THE EFFECT OF QUALITY OF EDUCATION ON NEUROPSYCHOLOGICAL TEST PERFORMANCE

By

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DECLARATION

I hereby declare that *The Effect of Quality of Education on Neuropsychological Test Performance* is my own work and that all resources used or quoted have been indicated and acknowledged by means of complete references

Signature

(Ms. Jeanie Cavé)

Date

This dissertation is dedicated to Ronald and Linda Cavé in thanks for their unwavering support and encouragement.

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ABSTRACT

Neuropsychologists are becoming increasingly aware that there is a complex interplay of cognitive, personality, and sociocultural factors that affect an individual's performance on neuropsychological tests. The current study investigated the effect of one aspect of the sociocultural environment, that is, quality of education, on performance on neuropsychological tests of executive function. The sample included 40 high school learners: Group A comprised learners with a high quality of education and Group B comprised learners with a low quality of education. Four tests of executive function were administered: the Verbal Fluency Test, the Design Fluency Test, the Stroop Test and the Wisconsin Card Sorting Test. Results indicated that quality of education significantly affected the participants' performance with Group A performing significantly better than Group B on all the tests of executive function. These findings have implications for the interpretation of neuropsychological test performance in cross-cultural research and practice.

Key Words: Neuropsychology; assessment; norm-referenced testing, norms, quality of education; cross-cultural neuropsychology; executive function; Verbal Fluency Test; Design Fluency Test; Stroop Test; Wisconsin Card Sorting Test.

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Chapter 1
Introduction

1.1 Neuropsychological assessment

Neuropsychology is the branch of psychology that explores the relationship between brain functioning and behaviour (Cohen & Swerdlik, 2002). It is the role of the neuropsychologist to assess individuals in order to draw inferences about the structural and functional characteristics of a person's brain. Since the 1990's, neuropsychology has gained institutional acceptance as a neuroscience and professional discipline and a major responsibility of the neuropsychologist is to conduct assessment (Perez-Arce, 1999). Neuropsychological assessment has grown from being used only for diagnostic purposes in the clinical setting to being an integral part of treatment evaluation and a major source of contribution to research in the field of neuroscience (Anderson, 2001).

According to Vanderploeg (2000), neuropsychological assessment has the following main aims: to aid in diagnosis by identifying the presence and type of neurological condition, discriminating between possible differential diagnoses, and providing neuroanatomical correlates of signs and symptoms, when other diagnostic examinations have failed or their results are ambiguous; to differentiate between brain disease or injury and other factors as causes of cognitive impairment, such as depression; to evaluate deficits and preserved functions in patients with neurological diseases or injury and to provide a description of an individual's cognitive, emotional, and psychological strengths and weaknesses; to assist in the planning of treatment, such as vocational planning, educational planning, and planning rehabilitation strategies, to evaluate scholastic problems or developmental delays in children, such as to differentiate between mental retardation, emotional problems and specific learning difficulties; to assist in forensic issues, such as disability and personal injury determination and competency evaluation; and to provide objective data for research that will increase knowledge and understanding of human neuropsychology.

A neuropsychological assessment does not comprise only of the administration of a test (Anderson, 2001). Test scores are only meaningful when compared with other test scores, with academic or occupational accomplishments, with medical history, with the reason for referral, and with the patient's behaviour during the assessment. Interpretation of the assessment extends beyond the cognitive evaluation of the patient (Lezak, 1995). Both quantitative (test data) and qualitative (background and behavioural data) are important in the process of neuropsychological assessment, and "each is incomplete without the other" (Lezak, 1995, p 151). The data obtained from testing provides a framework for integrating, interpreting, and understanding the other information used to compile a neuropsychological profile of a patient. Neuropsychological tests are a core component of the assessment process as they are thought to represent a scientific, systematic, and reliable method for obtaining a clinical picture of an individual's level of cognitive functioning (Vanderploeg, 2000). The growth of the field of neuropsychological assessment can be attributed to the recognised accuracy of neuropsychological tests in the evaluation of cognitive strengths and weaknesses in patients (Anderson, 2001). Neuropsychological tests form an integral part of the assessment process as they are relatively and uniquely sensitive to different patterns of impairment that are associated with different disorders and damage to different areas of the brain (Anderson, 2001).

Appropriate clinical decisions by neuropsychologists cannot be made on the basis of test scores alone (Mitrushina, Boone & D'Elia, 1999). However, in the South African context, clinicians often rely only on the narrow interpretation of test scores when making neurological diagnoses (Anderson, 2001). This problem is further compounded by the lack of representative, demographically-adjusted norms suitable for South African populations.

1.2 Norm-referenced testing

Most of the tests used in neuropsychological assessment are norm-referenced tests. This means that the raw scores obtained during the test are interpreted by comparing the individual's score to scores of a group of testtakers (Cohen & Swerdlik, 2002). Therefore, the individual's performance is only understood relative to scores obtained on the same test by a relevant population. The individual's raw score, therefore, is essentially meaningless. Meaning is only found by comparing the score to those of a norm group. Norms are established by administering a particular test to a defined, representative sample of testtakers in a process called standardisation. The range of performances is plotted on the normal curve, and norms are calculated based on this range (Cohen & Swerdlik, 2002).

An understanding of norm-referenced testing clearly indicates that the evaluation of a person's performance is dependant on a comparison with a norm group. If the assessment is to yield valid and meaningful information, it is crucial that the particular person is compared to an appropriate norm group (Anderson, 2001). The interpretive validity of neuropsychological test results can be maximised through the development and use of demographically-specific norms (Anderson, 2001). Further, the criteria that define norm groups need to be researched in order to facilitate fair testing. That is to say, it needs to be understood which factors, other than cognitive ability, most greatly affect performance on neuropsychological tests, so that norms can be developed based on these factors. Nell (2000) writes that good norms are few and far between, as methodological errors, and especially cultural bias, may render them meaningless.

Nell (2000) asserts that this is a dangerous situation, as clinicians who are 'armed' with norms presented in test manuals feel infallible, and use the norms blindly to make prognostic, diagnostic, and treatment decisions. Norms, according to Nell (2000), need to take into account cultural and demographic factors that affect neuropsychological test performance if data from tests are to be at all meaningful to neuropsychologists.

Thus, neuropsychological assessment is not a one-size-fits-all practice (Lamberty, 2002). Neuropsychologists are becoming increasingly aware that there is a complex interplay of cognitive, personality, and sociocultural factors that affect an individual's performance on neuropsychological tests (Bedel, Van Eeden & Van Staden, 1999; Brickman, Cabo & Manley, 2006; Greenfield, 1997; Nell, 2000).

Neuropsychologists, especially in South Africa, are often thrust into practice fields where they need to assess members of diverse cultures. South Africa has a widely diverse population, with eleven official languages, many ethnicities, and differential access to resources and opportunities, such as educational facilities. Therefore, it is crucial that neuropsychologists in South Africa should be able to carry out assessments and analyse results in a culturally competent manner. This means understanding the dynamic interplay of biology and socio-cultural environment in affecting cognitive abilities and, most importantly, being able to interpret test scores in context.

Neuropsychology plays a crucial role in the assessment, diagnosis and rehabilitation of individuals with compromised brain functioning and allows them access to resources. Therefore, it is crucial that the norms used by clinical neuropsychologists in South Africa should be appropriate to the South African context. Further, clinical psychologists in South Africa need to be aware of other factors that affect performance on psychological tests and the appropriateness of the tests that they are using, so that they are competent to work with people from diverse cultural groups and able to make valid interpretations about the cognitive functioning of these individuals.

A focus on culture fair assessment in the field of neuropsychology has resulted in much research being done to investigate factors, other than cognitive ability, that might affect performance on neuropsychological tests. Education is now considered to be one of the most influential of these factors (Acevedo, Loewenstein, Agrón, & Duara, 2007; Bedel, Van Eeden & Van Staden, 1999; Dick, Teng, Kempler, Davis & Taussig, 2002; Gasquoine, 1999; Gomez-Perez & Ostrosky-Solis, 2006; Lamberty, 2002; Beatty, Gonstovsky &

Mold, 2003; Manley & Echemendia, 2007; Nell, 2000; Ostrosky-Solis, & Lazano, 2006; Ostrosky-Solis, 2004; Reitan, & Wolfson, 2004; Rosselli & Ardila, 2003; Shuttleworth-Edwards, Kemp, Rust, Muirhead, Hartman & Radloff, 2004; Skuy, Schutte, Fridjhon & O'Carrol, 2001; Unverzagt et al., 1996).

Some researchers have investigated the effect of level of education in years on neuropsychological test performance and found it to be highly influential (Dick et al., 2002; Manley, Byrd, Tourdaji, & Stern 2004; Ostrosky-Solis, Ramírez & Ardila, 2004a; Ostrosky-Solis, Ramírez, Lozano, Picasso & Velez, 2004b). However, other researchers have found that level of education cannot be directly linked to performance on neuropsychological tests and that level of education has an uneven effect on neuropsychological test performance (Levav, Bartko, Frendh & Mirsky, 1998; Ostrosky-Solis, Ardila and Rosselli, 1999). It is argued that this is because different educational institutions differ greatly in terms of the quality of education they provide and therefore equivalent level of education does not necessarily result in equivalent educational achievement between individuals. Therefore, there has been a shift in the research to a focus on the effect of quality of education, rather than level of education, on neuropsychological test performance (Byrd, Sanchez & Manley, 2005; Johnson, Flicker & Lichtenberg, 2006; Manly et al., 2004 Manly, Jacobs, Tourdaji, Small & Stern, 2002). The aim of the study is to further investigate whether quality of education has an effect on neuropsychological test performance in the South African context.

1.3 Statement of the research problem

Neuropsychological tests are only valuable if they can provide valid and reliable information regarding an individual's cognitive functioning. The research problem is that factors other than cognitive ability may affect an individual's performance on neuropsychological tests and these factors need to be investigated and understood if neuropsychological tests are to be used appropriately.

The problem is that in a country as diverse as South Africa, performances of individuals are often compared to norm groups that do not always fairly represent them. Research is needed into factors that may affect neuropsychological test performance, such as quality of education, in order to advance the field of neuropsychological assessment.

The research question aims to address one aspect of this problem and is stated as follows: does quality of education affect performance on neuropsychological tests? The study aims to address this question by comparing the performance of individuals with high quality of education to individuals with poor quality of education on neuropsychological tests of executive function.

Executive function is only one cognitive function that is measured by various neuropsychological tests. Different neuropsychological tests have been developed to assess all cognitive abilities, such as memory, language, visuospatial processing, and executive function et cetera. A neuropsychological assessment of an individual will require a battery comprised of different tests of different modalities. Thus, it is important to examine the effects of factors that might affect performance on all types of neuropsychological tests, but this is beyond the scope of the current study. Instead of administering a full battery, the current study administered tests of executive function only. Executive function represents a higher-order cognitive ability that acts in a supervisory capacity over other cognitive abilities. It is important for everyday problem solving, the ability to plan and strategise goal-oriented behaviour, and other important adaptive behaviours (Banich, 2004). The development of executive function skills is largely influenced and shaped by the schooling experience (Ostrosky-Solis et al. 2004b).

Executive function is crucial to being able to adapt to the demands of society. Tests of executive function were chosen because important interpretations regarding a person’s ability to function competently in society are often made from the results of such tests and thus, it is crucial to understand how factors other than cognitive performance may affect performance on such tests.

1.4 Aims of and rationale for the study

The current study aims to investigate the effect of quality of education on performance on neuropsychological tests of executive function. Quality of education is different from level of education. Level of education is determined by the number of years of education the individual completes, while quality of education is determined by factors such as teacher to pupil ratio, per pupil expenditure, school facilities, teacher qualification, as well as, in South Africa, the history of the education system to which the school belongs (Shuttleworth-Edwards et al., 2004).

It is important to look at variables other than cognitive ability that affect neuropsychological test performance as an understanding thereof increases the appropriateness and usefulness of the practice of neuropsychological assessment for diagnostic, prognostic, treatment and recommendation purposes (Lamberty, 2002). One of these factors is quality of education. It is necessary to investigate the effect of quality of education on neuropsychological test performance in order to establish whether it is appropriate to interpret the performance of individuals from diverse educational backgrounds using the same norms. Understanding the contextual factors that affect performance on neuropsychological tests is important for the advancement of the field of neuropsychology in a country that is as culturally diverse as South Africa.

1.5 Research design

The effect of quality of education on neuropsychological test performance was investigated in this study with a between-groups research design. Four neuropsychological tests of executive function were administered to two groups of twenty learners each, one group of twenty from an advantaged, privileged, high quality of education school, and the other group of twenty from a disadvantaged, underprivileged, low quality of education school. Results were compared for statistically significant differences of means between the performances of the two groups.

1.6 Organisation of the study

The theoretical foundation and current literature relevant to the study are reviewed in Chapter 2, the research methodology of the study is discussed in Chapter 3, the results of the research are presented in Chapter 4, and Chapter 5 comprises a discussion of the results of the study.

Chapter 2
Theoretical Background

The aim of the current study is to investigate the effect of quality of education on performance on neuropsychological tests of executive function. This chapter presents the theoretical foundation of the study. Specifically, literature pertaining to neuropsychological assessment, quality of education, and executive function will be discussed in order to provide a theoretical background for the study.

2.1 Universalism in neuropsychological assessment

Most clinical neuropsychologists now agree that neuropsychological assessment is not a 'one-size-fits-all' method of gaining information for diagnostic, prognostic and decision-making purposes (Lamberty, 2002). However, this was not the case in the early perspectives of neuropsychological assessment. Perez-Arce (1999) notes that psychology has evolved out of a modernist epistemology that emphasises positivism and linear causal thinking. These scientific values shaped the early premises of neuropsychology as a discipline to posit a direct, unencumbered link between the neurobiological brain, cognitive processes and behaviour. Thus, assessment measures that were thought to be 'culture-free' were promoted as being the most valid and reliable methods for neuropsychological assessment of an individual's cognitive capacities and predicting his or her adaptive behaviours. This way of thinking in neuropsychology can be referred to as 'universalism', and describes neuropsychology as an atheoretical and acontextual neuroscience that regarded the brain as an organ with processes that proceed independently of fundamental socio-cultural variables. Later researchers, however, began to assert the role of culture influencing cognitive abilities (Bedel et al., 1999; Brickman et al., 2006; Greenfield, 1997; Nell, 2000; Perez-Arce, 1999).

One particularly pioneering study in cross-cultural neuropsychology was that of Luria's expedition to Uzbekistan in 1931 (Luria, 1979). This landmark study took place in the climate of drastic social change in a country developing from feudalism to collectivism, bringing with it exposure to Western thinking and social disruption. Basing his work on Vygotsky's theory of cortical development through mediation of social experience and Durkheim's idea that mind originates in society, Luria set out to determine whether different groups of Uzbek peasants, at different levels of modernisation, performed simple intellectual tasks in different ways. His findings confirmed his expectation, with the least modernised subjects functioning at the most concrete and basic level. Luria further found that the way the subjects reorganised the tasks was based on formal schooling, and that this produced qualitative changes in the thought processes of the individuals studied. According to Nell (1999), it was this expedition of Luria's in 1931 that pioneered the development of cross-cultural neuropsychology, despite the article not being published until nearly forty years after the expedition itself.

Despite his enthusiasm, and the retrospective value of these findings, Luria's study was not well received. He was accused of racism and forced to leave the Institute of Psychology (Nell, 1999). Why was this work so poorly received? According to Nell (1999), the study took place in the climate of universalism, where most neuropsychologists believed that neuropsychology, like its parent discipline of neurology, was governed by universally applicable principles. In such a context, research indicating otherwise did not fit, was rejected, and its author persecuted for its production. It would be many decades before the challenge to universalism and the promotion of cross-cultural neuropsychology would receive attention. In fact, a replica study of the Uzbek expedition by Gilbert in 1984 (cited in Nell, 1999) has also been under-recognised according to Nell (1999). Although this work was not suppressed and its author was not criticised, it did not receive much attention as, again, it highlighted cross-cultural neuropsychology in the face of universalism. Still today, it is a little-known study, despite its massive implications for the field of neuropsychology.

Recent authors have begun to argue against the pursuit of universalism in the field of neuropsychological assessment, asserting that it is an imaginary and ideological construct and can never be achieved (Bedel et al., 1999; Brickman, et al., 2006; Greenfield, 1997; Nell, 2000). Researchers in the field assert that the cognitive abilities assessed by most neuropsychological tests are learned and highly trained, and the way in which they are assessed depends on learning and exposure to Western education (Ardila, 1995; Ardila, Rosselli & Rosas, 1989; Gasquoine, 1999). People in different life circumstances require different skills that are adaptive to the demands of their environment. For instance, skills demanded for survival in the academic context, like abstract reasoning, may not be required in the rural context and may therefore not be well practiced and developed by farm workers (Teng & Manly, 2005).

Eviatar (2000) argues that culture affects the very organisation of the brain itself, which then influences higher order cognitive processes. This argument might be explained by the concept of plasticity in the brain. ‘Plasticity’ refers to the changes that can occur in the physiology of the brain as a result of experience (Banich, 2004). The brain has the ability to change due to environmental input. Culture, to a large degree, determines this environmental input, which causes changes to occur in the structure and organisation of the neural pathways in the brain. As cultures vary from one to another, so does the input and thus, so can the organisation of individuals’ brains vary from culture to culture. This variation due to the impact of culture is the reason why many neuropsychologists are now emphasising the importance of culture in neuropsychological assessment.

2.2 The importance of culture in neuropsychological assessment

The human mind is in part a product of its environment, and such an environment is defined by so many factors, including culture, that it can never be universal. Thus, culture-free testing is not possible.

Nell (2000) warns that attempting to test in a culture-free way does not serve the best interests of the individual being assessed because results obtained and analysed in a 'culture-free' way are nowhere near a valid and reliable representation of the person they attempt to describe. Nell (2000) argues that fairness in neuropsychological assessment lies in paying attention to the variables that make people unique.

Cross-cultural research has focused on comparisons between different neuropsychological tests in different cultures (Ostrosky-Solis & Lezano, 2006). Many tests used in neuropsychological practice have poor specificity across cultures (Johnson et al., 2006). Poor specificity, by definition, implies false positives and thus an overestimation of cognitive impairment. Indeed, Teresi, Holmes, Ramírez, Hurland and Lantigua (2001) note that there are markedly different prevalence ratios and incidence rates of cognitive impairment for different cultural subgroups. These researchers have questioned whether this is a reflection of the true levels of cognitive functioning of these groups or whether this is a reflection of cross-cultural bias in neuropsychological assessment measures.

Because of these questions regarding whether or not neuropsychological tests can be used appropriately across cultures, an emphasis has been placed on developing tests that are thought to be 'culture-free', or, not affected by non-cognitive factors. Initially, clinicians were in favour of non-verbal, or performance measures, as they were considered 'culture-free'. However, later research showed that non-verbal abilities are equally, if not more greatly, affected by culture than verbal skills (Rosseli & Ardila, 2003; Skuy et al., 2001).

This may be due to the phenomenon of test wiseness. Test wiseness was defined in 1965 by Millman, Bishop and Ebel (1965; pg. 707) as "a subject's capacity to utilise the characteristics and formats of the test and/or the test-taking situation to receive a high score". Test wiseness is thought to be independent of the individual's knowledge of the subject matter being assessed.

A lack of test wiseness may be due to lack of exposure to opportunities or support for practicing or developing the necessary skills, such as may be provided through education. A low level of test wiseness could result in poor performance on even those measures that purport to be “culture-free”.

In response to these findings, it can be argued that it is not possible to develop culture-free tests, but rather the ways in which the norms used to interpret the results of these tests are established need to be reconsidered. Teng and Manly (2005) concur and assert that the object is not to develop tests that have no correlation to group-specific factors, but rather to administer and score tests appropriately. They do not advocate ‘culture-free’ testing, but simply warn against testing “physicists with tests designed for art historians” (Teng & Manly, 2005, p 27). The emphasis is on the relevance and appropriateness of the assessment measures used and the appropriateness and relevance of the normative data used.

The use of inappropriate imported norms can greatly reduce the specificity of neuropsychological tests. This was found to be the case in a study conducted in South Africa by Anderson (2001). In this study, 20 neurologically intact, European-descent, English-Speaking South Africans were assessed using a battery of nine commonly used neuropsychological tests. The participants’ performances were evaluated against imported norms. The results indicated a large number of false positives of neuropathology in the sample, that is to say, that based on the test results, many of these participants would have been diagnosed in clinical practice as having neuropathology, despite being cognitively intact. The stringent exclusion criteria for participation in the study eliminated the chance of real neuropathology or structural distress affecting the results, and thus Anderson (2001) concluded that the results were false positives obtained due to the fact that imported norms were used. Therefore, Anderson (2001) concludes that it is crucial for the advancement of the field of neuropsychology to develop and use demographically appropriate norms.

Understanding how demographic and group factors affect neuropsychological test performance is the single most influential factor affecting the development of the field today as this increases the appropriateness and usefulness of the practice of neuropsychological assessment for diagnostic, prognostic, treatment and recommendation purposes (Lamberty, 2002). In terms of impact on neuropsychological test performance, culture, race and ethnicity have received much attention and tests are being developed and used with reference to 'culture fairness' (Brickman et al., 2006).

2.3 An emphasis on within-group variation

More recently there has been a shift in the literature from a focus on culture *per se* to a focus on other important factors within a particular sociocultural environment that may influence neuropsychological test performance. Within-group variation is a crucial component of cross-cultural neuropsychology that is still under-studied (Byrd et al., 2005). For example, Gasquoine (1999) and Helms, Jernigan, and Mascher (2005) strongly argue against using the concept of 'race' in neuropsychological research and practice as race is not a homogeneous variable and obscures within-group variation.

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Gasquoine (1999) criticises what he refers to as "race-norming", which is the practice of using different norms for different cultural and ethnic groups. He asserts that race-norming is highly controversial for two main reasons: first of all, culture and ethnicity are complex, multi-dimensional constructs that have not been clearly operationalised. He criticises researchers for using the terms culture, race and ethnicity interchangeably and comments that this reflects an insensitivity to the subtle differences that exist between groups that have major impacts on assessment. He also notes that cross-cultural neuropsychological research has categorised people into ethnic groups based on geography, self-identification or easily observable characteristics such as skin-colour or surname, which is irrelevant to neuropsychological assessment.

In addition, these criteria do not guarantee that the individual actually represents the culture to which they are assigned. Thus, when the variable of 'culture' is not reliably defined, its usefulness as an independent variable is questionable. This argument is supported by Helms et al. (2005) as they assert that the term 'race' lacks precise meaning and definition and thus is used inappropriately as an independent variable in research.

Secondly, race-norming according to Gasquoine (1999) opens neuropsychology to interpretations based purely on genetics, and this may result in racial discrimination, and may, according to Helms et al. (2005) give scientific legitimacy to the conceptually meaningless construct of race and can thereby perpetuate racial stereotypes and discrimination in society.

Shuttleworth-Edwards et al. (2004) note that individuals within a particular race, ethnicity or culture can no longer be thought of as being homogenous. Because of urbanisation, many more people from previously disadvantaged backgrounds are now being afforded opportunities, such as a higher quality of education, which may set them apart from other members of their racial or ethnic groups. There is much variance within cultural groups and within-group heterogeneity needs to be explored (Byrd et al., 2005; Skuy, 2001).

Therefore, it may be more useful to look at factors, such as education, that may account for differences in neuropsychological test performance other than the umbrella term 'culture'. The rising awareness of the importance of education for the interpretation of neuropsychological test performance is evident again and again throughout the literature (Acevedo, Loewenstein, Agrón, & Duara, 2007; Bedel, Van Eeden & Van Staden, 1999; Dick, Teng, Kempler, Davis & Taussig, 2002; Gasquoine, 1999; Gomez-Perez & Ostrosky-Solis, 2006; Lamberty, 2002; Beatty, Gonstovsky & Mold, 2003; Manley & Echemendia, 2007; Nell, 2000; Ostrosky-Solis, & Lazano, 2006; Ostrosky-Solis, 2004; Reitan, & Wolfson, 2004; Rosselli & Ardila, 2003; Shuttleworth-Edwards, Kemp, Rust, Muirhead, Hartman & Radloff, 2004; Skuy, Schutte, Fridjhon & O'Carrol, 2001; Unverzagt et al., 1996).

2.4 The effect of education on neuropsychological test performance

2.4.1 Level of education

The variables of culture and level of education are frequently confounded because it is difficult to distinguish between their effects as the education level of the individual is generally related to socio-economic status (Ostrosky-Solis et al., 2004a; Ostrosky-Solis et al., 2004b). Yet, studies have shown that culture and education have independent effects on neuropsychological test performance (Manly et al., 2004; Ostrosky-Solis et al., 2004a; Ostrosky-Solis et al., 2004b).

In an article by Ostrosky-Solis et al. (2004b), it was argued that culture dictates what is important for survival and education can be considered as a type of subculture that facilitates the development of certain skills instead of others. Ostrosky-Solis et al. (2004b) found that the effects of these two variables on neuropsychological test performance are different, and thus, the variable of education needs to be considered and researched in its own right. Similarly, Manley et al. (2004) found that education has an independent effect on neuropsychological measures and argue that adjustment for education may improve the specificity of neuropsychological measures.

Many researchers have conducted studies that have shown level of education to be an important influential factor in performance on neuropsychological tests. In Dick et al.,'s (2002) study, it was found that, in comparison to ethnicity and language, level of education had the greatest effect on performance and affected performances on several measures. In this study, Dick et al. (2002) evaluated the effectiveness of the Cross-Cultural Neuropsychological Test Battery (CCNB) in identifying cognitive impairment in minority individuals. The CCNB, according to these researchers, was developed in response to the growing need for a culturally fair method for assessing cognitive impairment in minority individuals.

The study was conducted in the United States of America and involved administering the CCNB, which consists of eleven tests, to 336 older adults and 90 adults with dementia from five ethnic groups: African-American, Caucasian, Chinese, Hispanic and Vietnamese. The ages of the participants ranged from 54 years to 99 years. Level of education was found to significantly affect performance on most of the tests, for the healthy adults as well as for adults with dementia. Level of education was found to affect more tests than both language and ethnicity, and the effects of education were greater for each test than language and ethnicity. Dick et al. (2002) argue that other investigators failed to eliminate the effects of education when attempting to develop fair assessment batteries.

Lamberty (2002) notes other studies that have looked at level of education, in terms of the number of completed years. This was found to be a neuroprotective factor in that individuals with a higher level of education typically show less impairment on traditional dementia screening tests and batteries in comparison with individuals with lower levels of education. A ‘neuroprotective factor’ means that education mediates the effects of and deficits associated with dementia as it is positively associated with the ability to compensate for such loses. This may be explained by the theory of cognitive reserve.

The model of cognitive reserve suggests that there are “certain aspects, such as innate intelligence or life experiences such as educational attainments, that may supply reserve, in the form of a set of skills or repertoires, that allows some people to cope with neuropathology better than others” (Scarmeas & Stern, 2003, p 625). The theory of cognitive reserve proposes an explanation to the phenomenon often observed in clinical practice and research that there is no direct linear relationship between the severity of brain damage or pathology and the degree of disruption of ability across individuals (Stern, 2003). According to Stern (2003) individual differences in cognitive reserve explains why some individuals exhibit less dysfunction relative to pathology or damage than others do.

Stern (2003) also notes that individual differences in cognitive reserve can stem from either innate or genetic factors, as well as from life experiences such as level of education. He suggests that level of education helps predict which individuals can sustain greater brain damage before demonstrating deficits.

This idea is supported by the studies noted by Lamberty (2002) that found that education contributed to a higher level of cognitive reserve in individuals with dementia, as the individuals with higher levels of education displayed fewer deficits associated with dementia than those with low levels of education. Other studies also note that education plays an important role in cognitive reserve (Evans et al., 1993; Gold, Andres, Etzadi, Arbuckle. Schwartzman & Chaikelson., 1995; Richards & Sacker, 2003; Scarmeas & Stern, 2003). Although it must be noted that other life experience factors, such as lifestyle, parental occupation, and occupational attainment also affect cognitive reserve, Richards and Sacker (2003) found that level of education attainment has the greatest effect on cognitive reserve when compared with these other factors.

2.4.2 Quality of education

In some research studies, there has been a shift from an investigation of the effects of level of education to an investigation on the effects of quality of education. Ostrosky-Solis et al. (1999) found that educational level had a significant effect on performance on many neuropsychological tests, especially tests of visuoconstructional abilities, verbal fluency and conceptual functions. However, they argue that the effect of level of education has an uneven effect on neuropsychological test performance. They found that although some tests were extremely sensitive to education level, others were relatively unaffected by this factor. This pattern was also observed in the study conducted by Levav et al. (1998).

In both studies, neuropsychological tests of processing speed and memory were minimally affected by level of education, whereas tests assessing the ability to solve a problem, shift strategies, and inhibit autonomic tendencies, in other words, executive function, were greatly affected by level of education. Ostrosky-Solis et al. (1999) found that level of education did not have a linear effect but rather showed a negatively accelerated curve; differences between zero and three years of education are huge, differences between three and six years are lower, and differences between six and nine are even lower and so on.

In addition to this, it can be argued that although useful at times, addressing the effect of level of education in years does not describe a homogenous group in terms of educational attainment due to the vast discrepancies of quality of education (Dick et al., 2002). This is particularly problematic in the South African context, as will be discussed later.

Nell (2000) writes that level of education in years is a crude indicator of educational attainment as it does not take into account factors that determine quality of schooling. He asserts that an individual with 12 years of education from an under-resourced rural school cannot be compared to an individual with the same years of education from a well-resourced urban school even in the same country. Nell (2000) asserts that quality of education, rather than level of education in years, is a more important demographic variable to take into account when developing norms.

Some researchers have used the variable of reading level to operationalise quality of education and found that it has a greater effect on neuropsychological test performance than level of education in years (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004). In a study by Manley et al. (2002), participants with equivalent educational level in years were tested on measures of reading ability as well as various neuropsychological tests.

These researchers found great discrepancies in performance among the participants that could not be explained by differences in years of education. Instead, they found that quality of education (as measured by reading level) was the greatest predictor of performance and the effect of culture was greatly reduced when scores were adjusted for quality of education. Byrd et al. (2005) also found that reading level, as a measure of quality of education, was a better predictor of performance than years of education when assessing participants on visuoperceptual tasks.

Johnson et al. (2006) found that in many participants, the reading level was much lower than expected based on educational level. This is further evidence that there is no approximate equivalence in educational outcomes in people with equivalent education in years. Education communicates culture-specific material on geography, history, and other culture-relevant information and is thus, culturally biased and culturally specific (Gasquoine, 1999). Therefore, years of education across cultures are not valid as an independent variable in neuropsychological assessment and a focus on quality of education is perhaps more useful.

It is possible to directly operationalise the variable of quality of education for research purposes as educational institutions differ greatly in terms of the quality of education they provide. This is especially true in the South African context, due to the legacy of the Apartheid government as well as vast differentials between demographics in terms of opportunities, resources and facilities (Skuy et al., 2001). During the time of Apartheid, the education of Black South Africans and White South Africans differed greatly. The education of Black South Africans was organised by a body called the Department of Education and Training (DET), which had different syllabi and examinations to the Private and White Government Schools (Model C Schools, as they were referred to). The private and Model C schools were modelled on the British Public School system and were of an equally high standard. The DET schools, however, were of a lower standard owing to lack of resources, which resulted in poorer facilities, high student-to-staff ratios, under qualified staff being employed, and lack of materials such as desks, books, and writing materials (Shuttleworth-Edwards et al., 2004). Although the Apartheid government no longer exists, its legacy still lives on in the difference in quality of education between former DET schools and the more privileged private and Model C schools (Kahn, 2004; Motala, 2006; Skuy et al., 2001) This difference is still evident today by the matric results produced by the different types of schools, especially in the subjects of mathematics and physical science (Kahn, 2004). Therefore, it may be more useful to examine the effect of quality of education, rather than level of education in years, on neuropsychological test performance in order to improve test specificity specifically in the South African context.

The effect of quality of education on neuropsychological test performance can be inferred from the comparison of two interesting studies: in one study, Avenant (1995) compared WAIS-R performance by Black South African university students from a historically Black university with an American standardisation sample. In another study, Shuttleworth-Jordan (1996) compared Black South African university students, who had an African first language, from a historically White university with an American sample (Shuttleworth-Edwards, 2004). The first study found that the scores of the South African students were significantly lower than their American counterparts, but the second study found that the Black South African students' scores were equivalent to those of the comparable American sample.

Yet, both of these studies were conducted with Black South African university students, and thus level of education was the same for participants in both studies, yet the results were discrepant: in the first study, the group of Black students from the traditionally Black university performed more poorly than their American counterparts, whereas in the second study, the group of Black University students from the traditionally White university performed equivalently with their American counterparts. But, the level of education was the same for all participants.

Shuttleworth-Edwards et al. (2004) argue that the discrepant findings of these two studies can therefore be attributed to quality of education and assert that quality of education can not only be called on to explain such findings of lowering scores despite matched educational level, but can also provide an explanation for lowering of scores on supposedly “culture-fair” performance tasks.

In a subsequent South African study, Shuttleworth-Edwards et al. (2004) investigated the cross-cultural influences on performance on Wechsler IQ tests. They studied WAIS-II test performance in a South African sample stratified in terms of language, as well as both level and quality of education. Shuttleworth-Edwards et al. (2004) compared the WAIS-III scores of the participants stratified according to three variables: the first variable was that of language, and there were two groups of White English first language participants and Black African first language participants; the second variable was level of education, and two groups were identified as Grade 12 level of education and graduate level of education; the third variable was quality of education, and again two groups were identified, that of advantaged educational opportunities and disadvantaged educational opportunities. For the third variable, quality of education, classification of advantaged versus disadvantaged educational opportunities was based on the type of school the participant had attended. That is to say, participants who attended White Private or Model C schools were considered to have had a high quality of education, whereas participants who have attended former Department of Education and Training (DET) schools were considered to have poor quality of education.

Shuttleworth-Edwards et al. (2004) administered the WAIS-III to 68 participants and compared two groups using each of the three variables discussed: language, level of education, and quality of education. The results of the comparison of the two groups identified for each variable showed that although differences were observed between groups on the variables of language and level of education, the greatest differences between groups was on the variable of quality of education.

That is to say, the results indicated that a higher quality of education correlated with higher scores on the Wechsler Adult Intelligence Scale III despite language and cultural differences. Even on performance tasks, which are traditionally thought to be “culture and education free”, the performance of participants with poor quality of education was significantly lower than the performance of participants with higher quality of education. Based on these findings, Shuttleworth-Edwards et al. (2004) concur with Rosselli and Ardila (2003) in that the procedural factor of test-taking skills, or test-wiseness, has a significant effect on IQ performance over and above pure language ability and crystallised knowledge.

In light of these findings, Shuttleworth-Edwards et al. (2004) acknowledge that a focus on how quality of education affects performance on neuropsychological tests does not imply a denial of other factors that are also influential in this regard. Factors such as language, quality of communication in the home, parental level of education and occupation, as well as material opportunities are also important factors affecting neuropsychological test performance that warrant investigation (Shuttleworth-Edwards et al., 2004). However, as Shuttleworth-Edwards et al. (2004) argue, the quality of education that a person receives is most likely to be positively associated with these aforementioned factors, and is a way of categorising these other important factors. Further, they argue while these variables are likely to be highly interrelated, they are unlikely to be completely overlapping in their effects and thus it is preferable to investigate the variable of quality of education directly.

A study by Skuy et al. (2001) compared performance on neuropsychological test batteries by urban African secondary school students in South Africa to American norms and found the South African scores to be much lower. These researchers attribute this to the poorer quality of education available to urban African students when compared to the American students.

The present study, however, wishes to examine the effects of quality of education by comparing different groups of South African students with each other: those who have had advantaged educational opportunities, and those who have had disadvantaged educational opportunities.

2.5 Executive function

The present study investigates the effect of quality of education on performance on neuropsychological tests of executive function. In order to define exactly what executive function is, it is useful to place the role of the frontal lobes in the context of Luria’s model, as the frontal lobes are thought to mostly represent the neuroanatomical site of executive function (Banich, 2004).

2.5.1 Luria’s model of cognitive function

Luria proposed that there are three functional units within the brain, and each unit functions at a primary, secondary and tertiary level, which Luria originally referred to as the first, second and third blocks (Luria, 1970). Unit one comprises of the sub-cortical regions as well as the brainstem. The function of this region is cortical arousal and wakefulness as well as regulating the energy level and tone of the cortex. The second functional region comprises the posterior regions of the cortex, namely the occipital, temporal and parietal lobes. The general function of the second unit is the reception, coding and storage of sensory information. At the primary level of functioning, there are the sensory receptors: the receptors for auditory information in the temporal lobes, the receptors for somatosensation in the parietal lobes, and visual receptors in the occipital lobes. At the second level of functioning in the second unit, sensory input is elaborated. Finally, it is integrated in the tertiary zones of the second functional unit.

From here, the information is sent to the tertiary level of the third functional unit, which is comprised of the frontal lobes. The main function of the frontal lobes, according to Luria, is the formation of intentions and programs for behaviour. Here, intentions are formed and this information is sent to the secondary level of the third unit where plans of action are formed, and finally to the primary level of the third unit, where execution of the plans is initiated (Luria, 1970). The frontal lobes are seen as acting in a supervisory capacity over the other functional units as they participate in a highly important way in every complex behavioural process. Table 2,1 provides a summary of Luria's model.

Table 2.1 A Summary of Luria's model of cognitive function

Subcortex & Brainstem	**Cortex**				
Unit 1		**Unit 2**			**Unit 3**
Regulation of cortical tone and maintenance of waking state		Reception, coding & storage of information			Programming, Regulation & verification of mental activity
		Temporal	**Parietal**	**Occipital**	**Frontal**
	Primary Level	Auditory receptors	General sensory receptors	Visual receptors	Motor receptors
	Secondary Level	Sensory reception, analysis and synthesis			Kinetic structure of movement (successive processing)
	Tertiary Level	Simultaneous spatial processing; abstraction and generalization of concrete stimuli			Speech regulation of motor act; executive function

An understanding of Luria's model provides insight into exactly what the role of executive function is: executive function at the tertiary level of the third unit. This level acts in a supervisory capacity over the other levels and functional unit in the cortex. Therefore, it is clear that executive functions play a role integrating all input for the purpose of forming and acting on intentions, in regulating the other cognitive processes and regulating behaviour.

2.5.2 Executive function: a higher-order cognitive function

Executive function plays a crucial role in a person's ability to adapt to the demands of society (Banich, 2004). The term 'executive function' is used to describe a complex group of adaptive abilities and processes that guide thought and behaviour.

These processes are central to organisation, planning, and execution of purposeful, goal-directed behaviour (Strauss, Sherman & Spreen, 2006). Executive functions are known as ‘higher order’ cognitive processes because they are seen as operating in a supervisory capacity over other behaviours.

These abilities are necessary in order to respond adaptively in novel situations in which a person must generate and execute a plan of action as well as monitor its effects. Executive functions are also needed in familiar situations where habitual responses must be suppressed in favour of a less familiar, but more adaptive response (Burgess, 2003). Thus, good executive function implies high impulse control, abstract thinking ability, volition, flexibility, self-monitoring ability and introspection. It is also thought that executive function plays a crucial role in adaptive social behaviour as it enables an individual to understand how others perceive him or her, to be tactful, and to resist impulsive behaviours in favour of more socially acceptable responses (Banich, 2004).

Poor executive function is associated with problems such as: psychological inertia, which is the disinclination to initiate, change or end an action; difficulty in making reasonable inferences about the world and estimating the frequency of events; problems predicting the behaviour of others when they must infer their beliefs or intentions; the inability to deal with novelty or react flexibly; difficulty staying in task or maintaining an attentional set for information that is most task-relevant; difficulty remembering the sequence of events or successfully sequencing behaviour to reach a goal; problems with switching strategies; an inability to utilize the relationships or contingencies among events to help govern behaviour; and also an inability to evaluate performance in both cognitive and social realms (Banich, 2004).

From the description of executive functions, it can be argued that they are crucial to adaptation to any educational, occupational, and social situation. An individual who needs to plan, guide, direct, and self-monitor goal directed, purposeful behaviour will rely heavily on executive functions (Strauss et al., 2006).

In a study of college students by Peterson, Guarino and Lavelle (2006), it was found that study strategies that these students used were related to their level of executive functioning. Effective self-regulatory strategies, time management, and concentration were seen in students with better executive functioning, as measured by the Executive Function Rating Scale designed by Lott and Peterson (1998) in their unpublished manual (Peterson et al., 2006). Further, they found that executive function played a role in the students' perceptions of life problems and anxiety as well as to effective test-taking strategies. Waber, Gerber, Turcios, Wagner and Forbes (2006) found that children's performance on high-stake achievement testing bears a clear and systematic relationship to their level of executive function, with executive function accounting for at least 40% of the variance these researchers observed in test scores. St Clair-Thompson and Gathercole (2006) found that executive function plays a role in scholastic achievement in 11- and 12-year-old children. Specifically, they found that the aspect of executive function referred to as updating abilities was closely linked with performance on both verbal and visuo-spatial working memory span tasks and achievement in English and Mathematics. They also found that the aspect of executive function referred to as inhibition abilities was linked to achievement in English, Mathematics and Science. Thus, they concluded that executive function is a crucial cognitive ability that affects a student's performance at school.

These studies provide data that indicates how important executive function is to a person's ability to adapt to the needs of society. It is because of this importance that the current study focuses on tests of executive function.

2.5.3 Assessing executive function

Besides the problem of universality already discussed, which affects neuropsychological assessment in general, there are certain problems that pertain specifically to the assessment of executive function. A major problem of assessing executive function is the problem of construct validity (Strauss et al., 2006). Validity of a test is the degree to which a test really measures the postulated constructs it purports to measure (Cohen & Swerdlik, 2002).

There is a limitation to the construct validity of tests of executive function, that is to say, are these tests *really* measuring executive function? The problem is that there is no clear consensus among neuropsychologists as to what exactly constitutes executive function and therefore it is difficult to say if a test really measures executive function or not as definitions vary (Strauss et al., 2006). Specifically, how problem-solving and strategic thinking manifest vary in different cultures. The expression of executive function is culture specific as it is a culture that influences the way in which a person plans and adapts their goal-oriented behaviour (Chan, Shum, Toulopolou & Chen, 2008). Chan et al. (2008) note there are so-called 'cold' and 'hot' aspects to executive function. The 'cold' aspects of executive function are abilities such as verbal reasoning, planning, sequencing, and attention. These are seen as the more mechanistic aspects of executive function. The 'hot' aspects are abilities such as being able to regulate social behaviour, adapting behaviour according to reinforcement, that is to say, reward and punishment, inferring information about the inner experience of others and their intentions, as well as decision-making involving interpretation. These are the considered the aspects of executive function that are based on intuition and emotion. The manifestation of especially the 'hot' aspects of executive function is to a large extent determined by culture, and this can greatly affect an individual's performance on a test of executive function (Chan et al., 2008). If this is the case, then tests of executive function may not have the same level of construct validity for population groups other than that on which the test was developed.

Although these researchers refer to the effects of 'culture', the current study does not focus on culture *per se* but rather on the effect of quality of education, because culture cannot be considered a homogenous variable. As discussed earlier in the chapter, considerable in-group variation can occur within a specific culture (Byrd et al., 2005). It is proposed that quality of education is a more useful variable to consider as a factor that may affect performance on neuropsychological tests of executive function, other than the factor of cognitive ability.

2.6. The effect of education on executive function

The effect of level of education on executive function has been explored in some studies and these studies will briefly be discussed next.

In a study conducted by Klenberg, Korman and Lahti-Nuuttila (2001) parental level of education was found to play an important influential role in the level of executive function in young children. In a study conducted with four hundred 3-to-12-year-old Finnish children, these researchers aimed to investigate the developmental sequence and factors that affect the developmental sequence of executive functions and attention. This was done by administering a battery of neuropsychological tests and comparing the data obtained to the participants' biographical information in order to find correlations between performance and factors such as age, gender, and parental level of education. In terms of executive function, the level of parental education significantly affected participants' performance on the Verbal Fluency Test, for both phonemic and semantic fluency, and the Design Fluency Test, with higher levels of parental education being associated with better performance by the participants.

Kempler, Teng, Dick, Taussig and Davis (1998) examined the effect of education on executive function as measured by the Verbal Fluency Test and found that level of education and age both affect performance on this measure, but not to the same extent. The results of this study indicate that level of education is a more potent variable than age in predicting performance of this test. These authors also noted that on the Semantic Animal Naming Category, participants from different ethnic groups named different animals and appeared to vary in the variety of animal names that they used, but they did not perform differently. Thus, ethnicity did not appear to affect the overall fluency performance. The factor of level of education was most influential.

In an investigation into the normative statistics available on the Controlled Oral Word Association Test (COWAT), Loonstra, Tarlow and Sellars (2001) found evidence from a number of studies that indicate that the COWAT is affected by age, gender and, most of all, level of education. The COWAT is another form of a verbal fluency measure very similar to the phonemic fluency condition of the Verbal Fluency Test used in the current study, which is discussed in the next chapter. In this study, these researchers combined normative statistics from other studies conducted with relatively small samples for the letters F, A, and S condition (FAS) of the COWAT in order to provide meta-norms broken down by age, gender, and level of education. Of the studies used for normative statistics, contradictory findings for the effects of age and gender were reported. That is to say, that some studies reported that age and gender affected performance, with males performing better than females and performance decreasing with advancing age in adults, on the COWAT, whereas other studies reported no age and gender effects with regard to participants' performance. However, all of the studies reviewed by Loonstra et al. (2001) reported that level of education was related to performance on the COWAT.

In a study conducted with 1,856 cognitively screened, healthy, Dutch-speaking adults, Van der Elst, Van Boxtel, Van Breukelen and Jolles (2006) found that age and education affected performance on the Stroop Word-Colour Test. They found that performance on this measure declined with advanced age and low education. Further, these researchers found also that education played a mediating role between age and performance by noting that age-related decline was more pronounced in participants with lower levels of education.

Plumet, Gil and Gaonac'h (2005) observed similar results in their study using the Wisconsin Card Sorting Test and the Verbal Fluency Test as measures of executive function with 133 healthy adult women. These researchers, too, found that executive function declined with age and lower levels of executive function, and that age-related decline was more pronounced in participants with lower education.

As discussed earlier in the chapter, the findings of these two studies relates to the theory of cognitive reserve, which holds that certain aspects of life experiences, such as education attainment, may supply a reserve, in the form of a set of skills or repertoires, that allows some people to cope better with neuropathology or damage than others (Satz, 1993; Scarmeas & Stern, 2003). Levav et al. (1998) also found that level of education had a large impact on the Stroop Colour-Word Test as well as on the Wisconsin Card Sorting Test.

In a study with 91 fifth-grade children, Waber et al. (2006) found that children who attended schools in disadvantaged areas had lower levels of executive function than their counterparts attending schools in privileged areas, and that this negatively affected their performance on standardised tests that are used to evaluate academic abilities. In this study conducted in Boston, Massachusetts, in the United States of America, these researchers set out to determine whether executive functions are selectively diminished in children from urban environments and to evaluate to what extent integrity of executive functions is associated with achievement test scores.

This complex study was conducted in an educational context where standards-based testing is becoming more and more prominent in evaluating learners in schools and also in determining critical decisions in later life such as university entrance and occupational appointment. Waber et al. (2006) note that with regard to performance on such tests, children from economically disadvantaged and minority backgrounds perform more poorly than their more advantaged peers. Thus, children from disadvantaged backgrounds are at higher risk of failing such tests as the Scholastic Aptitude Test (SAT), and doing so has major economic and social consequences for their prospects as adults. An examination into this observation lead these researchers to conclude that the participants' performance on these standardised tests showed a clear and systematic relationship to neuropsychological functioning, especially executive function. Further, they concluded that executive function was affected by the quality of education that the participant received.

The summary of the Waber et al. (2006) study is that children from low income, poor quality of education schools exhibit problems involving executive functions, and these executive function problems appear to be related to their performance on standards-based tests.

In another study that investigated the effect of quality of education on performance on neuropsychological tests of executive function, Johnson et al. (2006) aimed to investigate whether reading level, as a measure of quality of education, accounted for more variance in performance on tests of executive function than level of education in years. In this study, one hundred participants were recruited from the city of Detroit, in the United States of America and were assessed using five tests of executive function. The results of the data analysis found that reading level accounted for more variance in score than level of education. Further, reading level mediated the relationship between performance and education level. That is to say, that participants with lower level of education but high reading level performed relatively better than those with higher level of education but low reading level. This study seems to provide more evidence for the idea proposed by some researchers (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004) that quality of education has a greater impact than level of education on neuropsychological tests, more specifically on those of executive function.

2.7 Summary

The literature presented reflects a growing awareness that cognitive processes are shaped by socio-cultural factors as well as biological processes (Perez-Arce, 1999). Neuropsychologists need to be sensitive to the complex interplay of factors that affect performance on neuropsychological tests other than cognitive abilities, such as a variety of culture-specific factors, in order to improve the specificity of neuropsychological assessment measures (Ardila, 1995; Ardila et al., 1989; Gasquoine, 1999).

Moving away from a focus on the effect of culture *per se*, studies have shown that aspects of the sociocultural environment, such as education, have an independently influential effect on neuropsychological test performance (Manly et al., 2004; Ostrosky-Solis et al., 2004a; Ostrosky-Solis et al., 2004b). Recent research has shown that quality of education is more influential than level of education in years in affecting performance (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004).

The present study aims to investigate the effect of quality of education on performance on neuropsychological tests of executive function. The methodology adopted to achieve this aim is discussed in the next chapter.

Chapter 3
Methodology

3.1 Introduction

The overall aim of the study was to investigate the effect of quality of education on neuropsychological test performance. One particular aspect of neuropsychological functioning was selected, that of executive functions. The following is a detailed description of the methodology used to achieve the aim of the study.

3.2 Research design

3.2.1 Research strategy and design

The research design is a between-groups design. The mean raw scores for all the tests were compared and analysed for statistically significant differences between the two groups.

The research strategy is a correlational strategy. The correlational research strategy measures two variables as they naturally exist, and aims to describe the relationship between the two variables without attempting to prove an unambiguous causal relationship between the two variables (Gravetter & Forzano, 2003).

The current study is a correlational strategy as it simply measures two variables for each participant, namely quality of education and scores on neuropsychological tests, in order to describe the relationship between these two variables. A correlation can never indicate a causal relation, merely an association. Other more advanced statistical techniques can be used to investigate a possible causal relation and this would imply inclusion of all possible contributing variables.

3.2.2 Confounding variables

A confounding variable is an extraneous variable that is either unmonitored or eludes control and that can influence or distort the results of a study (Gravetter & Forzano, 2003). There were many confounding variables that were likely to come into play in the present study. These confounding variables are other factors, besides quality of education, that might affect the participants' performance on the neuropsychological tests. These include: age, gender, level of education, home language, parental level of education, quality of communication in the home, wealth of knowledge and cultural opportunities in the social environment, medical history of the participants and intrapersonal characteristics of the participants. These confounding variables are discussed next.

Age, gender, and level of education: the two groups were controlled for age, gender and level of education. Each group consisted of ten males and ten females and statistical tests for gender differences were applied within each group in order to ascertain whether or not there were gender effects. These results are presented in detail in chapter 4. The mean age of participants was matched for each group, so that age could not affect the differences in performance that were observed. The level of education in years was matched for each group as only grade eleven and twelve learners participated in the study.

Home language: although English was not the home language for some of the participants in Group A and all of the participants in Group B, the language of education in both groups was English. The researcher spent time talking to each participant at the beginning of the assessment sessions in order to establish whether or not the participant was competent enough in English to participate in the study. All participants were judged as being competent enough in English to comprehend the instructions of the neuropsychological tests used in the study. Their competency was evaluated by the researcher who engaged in conversation with each participant and the judgement of competency was based on each participants' ability to comprehend and respond to the researcher. Only one of the tests relies on verbal ability, namely, the Verbal Fluency Test. A non-verbal analogue for this test, the Design Fluency Test was used in order to control for the effects of language for the purposes of this study.

Parental level of education, quality of communication in the home, and wealth of knowledge and cultural opportunities in the social environment: it was not possible to control for these variables in the present study. A study that aims to establish a clear causal relationship between quality of education and neuropsychological test performance would need to control for these variables, but this is beyond the scope of the present study. Further, the study proceeds from the assumption that quality of education is a reflection of other social and environmental variables such as parental level of education, quality of communication or stimulation in the home, and wealth of knowledge and cultural opportunities in the home (Shuttleworth-Edwards et al., 2004).

Medical history of the participants may have represented a confounding variable in the study, as neurological, psychiatric, and other medical conditions may have affected participant's performances on the tests. For instance, it is well known that neurological disorders such as epilepsy can greatly affect the functioning of a person's brain which would then affect their ability to perform on a neuropsychological test. If there is a pre-existing neuropathology in a participant, then the results of the performance would have been affected by the neuropathology itself and not necessarily by the effect of quality of education the participant receives. Medical conditions that may have affected the participants' performances were controlled for by taking a medical history of the participant and no participant had a history of neurological, psychiatric or other serious medical illness. The medical history was included in the demographic forms that were completed by the parents of the child and re-checked by the researcher with the child *(See Appendix III, p103)*. Thus, it can be concluded that pre-existing medical conditions do not represent a confounding variable in the current study.

Intrapersonal variables such as motivation and personality and overall cognitive functioning also represent confounding variables in the current study (Lezak, 1995). In-depth investigation and analysis of these variables would be crucial in establishing the contribution of these variables to performance on neuropsychological tests, but this is beyond the scope of the current study and these factors were not controlled for.

3.2.3 Hypotheses

The aim of the study is to investigate the effect of quality of education on neuropsychological test performance. Thus, the main test hypothesis and null hypothesis of the study are, respectively:

H1: There is a statistically significant difference between the mean performances of the two groups on each of the tests of executive function.

H0: There is no statistically significant difference between the mean performances of the two groups on each of the tests of executive function.

In order to control for gender effects, that is to say that gender might be a factor other than cognitive ability that affects each participant's performance on the tests, the mean scores of the males and females within each group were compared and analysed for statistically significant differences. Therefore, another hypothesis was tested for each group (Group A and Group B) separately:

H1: There is a statistically significant difference between the mean scores of males and females

H0: There is no statistically significant difference between the mean scores of males and females

3.3 Sample

3.3.1 Sampling methods

Cluster sampling was used to obtain the required sample. The researcher personally approached high schools that met the research criteria of high or low quality of education for assistance.

High schools that agreed to participate were given detailed information regarding the rationale of the study as well as the necessary procedures in order to conduct the study, that is to say, how many participants were needed, from which grade, how much time participation would involve, and schedules for assessment. The researcher addressed the Grade 11 and Grade 12 learners at each school, providing them with detailed information of the study, stressing confidentiality. Pupils were invited to participate through motivation letters and consent forms sent home to the parents. Participation was on a completely voluntary basis and those learners who brought back signed consent forms were included in the study.

3.3.2 The schools

The legacy of the Apartheid regime makes quality of education easy to operationalise in the South African context: schools that were previously DET schools fall into the poorer quality category while previously private and model C schools fall into the higher quality category (Shuttleworth-Edwards et al., 2004). As discussed in Chapter 2, previous studies have used reading level to operationalise quality of education (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004). In South Africa, where there are 11 official languages, reading level may not be a useful measure of quality of education. Therefore, the present study operationalises quality of education based on the following criteria described by Johnson et al. (2006), Nell (2000) as well as Shuttleworth-Edwards et al. (2004) as being factors determining quality of education: Private school or Model C school versus former DET school, staff to pupil ratio, teacher qualifications, the quality and accessibility of the library and science laboratory, and access to facilities such as books, electricity, desks and writing equipment, computers, and the internet.

Two private schools in Johannesburg agreed to participate in the study. In both schools, class size does not exceed 25 students. Many staff members at both schools have master’s and doctorate degrees. Both schools have well-equipped libraries, that are regularly updated with new material. Both schools have computer centres, the first school having fifty computers and the second school having twenty eight computers, as well as access to the internet for the learners to conduct research, under supervision. Both private schools have fully functional science laboratories with ample materials and apparatus. The learners have access to books, writing materials, and all desks and chairs were in good working condition. Each classroom at both schools has overhead projectors as well as white boards and chalkboards.

Two government schools in Johannesburg agreed to participate in the study. Both schools had been former DET schools. In both schools, class size ranges from 45 to 60 per class. None of the teachers at either school has obtained an honours degree, and at one school, some teachers have only obtained diplomas. Neither of the government schools has a library, computers, access to the Internet, or fully equipped science laboratories. One government school has two microscopes, while the other does not have any. At both schools, the science teachers complain that they do not have the necessary chemicals and equipment to teach matric chemistry. Only one of the government schools has electricity. Neither school has overhead projectors. At both schools, the desks and chairs are mostly broken, and the classrooms are dirty and vandalised. Only some classrooms at both schools have chalkboards.

From the afore-mentioned characteristics of the schools that participated in the study, it can be asserted that Group A schools represent a high quality of education, while Group B schools represent a low quality of education, according to the criteria described by Johnson et al. (2006) Nell (2000) and Shuttleworth-Edwards et al. (2004).

3.3.3 The participants

Two groups of participants were included in the study: one private school group (Group A) and one government school group (Group B). The two groups were matched for age and gender. Each group comprised of 20 learners, and so there were 40 participants in total.

Chapter 4 presents a detailed description of the demographic characteristics of each group (see Table 4,1) such as age, home language, parental level of education and parental occupation, handedness and relevant medical conditions.

3.4. Measurement instruments

3.4.1 Verbal Fluency Test

The historical roots of the Verbal Fluency Test stems back to the Thurstone Word Fluency Test designed by Thurstone and Thurstone in 1962 (Mitrushina, Boon & D'Elia, 1999). The Thurstone Test originally was in written format, that is, it required the participant to write all their responses. This came to be considered a limitation of Thurstone and Thurstone's format as it introduced confounding variables such as motor control and dexterity, and later versions of verbal fluency tests now require oral responses.

The Verbal Fluency Test used in the present study is one such version that requires the participant to respond orally, although written versions of this test are still used in clinical practice. The Verbal Fluency Test can be administered to individuals aged 2 years to 95 years. The Verbal Fluency Test assesses executive function by evaluating the spontaneous production of words under restricted search conditions within a time limit. The subject is given one minute per trial to name as many words that satisfy the condition as possible. There are two conditions: Phonemic Fluency, that is, words beginning with a particular letter (F, A, S); and Semantic Fluency that is, words within a particular category (animals, things to eat, things in the street).

In the phonemic fluency condition, no proper nouns or numbers are accepted, nor is the same word with a different ending e.g. eat and eating or plurals (Strauss et al., 2006).

Aspects of executive function measured by the Verbal Fluency Test are cognitive flexibility, the ability to shift set, as well as the ability to modify behaviour to satisfy environmental demands. The individual has to respond flexibly by producing a variety of responses that satisfy a certain criterion, and then has to adjust their responses according to new criteria introduced by the assessor, first shifting between letters, to shifting to categories, then shifting between categories, all the while adhering by restrictions placed on responses by the assessor (Strauss et al., 2006).

Mitrushina, Boone, Razini & D'Elia (2005) note that recent research into the Verbal Fluency Test suggest that there are other cognitive mechanisms, besides executive function, that underlie an individual's ability to efficiently organise the retrieval and recall of word generation. These mechanisms are multidimensional and involve processes such as auditory attention and short-term memory (recalling which words have already been listed), language abilities, and long-term vocabulary storage. Language plays a major role in performance on the Verbal Fluency Test, and some compendia of tests even list it under language, and not executive function (Mitrushina et al., 1999). The problem of assessing executive function is that 'executive function' refers to a number of meta-cognitive processes that are difficult to concretely operationalise. Despite the confounding variables of language, memory, and attention, the Verbal Fluency Test is widely used in clinical practice to assess executive function (Mitrushina et al., 2005; Strauss et al., 2006) and thus was included in the current study.

In terms of scoring procedures, for phonemic fluency, the total correct is the sum of all admissible words for the three letters. For semantic fluency, the total correct is the sum of all admissible words for the three categories.The total verbal fluency score comprises of the total phonemic score plus the total semantic fluency score (Strauss et al., 2006)

It has been shown that internal consistency reliability for the Verbal Fluency test is quite high 0,30 – 0,90 (Shunk, Davis & Dean, 2006). Inter-rater reliability was reported to be near perfect by Spreen and Strauss (1998). Inter-rater reliability is reported to be very high at 0,98 and test-retest reliability is also high at .074 (Mitrushina et al., 2005).

3.4.2 Design Fluency Test

There are many versions of measures of design fluency that have been developed in the field of neuropsychology (Mitrushina et al., 2005). The current study uses the version developed by Jones-Gotman and Milner in 1977, These clinicians developed the Design Fluency Test as a non-verbal analogue to the verbal fluency task as a measure of executive function. Aspects of executive function measured by the Design Fluency Test include cognitive flexibility, the ability to shift set as well as the ability to modify behaviour to satisfy environmental demands. It can be administered to individuals ranging from 5 years to 72 years. In this test, the subject must produce as many novel, abstract designs as quickly as possible within a specific time limit.

There are two conditions: a free condition (five minutes), in which there are no restrictions placed on the number of lines the participant may include in each design, and a four-line condition (four minutes) in which the participant is instructed to produce designs that comprise exactly four lines in each (Strauss et al., 2006).

According to Hanks, Allen, Ricker and Deshpande (1996), there are a number of factors that make the use of the Design Fluency Test problematic in the clinical setting and thus this test is not as widely used as the verbal fluency test or the other two tests of executive function used in the present study. These factors include the effect of design complexity on the rate of production of designs, and also the somewhat subjective interpretation of exactly what constitutes a perserverative response versus a novel design.

Strauss et al. (2006) also note that the lack of clarity on perserverations reduces the reliability of the Design Fluency Test. Therefore, in clinical practice, the Ruff Figural Fluency Test is more widely used than the Design Fluency Test designed by Gotman-Jones and Milner (Mitrushina et al., 2005). However Mitrushina et al. (2005) note that although the Ruff Test may increase the scoring reliability of measuring design fluency in participants, the unstructured Jones-Gotman version has better construct validity for measuring executive function as it is a better measure of the initiation and organisation of output found to be deficient in executive dysfunction.

Even though the Design Fluency Test is not as widely used in the clinical setting as the other tests used in this study at present, it has been included in the current study as a valuable performance measure of the cognitive flexibility and production spontaneity aspects of executive function and is potentially useful in clinical practice.

There is one basic score for each condition, namely the novel output score. This is the total number of drawings minus the all errors. The following are considered errors: perserverative responses, scribbling, nameable drawings, and incorrect number of lines (for the four-line condition). Perserverations are drawings that are rotations or mirror images of previous drawings, variations on a theme, and complicated drawings that differ only slightly from previous drawings (Strauss et al., 2006).

Strauss et al. (2006) report the test-retest reliability of the Design Fluency Test to be adequate (0,70) in the four-line condition for the total number of drawings, but poor for the free condition. Inter-rater reliability is reported as high, 0,74 – 0,98 (Mitrushina et al., 2005).

3.4.3 The Stroop Test

The Stroop Test is named after the psychologist John Ridley Stroop who developed the test in 1933 (Imbrosciano & Berlach, 2005). Since then, it has become one of the most widely used neuropsychological tests.

The Stroop Test is so widely used, that is has been translated into many languages, including Chinese, Czechoslovakian, German, Hebrew, Swedish, and Japanese among others (Mitrusina et al., 1999) and many versions for administration have been developed (Mitrushina et al., 1999). The Stroop Test was found to be the eighth most frequently used test for executive function by neuropsychologists in a study by Rabin, Barr and Burton (2005) who surveyed 747 doctorate-level neuropsychologists in North America. It can be administered to individuals aged 5 years to 90 years

Aspects of executive function measured by the Stroop are selective attention, cognitive flexibility, the ability to suppress an automatic, habitual response in favour of another, less familiar one, and goal oriented behaviour (Strauss et al., 2006).

The version of the Stroop Test used in the present study is called the Stroop Neuropsychological Screening Test (SNST), and was developed by Trenerry and colleagues in 1989, In this test, the participant is first shown a page with words listed in columns. The words are all the names of colours and are printed in colours that are different to the name indicated in printed word. The participant has to read the words aloud as quickly and as accurately as possible, while ignoring the colours of the ink that the words are printed in. This is the Form C condition. Next, the participant is given a similar page but must name aloud the colour of the ink this time while ignoring the name that the word spells. This is the Form C-W condition. There is only one trial per condition, that is to say, the participant is only asked to complete one page per condition. The participant is allowed a maximum of 120 seconds within which to complete the page.

When a word such as blue, green, red, etc. is printed in a colour differing from the colour expressed by the word's real meaning (e.g. the word "red" printed in blue ink), a delay occurs in the processing of the word's colour, leading to slower test reaction times and an increase in mistakes.

The score on Form C is taken as a baseline for comparison with Form C-W, as it is theorised that executive function is not relied upon for performance in Form C, only in Form C-W (Imbrosciano & Berlach, 2005).

For each of the two conditions, there are three scoring criteria: Time completed, number of incorrect responses, and number of correct responses. The maximum time allowed is 120 seconds per condition. The maximum number of correct responses possible is 112, For each trial, the participant is scored on three criteria: number of correct responses, number of incorrect responses, and time completed (Trenerry, Crosson, DeBoe, & Leber, 1989). The SNST has high test-retest reliability of 0,90, limited practice effects of 5 per cent (Trenerry et al., 1989) and high validity coefficients of 0,62 to 0,80 (Trennery et al., 1989).

3.4.4 The Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) was first developed in 1948 by Berg et al. (Mitrushina et al., 2005) and since then has been widely used in clinical practice and in hundreds of research studies in the field of neuropsychology in order to tap into executive function (Mitrushina et al., 2005). Since 1948, different versions of the WCST have been developed and adapted. One of the most popular versions was developed by Heaton (1981). This is the version that was used in the current study. Aspects of executive function measured by the Wisconsin Card Sorting Test (WCST) are: strategic planning, organised searching, the ability to use environmental feedback to shift cognitive set, goal-oriented behaviour as well as the ability to modulate impulsive responding (Strauss et al., 2006). The WCST can be administered to individuals aged 5 years to 89 years. It was found to be the most often used test for executive function by neuropsychologists in a study conducted by Rabin et al. (2005) who surveyed 747 doctorate-level neuropsychologists in North America.

In the version of the WCST used in the current study, the test consists of four stimulus cards, placed in front of the testee. The testee is then given two decks of cards, each containing 64 cards, which have designs similar to the stimulus cards, varying in colour, geometric form and number. The testee is told to match each of the cards in the decks to one of the key cards and is given feedback each time if he/she is right or wrong. The assessor changes the sorting criterion periodically, but does not give the subject any warning that he/she is doing so. For instance, initially the criterion is form. Once the participant has sorted ten consecutive cards correctly according to form, the tester changes the criterion to colour. Once the participant has sorted ten consecutive cards correctly according to colour, the tester changes the criterion to number, then back to form and so forth. The test is completed when the participant has either completed six sets of ten consecutive correct responses (form, colour, number, form, colour, number) or when all 128 cards have been placed, whichever occurs first (Heaton, 1981).

For the WCST, the participant was given three scores: number of sets completed (form, colour, number et cetera), number of incorrect responses, and the number of perserverative responses. The maximum number of sets completed is six. An incorrect response is defined as the participant placing the test card below a key card that does not match the assessor's criterion (Heaton, 1981) The criteria for perserverative responses that were followed were those specified in the manual by Heaton (1981). There are three conditions in which a perserverative response can be scored: a response that would have been correct in the previous set is considered a perserverative response. For instance, continuing to place the card according to form when the criterion has changed to colour, and the assessor responds that the match is incorrect. Another condition for a perserverative response is when the participant makes an unambiguous incorrect response before the first trial and perserverates by continuing to make this response. An unambiguous response is one in which the stimulus card matches the key card according to one criterion only, that is to say, form or colour or number. The final condition for scoring a perserverative response is when the participant makes three consecutive unambiguous incorrect responses in a trial.

According to the manual written by Heaton (1981), the number of perserverative responses is the most useful diagnostic measure derived from the WCST.

The WCST has generally low test-retest reliability (Strauss et al., 2006) but high inter-rater reliability of 0,94 (Anderson, Demasio, Jones & Tranel, 1991). The WCST has adequate internal reliability coefficients ranging from 0,37 to 0,72 (Mitrushina et al., 2005). Inter-rater reliability is high at 0,88 – 0,93 and there is also adequate concurrent validity (Mitrushina et al., 2005).

3.5 Procedure

The four measures of executive function discussed were administered to 20 learners from two private schools in Johannesburg, and 20 learners from two government schools in Johannesburg. Each learner was assessed individually with the researcher, in a private room. Each assessment period took approximately 45 minutes to one hour. The assessment sessions took place before school, after school, and during breaks so as not to disrupt teaching time. The four tests were administered in alternating order so that order effects would not influence the observations. The scoring procedures used were those provided by Strauss et al. (2006), Trenerry et al. (1989) and Heaton (1981) for the fluency tests, the Stroop test and the WCST respectively. The responses were scored by the researcher, and ten per cent of the scoring was checked for accuracy in terms of scoring by an experienced neuropsychologist. The mean raw scores for each group were analysed using statistical procedures.

3.6 Statistical procedures and data analysis

The main test hypothesis indicates a between groups analysis for statistically significant difference of means. The data was tested for normality, that is to say, whether or not the data follows the normal distribution curve. The tests for normality that were applied were Kolmogorov-Smirnov Test and the Shapiro-Wilk Test.

Then, both parametric and non-parametric statistical tests were used in order to determine whether there was a statistically significant difference between the means of the two groups. These tests were, respectively, the Independent Samples T-test and the Mann-Whitney test.

3.7 Ethics

Most of the participants in the study were legally minors, so issues of informed parental consent were taken into consideration. Consent forms were sent home to the parents, and signed consent forms for each participant were collected prior to each assessment session. Confidentiality was discussed on three occasions: when the researcher addressed the learners as a group for recruitment of participants; in the motivational letters sent home; as well as at the beginning of each assessment session. As all the learners were either in Grade 12 or Grade 11, sensitivity to syllabus demands and minimal disruption to the learners was emphasised, thus, the research procedure was designed in such a way as to assess learners before, between, or after classes so that they would not miss any important teaching time. Participants were informed that they were at liberty to withdraw from the research at any time. One participant from Group A chose to withdraw after two tests were administered as he was pressured to fulfil other sporting and cultural activity obligations and did not have time to complete participation.

3.8 Summary

This chapter discussed the methods for data collection and analysis. In order to investigate the effect of quality of education on neuropsychological test performance, four neuropsychological tests of executive function were administered to two groups of participants: one group from schools that meets the criteria for good quality of education (Group A) and one group from a schools that meet the criteria for poor quality of education (Group B). The performances of the two groups on each of the tests was compared and analysed for statistically significant difference. The results of the statistical analysis are presented in Chapter 4.

Chapter 4
Results

4.1 Introduction

The aim of the study is to analyse whether quality of education has an effect on neuropsychological test performance. This was done by assessing two groups, one with a high quality of education (Group A) and one with a low quality of education (Group B), on four neuropsychological tests of executive function. The demographic characteristics of the participants are presented in Table 4,1,

Table 4.1 Demographic characteristics of the participants

Demographic Characteristics		**Group A: N (%)**	**Group B: N (%)**
Age (mean)		17 yrs, 6 mnths, 10dys	17 yrs, 5 mnths, 14 dys
Gender	Male	10 (50%)	10 (50%)
	Female	10 (50%)	10 (50%)
Home Language	English	15 (75%)	0 (0%)
	Xhosa	1 (5%)	2 (10%)
	Zulu	1 (5%)	5 (25%)
	Sotho	2 (10%)	3 (15%)
	Spanish	1 (5%)	0 (0%)
	Tswana	0 (0%)	2 (10%)
	Pedi	0 (0%)	5 (25%)
	Venda	0 (0%)	1 (5%)
	Ndebele	0 (0%)	1 (5%)
	Kgaogelo	0 (0%)	1 (5%)
Handedness	Right	19 (95%)	20 (100%)
	Left	1 (5%)	0 (0%)
Repeated Grades at School	yes	2 (10%)	8 (40%)
	no	18 (90%)	12 (60%)
Years in current school (mean)		4,8	4,3
Parental highest level of education	Uncertain	0 (0%)	4 (20%)
	Lower than Matric	0 (0%)	7 (35%)
	Matric	3 (6%)	8 (25%)
	Diploma	0 (0%)	1 (5%)
	Bachelor's Degree	12 (60%)	0 (0%)
	Honours Degree	2 (10%)	0 (0%)
	Master's Degree	3 (15%)	0 (0%)

Table 4.1 continued: Demographic characteristics of the participants

Parental Occupation	Unemployed	0 (0%)	5 (25%)
	Domestic Worker	0 (0%)	11 (55%)
	Manual Labourer	0 (0%)	3 (15%)
	Professional	17 (85%)	1 (5%)
	Other	3 (15%)	0 (0%)
Neurological/psychological/other medical disorders	yes	0 (0%)	0 (0%)
	no	20 (100%)	20 (100%)
Treated by occupational therapist	yes	0 (0%)	0 (0%)
	no	20 (100%)	20 (100%)
Currently taking prescription medication	yes	0 (0%)	0 (0%)
	no	20 (100%)	20 (100%)

Table 4.1 presents the demographic information of the participants of the study. The mean age of participants in each group is roughly the same, with the mean age of Group A being 17 years, 6 months and 10 days and Group B being 17 years, 5 months and 14 days. The difference in mean age between the two groups is less than a month. The two groups were matched for gender, and each group consists of ten males and ten females. The predominant home language in Group A is English, with 75 per cent (*n = 15*) of the participants speaking English as a home language. In Group B, none of the participants speak English as a home language. The predominant home languages in Group B are Zulu and Pedi, with 25 per cent (*n = 5*) of the participants in Group B speaking each of these as home languages.

The participants in both groups are predominantly right-handed, with only one participant in Group A being left-hand dominant. Handedness was taken into consideration as it has implications for brain organisation and functioning (Banich, 2004). Handedness implies the dominance of the contralateral hemisphere in an individual. The two hemispheres are known to be characterised by very different patterns of behaviour and functioning. For instance, the left hemisphere is associated with logical, analytical, mathematical and language functions while the right hemisphere is associated with creative, intuitive, and emotional functions. These patterns of functioning that characterise each hemisphere can be related to the 'cold' and 'hot' aspects of executive function, respectively, described by Chan et al. (2008), which are discussed in Chapter 2.

Also, left-handed individuals are less lateralised in their functions than right-handed individuals, meaning that their cognitive functions are more likely to be shared by both hemispheres rather than be dominated by one hemisphere (Banich, 2004). From this information, it is argued that handedness may affect performance on neuropsychological tests. As only one participant in the current study is left-handed while all the other participants are right-handed, handedness can be considered controlled for and as having not affected the results obtained.

The groups are disparate in terms of whether each participant had ever repeated a grade at school or not. In Group A, only 10 per cent (*n = 2*) of participants had ever repeated grades at school, whereas in Group B, 40 per cent (*n = 8*) of the participants had repeated a grade at school. The groups are comparable in terms of the number of years each participant has spent in the current school. In Group A, the mean number of years spent in the current school is 4,8 years, in Group B, the mean number of years spent in the current school is 4,3 years. All participants who had attended another school prior to attending the current school had previously attended schools of similar quality of education.

The parents of the participants in Group A have higher levels of education than the parents of the participants in Group B. In Group A, 60 per cent (*n = 12*) of the parents have Bachelor's degrees, 10 per cent (*n = 2*) have Honours degrees, and 15 per cent (*n = 3*) have Master's Degrees. None of the parents in Group A have lower than matric education level. In Group B, however, 35 per cent (*n = 7*) of the parents have not obtained a matric certificate, 25 per cent (*n = 8*) have obtained a matric certificate and only one parent has a tertiary qualification, namely, a diploma. None of the parents in Group B had obtained university degrees. There is also a higher level of unemployment of the parents in Group B than in Group A with 25 per cent (*n = 5*) of the parents in Group B being unemployed while no parent in Group A is unemployed.

In terms of medical history, none of the participants in Group A nor in Group B reported any history on neurological, psychological, or other serious illness. No participant in the study has ever sustained a serious head injury, experienced seizures, nor is any participant on chronic medication.

The implications of the demographic differences between Group A and Group B are discussed in more detail in the next chapter.

4.2 Statistical tests used to assess significant difference between group means

Three types of statistical tests were applied to the data: tests of normality, parametric tests for significant difference between means, and non-parametric tests for significant difference between means. First, tests for normality were applied to the data in order to ascertain whether or not the data followed the normal distribution curve, which is a bell-shaped, smooth, mathematically defined curve that is highest at the centre and gradually tapered at each side, approaching, but never actually touching, the *y*-axis (Cohen & Swerdlik, 2002). The reason the data is tested for normality is to establish which type of statistics needs to be applied in order to assess differences between means. If the data follows the normal distribution curve, then parametric statistics can be applied. If the data does not follow the normal distribution curve, then non-parametric statistics must be applied. The two tests of normality that were used are the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test.

Next, parametric and non-parametric tests for statistically significant differences of means were applied. A ‘statistically significant difference’ means that the difference observed between the two groups is unlikely to have occurred by chance, but rather is affected by an underlying variable. There are different levels of significance, which indicate the degree to which it can be assumed that the difference is significant, and not due to chance alone. These levels, ranging from lowest level of certainty to highest level of certainty, are: the 0,10 level, which means that there is 90% certainty that the observations are not due to chance alone; the 0,05 level, which means that there is 95% certainty that the observations are not due to chance alone; and the 0,01 level, which means that there is 99% certainty that the observations are not due to chance alone. However, for cognitive tests, results that are significant on the 0,01 level are not considered statistically significant (Cohen & Swerdlik, 2002).

For the variables that were found to follow the normal distribution curve, a parametric statistical test for significant difference between means was applied, namely the Independent-Samples T-test. Three tests are conducted when the Independent Samples T-test is applied. The first test is Levene's Test for Equality of Variances. The second and third tests are t-tests for the equality of means. The second test is a t-test that assumes that the variances are equal, and the third test is a t-test that assumes that the variances are not equal. For variables that did not follow the normal distribution curve, a non-parametric statistical test for significant difference between means was applied, namely the Mann-Whitney Test.

Data were analysed for significant differences between the means of groups A and B as well as within groups A and B. For the latter, the mean of the scores obtained by the male participants was compared to the mean of the scores obtained by the female participants in each group. This was done in order to control for gender effects, that is to say, to assess whether gender affected the performances of the participants. If no significant gender difference of means is observed, it could be concluded that gender did not affect the performance of the participants.

The data obtained on each of the neuropsychological measures from the two groups, that is to say, the advantaged school group (Group A) and the disadvantaged school group (Group B), were compared in order to establish whether there were statistically significant differences between the mean scores of each group. Group A performed better than Group B on all the measures. The results of the statistical analyses of the data will be presented separately for each test.

4.3 Verbal Fluency Test

The verbal fluency test requires the participant to list as many words as possible that meet a specific criterion provided by the tester within the time constraint of one minute. There are two conditions: a phonemic fluency condition and a semantic fluency condition. For the phonemic fluency condition, the participant has to list words that begin with a specific letter of the alphabet. For the semantic fluency condition, the participant has to list words that fall into a specific category, such as animals. There are three trials within both the phonemic and semantic conditions. The score that is obtained is the number of correct words listed by the participant in one minute. Each participant received three scores: a phonemic fluency score; a semantic fluency score; and a total verbal fluency score (phonemic score + semantic score).

4.3.1 Results of the tests for normality of the data distribution

Table 4.2 Tests of normality for the Verbal Fluency Test

	Kolmogorov-Smirnov (a)		**df=40**	**Shapiro-Wilk**		**df=40**
	Statistic	**P-value**	**Significance**	**Statistic**	**P-value**	**Significance**
Phonemic Fluency	0,127	0,106	None	0,956	0,125	None
Semantic Fluency	0,143	0,039	*	0,958	0,140	None
Total Verbal Fluency	0,999	0,200[1]	None	0,959	0,154	None

[1] This is a lower bound of the true significance.

* Significant at α=0,10

Alternative Hypothesis H1: Observations do not follow the normal distribution.

Null Hypothesis H0: Observations follow the normal distribution.

Table 4.2 presents the results of the tests for normality for the Verbal Fluency Test. From the data, it is clear that all three scores obtained for the Verbal Fluency Test, namely phonemic fluency, semantic fluency, and total verbal fluency, were found to follow the normal distribution curve and therefore were analysed for significant differences between means using a parametric statistical test.

4.3.2 Results of statistical analysis for group differences between means

Table 4.3 Comparison of Group A and Group B for the Verbal Fluency Test

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Phonemic Fluency	A	20	35,70	11,05	2,47
	B	20	23,80	7,98	1,79
Semantic Fluency	A	20	58,85	10,41	2,33
	B	20	39,05	6,48	1,45
Total Verbal Fluency	A	20	94,55	18,21	4,07
	B	20	62,85	10,89	2,44

Table 4.3 presents the parametric description of the data obtained from the Verbal Fluency Test. This data was analysed for significant differences between the means of the two groups, and the results are presented in Table 4.4.

Table 4.4 T-Test results for significant differences between means in Verbal Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Phonemic Fluency	1,751	0,194	2	3,905	38	0,000***
			3	3,905	34,597	0,000***
Semantic Fluency	5,222	0,028**	2	7,223	38	0,000***
			3	7,223	31,794	0,000***
Total Verbal Fluency	5,621	0,023**	2	6,681	38	0,000***
			3	6,681	31,054	0,000***

*** Significant at α=0,01

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the T-test for independent samples (Table 4.4) clearly indicates that there are highly significant differences between the means of the performances of Groups A and B on a 0,01 level for phonemic fluency, semantic fluency, and total verbal fluency. Thus, Group A performed significantly better than Group B on all scores of verbal fluency.

4.3.3 Results of statistical analysis of gender differences

The mean scores of the males of Group A were compared with the mean scores of the females of Group A, and the mean scores of the males and females of Group B were compared in order to control for gender effects on Verbal Fluency.

Table 4.5 Comparison Verbal Fluency of males and females in Group A

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Phonemic Fluency	Male	10	35,2	8,08	2,56
	Female	10	36,2	13,85	4,38
Semantic Fluency	Male	10	58,9	9,98	3,16
	Female	10	58,8	11,36	3,59
Total Verbal Fluency	Male	10	94,1	14,56	4,60
	Female	10	95,0	22,09	6,98

Table 4.5 presents the description of the T-test data obtained for the males and females of Group A for Verbal Fluency. Table 4.6 presents the results of the T-Test.

Table 4.6 T-test results for gender differences between means in Verbal Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Phonemic Fluency	2,138	0,161	2	-0,197	18	0,846
			3	-0,197	14,492	0,846
Semantic Fluency	0,078	0,783	2	0,021	18	0,984
			3	0,021	17,707	0,984
Total Verbal Fluency	1,333	0,263	2	-0,108	18	0,916
			3	-0,108	15,578	0,916

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

The results of the T-test for independent samples (Table 4.6) clearly indicate that there are no statistically significant differences between the means of the performances of the males and the females of Group A for Verbal Fluency.

Table 4.7 Comparison of Verbal Fluency Scores for males and females in Group B

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Phonemic Fluency	Male	10	21,2	6,81	2,15
	Female	10	26,4	8,55	2,70
Semantic Fluency	Male	10	41,0	6,98	2,21
	Female	10	37,1	5,61	1,77
Total Verbal Fluency	Male	10	62,2	11,73	3,71
	Female	10	63,5	10,59	3,35

Table 4.7 presents the description of the T-test data obtained for the males and females of Group B for the Verbal Fluency Test. Table 4.8 presents the results of the T-test.

Table 4.8 T-test results for gender differences in Verbal Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		T	df	Sig. (2-tailed)
Phonemic Fluency	0,191	0,668	2	-1,504	18	0,150
			3	-1,504	17,142	0,151
Semantic Fluency	0,274	0,607	2	1,378	18	0,185
			3	1,378	17,204	0,186
Total Verbal Fluency	0,171	0,684	2	-0,260	18	0,798
			3	-0,260	17,815	0,798

Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.
Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.

The results of the T-test for Independent Samples (Table 4.8) clearly indicates that there are no statistically significant differences between the mean performances between the males and females of Group B for Verbal Fluency.

In summary, the tests for normality indicated that the data from all three scores of Verbal Fluency, phonemic fluency, semantic fluency and total verbal fluency, could be analysed for significant differences between means using parametric statistical tests. There are highly significant differences between the means of Groups A and B, with Group A performing significantly better. No significant gender differences between mean performances were found for Group A or Group B.

4.4 Design Fluency Test

In the Design Fluency Test, the participants are required to produce as many abstract novel designs as they can in a specific amount of time. Each design must meet certain criteria: it must not be nameable, must not be a scribble, and must be very different from all preceding designs. The score obtained is a novel output score, which is the total number of correct designs that meet the tester's aforementioned criteria.

There are two conditions: a free condition, in which there are no restrictions placed on the number of lines required in each design; and a four-line condition, in which it is required that each design comprise of exactly four lines. Each participant was given three scores: a free condition score; a four-line condition score; and a total design fluency score (free condition + four-line condition).

4.4.1 Results of the tests for normality of the data distribution

Table 4.9 Tests of normality for the Design Fluency Test

	Kolmogorov-Smirnov (a)		df=40	Shapiro-Wilk		df=40
	Statistic	P-value	Significance	Statistic	P-value	Significance
Free Condition	0,088	0,200[1]	None	0,961	0,179	None
Four-line condition	0,101	0,200[1]	*	0,909	0,003	*
Total Design Fluency	0,106	0,200[1]	None	0,960	0,174	None

[1] This is a lower bound of the true significance.
* Significant at α=0,10

Alternative Hypothesis H1: Observations do not follow the normal distribution.
Null Hypothesis H0: Observations follow the normal distribution.

Table 4.9 presents the results of the tests for normality for the Design Fluency Test. The results indicate that the data obtained from the free condition, as well as the total design fluency score, were found to follow the normal distribution and therefore were analysed for significant differences between means using a parametric statistical test.

However, the data obtained from the four-line condition did not follow the normal distribution curve and therefore had to be analysed for significant differences between means using a non-parametric statistical test.

4.4.2 Results of statistical analysis of group differences between means

4.4.2.1 Free Condition and Total Design Fluency

Table 4.10 Comparison Group A and Group B on the Design Fluency Test

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Free Condition	A	20	17,40	3,97	0,89
	B	20	10,90	4,04	0,90
Total Design Fluency	A	20	34,15	7,69	1,72
	B	20	19,30	5,82	1,30

The data of the scores for the Free Condition as well as for the Total Design Fluency were analysed using the Independent Samples T-test, and the description of the T-test data is presented in Table 4.10. The results of the T-test are presented in Table 4.11.

Table 4.11 T-Test results for significant difference between means in Design Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Free Condition	0,068	0,796	2	5,136	38	0,000***
			3	5,136	37,988	0,000***
Total Design Fluency	0,527	0,472	2	6,887	38	0,000***
			3	6,887	35,405	0,000***

*** Significant at $\alpha=0,01$

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the Independent Samples T-test (Table 4.11) clearly indicates that there are highly significant differences between the means of Group A and Group B on a 0,01 level for the Free Condition Trial of Design Fluency as well as for the Total Design Fluency, with Group A performing significantly better than Group B.

4.4.2.2 Four-line Condition

It was found that the scores for the Four-Line condition of the Design Fluency Test did not follow the normal distribution curve, and thus were analysed using the Mann-Whitney Test, which is a non-parametric statistical measure. The description of the Mann-Whitney data as well as the results for significant difference of means are presented in Table 4.12.

Table 4.12 Comparison of Groups A and B for Significant Differences of Means in Design Fluency

	Group	N	Mean Rank	Mann-Whitney U Value	Significance
Four-line Condition	A	20	593,50		
	B	20	226,50		
	Total	40		50,0	0,000***

*** Significant at α=0,01

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the Mann-Whitney Test (Table 4.12) clearly indicate that there are highly significant differences between the means of Groups A and B for the Four-line condition of the Design Fluency Test, with Group A performing significantly better than Group B.

4.4.3 Results of statistical analysis for gender differences

The mean scores of the males of Group A were compared with the mean scores of the females of Group A, and the mean scores of the males and females of Group B were compared in order to control for gender effects on Design Fluency.

4.4.3.1 Gender differences in Free Condition and Total Design Fluency Group A

Table 4.13 Comparison of Design Fluency scores for males and females in Group A

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Free Condition	Male	10	15,2	2,30	0,73
	Female	10	18,3	6,18	1,96
Total Design Fluency	Male	10	32,3	5,66	1,79
	Female	10	36,0	9,23	2,92

The data obtained for Group A for the Free Condition Trial as well as for the Total Design Fluency were analysed using the Independent-Samples T-test. The description of the T-test data is presented in Table 4.13. Table 4.14 presents the results of the T-test for significant differences between means.

Table 4.14 T-test results for gender differences of means in Design Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Free Condition	1,993	0,175	2	-1,486	18	0,155
			3	-1,486	11,443	0,164
Total Design Fluency	0,354	0,559	2	-1,081	18	0,294
			3	-1,081	14,931	0,297

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.

Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

Table 4.14 indicates that there are no statistically significant differences between means of the males and females of Group A for the Free Condition Trial and the Total for the Design Fluency Test.

4,4,3,2 Gender differences in Four-Line Condition Group A

The data from the Four-Line Condition of the Design Fluency Test for Group A was analysed using the Mann-Whitney Test. The description of the data as well as the results of the test for significant differences between means are presented in Table 4.15.

Table 4.15 Comparison of Design Fluency scores for males and females in Group A

	Group	N	Mean Rank	Mann-Whitney U Value	Significance
Four-line Condition	Male	10	8,70		
	Female	10	12,30		
	Total	20		32,0	0,190

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

The results of the Mann-Whitney Test (Table 4.15) clearly indicate that there are no statistically significant differences between the mean performances of the males and females within Group A for the Four-Line Condition of the Design Fluency Test.

4.4.3.3 Gender differences in Free Condition and Total Design Fluency Group B

Table 4.16 Comparison of Design Fluency Scores for males and females in Group B

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Free Condition	Male	10	10,3	4,79	1,51
	Female	10	11,5	3,27	1,04
Total Design Fluency	Male	10	18,0	7,07	2,24
	Female	10	20,6	4,22	1,33

The data obtained for Group B for the Free Condition Trial was analysed using the Independent-Samples T-test. The T-test description of the data is presented in Table 4.16. Table 4.17 presents the results of the T-test for significant differences between means.

Table 4.17 T-test results for gender differences in Design Fluency

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Free Condition	1,176	0,293	2	-0,654	18	0,521
			3	-0,654	15,913	0,522
Total Design Fluency	2,999	0,100	2	-0,998	18	0,331
			3	-0,998	14,693	0,334

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.

Table 4.17 indicates that there are no statistically significant differences between the means of the performances of the males and females of Group B for the Free Condition Trial and the Total for the Design Fluency Test.

4.4.3.4 Gender differences in Four-Line Condition Group B

The data from the Four-Line Condition of the Design Fluency Test for Group A was analysed using the Mann-Whitney Test. The description of the data as well as the results of the test for significant differences between means are presented in Table 4.18.

Table 4.18 Comparison of Design Fluency scores for males and females in Group B

	Group	N	Mean Rank	Mann-Whitney U Value	Significance
Four-line Condition	Male	10	8,85		
	Female	10	12,15		
	Total	20		33,5	0,218

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.

The results of the Mann-Whitney Test (Table 4.18) clearly indicate that there are no statistically significant differences between the mean performances of the males and females within Group B for the Four-Line Condition of this test.

To summarise, the tests for normality applied to the data obtained for the Design Fluency test indicated that the data for the Free Condition and the Total Design Fluency followed the normal distribution curve and therefore were analysed for significant differences between means using the Independent-Samples T-test. The data from the four-line condition, however, did not follow the normal distribution curve and therefore the Mann-Whitney Test was used. The T-test and the Mann-Whitney Test clearly indicated that there are highly significant differences between the means of the performances of Group A and Group B for all scores of the Design Fluency Test, with Group A performing significantly better. The statistical analysis of the males compared to the females in Group A and the males compared to the females in Group B showed no significant differences between means of the performances of the males and females and therefore it can be concluded that there were no gender effects observed for the Design Fluency Test.

4.5 Stroop Test

In the Stroop Test there are two conditions. In Form-C, the participant is shown a page with words listed in columns. The words are all the names of colours and are printed in colours that are different to the name indicated in printed word. The participant has to read the words aloud as quickly and as accurately as possible, while ignoring the colours of the ink that the words are printed in.

In the second condition, Form C-W, the participant is given a similar page but must name aloud the colour of the ink this time while ignoring the name that the word spells. In both conditions, the participant is given a maximum of 120 seconds within which to complete the page.

For each condition, the participant was scored on three criteria: number of correct responses; number of incorrect responses; and time of completion. It must be noted, that for Form C, all participants from both Group A and Group B responded correctly for all words presented, and no participant gave an incorrect response. Therefore, the scores for Form C correct responses and Form C Incorrect Responses were the same for Group A and B and therefore were omitted from statistical analysis.

4.5.1 Results of the tests for normality of the data distribution

Table 4.19 Tests of normality for the Stroop Test

	Kolmogorov-Smirnov (a)		df=40	Shapiro-Wilk		df=40
	Statistic	P-value	Significance	Statistic	P-value	Significance
Form-C Time (s)	0,128	0,095	*	0,926	0,012	**
Form C-W Correct	0,172	0,005	***	0,879	0,000	***
Form C-W Incorrect	0,275	0,000	***	0,677	0,000	***
Form C-W Time (s)	0,396	0,000	***	0,521	0,000	***

[1] This is a lower bound of the true significance.
* Significant at α=0,10
** Significant at α=0,05
*** Significant at α=0,01

Alternative Hypothesis H1: Observations do not follow the normal distribution.
Null Hypothesis H0: Observations follow the normal distribution.

The results of the tests of normality for the data of all the scores of the Stroop Test, presented in Table 4.19, indicate that the data does not follow the normal distribution curve and therefore must be analysed for significant differences between means using the non-parametric test, the Mann-Whitney test.

4.5.2 Results of statistical analysis of group differences between means

Table 4.20 presents the description of the data for the four scores of the Stroop Test as well as the results of the Mann-Whitney test for significant differences between means for Group A and Group B.

Table 4.20 Comparison of Groups A and B for the Stroop Test

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Form C Time (s)	A	20	309,50		
	B	20	510,50		
	Total	40		99,5	0,006***
Form C-W Correct	A	20	529,50		
	B	20	290,50		
	Total	40		80,5	0,001***
Form C-W Incorrect	A	20	284,00		
	B	20	536,00		
	Total	40		74,0	0,000***
Form C-W Time (s)	A	20	356,50		
	B	20	463,50		
	Total	40		146,5	0,149*

* Significant at α=0,10
*** Significant at α=0,01

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the Mann-Whitney test (Table 4.20) indicate there are significant differences in the means of the performance of Groups A and B for the scores of Form C Time, Form C-W Correct, Form C-W Incorrect on the Stroop Test with Group A performing significantly better than Group B. The differences in mean performances for Form C Time, Form C-W Correct and Form C-W incorrect are only significant on the 0,01 level and are therefore not considered to be statistically significantly different.

4.5.3 Results of statistical analysis of gender differences

The mean scores of the males of Group A were compared with the mean scores of the females of Group A, and the mean scores of the males and females of Group B were compared in order to control for gender effects on the Stroop Test. Table 4.21 presents the description of the Mann-Whitney data and results for the Stroop Test for Group A, male versus female.

Table 4.21 Comparison of Stroop scores for males and females in Group A

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Form C Time (s)	Male	10	9,85		
	Female	10	11,15		
	Total	20		43,5	0,631
Form C-W Correct	Male	10	8,55		
	Female	10	12,45		
	Total	20		30,5	0,143
Form C-W Incorrect	Male	10	12,05		
	Female	10	8,95		
	Total	20		34,5	0,247
Form C-W Time (s)	Male	10	10,75		
	Female	10	10,25		
	Total	20		47,5	0,853

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

The results of the Mann-Whitney test (Table 4.21) indicate that there are no significant differences between the mean performances of males and females of Group A for the Stroop Test. Table 4.22 presents the description of the Mann-Whitney data and results for the Stroop Test for Group B, male versus female.

Table 4.22 Comparison of Stroop scores for males and females in Group B

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Form C Time (s)	Male	10	13,90		
	Female	10	7,10		
	Total	20		16,0	0,009
Form C-W Correct	Male	10	8,20		
	Female	10	12,80		
	Total	20		27,0	0,089
Form C-W Incorrect	Male	10	11,00		
	Female	10	10,00		
	Total	20		45,0	0,739
Form C-W Time (s)	Male	10	10,10		
	Female	10	10,90		
	Total	20		46,0	0,796

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.

The results of the Mann-Whitney test (Table 4.22) indicate that there are no significant differences between the mean performances of the males and females of Group B for the Stroop Test for the scores of Form C-W Time, Form C-W Correct, and Form C-W Incorrect. However, there was a significant difference observed between the mean performances of the males and females in Group B in terms of the score of Form C time, with males performing significantly faster than females.

The tests of normality indicated that all the data obtained for the Stroop Test did not follow the normal distribution curve and therefore the Mann-Whitney Test was used to analyse significant difference between means. The results of the Mann-Whitney test showed significant differences between the means of the performances of Groups A and B for all scores of the Stroop Test, with Group A performing significantly better, except for the score of Form C-W Time Completed, where no significant differences were observed. There were no significant differences observed between the means of the performances of the males and females neither of Group A nor of Group B, and thus no gender effects were observed, except for on the score of Form C Time Completed for Group B, where the males performed faster than the females.

4.6 The Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) consists of four stimulus cards, placed in front of the subject. The participant is then given two decks of cards, each containing 64 cards, which have designs similar to the stimulus cards, varying in colour, geometric form and number. The participant is told to match each of the cards in the decks to one of the key cards and is given feedback each time if he/she is right or wrong. The tester changes the sorting criterion periodically, but does not give the participant any warning that he/she is doing so. For instance, initially the criterion is form. Once the participant has sorted ten consecutive cards correctly according to form, the tester changes the criterion to colour.

Once the participant has sorted ten consecutive cards correctly according to colour, the tester changes the criterion to number, then back to form and so forth. The test is completed when the participant has either form, colour, number) or when all 128 cards have been placed, whichever occurs first.

For the WCST, the participant was given three scores: number of sets completed (form, colour, number et cetera); number of incorrect responses; and the number of perserverative responses. Chapter 3 provides an in-depth definition of perserverative responses.

4.6.1 Results of the tests for normality of the data distribution

Table 4.23 Tests of normality for the WCST

	Kolmogorov-Smirnov (a)		df=40	Shapiro-Wilk		df=40
	Statistic	P-value	Significance	Statistic	P-value	Significance
Sets completed	0,271	0,000	***	0,843	0,000	***
Incorrect Responses	0,122	0,137	None	0,945	0,052	*
Perserverations	0,102	0,200[1]		0,942	0,039	**

[1] This is a lower bound of the true significance.
* Significant at α=0,10
** Significant at α=0,05
*** Significant at α=0,01

Alternative Hypothesis H1: Observations do not follow the normal distribution.
Null Hypothesis H0: Observations follow the normal distribution.

The results of the test of normality for the WCST, presented in Table 4.23, indicate that the data for the Incorrect Responses on the WCST follow the normal distribution curve and therefore can be analysed using the Independent-Samples T-Test, whereas the data for the Number of sets completed and the Perserverative responses do not follow the normal distribution curve and therefore must be analysed for significant difference between mean using the Mann-Whitney Test.

4.6.2 Results of statistical analysis for mean group differences

4.6.2.1 Incorrect Responses

Table 4.24 Comparison of Group A and B on the WCST

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Incorrect Responses	A	20	29,20	16,43	3,67
	B	20	61,80	20,89	4,67

The description of the T-test data for the Incorrect Responses of the WCST is presented in Table 4.24. The results of the T-test for significant difference between means are presented in Table 4.25.

Table 4.25 T-Test Results for Significant difference between means in the WCST

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Incorrect Responses	1,112	0,298	2	-5,486	38	0,000***
			3	-5,486	36,003	0,000***

*** Significant at α=0,01

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the T-test (Table 4.25) indicate that there are highly significant differences, level 0,01, between the mean scores of Groups A and B for the number of Incorrect Responses on the WCST, with Group A performing significantly better than Group B.

4,6,2,2 Sets Completed and Perserverations

Table 4.26 presents the description of the Mann-Whitney data and results for the scores of the number of sets Completed and Perserverations for the WCST.

Table 4.26 Comparison of Groups A and B mean differences for the WCST

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Sets Completed	A	20	550,00		
	B	20	270,00		
	Total	40		60,0	.000***
Perserverations	A	20	269,00		
	B	20	551,00		
	Total	40		59,0	.000***

*** Significant at α=0,01

Alternative Hypothesis H1: There is a statistically significant difference between the means of Group A and Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of Group A and Group B.

The results of the Mann-Whitney Test (Table 4.26) clearly indicate that there are highly significant differences, on the 0,01 level, between the mean performances of Group A and B for the number of Trials Completed as well as the number of Perserverative Responses on the WCST, with Group A performing significantly better than Group B.

4.6.3 Results of statistical analysis of gender differences

The mean scores of the males of Group A were compared with the mean scores of the females of Group A, and the mean scores of the males and females of Group B were compared in order to control for gender effects on the Wisconsin Card Sorting Test (WCST).

4.6.3.1 Gender differences in Incorrect Responses Group A

Table 4.27 Comparison of WCST scores for males and females in Group A

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Incorrect Responses	Male	10	29,3	14,63	4,63
	Female	10	29,1	18,86	5,97

The data for the Incorrect Responses on the WCST between males and females of Group A were analysed for significant differences of means using the Independent-Samples T-Test. Table 4.27 presents the T-test description of the data and Table 4.28 presents the results of the T-test for Group A.

Table 4.28 T-test Results for gender differences in the WCST for Group A

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Incorrect Responses	1,048	0,320	2	0,026	18	0,979
			3	0,026	16,950	0,979

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

The results of the T-test (Table 4.28) clearly indicate that there are no significant differences in the mean performances between the males and females of Group A for the number of Incorrect Responses on the WCST.

4.6.3.2 Gender differences in Sets Completed and Perserverations Group A

The data obtained for the number of Trials Completed and Perserverations for males versus females of Group A on the WCST were analysed for significant difference between means using the Mann-Whitney Test. Table 4.29 presents the description of the data and the results of the test.

Table 4.29 Comparison of WCST scores for males and females in Group A

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Sets Completed	Male	10	10,65		
	Female	10	10,35		
	Total	20		48,5	0,912
Perserverations	Male	10	11,40		
	Female	10	9,60		
	Total	20		41,0	0,529

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group A.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group A.

The results of the Mann-Whitney test (Table 4.29) clearly indicates that there are no significant differences between the mean performances of the males and females of Group A for the Trials Completed and the number of Perserverations on the WCST.

4.6.3.3 Gender differences in Incorrect Responses Group B

Table 4.30 Comparison of WCST scores for males and females in Group B

	Group	N	Mean	Std. Deviation	Std. Error of measurement
Incorrect Responses	Male	10	57,1	23,10	7,30
	Female	10	66,5	18,40	5,82

The data for the Incorrect Responses on the WCST between males and females of Group B were analysed for significant difference between means using the Independent-Samples T-Test. Table 4.30 presents the T-test description of the data and Table 4.31 presents the results of the T-test for Group B.

Table 4.31 T-test Results for gender differences in WCST for Group B

	Levene's Test for Equality of Variances		T-test for Equality of Means			
	F-test		T-test			
		P-value		t	df	Sig. (2-tailed)
Incorrect Responses	0,119	0,734	2	-1,007	18	0,327
			3	-1,007	17,143	0,328

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.

The results of the T-test (Table 4.31) clearly indicate that there are no significant differences in the mean performances between the males and females of Group B for the number of Incorrect Responses on the WCST.

4.6.3.4 Gender differences in Sets Completed and Perserverations Group B

The data obtained for the number of Trials Completed and Perserverations for males versus females of Group B on the WCST were analysed for significant differences of means using the Mann-Whitney Test. Table 4,32 presents the description of the data and the results of the test.

Table 4.32 Comparison of WCST scores for males and females in Group B

	Group	N	Mean Rank	Mann-Whitney Value	Significance
Sets Completed	Male	10	9,95		
	Female	10	11,05		
	Total	20		44,5	0,684
Perserverations	Male	10	8,30		
	Female	10	12,70		
	Total	20		28,0	0,105

Alternative Hypothesis H1: There is a statistically significant difference between the means of the males and females of Group B.
Null Hypothesis H0: There is no statistically significant difference between the means of the males and females of Group B.

The results of the Mann-Whitney test (Table 4.32) clearly indicates that there is no significant difference between the mean performances of the males and females of Group B for the Trials Completed and the number of Perserverations on the WCST.

In summary, the tests of normality for the data on the WCST indicated that the data for the number of Incorrect Responses follow the normal distribution curve and therefore can be analysed for significant difference between means using the Independent-Samples T-test, whereas the data for the number of Trials Completed and the number of Perserverations do not follow the normal distribution curve and therefore must be analysed using the Mann-Whitney Test. The T-test and the Mann-Whitney test indicated highly significant differences between the mean performances of Groups A and B for all the scores of the WCST, with Group A performing significantly better. The scores for males and females of Group A as well as the scores for the males and females of Group B were compared and no significant differences in mean performances were found. Therefore it can be concluded that no gender effects were observed for the WCST for both Group A and Group B.

4.7 Summary of results

In order to analyse whether quality of education has an effect on neuropsychological test performance, the performance of participants from two groups, namely a high quality of education group and a low quality of education group, was compared and analysed for statistically significant differences of means.

For the data that followed the normal distribution curve, parametric statistical tests were used, but for data that did not follow the normal distribution curve, non-parametric statistical tests were used. These were the Independent Samples T-test and the Mann-Whitney test, respectively.

The results of the T-test showed that the means of Group A and Group B are significantly different for the scoring criteria Phonemic Fluency, Semantic Fluency, Total Verbal Fluency, Free Condition Design Fluency, Total Design Fluency, and Incorrect Responses on the WCST at a 1% level of significance, that is to say that it is 99% certain that the differences observed are not due to chance alone. The results of the Mann-Whitney test also showed that the means of Group A and Group B are significantly different for the scoring criteria of all scores of the Stroop test as well as for Sets Completed and Perserverative Responses of the WCST at a 1% level of significance, except for the scores on the Stroop Form C-W Time criterion, where the differences of means are significant at 10% level, and therefore are not considered statistically significant. To control for the effects of gender, the mean performance of the male participants was compared with that of the female participants within each group, A and B. Again, both parametric and non-parametric tests were used for appropriate data. The T-test and the Mann-Whitney test both clearly show that there were no significant differences between the means of the males and females of Group A, nor between the males and females of Group B for all the scores of all the tests, except for the Form C Time Completed between the males and females of Group B, where the males performed significantly faster. Thus, it can be concluded that there are highly significant differences between the mean performances of the learners receiving good quality education, Group A, as compared with the performances of the learners at the disadvantaged school, Group B, with Group A performing significantly better. However, no significant differences of means are found between males and females of each group, indicating that gender did not have an effect on the performance of the participants.

Chapter 5 follows with an in-depth discussion of these results and their implications.

Chapter 5
Discussion

5.1 Summary of the study

This study aimed to investigate the effect of quality of education on neuropsychological test performance. The rationale for the study is that much research is needed in order to investigate the factors, other than cognitive ability, that affect performance on neuropsychological tests in order to assure that neuropsychological tests are used appropriately for a wide range of individuals. Tests of executive function were chosen as executive function is an important, higher-order cognitive function. Administering an entire neuropsychological test battery was beyond the scope of the current study. The researcher approached schools that met the criteria proposed by Johnson et al. (2006), Nell (2000) as well as Shuttleworth-Edwards et al. (2004) for high versus low quality of education. Two groups of participants were recruited: Group A (*n= 20)* representing the high quality of education group and Group B *(n = 20)* representing the low quality of education group. The Groups were matched for age and level of education. Four neuropsychological tests of executive function were administered to each participant, namely, the Verbal Fluency Test, The Design Fluency Test, The Stroop Test and The Wisconsin Card Sorting Test. The mean performance of Group A was compared to the mean performance of Group B and analysed for statistically significant differences of means. The results indicated that there are highly significant differences between the mean performances of Group A and Group B on all four tests of executive function, with Group A performing significantly better than Group B on every score.

This Chapter will present a discussion of the results presented in Chapter 4 as well as a discussion of the study in general. A conclusion and summary of the study, as well as recommendations for future research and practice, are also presented.

5.2 Discussion of demographic information of participants

A brief commentary on the differences in demographic details between Group A and Group B is presented in Chapter 4. However, some demographic factors require further explanation.

The demographic characteristics of the participants seem to support the observation suggested by Shuttleworth-Edwards et al. (2004) that quality of education of the participant is related to the level of education of the participant's parent. Indeed, the parents of Group A participants had higher levels of education than the parents of Group B participants. In Group A, 60 per cent of the parents had Bachelor's degrees, 10 per cent had Honours degrees, and 15 per cent had Master's Degrees. None of the parents in Group A had lower than matric education level. In Group B, however, 35 per cent of the parents had not obtained a matric certificate, 25 per cent had obtained a matric certificate and only one parent had a tertiary qualification, namely, a diploma. None of the parents in Group B had obtained university degrees. Thus, this is consistent with Shuttleworth-Edwards et al. (2004) who assert that quality of education is an organising variable for socio-demographic factors that affect neuropsychological test performance. Some other such factors, for instance quality of communication in the home, were not investigated in the current study. This represents a possible limitation of the study and is further discussed in the next section, along with the other limitations of the current study.

It must also be emphasised that the two groups were matched for level of education. Level of education has been suggested as an important influential variable affecting performance on neuropsychological tests (Manly et al., 2004; Ostrosky-Solis et al., 2004a; Ostrosky-Solis et al., 2004b). However, significant differences were observed between the mean performances of Group A and Group B, despite the groups being matched for level of education.

The results of the study therefore indicate that groups that are matched for level of education but not for quality of education do not perform at the same level on neuropsychological tests of executive function. This is further corroborating evidence for the research that suggests that quality of education is a more influential variable than level of education that may affect neuropsychological test performance (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004)

As mentioned in Chapter 4, the groups are disparate in terms of whether each participant had ever repeated a grade at school or not. In Group A, only 10 per cent ($n = 2$) of participants had ever repeated grades at school, whereas in Group B, 40 per cent ($n = 8$) of the participants had repeated a grade at school. This might imply that there are intrapersonal differences between the participants in the two groups in terms of overall cognitive ability. This is discussed further in the limitations section of this chapter.

5.3 Discussion of results of statistical analysis

The results presented in the previous chapter show that for every score on all four tests administered, that is to say the Verbal Fluency, Design Fluency, Stroop Test and Wisconsin Card Sorting Test, there are significant differences between the mean scores of Group A, the private school participants who represent good quality of education, and Group B, the government school group, who represent poor quality of education, with Group A performing significantly better than Group B on each score. This suggests that quality of education has an effect on neuropsychological test performance. The groups were matched for age and no gender effects were found, except for the score of Form C time in Group B, with the males performing significantly faster than the females. The differences observed between the means for all the scores were highly significant on all the tests, on a 0,01 level of significance, except for the Stroop test, and this requires further discussion.

The results of the Stroop test are of particular interest. In the Stroop test, the participant is shown a page with the names of colours typed in four columns, with each word printed in a colour that does not match the name of the colour typed. For instance, “blue” will be typed in green ink and “green” will be typed in red ink, et cetera. As mentioned in Chapter 3, there are two conditions. In the first condition, Form C, the participant has to read the word spelled on the page, while ignoring the colour of the ink. In the second condition, Form C-W, the participant has to name the colour of the ink while ignoring the word spelled. The score on Form C is taken as a baseline for comparison with Form C-W, as it is theorised that executive function is not relied upon for performance in Form C, only in Form C-W. For each of the two conditions, there are three scoring criteria: Time completed, number of incorrect responses, and number of correct responses. The maximum time allowed is 120 seconds per condition. The maximum number of correct responses possible is 112, For each trial, the participant is scored on three criteria: number of correct responses, number of incorrect responses, and time completed.

What is of interest in the results of the Stroop Test is that both groups obtained the same number of correct responses and incorrect responses for Form C. That is to say, in both groups, all participants achieved the maximum of 112 correct responses. Since it is theorised that Form C does not tap into executive function, whereas Form C-W does (Imbrosciano & Berlach, 2005) it can be summarised that no significant difference was found between the groups in terms of correct responses when performance did not tap into executive function, whereas highly significant differences were found when performances did tap into executive function. Therefore, it can be interpreted that the differences observed were due, in fact, to differences in the two groups’ ability to perform on tests of executive function, and not due to other factors such as reading ability. It must be noted though that the mean score for Time Completed for Form C-W on the Stroop test was not significantly different for the two groups. That is to say, although Group B made significantly more mistakes than Group A did, the time it took the two groups to complete the Stroop did not differ significantly.

This suggests that the two groups have similar levels of processing speed as well as reading level, but that their ability to successfully suppress a habitual but incorrect response in favour of a less habitual but correct response is disparate. Again, this suggests that the two groups have different levels of performance in terms of executive function, and not necessarily in terms of other factors such as reading level or processing speed. These results on the Stroop call into question the use of reading level as a way of operationalising quality of education, which has been done in many studies (Byrd et al., 2005; Johnson et al., 2006; Manly et al., 2002; Manly et al., 2004). The current study found, however, that the two groups that differed in terms of quality of education did not in fact differ in reading level. Further, the two groups that differed in the ability to perform on tests of executive function did not differ in terms of reading level, suggesting that quality of education may have specific effects on some cognitive processes, such as executive function, but not on others. More research is needed into whether reading level is a valid measure of quality of education attained by an individual as well as into the effects of quality of education on neuropsychological tests of other cognitive modalities.

It must also be mentioned that the males in Group B completed the Stroop form C significantly faster than the females of Group B did. This was the only score of all the tests in which gender differences were found. This result may suggest that gender has an effect on processing speed when there is a lower level of education, as no gender differences were observed were observed for this score of the Stroop for Group A. More in-depth is needed into the complex interplay of biological and environmental factors that affect performance on neuropsychological tests.

Overall, the results indicate that Group A performed significantly better than Group B. It must be emphasised, however, that neuropsychological tests, like all psychological tests, cannot directly measure constructs in the same way that a scale can measure weight or a ruler can measure length (Cohen & Swerdlik, 2002). That is to say, neuropsychological tests cannot directly measure nor give a completely accurate indication of a cognitive function.

Therefore, the results do not necessarily suggest that Group A has better executive functioning *per se* than Group B, only that Group A performed better at the tests of executive function than Group B did. Possible explanations for the differences observed in performances of the two groups are discussed next. Further research is needed to delineate definite explanations for the results obtained in the study, therefore it is emphasised that the explanations proposed next are tentative hypotheses based on the theories discussed in Chapter 2.

The differences observed between the performances of Group A and Group B may be due to the impact quality of education has on test-wiseness as well as its effects on the manifestation of skills that are measured in neuropsychological tests. As discussed in Chapter 2, Millman et al. (1965, p 707) defined test wiseness as “a participant’s capacity to utilise the characteristics and formats of the test and/or the test-taking situation to receive a high score”. Test wiseness is thought to be independent of the individual’s knowledge of the participant matter being assessed. If an individual has a low level of test wiseness, due to lack of adequate quality educational opportunity, it would follow that he or she would perform poorly on neuropsychological tests. Further, neuropsychological tests measure a person’s functioning which this is often the product skills learned at school, rather than of innate, or fluid intelligence, as in the case of IQ test performance (Shuttleworth-Edwards et al., 2004). Many researchers acknowledge that the abilities assessed in most neuropsychological tests are learned and highly trained, and the way in which they manifest is determined by exposure to Western education (Ardila, 1995; Ardila et al., 1989; Gasquoine, 1999).

Thus, the quality of education a person receives will determine the level of skills obtained by the individual as measured by neuropsychological tests. Chan et al. (2008) also argue that culture affects the manifestation of executive function, and thus will affect an individual’s performance on tests of executive function.

Using Chan et al.'s argument to explain the differences observed between the performances of the two groups, it could be said that perhaps education influences the way in which executive function is manifested. It is possible that the education a person receives forms part of the environment that shapes their problem-solving and self-regulatory abilities.

Another possible explanation for the differences observed between the two groups may be the effect that environmental factors, such as quality of education, might affect the organisation of the brain itself (Eviatar, 2000). This can be explained by the concept of plasticity, which is defined as the changes that can occur in the physiology of the brain as a result of experience (Banich, 2004). As discussed in Chapter 2, the brain has the ability to change due to environmental input. Quality of education represents such environmental input that may cause changes to occur in the structure and organisation of the neural pathways in the brain. This explanation would imply that the differences observed between Group A and Group B are in fact due to differences in executive function, *per se,* but this hypothesis cannot be tested in the current study and thus remains a tentative hypothesis rather than a definite explanation. Again it is emphasised that the conclusion drawn in the current study refers to the ability to perform on tests of executive function rather than executive function *per se.*

The differences observed might also be due to other factors that are often correlated with the quality of education a person receives, such as quality of communication in the home, parental education, and wealth of social opportunities available. According to Shuttleworth-Edwards et al. (2004), an emphasis on the effect of quality of education on neuropsychological test performance does not mean a denial of the effects of these variables. Instead, quality of education can be seen as a meta-factor that often implies these other factors. That is to say, when an individual is attending a high quality of education school, it is most likely that he or she comes from a home where the importance of education is emphasised, the parents themselves are educated, the parents emphasise communication and learning in the home, the parents are able to provide socio-cultural opportunities to the children. It may be these factors that affected the results obtained in the current study.

Intrapersonal factors such as motivation, personality, and general cognitive ability may also have had an effect on the participants' performances in the study and may account for the differences observed between the two groups. Personality, emotional state and motivation might affect a participant's performance in that they can influence the way in which a participant responds (Lezak, 1995; Vanderploeg, 2000). A more highly motivated participant, or a participant with a personality characterised by high need for achievement and low anxiety, is more likely to perform better than a participant who is not highly motivated or is overly anxious. Overall cognitive ability can also affect a participant's performance as a participant with a better overall cognitive ability is more likely to perform better than a participant with poor cognitive ability, perhaps despite other influential environmental factors (Lezak, 1995; Vanderploeg, 2000). There is a complex interplay of personality, environmental, and biological factors that determine an individual's performance on neuropsychological tests (Ardila et al., 1989; Ardila, 1995; Gasquoine, 1999). Since these mentioned personality and biological factors were not controlled for in the current study, it cannot be concluded absolutely whether personality, biological, or environmental, in this case quality of education, factors caused the differences observed between the mean performances of Group A and Group B. The possible effects of these factors on the participant's performance represents a limitation of the study and is further discussed later in the chapter.

Performance on a neuropsychological test is mediated by other factors than the construct being measured. The results obtained in the current study indicate that there is a significant difference between the mean performances of advantaged learners versus disadvantaged learners, and thus it may be suggested that quality of education could be one such factor that affects performance on neuropsychological tests of executive function.

It is clear that there is a relationship between quality of education and performance on neuropsychological tests of executive function. The nature of this relationship, however, is not clear. That is to say, it is not clear whether quality of education *per se* is responsible for the differences observed or whether quality of education is associated with other demographic and personality factors that affect performance. Still, the differences observed between the two groups in the current study suggest that quality of education should be taken into account when using, interpreting, and developing norms for neuropsychological tests of executive function.

Whatever the reason is behind the differences observed, it is nevertheless clear that the participants from the disadvantaged educational background performed significantly more poorly than the participants from the advantaged educational background. The implication of these findings is that neuropsychologists cannot appropriately use the same norms for assessing the performance of individuals from disadvantaged educational backgrounds as they use when assessing individuals from advantaged educational backgrounds. As Anderson (2001) found in his study, using imported norms that were not developed on a representative norm group can lead to false positives in diagnosis of neuropathology. This means that an individual from Group B in the current study might be misdiagnosed with neuropathology when compared with imported norms, despite being neurologically intact. Such occurrences are likely to reduce the quality of service delivery in the profession on neuropsychology in South Africa. Individuals will not benefit from the inappropriate diagnosis, prognosis, treatment, and recommendation decisions made by neuropsychologists using unrepresentative norms.

5.4 Participant observations

There were interesting observations made on some on the tests of the individual participants' performances that deserve further discussion. It must be emphasised that this is a qualitative discussion based on observations of performances and of the individual characteristics of the participants, not a discussion based on quantitative statistical analysis.

It is argued by many that the Verbal Fluency Test is affected by other cognitive abilities besides executive function, such as language abilities (Mitrushina et al., 2005). In the current study the Verbal Fluency test was administered in English and therefore it can be argued that the participants with English as a home language had an unfair advantage over the participants whose home language was not English. However, it must be noted that the medium of instruction at all of the participating schools is English. Further, in Group A, the highest Verbal Fluency Score, total of 139 was obtained by a participant whose home language is Sotho. Her closest competitor was a participant whose home language is Spanish, and he obtained a score of 115, The next highest score was 114, and this was obtained by two participants: a participant whose home language is Xhosa, and a participant whose home language is English. Therefore, the top scores on Verbal Fluency were obtained mostly by participants whose home language is not English, and thus it can be concluded that language may not have been the most influential factor in performance on verbal fluency.

The highest Verbal Fluency score, of 83, in Group B was obtained by a participant whose home language is Xhosa. This participant has an interesting background. He is the son of a domestic worker and a veterinary assistant. The participant has a close relationship with the son of his mother's employers, who is the same age as the participant. The participant is treated as though he were another child in the family and reports a close relationship with his mother's employers, whom he feels are like second parents to him. In fact, they have offered to pay for him to further his education at university, in any course he chooses, once he has finished school, but only if he obtains good results. This indicates that there is an emphasis on education in the home. The participant socialises on weekends with the son of this family and all of his friends, who are privately educated. What is also of note is that this participant is a member of the South African Equestrian Vaulting Team and has travelled all over the world to compete. The researcher spent time during the assessments to get to know all the participants, in order to build rapport, and observed immediately that this participant spoke better than his classmates, and had a wider frame of reference for social and political events.

Therefore, it is not surprising that this participant obtained the highest score for Verbal Fluency of the participants in Group B, suggesting that quality of communication in the home, emphasis on education in the home, and socio-cultural opportunities do indeed play a role in performance on neuropsychological tests. But, his score is significantly lower than the highest Group A score, and only 16 points higher than the lowest Group A score, indicating that his Verbal Fluency, although the best of Group B, is weak in comparison with Group A. This suggests that the low quality of education he receives still affected his performance, despite these other advantages he has in the home environment. In other words, it appears in this case that quality of education actually mediates other socio-demographic variables that may affect an individual's performance. This participant's scores were also the best in Group B for the Stroop Form C-W, as he only had one incorrect response and completed the trial in 109 seconds. He is also one of only three participants in Group B to achieve the maximum of six sets completed on the Wisconsin Card Sorting Test (WCST).

Of the other two participants who completed all six sets on the WCST in Group B, one is a chess player. This participant has played chess in a community project for the past five years. He made only three perserverative errors throughout the test, which is very low compared to the other participants in group B, who made up to thirty perserverative errors each. It can be hypothesised that the cognitive flexibility and strategic thinking required in chess played a role in this participants' performance. Also, chess requires the player to make inferences about the opponent's intentions, and this is also an aspect of the WCST. The impact that playing chess may have on executive function might be an interesting research question for future studies.

In terms of the differences observed between the performances of Group A versus Group B on the WCST, it is interesting to note that in Group A, only five participants did not complete all six sets, whereas in Group B, only three participants did complete all six sets.

The best performance in Group A was obtained by the Sotho-speaking participant who obtained the best Verbal Fluency score. She completed all six sets with only seven incorrect responses and no perserverative errors. This further suggests that race and culture *per se* are not as influential as quality of education in affecting performance on neuropsychological tests of executive function as it was a participant whose home language is not English who performed the best on these measures of executive function.

5.5 Limitations of the study

The current study is limited in terms of the range of neuropsychological tests administered. In order to fully investigate the effects of quality of education, a full neuropsychological test battery should be administered.

This should be taken into consideration for future research. Other methodological issues that limited the study were those concerning the intrapersonal factors that may have affected individuals' performances as well as sample size limitations.

In terms of intrapersonal factors such as motivation and personality, these were not controlled for and thus represent a limitation of the study. In terms of the intrapersonal factor of overall cognitive ability, it must be noted that in Group A, only two participants have ever repeated a grade at school, whereas in Group B, eight participants have repeated grades at school.

Thus, it might be suggested that there are intrapersonal differences in the abilities of the participants in Groups A and B that may have affected the findings of the study. However, it can also not be clear whether these participants repeated grades at school because of lack of ability or because of poor educational opportunities. This would need to be taken into consideration in future studies.

The sample size of the entire study is *n = 40,* Although this was sufficient for meaningful statistical analysis of differences between means, this sample size is relatively small. This small sample size, due to limited resources, is another limitation of the study. Also, the small sample size limits the generalisability of the results of the study.

Finally, as Shuttleworth-Edwards et al. (2004) suggest, quality of education represents a way for organising many other environmental factors that may affect performance on neuropsychological tests, such as quality of communication in the home and parental education. Although some of these demographic variables were investigated, as discussed in the previous section, the study is limited as not all relevant variables were investigated and those that were, were only qualitatively interpreted. More advanced statistical procedures, which were beyond the scope of this study, are needed to fully understand the correlation between these variables and quality of education, as well as these variables and performance on neuropsychological test performance.

5.6 Recommendations

Based on the results of the study as well as the limitations of the study that have been acknowledged, there are some recommendations that are made. First, the results clearly indicate that there is a relationship between quality of education and neuropsychological test performance. This suggests that the way in which norms are developed in such tests, and the way in which test scores are interpreted, need to be revised, taking into account quality of education.

In addition to revising norms, the nature of the relationship between quality of education and neuropsychological test performance needs to be further investigated in future research.

Recommendations for future studies would be for the current study to be repeated across South Africa with the following modifications: larger samples, an entire neuropsychological test battery to be administered, and further investigation into and statistical analysis of intrapersonal and demographic variables.

5.7 Conclusion

Based on the results and observations of this study, it can be concluded that performance on neuropsychological tests of executive function appears to be related to quality of education. It is suggested that it is more useful to consider quality of education, rather than culture *per se,* when considering the appropriateness of neuropsychological tests of executive function and when interpreting test results. It is recommended that more research into the relationship between quality of education and neuropsychological tests be conducted and it is also recommended that neuropsychologists take quality of education into consideration when developing test norms and when interpreting test results.

In the context of a growing awareness of cross-cultural issues in neuropsychological assessment, there needs to be research into factors other than cognitive ability that might affect an individual's performance. There is also a growing awareness that culture is not a homogenous variable, and within-group variation is prominent. Race and culture are no longer useful variables for developing norms and for conducting research into cross-cultural neuropsychological assessment. This study has suggested that quality of education may be a more useful variable when considering the appropriate use of neuropsychological tests on individuals with discrepant demographic backgrounds. Clinicians working with individuals with a disadvantaged educational background should administer caution when drawing conclusions regarding diagnosis, prognosis, and recommendations from neuropsychological tests of executive function.

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APPENDIX I

Motivation letter to schools

Dear Sir/Madam,

My name is Jeanie Cave, and I am currently completing my Masters Degree in Clinical Psychology at The University of South Africa. As part of my degree, I am undertaking a research project that will contribute greatly to the advancement of psychology in our country. I would like to invite your school to be a part of this research, and in that way help further this important field of human science.

I would like to conduct my research with Grade 11 and 12 learners and I would ideally like 25 learners from your school, but will be happy with any number that are willing to participate. The research will involve administering 4 short psychological assessment measures to each learner individually. I will need to meet with each child for a single one-hour session. After that, I will not need anything further from the learners.

I would like to just emphasise that I am only asking for one hour per child. Once I have collected the data, I will not need any further assistance from your school.

I appreciate that your learners are under much pressure and have very busy schedules. I would like to schedule assessments for before school, after school, and during breaks et cetera, so that no valuable teaching time is lost. I will ask each student to make an appointment with me individually. If this is not convenient, I am flexible and open to suggestions.

I would like to assure you that your learners are not going to be compared with each other, or with learners from other schools in the area. I can also assure you that the research is completely confidential. Neither the learners' names nor your school's name will appear anywhere in my report. Indeed, parental consent will be sought and participation is completely voluntary.

I hope you will take time to consider my request. I know it may appear that your school will benefit nothing from helping me, but please be assured that this research will help the many, may people who need to make use of our country's psychological resources and promote culture-fair testing.

Thank you for your consideration. Please do not hesitate to contact me if you have any further queries.

Cell: 083 695 1432; e-mail: jeanie.cave@gmail.com

Kind Regards,

Jeanie Cave'
BA Psychology (Cum Laude)
BA (hons) Psychology (Cum Laude)

APPENDIX II

Consent form

Dear Sir/Madam,

My name is Jeanie Cave', and I am currently completing my Masters Degree in Clinical Psychology at The University of South Africa. As part of my degree, I am undertaking a research project that will contribute greatly to the advancement of psychology in our country. I would like to invite your child to be a part of this research, and in that way help further this important field of human science.

I would like to conduct my research with Grade 11 and 12 learners. The research will involve administering 4 short psychological assessment measures to each learner individually. I will need to meet with each girl twice, and will need 30 minutes in each session. After that, I will not need anything further from your child.

I would like to assure you that the research is completely confidential. Neither the learners' names nor your school's name will appear anywhere in my report. Participation is completely voluntary.

I hope you will take time to consider my request. I know it may appear that your child will benefit nothing from participation in this research project, but please be assured that this research will help the many, many people who need to make use of our country's psychological resources.

If you are willing to allow your child to participate, I thank you and ask that you please complete the consent form below. Please include your name and contact number so that I can contact you to schedule an appointment for your child.If possible, your child could come for a session before school, after school, during lunch, or during an admin period. I will schedule appointments with each child individually according to his or her availability. My contact details are: Cell: 083 695 1432,

Thank you for your consideration. Please do not hesitate to contact me if you have any further queries.

Kind Regards,

Jeanie Cave'
BA Psychology (Cum Laude)
BA (hons) Psychology (Cum Laude)

____

RETURN CONSENT FORM

I, ____ parent/guardian of ________

____ hereby give consent for him/her

to participate in the research study conducted by Ms. Jeanie Cave.

Contact____

Signed ____

Date ____

APPENDIX III

Demographic questionnaire

Participant Biographical Information

- Date of Birth:_________________________________ Gender: M/F_________
- Home Language: ____________________________
- **Which hand does the participant use most? (left/right/both)___________________**
- Has the participant ever repeated a grade? If so, which one/s?_______________
- How long has the participant been in this school?__________________________
- **If the participant has ever attended a different school?**

School	Period Attended
1,	
2,	
3,	

Parent/Guardian Biographical Information

What is the parent/s occupation? ____

What is their highest level of education?_____________________________________

Participant Medical Background

- **Does the participant have any history of head injury or neurological condition, seizures, serious illness, psychiatric disorder or learning difficulty?**

  no **yes (*If yes, please indicate):***

Condition/Injury/Illness	Onset Date	Treatment

- **Is the participant currently being treated by an occupational therapist?**

  no **yes (*If yes, please indicate):***

In therapy since	In therapy for

- **Is the participant currently taking any prescription medication, including medication for ADHD, like Ritalin?**

  no **yes (*If yes, please indicate):***

Medication	Used since **(mm/yyyyy)**