimensions of trait anxiety and contains a 60-item inventory consisting of 15 response items for each of the four general situations. Items are rated on a five-point intensity scale that ranges from 1 (not at all) to 5 (very much). This scale yields four separate trait anxiety scores, namely social evaluation, physical danger, ambiguous and daily routine.

EMAS-P

This scale is a measure of the respondent's subjective perception of the type and degree of threat evoked by a specific situation. Four types of threats are assessed, namely social evaluation, physical danger, ambiguous and daily routines.

These four types of threats parallel the four trait anxiety dimensions assessed by the EMAS-T (Endler, Edwards & Vitelli, 2009). In addition, there is also a fifth item that assesses perceptions regarding the degree of threat in the individuals' immediate situation (Flood & Endler, 1980). Each item has a 5-point intensity response scale ranging from 1 (not at all) to 5 (very much). Open-ended items allow respondents to identify specific aspects of their immediate situation that may be perceived as stressful, and provide a

manipulation check to identify discrepancies in answers given (Endler, Edwards & Vitelli, 2009).

Certain aspects of this measure and its development make it useful for researchers interested in anxiety measurement (Endler, Edwards & Vitelli, 2009).

Validity, reliability, standardisation and norms

The EMAS scales are derived from an interaction model of personality that proposes that anxiety is a function of the interaction of person and situation variables.

Overall values tend to be moderately high for items on the four subscales with correlations averaging around .60 or .70. The EMAS-P has no item correlation since each scale consists of only one item.

The criterion validity of the EMAS-T has been assessed with regard to a variety of self-report measures of anxiety including Spielberger (1983), State-Trait Anxiety Inventory (STAI) and the Neuroticism scale of the Eysenck and Eysenck (1968) Personal Inventory. The pattern of correlations between the dimensions and various anxiety measures generally supports the validity of EMAS as a multidimensional measure of trait anxiety (Endler, Edwards & Vitelli, 2009). EMAS-P subscales are reactive because they evaluate perceived anxiety or threats particular to the situation, therefore scores will vary. With regard to construct validity for the EMAS-T, inter-correlations among the four subscales were low to moderate across different samples ranging from -.01 to .64.

When looking at reliability scores, overall alpha coefficients are high ranging from .82 for adolescents on daily routines to .96 for psychiatric outpatients on the same subscale. These results indicate very good internal consistency for EMAS. In terms of test-retest, stability over time has been examined in three studies. Over a two-week period, test-retest reliabilities were found to range from .60 for daily routines subscales to .79 for physical danger, indicating adequate temporal stability (Endler, Edwards & Vitelli, 2009). Coefficient

alpha reliability cannot be computed for EMAS-P due to the five independent items. Items are reactive so low test-retest correlation coefficients are expected (Endler, Edwards & Vitelli, 2009).

EMAS has been developed and standardised using a variety of populations including adults, college students and adolescents, as well as military and clinical populations. It was derived and developed in conjunction with the interaction model of anxiety (Endler, 1975). Three factor analyses were performed to clarify the empirical relation between state and trait anxiety, and the variables within the distinction between state and trait anxiety.
Factor analysis of the state items provided support for the separate dimensions of cognitive and autonomic anxiety. Four congruent factors were associated with increases in state anxiety and four general situations: social evaluation, physical danger, ambiguous and daily routines (Endler, Parker, Bagby & Cox, 1991). During previous research, EMAS was administered to almost 1,900 respondents from different age groups. Various samples were also combined through an examination of normative data to yield five population groups on which EMAS was standardised, these included adults, undergraduates and adolescents (Endler, Parker, Bagby & Cox, 1991).

Time taken to administer

All three scales (EMAS-S, EMAS-T and EMAS-P) can be completed in approximately 25 minutes. EMAS-T and EMAS-P can be completed in 10 minutes. These are self-completed measures so completion times will vary due to individual differences.

Suitable age groups

All three scales can be administered to individuals or groups. They can be used with a wide range of people including adolescents, adults, clinical patients and the elderly. These scales can be administered to anyone who reads at an eighth-grade level or higher.

LACS English Fluency Test

Development and Distributors: LACS Centre – Software Development and Consulting

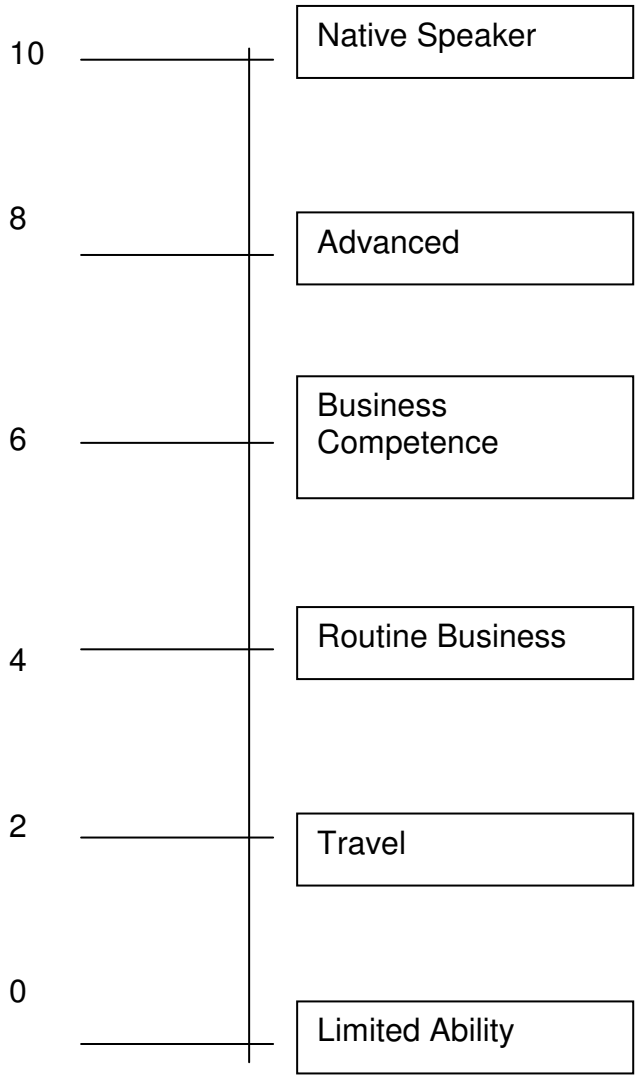
LACS is the abbreviation for Language and Communication Skills. This reflects the organisation's orientation towards and origin in developing materials and delivering courses in work-related language learning. The LACS English Fluency Test is a short (approximately 10 minutes) online test and is a measure of a person's fluency in speaking English.

The differential element between this test and other computer-based assessments is that it tests more than English knowledge. The test method requires mental activity that is much closer to that involved when speaking. The test is suitable for use with large numbers of individuals due to the convenience of taking it with most web browsers. Other uses of this test include:

- Placement assessment
- Test validation
- Recruitment

After completion, a test score is given on a scale from 0 to 10 in increments of one decimal place. This scale then assigns a description of English ability to an individual according to the score received:

Figure 3.2. LACS English fluency test scale



The benefits of the abovementioned data collection methods include:

- Standardised administration procedures ensuring valid data;
- The researcher can answer any questions prior to the measurements to aid participants' understanding;
- Measurement instruments are specifically designed to give a measure of attention, *fluid intelligence* and *test anxiety*;
- Numerical data are obtained which can be analysed by the use of quantitative statistics.

The test administrator increases the success of data collection by:

- Creating a comfortable test environment without disturbances;

- Giving adequate instructions and explanations of the tests during administration;
- Debriefing participants after assessment to work through any negative feelings and to answer questions that participants might have.

3.1.6 Factors to consider when using measurement/testing as a data collection method

The following section deals with some important factors that need to be taken into account when applying psychometric instruments to measure cognitive abilities (Morrow et al, 2005).

Measurement error: The qualities of the measurements were assessed. Measures proved to be valid (measure accurately what it purports to measure). Obtained scores are always true scores combined with some degree of measurement error. Thus, in real-life situations, the individuals' observed scores will fluctuate from test administration to test administration. For the purpose of the research, the tests were only administered once.

Selection bias: Care was taken to ensure that participants were representative of the target population as specified in the sampling procedure section, so that appropriate conclusions can be drawn. The possibility of selection bias should always be considered when defining a study sample.

Information bias: This cannot usually be totally eliminated, especially in the case of questionnaires. The aim was to keep information bias to a minimum, to identify biases that could not be avoided, to assess their potential impact, and to take this into account in the interpretation phase. Information bias in this context includes individuals who might misunderstand the assessor or participants who become confused with all the information given. These biases were kept to a minimum by explaining all tests to the participants using examples as well as leaving enough time for questions before commencing with the tests.

When choosing participants to participate in the measurements, an important consideration was to recruit individuals within the age range specified by the instruments. The respondent variables also had to be similar to the target population. Participants' language, cultural background, age, educational level and occupation were all considered.

The test administrator was familiar with the test material and had completed all the necessary training to use the measures. Each measure had its own administration procedure which was strongly adhered to and followed to the point. The testing facilities included TransUnion's boardroom for groups tested in Pretoria, and Standard Bank's boardroom and a private venue room for groups tested in Johannesburg. These venues were free of disturbances, had adequate lighting and comfortable seating, and tables were arranged in a manner that provided a full view of the test administrator. All materials such as pencils, sharpeners, test booklets and other accessories needed were ready before commencement of the test procedure. An assistant was present to help with facilitation and handing out equipment. Throughout the assessment procedure, the administrator and her assistant adhered to all ethical standards such as informed consent and confidentiality.

3.2 Motivating the two group research design

Quantitative research is the systematic scientific investigation of quantitative properties and phenomena and their relationships. The objective of quantitative research is to develop and employ mathematical models, theories and hypotheses pertaining to natural or social phenomena. A quantitative methodology was chosen as the most appropriate design for the research, as the process of measurement was central to the quantitative research design (Terre Blanche & Durrheim, 2002).

The research design in this research followed a two group post-test only design where the two groups were assumed to be probabilistically equivalent in terms of educational level and English ability. This research design was used to measure the groups on the three measures and to compare them by

testing for the differences between the means and so forth. This two group research design included more than one dependent variable namely:

1. Test anxiety
2. Attention
3. Overall TST result

The independent variable was racial group. Due to the fact that there was more than one dependent variable, both Multivariate Analysis of Variance (MANOVA) and multiple linear regression were used to analyse the data.

In order to obtain accurate data in terms of the variables measured (*fluid intelligence*, attention and *test anxiety*), systematic, standardised measures were needed. This translation of phenomena into variables facilitated the research by providing numeric scores by which the variables being investigated could be classified and arranged in a systematic way, and allowed inferences to be made about how much of certain characteristics the participants 'possessed' (Terre Blanche & Durrheim, 2002).

3.3 Ethical aspects

Emphasis is placed on the issue of fair and valid testing and measurement for all cultural groups. It is the main objective of the research to investigate factors, such as *test anxiety*, that might contribute to poor scores on certain measures for individuals or different cultural groups. The aim is therefore not to compare the scores of different cultural groups on intelligence measures, but rather to compare the individuals on different measures to investigate if *test anxiety* does have an impact on their performance. The reason for dividing participants into different groups was to see if individuals from African cultures as a group have higher *test anxiety* scores, and if this impacted negatively on the group's performance.

All participants received an informed consent form (Appendix A) prior to participation, which explained the measures that would be administered to them as well as possible negative effects that they might experience such as tiredness or mild *test anxiety* due to the measurements. The researcher

avoided these negative effects as much as possible by ensuring ample break times throughout the testing procedure. Participants had to complete and sign an informed consent form before being included in the research. This was done to ensure voluntary participation in the research.

Confidentiality was ensured for all participants, and they were assured that information would not be made available to anyone who was not directly involved in the study (Trochim, 2001). Participants were also informed that they would not personally receive any feedback in terms of the scores obtained, the reason being that data were collected purely for research purposes and not to inform individuals about their functioning.

Anonymity, with participants remaining anonymous throughout the study even to the researcher, was not possible due to the fact that individuals' scores from different measures had to be compared. However, the researcher ensured anonymity by not identifying any individual whilst writing about the results.

In terms of competence, the researcher underwent training in the administration of TST and received permission to administer all other measures included for the purpose of the research. The entire research process, including data collection and analysis, was also conducted under the supervision of a supervisor.

CHAPTER 4: RESULTS

Multivariate Analysis of Variance (MANOVA) was used due to the existence of more than one dependent variable (*fluid intelligence, test anxiety and attention*) and one independent variable (*racial group*) to explore if African and Caucasian individuals differ in terms of their *test anxiety*, *attentional resources* and *fluid intelligence* scores.

Multiple linear regression was used to answer the following two questions:

- Are there differences between the groups as reflected through scores obtained on the *fluid intelligence* measure?
- Does a relationship exist between *test anxiety* levels, attention and *fluid intelligence* scores?

Data analysis commenced once data cleaning and checking had been performed. Certain prerequisite analyses were conducted: the basic traits of the data were established (under the section data profile), the assumptions required for the use of MANOVA and multiple linear regression were tested (in the second subsection of the data profile section), and the simple statistics for the groups were completed (in the summary statistics section). All statistical analyses were conducted using the statistical program SPSS, version 17 (IBM® SPSS® Statistics Inc, 2011). Scatter diagrams were produced and analysed to locate any influential outliers and to assess the impact of these data points on the results (in the outliers section). The descriptive data of the results are presented below and in the data profile section.

The first research question (are there racial differences in trait anxiety as reported by different groups?) was answered using MANOVA. The second research question (does trait anxiety play a role in poor performance on the TST for different racial groups?) was answered using multiple linear regression. t-tests and comparisons of means were applied to address the third research question (what is the influence of attention on performance on the TST for the different groups?) as well as the fourth question (what is

reflected by subtest scores obtained on the *fluid intelligence* measure between groups?).

Different variables were created for the purpose of data analysis. The first of these was the ethnic group, a score which splits the sample into a group of 25 black and 25 white individuals. The next variable was a fluid intelligence score which was computed by calculating an individual's overall TST score from scores obtained on the subtests. The D2 Test of attention produced the attention score, while *test anxiety* (social evaluation) was calculated from the overall EMAS-T score.

4.1 Data profile

The African group was called Group 1 and the Caucasian group was named Group 2.

Group 1 (African group) included 20 females and 5 males between the ages of 23 and 40 years. Group 2 (Caucasian group) included 16 females and 9 males between the ages of 21 and 47 years.

Below, the collected data are described and the results of the statistical analyses pertaining to the four research questions are set out.

<u>Testing the parametric assumptions</u>

This section tests the assumptions required for parametric tests and the next describes the identification and exclusion of the outlying points in the outliers section. The summary statistics are presented for each group and for each test in the summary statistics section, and serves as the foundation for the analysis of the correlations and comparison of means tests.

The assumptions required for the use of parametric statistics were normality of distribution, homogeneity of variance across groups (assessed with Levene's test), interval data and independence. Given the combined group size of N=50, the Kolmogorov-Smirnov test of normality was deemed

appropriate for assessing data distribution. The test of normality, while not definitive in and of itself, is a useful index of the normality of the distribution (Field, 2009). Decisions regarding the normality of the data were made using simple comparisons of the median and mean summary statistics and the Kolmogorov-Smirnov statistic. The attentional, anxiety and *fluid intelligence* scores for both the African and Caucasian groups were normally distributed ($p>.05$) (Table A in Appendix B).

A series of Levene's tests indicated that anxiety and attention scores met the assumption of equal variance between groups [$F(1,48)=0.37$, ns] [$F(1,48)=0.34$, ns]. *Fluid intelligence* scores indicated significantly different variances for the two groups ($p<.01$). Thus the homogeneity assumption was violated for *fluid intelligence*, however, all assumptions pertaining to correlations, multiple regression and MANOVA were met (Table B in Appendix B). Non-parametric analyses were deemed appropriate for use in correlations (Kendall's Tau) due to the small sample size. The correlation table (Table C in Appendix B) shows the correlation coefficients for the variables under study; coefficients were computed using Pearson Correlation as the data was normally distributed. *Fluid intelligence* was significantly correlated with attention ($p<.001$), as was anxiety ($p<.05$). Anxiety was not significantly correlated with attention ($p>.01$).

4.2 Summary statistics and outliers

Table D in Appendix B shows the summary statistics and sample sizes of the variables under study. Two outliers were identified in both groups. These individuals performed very well despite their trait anxiety scores being above 53; however, only scores that would have resulted in non-linearity were excluded from the analysis.

4.3 Core results

4.3.1 Research question 1: Are there racial differences in trait anxiety as reported by different groups?

The following results were obtained using MANOVA in an attempt to explore the model of *attentional resources*, *test anxiety* and *fluid intelligence*, and to explain the relationship between these variables for the two research groups.

Multivariate tests – investigating statistically significant differences amongst groups in a linear combination of the dependent variables:

Table 4.3: Differences in trait anxiety per group (ETH-Race)

Multivariate Tests[b]

Effect		Value	F	Hypothesis df(standard deviation)	Error df (standard deviation)	Sig.(significance)	Partial Eta Squared
Intercept	Pillai's Trace	.979	724.513[a]	3.000	46.000	.000	.979
	Wilks' Lambda	.021	724.513[a]	3.000	46.000	.000	.979
	Hotelling's Trace	47.251	724.513[a]	3.000	46.000	.000	.979
	Roy's Largest Root	47.251	724.513[a]	3.000	46.000	.000	.979
ETH (Race)	**Pillai's Trace**	**.578**	**20.975[a]**	**3.000**	**46.000**	**.000**	**.578**
	Wilks' Lambda	**.422**	**20.975[a]**	**3.000**	**46.000**	**.000**	**.578**
	Hotelling's Trace	**1.368**	**20.975[a]**	**3.000**	**46.000**	**.000**	**.578**
	Roy's Largest Root	**1.368**	**20.975[a]**	**3.000**	**46.000**	**.000**	**.578**

a. Exact statistic

b. Design: Intercept + ETH (Race)

Pillai's trace (due to small sample size)

.578 sig **(p=.000)**

Thus there is a statistical significance between the groups in terms of *fluid intelligence*, *attention* and *test anxiety* scores (see table 4.3).

Between-subjects effects – investigate if groups differ on all the dependent measures or just some:

Bonferroni adjustment

.05/3 (dependent variables) = 0.017

Table 4.4.: Differences on dependent measures of fluid intellligence, attention and trait anxiety

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	***Fluid intelligence* Score**	**47632.823[a]**	**1**	**47632.823**	**64.565**	**.000**	**.574**
	Attention scores	**24775.380[b]**	**1**	**24775.380**	**16.371**	**.000**	**.254**
	Trait anxiety (social evaluation)	**69.620[c]**	**1**	**69.620**	**.810**	**.373**	**.017**
Intercept	*Fluid intelligence* Score	613959.796	1	613959.796	832.205	.000	.945
	Attention scores	1614604.500	1	1614604.500	1066.873	.000	.957
	Trait anxiety (social evaluation)	125500.500	1	125500.500	1459.704	.000	.968
ETH (Race)	*Fluid intelligence* Score	47632.823	1	47632.823	64.565	.000	.574
	Attention scores	24775.380	1	24775.380	16.371	.000	.254
	Trait anxiety (social evaluation)	69.620	1	69.620	.810	.373	.017
Error	*Fluid intelligence* Score	35412.032	48	737.751			
	Attention scores	72643.120	48	1513.398			
	Trait anxiety (social evaluation)	4126.880	48	85.977			
Total	*Fluid intelligence* Score	697004.651	50				
	Attention scores	1712023.000	50				
	Trait anxiety (social evaluation)	129697.000	50				
Corrected Total	*Fluid intelligence* Score	83044.855	49				
	Attention scores	97418.500	49				
	Trait anxiety (social evaluation)	4196.500	49				

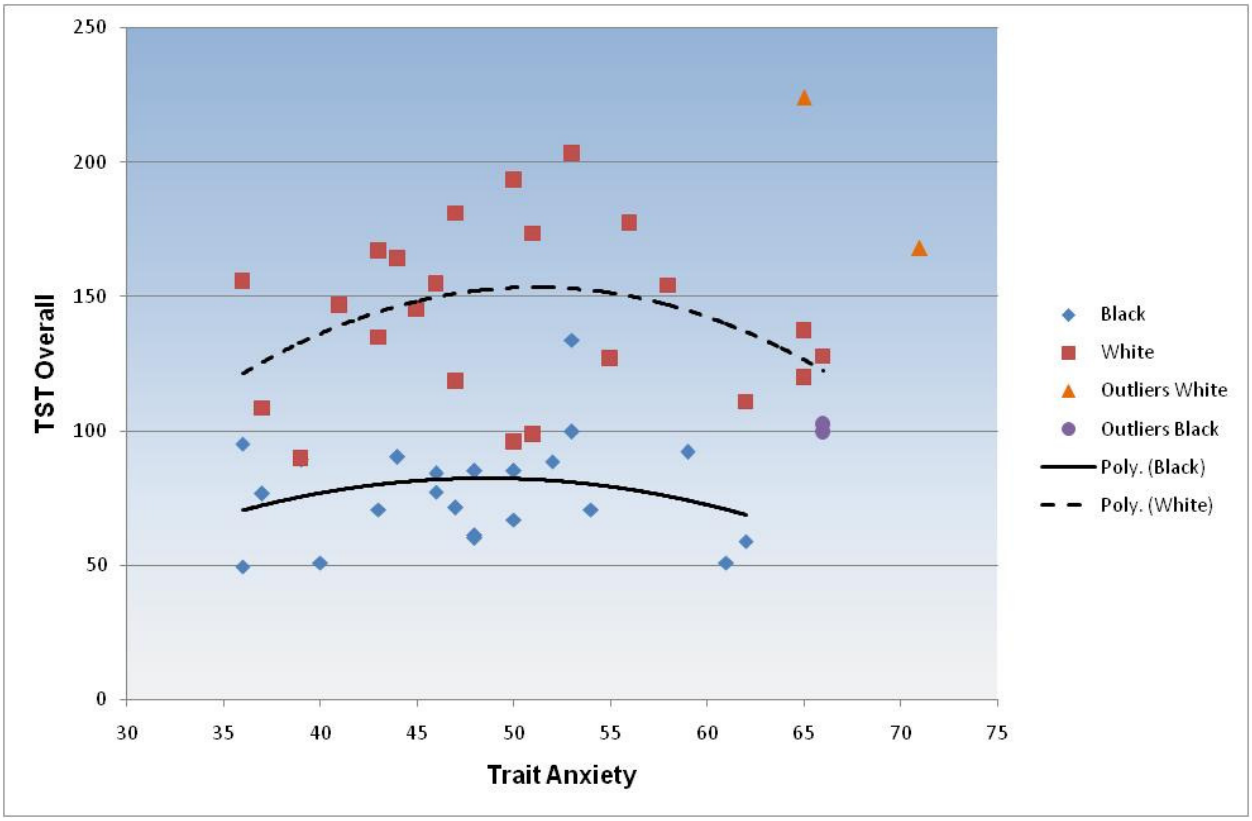
a. R Squared = .574 (Adjusted R Squared = .565)

b. R Squared = .254 (Adjusted R Squared = .239)

c. R Squared = .017 (Adjusted R Squared = -.004)

The only significant difference between groups is seen in *fluid intelligence* scores and attention. No significant differences were found on *test anxiety* scores as can be seen in the significance column in Table 4.4.

Figure 4.5: XY plot of TST overall score and trait anxiety split by race



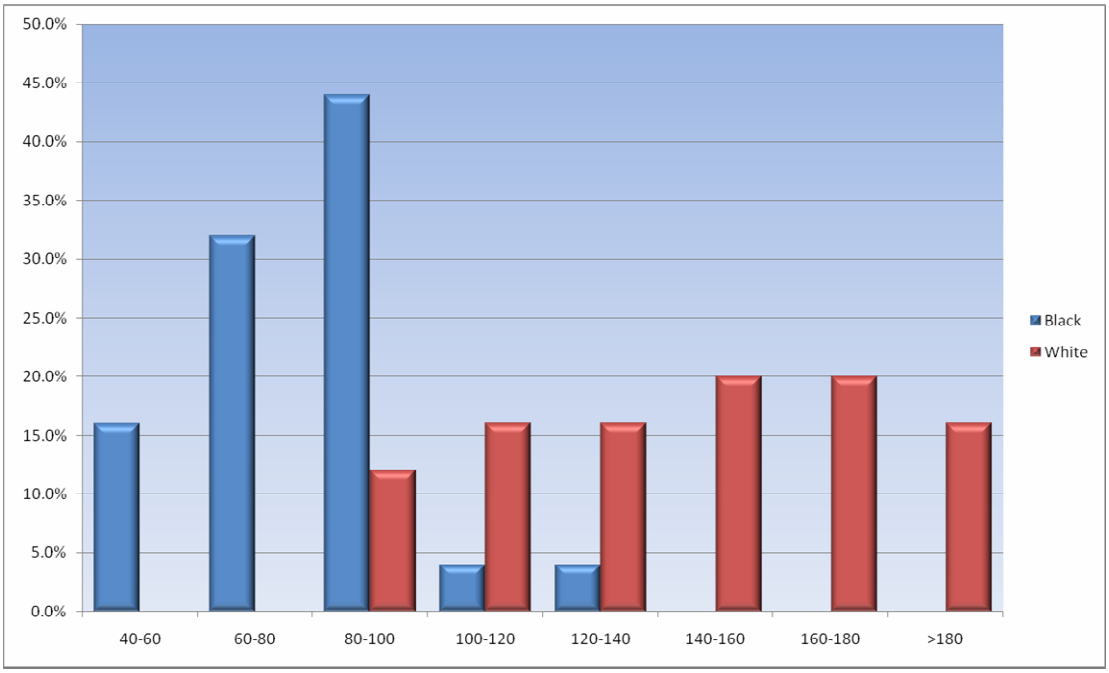
As can be seen in figure 4.5, both groups exhibit the same inverted U-shape movement. For each racial group on its own, the quatradic fit is much more significant than the linear fit, and this results in the inverted U shape shown in the graph. An independent-samples t-test was conducted to compare the trait anxiety scores for the two groups. There was no significant difference in scores for African (black) individuals (M=48.92, SD=8.92) and Caucasian (white) individuals [M=51.28, SD=9.61; t(48)=0.9, p=.37]. The magnitude of the differences in the means was very small (eta squared=0.02).

Using the TST overall score as the dependent variable and the *test anxiety* score and race as independent variables, a regression analysis (excluding the outliers) indicated that trait anxiety is weakly correlated with overall TST scores [.225].

When splitting the sample by race, the trait anxiety significant levels are 0.264 and 0.111 for Africans and Caucasians respectively, thus the trait anxiety has a lesser effect on TST overall performance for the African group. Hence, the MANOVA analysis and other results seem to indicate that there are no racial differences in trait anxiety for the different groups.

4.3.2 Research question 2: Does trait anxiety play a role in poor performance on the TST for different racial groups?

Figure 4.6: Overall distribution of TST overall scores by race



Overall performance on the TST split by race (figure 4.6) shows the highest score obtained by 4% of the African group to be 120-140. The majority of individuals within this group (44%) had a score ranging from 80-100. For 16% of the Caucasian group the highest score obtained was >180, with 40% having a score within the 140-180 range. The lowest score obtained by 12% of the Caucasian group (80-100) was the highest score obtained by the majority (44%) of the African group. Thus it is evident that the African group

scored considerably lower overall compared to the Caucasian group. The distribution shows that the Caucasian group has a larger spread, thus indicating a greater variance (1,206). The African group showed more similarity in its scores, peaking at between 80 and 100 (lower variance 384). The next research question to address is whether this difference in performance can be attributed to *test anxiety* for different groups.

Through the use of multiple linear regression, the second research question was investigated for both groups by using trait anxiety as the variable for the first model, followed by using both trait anxiety and attention in the second model. The dependent variable for both models was *fluid intelligence*.

Table 4.7: Hierarchical multiple regression - ANOVA

ANOVA[c]

Ethnicity (Race)	Model		Sum of Squares	df	Mean Square	F	Sig.
African (Black)	1	Regression	376.390	1	376.390	.978	.333[a]
		Residual	8849.197	23	384.748		
		Total	9225.587	24			
	2	Regression	2747.566	2	1373.783	4.666	.020[b]
		Residual	6478.021	22	294.455		
		Total	9225.587	24			
Caucsian (White)	1	Regression	1621.377	1	1621.377	1.518	.230[a]
		Residual	24565.068	23	1068.046		
		Total	26186.446	24			
	2	Regression	5954.587	2	2977.294	3.237	.059[b]
		Residual	20231.858	22	919.630		
		Total	26186.446	24			

a. Predictors: (Constant), Trait anxiety (social evaluation)

b. Predictors: (Constant), Trait anxiety (social evaluation), Attention scores

The initial model did not significantly improve the ability to predict the outcome variable (fluid intelligence); however, the new model (containing attention as

an extra predictor) shows significant values ($p<0.05$) in terms of predicting *fluid intelligence*, especially for the African group as can be seen in Table 4.7. The overall model's success in predicting *fluid intelligence* is described in the output below:

Table 4.8: Hierarchical multiple regression

Model Summary[c]

Ethnicity	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
						R Square Change	F Change	df1	df2	Sig. F Change	
African (Black)	1	.202[a]	**.041**	.000	19.615	.041	.978	1	23	.333	
	2	.546[b]	**.298**	.234	17.160	**.257**	8.053	1	22	.010	**2.515**
Caucasian (White)	1	.249[a]	**.062**	.021	32.681	**.062**	1.518	1	23	.230	
	2	.477[b]	**.227**	.157	30.325	**.165**	4.712	1	22	.041	**2.836**

a. Predictors: (Constant), Trait anxiety (social evaluation)

b. Predictors: (Constant), Trait anxiety (social evaluation), Attention scores

c. Dependent Variable: *Fluid intelligence* Score

<u>African Group (Group 1)</u>

(Refer to *table 4.8)*

Model 1: *Test anxiety* accounts for 4.1% of variance in *fluid intelligence*

Model 2: When other predictors are included it explains 29.8% of the variance in *fluid intelligence*. Thus attention accounts for 25.7% of variance in *fluid intelligence* (Durbin-Watson assumption was met (2.5) not larger than 3).

<u>Caucasian Group (Group 2)</u>

(Refer to *table 4.8)*

Model 1: *Test anxiety* accounts for 6.2% of variance in *fluid intelligence*.

Model 2: *Test anxiety* accounts for 22.7% of variance in *fluid intelligence*.

Thus attention explains 16.5% of variance in *fluid intelligence* (Durbin-Watson assumption was met (2.8) not larger than 3). Attention has a stronger relationship with changes in *fluid intelligence* scores than *test anxiety*.

In looking at the parameters of the second model for both groups, it was found that attention ($t(25)=2.8$, $p<0.05$) for the black group and white group ($t(25)=2.2$, $p<0.5$) is the significant predictor of *fluid intelligence* performance and not trait anxiety (Table E in Appendix B).

African Group

Step 1	**B**	**SE B**	**ß**
Constant	58.22	22.32	
Trait anxiety	0.44	0.45	0.20

Step 2	**B**	**SE B**	**ß**
Constant	26.49	22.50	
Trait anxiety	0.24	0.40	0.11
Attention	0.26	0.09	0.52*

** $p \leq 0.01$*

Note: R^2 =.04 for step 1, ΔR^2=.00 Not significant

Caucasian Group

Step 1	**B**	**SE B**	**ß**
Constant	97.84	36.17	
Trait anxiety	0.86	0.69	0.25

Step 2	**B**	**SE B**	**ß**
Constant	39.89	42.89	
Trait anxiety	0.63	0.65	0.18
Attention	0.34	0.16	0.41*

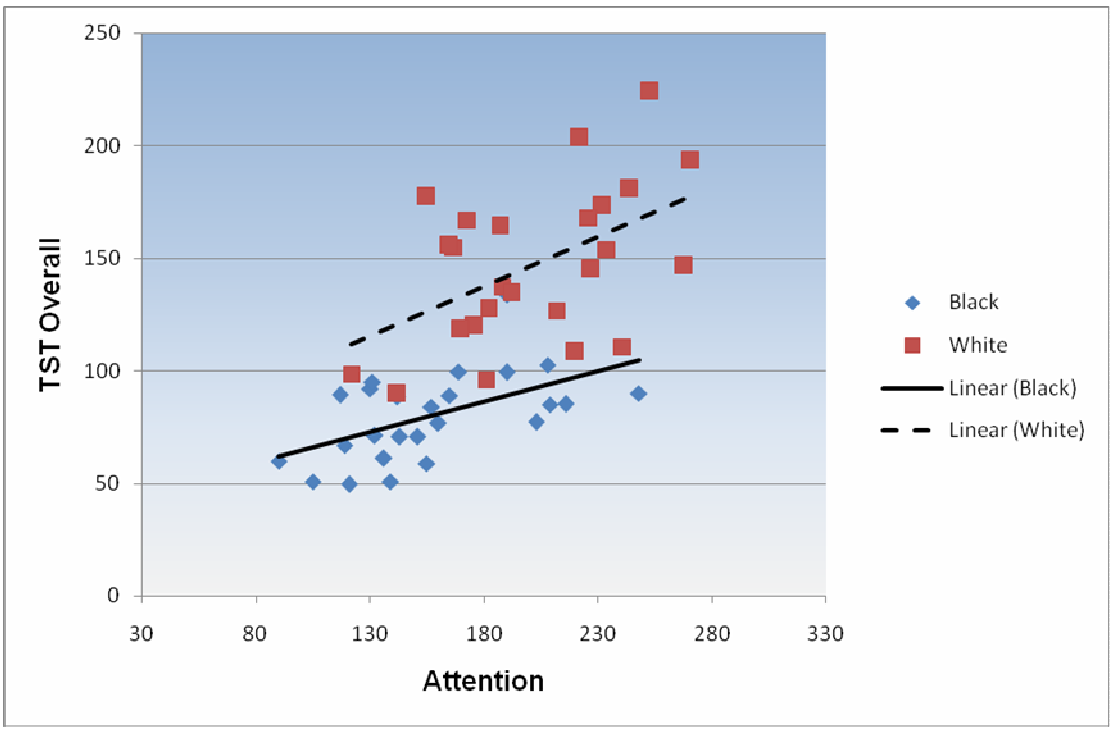
** $p<0.05$*

Note: R^2 =.06 for step 1, ΔR^2=.02 ($p<.05$)

Test anxiety is therefore not the main contributor to low overall TST performance for both groups.

4.3.3 Research question 3: What is the influence of attention on performance on the TST for the different groups?

Graph 4.9: XY plot of TST overall score and attention split by race



An independent-samples t-test compared attention scores between the two groups. A significant difference was found between the African (black) [M=157.44, SD=38.26] and Caucasian (white) groups [M=201.96, SD=39.54; t(48)=4.05, p=.000]. A total of 25% of the variance in attention can be explained by race (eta squared=.25). Overall, the African group was found to have lower overall attention, with the highest score being 248. The highest attention score achieved by the Caucasian group is 271. There is a positive relationship between the score obtained and attention, thus the higher the attention score the higher an individual's attention span is. A score of 271 indicates higher attention than a score of 248. The high correlation between attention and TST performance explains the low overall scores received on the TST for Group 1. The conclusion can be drawn that low attention scores account for low performance on the TST for both groups.

4.3.4 Research question 4: What is reflected by subtest scores obtained on the *fluid intelligence* measure between the groups?

Table 4.10: Distribution of minimum percentages received on TST sub-tests

Subtest	Percentage of African individuals	Percentage of Caucasian individuals	Grand total
NSA_adj	8.00%	0.00%	4.00%
SV_adj	44.00%	24.00%	34.00%
REA_adj	40.00%	72.00%	56.00%
WM_adj	8.00%	4.00%	6.00%
Grand Total	**100.00%**	**100.00%**	**100.00%**

Overall, individuals obtained the lowest scores for the Reasoning (REA) (56%) and Spatial Visualisation (SV) (34%) subtests. These subtests thus contribute to low TST scores for both groups. The African group showed the poorest performance on Spatial Visualisation (SV) (44%), followed by Reasoning (REA) (40%). Problematic subtests in terms of the Caucasian group also included Reasoning (REA) (72%) and Spatial Visualisation (SV) (24%). Number, Speed and Accuracy (NSA) as well as Working Memory (WM) have an equal percentage of low performers (8%) in the African group, while 4% of the Caucasian group obtained low scores on the Working Memory (WM) test. Spatial Visualisation (SV) and Reasoning (REA) scores detracted most from the overall TST score.

According to literature, *attentional resources* and reasoning ability are closely related as both aspects are part of working memory. Working memory capacity or executive attention is reflected in abstract reasoning tasks (Engle, 2002), meaning that decreased attention results in lower reasoning scores. It can be speculated when seen in conjunction with the above results and literature that the reason for the poor performance on the Reasoning subtest could be due to individuals having low attention.

CHAPTER 5: DISCUSSION

The researcher aimed to investigate the model forming the base for the problem statement, which includes *fluid intelligence*, *attentional resources* and *test anxiety*. The model's explanation of the relationship between the variables is that an increase in *test anxiety* will result in a decrease in *attentional resources* and *fluid intelligence* (as proved by Meijer, 2001). Decreased *attentional resources*, it was hypothesised, would have a negative influence on *fluid intelligence* scores and test performance. The research also aimed to explain if African racial groups experience higher *test anxiety* (trait anxiety) levels than Caucasian individuals, resulting in poor overall *fluid intelligence* and therefore poor TST scores.

The following research questions were addressed:

- Are there racial differences in trait anxiety as reported by different groups?
- Does trait anxiety play a role in poor performance on the TST for different racial groups?
- What is the influence of attention on performance on the TST for the different groups?
- What is reflected by subtest scores obtained on the *fluid intelligence* measure between groups?

The first research question was answered using MANOVA; the second was answered using multiple linear regression, and the third and fourth questions using t-tests and comparisons of means.

The research questions and the implications of their results will be interpreted individually, in the same order as mentioned throughout the study. Relationships were classified as significant if values were $p<.05$ or $p<.01$.

In terms of demographics, the sample was made up of two groups. The first group consisted of African individuals, while the second group contained Caucasian individuals. Both groups had high enough English language

abilities to complete the assessments sucessfully and similar educational levels as proven by scores obtained on the LACS English ability test and self-reported tertiary qualifications. The two groups did not differ in terms of gender (although there were only 14 males in the total number of individuals measured).

Are there racial differences in trait anxiety as reported by different groups and does trait anxiety play a role in poor performance on the TST for these groups?

Trait anxiety significant levels were 0.264 and 0.111 for African and Caucasian groups respectively, after splitting the sample by race (as measured by EMAS-T), thus the trait anxiety had a lesser effect on TST performance for the African group and did not have a significant effect on TST performance overall. These results suggest that *test anxiety* (trait anxiety) is not the main contributor to low overall TST (*fluid intelligence*) scores in these two groups. In support of these findings, it can be mentioned that research done by Herrnstein and Murray (1994) also found that differences in *test anxiety* for African and Caucasian groups showed either insignificant results or showed that Caucasian respondents were slightly more anxious than African respondents. Therefore, *test anxiety* (trait anxiety) is found not to be the key factor contributing to performance differences between the groups, contrary to the researcher's initial hypothesis.

However, *attentional resources*, measured by the D2 Test of Attention, were found to have significant influences on overall TST performance; this variable will be discussed in the following section.

What is the influence of attention on performance on the TST for the different groups?

Attention ($t(25)=2.8$, $p<0.05$) for the African group and ($t(25)=2.2$, $p<0.5$) for the Caucasian group was found to be a significant predictor of overall *fluid*

intelligence performance. A significant difference was found between the African [M=157.44, SD=38.26] and Caucasian groups [M=201.96, SD=39.54; t(48)=4.05, p=.000] on attention scores. Overall, the African group was found to have lower overall attention with the highest score being 248. The highest attention score received by the Caucasian group was 271. Results also indicate that 25% of the variance in attention can be explained by race (eta squared=.25).

The construct controlled attention has a strong relationship with the construct general *fluid intelligence* (Miyake & Shah, 1999). People who differ on tasks of working memory, which encompasses *fluid intelligence*, show systematic differences in other controlled attention measures (Miyake & Shah, 1999).

Previous research showed that African individuals are more susceptible to boredom compared to Western individuals. Boredom relates to the psychological aspects of attention, arousal and information processing, and suggests a lack of stimulation. Boredom occurs in situations in which people perceive their capabilities to be greater than the situational opportunities, while anxiety comes in when individuals perceive the demands of the situation to be greater than their ability to perform (Csikszentmihalyi, 1975). This could be a reason for lower scores when interpreted according to the Yerkes-Dodson model. As previously discussed, the law states that an inverted U-shaped relationship exists between performance and the level of arousal (Yerkes & Dodson 1908), and that high arousal (anxiety) causes a narrowing of the field of attention (Baddeley, 2007), while low arousal due to boredom can result in poor performance. According to the literature, there are individual differences in people's attentional abilities (Miyake & Shah, 1999), but no extensive research has been done to investigate whether or not this is consistent for different racial groups. This issue clearly needs to be explored in future research.

What is reflected by subtest scores obtained on the *fluid intelligence* measure between groups?

Overall, the lowest scores for both groups were obtained for the Reasoning (REA) and Spatial Visualisation (SV) subtests. Group 1 obtained the poorest scores on Spatial Visualisation (SV), followed by Reasoning (REA). Group 2 showed the poorest performance on the Reasoning (REA) and Spatial Visualisation (SV) subtests.

Gender, however, related strongly to the Spatial Visualisation subtest with males tending to score better on this subtest than females (Ben-Chaim, Lappan & Houang, 1988), and males also performed better on the Reasoning subtest.

Colom, Contreras, Botella, and Santacreu (2002) have demonstrated that a test of reasoning based on linear syllogisms or a three-term series (John is better than Peter : Peter is better than Paul : Who is worse?), the same as is found in the TST, requires mental transformation of the verbal information into a mental spatial diagram or a mental model (Sternberg, 2000). Thus, the demonstrated male advantage in overall spatial processing provides a possible reason for their better performance in verbal reasoning tests. The fact that spatial visualisation and reasoning are low within both groups could be due to the fact that there were more female participants in the sample. Given the small ratio of males to females in this sample, further research should be done before any conclusions regarding gender differences can be drawn.

The findings presented above are sufficient to answer the research questions. There was a weak relationship between *test anxiety* for the different groups and its influence on overall TST performance (*fluid intelligence* scores). The analysis implies that *attentional resources* constitute the main predictor of overall *fluid intelligence* scores, and that these scores were lower for Group 1 than Group 2. Further research is required to test whether the relationship

between attention for different racial groups and test performance translates into a significant difference. This issue is worthy of further investigation, because it may contribute to an enhanced understanding of why certain racial groups perform poorly on measures of *fluid intelligence*. Hence, even though the main hypothesis put forward in this study did not find support in the data, these research findings are still valuable in terms of the implications they have for further research.

5.1 Contribution to knowledge

The current study has paved the way for researchers to address a gap in the literature. The *fluid intelligence*, *attentional resources* and *test anxiety* model involves different variables that impact on *fluid intelligence* scores. The first step in addressing this was to examine the relationships between the variables of interest, while the second was to determine if relationships between these variables and *fluid intelligence* scores exist. Relationships directly of interest to the research questions were identified: a weak relationship was found to exist between *test anxiety* and *fluid intelligence* scores for the different racial groups and it was also found that attention was the main predictor of overall *fluid intelligence* scores. Only the latter relationship translated into statistically significant results. There is sufficient evidence in the current study to show that attention plays a significant role in the performance on measures of *fluid intelligence*, and that African individuals score lower on overall attention measures compared to Caucasian groups. Further research (in a larger sample, with greater power) is implicated, particularly in terms of attention scores for the different groups.

This research was mainly exploratory in nature, and was therefore not intended to prove a point conclusively, but rather to guide future investigation in the area. The latter goal was achieved by investigating the relationships between *test anxiety*, attention, *fluid intelligence* and race. The study investigated the issue of whether or not there is a difference in *fluid intelligence* (TST scores) between different racial groups. The inference made, and tested, here is that the difference does not lie within *test anxiety* as

was assumed, but in *attentional resources* between the groups. However, it should be remembered that human beings consist of a multitude of factors, emotions and cognitive abilities. It is therefore impossible for one research study to examine all the variables that play a role in test performance outcomes. There might be other factors that contribute to low scores in *fluid intelligence* measures that lie outside the variables studied here.

Other problems which may have affected the output of the research include the small sample size and resulting moderate power of the statistics which have been noted as a limitation throughout; the use of self-report data in the EMAS-T; and possibly the interaction between the participants and the researcher which may have affected how participants perceived the testing situation. Furthermore, extensive research in a larger sample with test administrators from different races (perhaps making use of a test-retest methodology) may address these issues.

The expectations which emerged from the literature were as follows: African individuals were expected to perceive testing situations as anxiety provoking due to previous experiences and thoughts regarding their performance as discussed in the literature review. *Test anxiety* would then have been the main contributor to low *attentional resources*. Respondents (in this research study) from Group 1 did not experience high levels of *test anxiety* in the testing situation. *Test anxiety* for Group 1 was much lower than for Group 2; however, attention did come to the fore as an explanation for differences in scores which shows that a difference between the groups does indeed exist.

5.2 Directions for future research

The significant relationship between attention and overall *fluid intelligence* scores may be of interest in future studies. Individuals from Group 1 had overall lower attention within the testing situation, which could be attributed to lower motivation to do well, boredom or even fatigue if we take into account that the groups were measured late in the afternoon after individuals had returned from work. However, reasons for this should be explored through

further research. This research may investigate which factors contribute to low attention for this specific cultural group, and if susceptibility to boredom may have an influence on performance.

5.3 Conclusion

The first research question regarding the existence of a relationship between *test anxiety* and poor performance on the TST test (*fluid intelligence* test) for different racial groups found that no significant relationship exists between the individuals' *test anxiety* levels and their *fluid intelligence* scores. There was, however, a significant relationship between attention scores and *fluid intelligence* test performance, as well as differences between racial groups on this variable. Further research into these relationships will be of value.

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Appendix A: Informed consent form

Informed consent.

The research results will only be available to individuals directly involved with the study. Results will only be used for research purposes.

I have read the above information and have a clear understanding thereof.

I agree with all statements made.

By signing this contract I consent to participate (voluntarily) in the research study.

Participant's name and surname: _____

Participant's signature: _____

Date: _____

Researcher's name and surname: _____

Researcher's signature: _____

Date: _____

Appendix B: Data analysis tables

Table A: Assumption of normality

Test for normality - attention (Kolmogorov-Smitnov)

Descriptives

	Race			Statistic	Std. Error
Attention scores	African (Black)	Mean		157.44	7.651
		95% Confidence Interval for Mean	Lower Bound	141.65	
			Upper Bound	173.23	
		5% Trimmed Mean		155.90	
		Median		151.00	
		Variance		1463.423	
		Std. Deviation		38.255	
		Minimum		100	
		Maximum		248	
		Range		148	
		Interquartile Range		60	
		Skewness		.640	.464
		Kurtosis		-.262	.902
	Caucasian (White)	Mean		201.96	7.908
		95% Confidence Interval for Mean	Lower Bound	185.64	
			Upper Bound	218.28	
		5% Trimmed Mean		202.42	
		Median		192.00	
		Variance		1563.373	
		Std. Deviation		39.540	
		Minimum		122	
		Maximum		270	
		Range		148	
		Interquartile Range		62	
		Skewness		-.035	.464
		Kurtosis		-.782	.902

Test for normality - fluid intelligence (Kolmogorov-Smitnov)

Fluid intelligence Score	African (Black)	Mean		79.95	3.921
		95% Confidence Interval for Mean	Lower Bound	71.85	
			Upper Bound	88.04	
		5% Trimmed Mean		78.98	
		Median		84.08	
		Variance		384.399	
		Std. Deviation		19.606	
		Minimum		50	
		Maximum		134	
		Range		84	
		Interquartile Range		27	
		Skewness		.515	.464
		Kurtosis		.880	.902
	Caucasian (White)	Mean		141.68	6.606
		95% Confidence Interval for Mean	Lower Bound	128.04	
			Upper Bound	155.31	
		5% Trimmed Mean		141.10	
		Median		137.33	
		Variance		1091.102	
		Std. Deviation		33.032	
		Minimum		90	
		Maximum		203	
		Range		114	
		Interquartile Range		54	
		Skewness		.302	.464
		Kurtosis		-.889	.902

Test for normality - trait anxiety (Kolmogorov-Smitnov)

Trait anxiety (social evaluation)	African (Black)	Mean		48.92	1.783
		95% Confidence Interval for Mean	Lower Bound	45.24	
			Upper Bound	52.60	
		5% Trimmed Mean		48.69	
		Median		48.00	
		Variance		79.493	
		Std. Deviation		8.916	
		Minimum		36	
		Maximum		66	
		Range		30	
		Interquartile Range		12	
		Skewness		.398	.464
		Kurtosis		-.569	.902
	Caucasian (White)	Mean		51.28	1.923
		95% Confidence Interval for Mean	Lower Bound	47.31	
			Upper Bound	55.25	
		5% Trimmed Mean		51.26	
		Median		50.00	
		Variance		92.460	
		Std. Deviation		9.616	
		Minimum		36	
		Maximum		67	
		Range		31	
		Interquartile Range		17	
		Skewness		.256	.464
		Kurtosis		-1.064	.902

Test for normality overall (Kolmogorov-Smitnov)

Tests of normality

	Race	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Attention scores	African (Black)	.127	25	.200*	.950	25	.248
	Caucasian (White)	.119	25	.200*	.970	25	.640
Fluid intelligence score	African	.103	25	.200*	.951	25	.260
	Caucasian	.105	25	.200*	.961	25	.430
Trait anxiety (social evaluation)	African	.101	25	.200*	.950	25	.250
	Caucasian	.123	25	.200*	.940	25	.150

a. Lilliefors Significance Correction

* This is a lower bound of the true significance

Table B: Assumption of homogeneity of variance

Homogeneity of variance – Levene's test

Test of homogeneity of variance

		Levene Statistic	df1	df2	Sig.
Trait anxiety (social evaluation)	Based on Mean	.374	1	48	.544
	Based on Median	.349	1	48	.557
	Based on Median and with adjusted df	.349	1	47.998	.557
	Based on trimmed mean	.389	1	48	.536
Attention scores	Based on Mean	.335	1	48	.566
	Based on Median	.283	1	48	.597
	Based on Median and with adjusted df	.283	1	47.793	.597
	Based on trimmed mean	.377	1	48	.542
Fluid intelligence Score	Based on Mean	8.842	1	48	.005
	Based on Median	7.841	1	48	.007
	Based on Median and with adjusted df	7.841	1	42.866	.008

Test of homogeneity of variance

		Levene Statistic	df1	df2	Sig.
Trait anxiety (social evaluation)	Based on Mean	.374	1	48	.544
	Based on Median	.349	1	48	.557
	Based on Median and with adjusted df	.349	1	47.998	.557
	Based on trimmed mean	.389	1	48	.536
Attention scores	Based on Mean	.335	1	48	.566
	Based on Median	.283	1	48	.597
	Based on Median and with adjusted df	.283	1	47.793	.597
	Based on trimmed mean	.377	1	48	.542
	Based on Mean	8.842	1	48	.005
	Based on Median	7.841	1	48	.007
	Based on Median and with adjusted df	7.841	1	42.866	.008
	Based on trimmed mean	8.723	1	48	.005

In terms of trait anxiety, the variances were equal for the African and Caucasian groups:

$F(1,48) = 0.37$, ns

For attention, the variances were equal for the two groups:

$F(1,48) = 0.34$, ns

Fluid intelligence showed significantly different variances between the two groups:

$F(1,48) = 8.84$, $p<.01$

Thus, the homogeneity assumption has been violated for *fluid intelligence*, however, all assumptions pertaining to correlations and multiple regression have been met.

Table C: Analysis - bi-variate correlation

Kendall's Tau – non-parametric

Correlations

			Attention scores	*Fluid intelligence* Score	Trait anxiety (social evaluation)
Kendall's tau_b	Attention scores	Correlation Coefficient	1.000	.479**	.158
		Sig. (1-tailed)	.	.000	.056
		N	50	50	50
	Fluid intelligence score	Correlation Coefficient	.479**	1.000	.168*
		Sig. (1-tailed)	.000	.	.045
		N	50	50	50
	Trait anxiety (social evaluation)	Correlation Coefficient	.158	.168*	1.000
		Sig. (1-tailed)	.056	.045	.
		N	50	50	50

* Correlation is significant at the 0.05 level (1-tailed)

** Correlation is significant at the 0.01 level (1-tailed)

Pearson correlation – attention and fluid intelligence

Correlations

Race			Attention scores	Fluid intelligence scores
African (Black)	Attention scores	Pearson Correlation	1	.535**
		Sig. (1-tailed)		.003
		N	25	25
	Fluid intelligence score	Pearson Correlation	.535**	1
		Sig. (1-tailed)	.003	
		N	25	25
Caucasian (White)	Attention scores	Pearson Correlation	1	.441*
		Sig. (1-tailed)		.014
		N	25	25
	Fluid intelligence score	Pearson Correlation	.441*	1
		Sig. (1-tailed)	.014	
		N	25	25

** Correlation is significant at the 0.01 level (1-tailed)

* Correlation is significant at the 0.05 level (1-tailed)

Pearson correlation – trait anxiety and fluid intelligence

Correlations

Race			Trait anxiety (social evaluation)	Fluid intelligence score
African (Black)	Trait anxiety (social evaluation)	Pearson Correlation	1	.202
		Sig. (1-tailed)		.166
		N	25	25
	Fluid intelligence score	Pearson Correlation	.202	1
		Sig. (1-tailed)	.166	
		N	25	25
Caucasian (White)	Trait anxiety (social evaluation)	Pearson Correlation	1	.249
		Sig. (1-tailed)		.115
		N	25	25

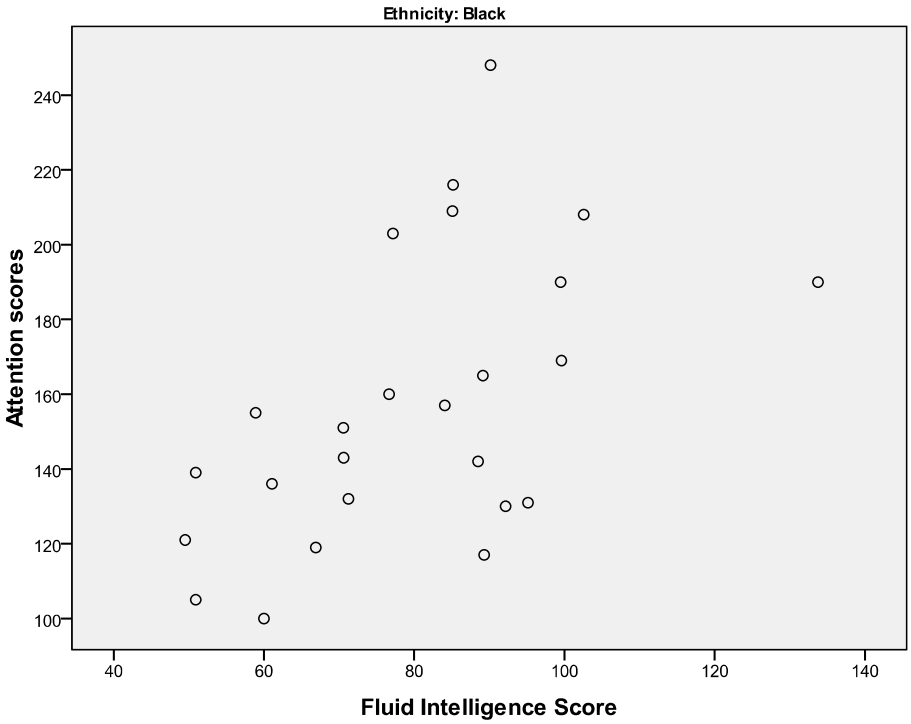
	Fluid intelligence score	Pearson Correlation	.249	1
		Sig. (1-tailed)	.115	
		N	25	25

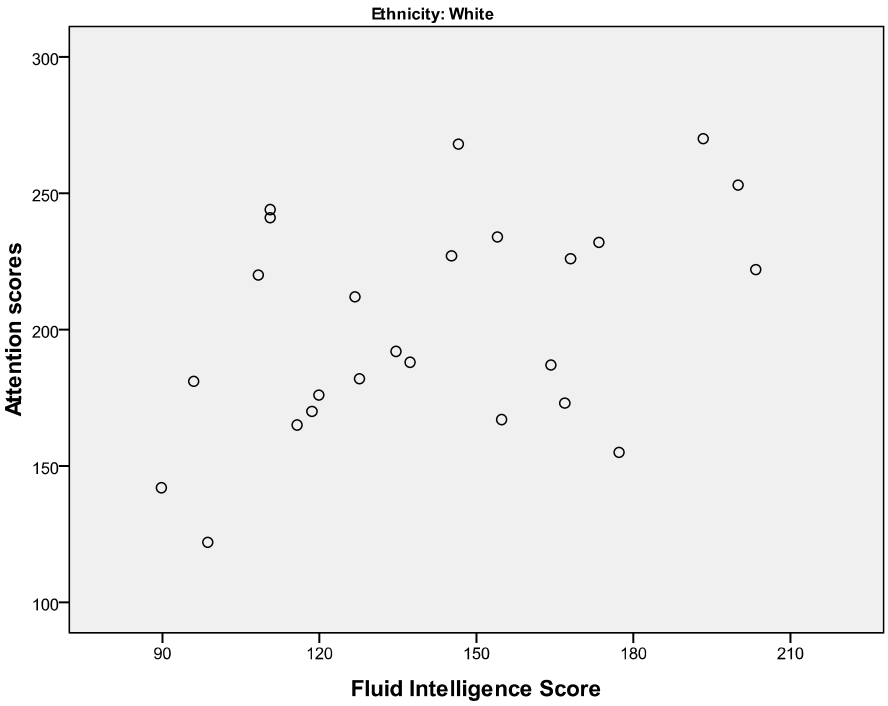
Correlations

Race			Trait anxiety (social evaluation)	Attention scores
African	Trait anxiety (social evaluation)	Pearson Correlation	1	.178
		Sig. (1-tailed)		.198
		N	25	25
	Attention scores	Pearson Correlation	.178	1
		Sig. (1-tailed)	.198	
		N	25	25
Caucasian	Trait anxiety (social evaluation)	Pearson Correlation	1	.159
		Sig. (1-tailed)		.223
		N	25	25
	Attention scores	Pearson Correlation	.159	1
		Sig. (1-tailed)	.223	
		N	25	25

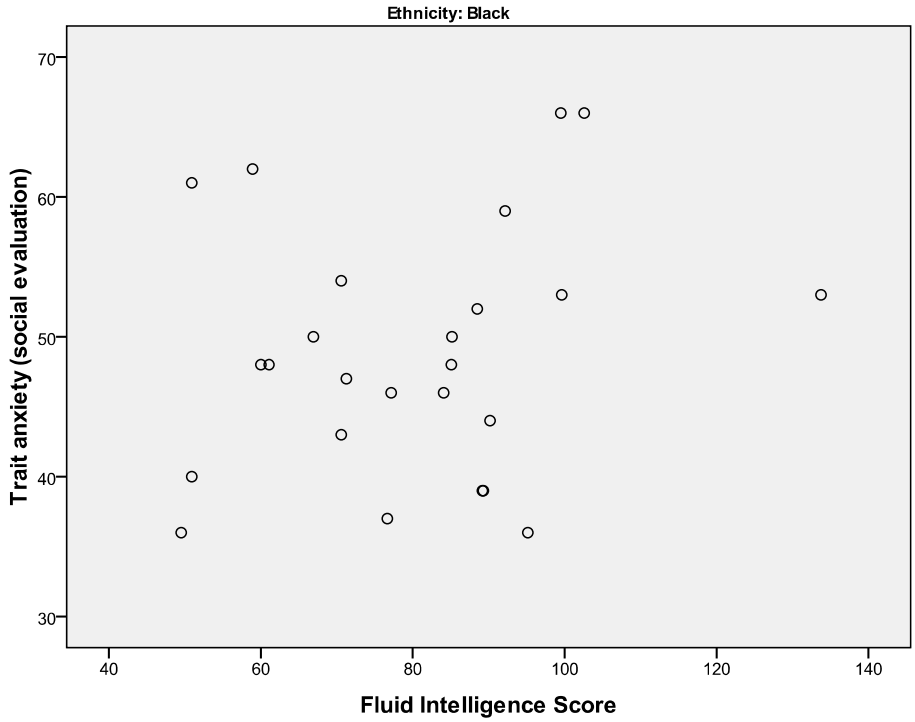
Table D: Assumption of linearity

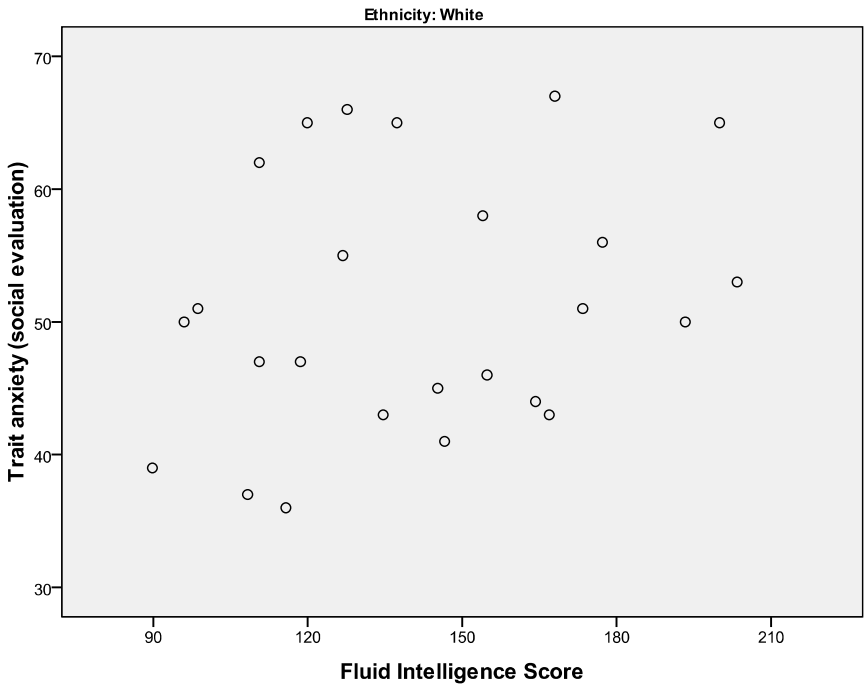
Scatterplot: fluid intelligence and attention





Scatterplot: fluid intelligence and test anxiety





Scatterplots do not show non-linearity.

Table E: Hierarchical multiple regression coefficients

Coefficients[a]

Race	Model		Unstandardised coefficients		Standardised coefficients	t	Sig.	95.0% Confidence interval for B		Correlations			Co-linearity statistics	
			B	Std. error	Beta			Lower bound	Upper bound	Zero-order	Partial	Part	Tolerance	VIF
African	1	(Constant)	58.218	22.316		2.609	.016	12.053	104.382					
		Trait anxiety (social evaluation)	.444	.449	.202	.989	.333	-.485	1.373	.202	.202	.202	1.000	1.000
	2	(Constant)	26.492	22.497		1.178	.252	-20.165	73.149					
		Trait anxiety (social evaluation)	.243	.399	.110	.609	.549	-.585	1.071	.202	.129	.109	.968	1.033
		Attention scores	.264	.093	.515	2.838	.010	.071	.457	.535	.518	.507	.968	1.033
Caucasian	1	(Constant)	97.843	36.172		2.705	.013	23.016	172.670					
		Trait anxiety (social evaluation)	.855	.694	.249	1.232	.230	-.580	2.290	.249	.249	.249	1.000	1.000
	2	(Constant)	39.890	42.888		.930	.362	-49.054	128.834					
		Trait anxiety (social evaluation)	.629	.652	.183	.965	.345	-.723	1.982	.249	.201	.181	.975	1.026
		Attention scores	.344	.159	.412	2.171	.041	.015	.673	.441	.420	.407	.975	1.026

a. Dependent variable: fluid intelligence score