The effects of level and quality of education on the performance of South African adults on three commonly-used neuropsychological tests

Jenny-Lee Lowin

ACSENT Laboratory
Department of Psychology
University of Cape Town, South Africa

Supervisor: Kevin G. F. Thomas, Ph.D.

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ABSTRACT

The level and quality of education experienced by an individual have important effects on their neuropsychological test performance. These effects give rise to the need for continuing collection of normative data, particularly in the South African context, where rapid urbanization and increased access to educational resources is altering the collective face of the population. This study describes the effects that level and quality of education have on three commonly-used neuropsychological tests: the Trail Making Test (TMT), the CLOX Executive Clock Drawing task, and the Rey Auditory Verbal Learning Test (AVLT). These three assessment instruments, which form part of the Groote Schuur Memory Clinic's neuropsychological test battery, were administered to two groups of South African individuals. Participants were 56 healthy volunteer males and females ranging from 18 to 25 years of age and 53 healthy volunteer males and females older than 60 years of age. Results showed that individuals in the YA group performed statistically significantly better than individuals in the OA group on all three tests. Simple linear regression analyses showed that, for the combined group, level and quality of education had a negligible impact on test performance. Performance differences between individuals with low- and- high qualities of education were more pronounced within the OA group, however. This latter finding, in particular, suggests that cohort effects (perhaps as a result of historical events) should be taken into account when judging the likely impact of education on neuropsychological test performance in South Africa.

Keywords: education, South African, Alzheimer's Disease, TMT, CLOX, AVLT, neuropsychological performance.

Neuropsychological test performance is influenced by differences on a variety of socio-cultural and biological variables. Examples of the latter include age, gender and IQ. Examples of the former include level and quality of education, race, socio-economic status, level of acculturation and language (Boone, Victor, Wen, Razani, & Ponton, 2007; Lezak et al., 2004; Mitrushina, Boone, Razani, & D'Elia, 2005). In South Africa, in particular due to the influence of Apartheid, variables such as level and quality of education are important to consider when assessing individual test performance (Nell, 2000).

Level of Education

Level of education is conventionally defined as the total number of years of education an individual has achieved, based on the number of years it usually takes to complete a particular grade/level of education (Shuttleworth-Edwards et al., 2004). For instance, in the South African educational system, students usually take 12 years to complete matric (Grade 12); thus, any individual with a matric certificate (and no tertiary education) is regarded as having a level of education equal to 12 years.

Level of education is an important factor influencing individual performance on neuropsychological tests (Ardila, 1996; Ardila et al., 2000; Hooren et al., 2007; Strauss, Sherman, & Spreen, 2006). Richardson and Marottoli (1996) clearly demonstrated this effect. They provided normative data adjusted for level of education and showed that the performance of older individuals on a variety of common neuropsychological tests was worse when they had less than 12 years of education as opposed to more than 12 years of education. Additionally, Hooren et al. (2007) showed that individuals with a middle (estimated by intermediate secondary and intermediate vocational education) or high (estimated by any higher tertiary/secondary/vocational education) level of education outperformed individuals with a low level of education (estimated by elementary/lower vocational education) on a variety of neuropsychological tests.

Quality of Education

In South Africa, Shuttleworth-Jordan (1996) conducted a study to compare the performance of African first-language students to English first-language students on a range of neuropsychological tests. They matched individuals on level of education but still found performance differences, which they attributed to the individual's quality of education. This finding supports the assertion by Manly et al. (2000) who stated that if one looks merely at level of education as a predictor of test performance, it is likely to explain only a small proportion of the variation found in the data. However, by including both quality and level of education as predictors of test performance, one is more likely to explain a larger proportion of this variation.

Quality of education consists of a variety of factors that collectively describe an individual's educational background. For example, certain individuals might come from a disadvantaged socio-economic background, which impacts on the type of the school they attend, the resources available at that school, and the actual educational processes in which they engage. Quality of education is therefore regarded as either being high (i.e., having an advantaged educational background) or low (i.e., having a disadvantaged educational background).

The impact of quality of education on neuropsychological test performance is particularly relevant in South Africa, as this country has a long history of rule under Apartheid, whereby individuals received different types (and qualities) of education based upon their individual appearance. Specifically, White individuals received an education of a much higher quality than did Indians, Blacks, Asians and Coloureds.

South African empirical studies of the effects of education on neuropsychological test performance have confirmed that non-white individuals, particularly those with poor quality of education, perform more poorly than do White individuals. For instance, Shuttleworth-Edwards et al. (2004) found that Black African people who had been educated at Department of Education and Training (DET) schools performed more poorly than did White people (who had been educated at Model C schools) on a neuropsychological test battery. They attributed these differences to the quality of education that the Black African people in their sample had received.

One element of education quality that is emphasized by Shuttleworth-Edwards et al. (2004) is that of 'test wiseness'. This term refers to the fact that, as people are tested over and over again (in school, in job interviews, etc.), they become more and more familiar with the demands of the testing situation (e.g., they know to perform with both speed and accuracy) and more and more knowledgeable about and comfortable in the role of test-taker (e.g., they know to attend to the examiner's instructions and to remain quiet in the testing room). Individuals from a disadvantaged background may not have the multiple testing opportunities afforded to their advantaged counterparts, and therefore may not acquire this familiarity, knowledge, and comfort; they will be less 'test-wise.' Shuttleworth-Edwards et al. (2004) showed that this lack of 'test wiseness' had a debilitating effect on the ability of Black African individuals to perform at a suitable standard on a variety of neuropsychological tests.

'Test wiseness' has been known to affect an individual's performance on neuropsychological tests. One should therefore take this into consideration when applying tests to educationally disadvantaged individuals (Nell, 2000).

Another important component of education quality is language proficiency. For instance, Shuttleworth-Edwards et al. (2004) showed that a high level of English proficiency, through its links to a higher quality of education, was associated with better performance on standard neuropsychological tests.

Verbal and Non-verbal Neuropsychological Tests

From the above discussion, it is clear that both level and quality of education are important factors affecting individual performance on neuropsychological tests. However there is still considerable debate as to whether education has differential effects on verbal and non-verbal neuropsychological tests. It has traditionally been held that non-verbal tests are more likely to be culture-free and that therefore education-related variables (particularly those associated with quality of education, such as test-wiseness) would not affect individual performance as much on these tests. Roselli and Ardila (2003), however, found a relationship between education level and performance on non-verbal tests which indicates that this notion might in fact not be true (see also Perez-Arce & Puente, 1996; Rosselli, Ardila, Bateman, & Guzman, 2001; Unverzagt et al., 1996 for other data confirming this finding).

The current study focuses on three commonly used neuropsychological tests: one traditionally considered 'verbal' (the Rey Auditory Verbal Learning Test (AVLT)) and two traditionally considered 'non-verbal' (the Trail Making Test (TMT) and the CLOX Executive Clock Drawing task).[1] Previous studies have shown that performance on these tests is affected by level and quality of education. These findings, which are reviewed below, illustrate that no matter what a test's face value is, it is confounded by variables such as level and quality of education.

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[1]Some psychologists would argue with these traditional designations, preferring to define 'non-verbal' tests as those with neither expressive nor receptive language demands, and with no demands on knowledge of the alphabet or any other speech/language-based ability. In this study, however, I use the traditional definitions, which largely revolve around whether or not a test requires verbal output for successful completion.

The Rey Auditory Verbal Learning Test (AVLT)

The AVLT is a word list learning test that is used to assess an individual's ability to encode, consolidate, store and retrieve verbal information. It assesses immediate memory span, new learning and recognition memory. Because the AVLT is easy to administer, it has gained worldwide acceptance as a very useful means of neuropsychological assessment (Strauss et al., 2006). For instance, it has been used in studies in Greece, the United States and Australia (Messinis, Tsakona, Malefaki, & Papathanasopoulos, 2007; Query & Megran, 1983; Schoenberg et al., 2006; Lezak et al, 2004).

The AVLT presentation initially consists of a list of 15 nouns. This list of nouns (List A) is read aloud to the participant five consecutive times. Each trial is followed by a free-recall test. After the list has been read five times, the participant is presented with another list of 15 nouns (List B). These words are completely different to the words found in List A, and presentation is also followed by a free-recall test. As soon as List B has been presented and the free recall done, a delayed recall test of List A is done. Then after a 20-minute delay, the participant is required to repeat as many words from List A that he/she can remember. Straight after this, a list of words containing all the 15 nouns plus a mixture of other semantically related words are individually read to the participant. Finally, the participant is required to confirm whether or not he/she recognizes each word belonging to List A (Strauss et al., 2006).

AVLT: International studies

The AVLT is significantly affected by certain demographic variables, including level and quality of education. For instance, Query and Megran (1983) developed age-related norms for white male inpatients (19-81 years of age) at a Veterans Administration Medical Centre in North Dakota. They found that level of education was significantly associated with (a) steeper learning curves in the younger participants, and (b) higher levels of recall in the older participants.

Schoenberg et al. (2006) also found that performance on the AVLT was related to level of education. They used data obtained from a large tertiary center in the United States. A total of 392 participants (all older than 18 years) were used. They found that individuals with a higher level of education (i.e., greater than 16 years) performed better on recall than those who had a low level of education (i.e., less than 12 years of education).

AVLT: South African studies

Normative data has not yet been published on the performance of South African individuals on the AVLT. However, Thornton (2007) provided unpublished normative data for Coloured participants in South Africa. These individuals came from rural disadvantaged areas in the Northern Cape and thus had all experienced a low quality and few years of education. As shown in Appendix A (Table A1), there is a significant difference between the means obtained by Thornton (2007) and those presented by Strauss et al. (2006, p.786). The means obtained from Thornton (2007) are much lower; this discrepancy can at least partially be attributed to the lower quality and level of education of participants in that study.

The Trail Making Test (TMT)

The TMT is a commonly-used, easy to administer, short (approximately 5 to 10 minutes) neuropsychological test consisting of two parts. The first part (TMT-A) requires individuals to connect 25 encircled numbers on a piece of paper by drawing lines between them. They are required to connect the numbers in sequence order, i.e., 1 to 2, 2 to 3, etc. TMT-A taps visual attention and psychomotor processing speed. The second part of the test (TMT-B) requires individuals to connect 25 encircled numbers and letters on a piece of paper. They are required to connect the numbers and letters alternating between the two, i.e., 1-A, 2-B, 3-C, etc. TMT-B adds cognitive flexibility and sequencing ability to the demands of TMT-A (Strauss et al., 2006). Because it is an entirely non-verbal test, the TMT has traditionally been considered to be relatively free of the influence of education. Recent studies have, however, shown this to be a false assumption.

TMT: International studies

Seo et al. (2006), in the process of developing TMT norms for Korean elders, found that level of education significantly affected test performance. They tested 977 healthy individuals aged between 60 and 90 years. Specifically, they noted that individuals with higher levels of education (greater than 7 years of education) performed better than individuals with lower levels of education (less than 7 years of education). Furthermore, these researchers also found that these effects of education were consistent across both TMT-A and TMT-B.

Data from Tombaugh (2004), which were based on a sample of 911 community-dwelling volunteers, concur with this finding of consistent level of education effects on both TMT-A and TMT-B. However, that study also found that, in individuals older than 54 years, higher levels of education were associated with improved performance as opposed to individuals older than 54 years with lower levels of education.

Several independent studies confirm that TMT-B performance is more sensitive to level of education than is TMT-A performance. For instance, an Australian study of 363 participants between the ages of 60 and 90 found years of education to significantly impact performance on TMT-B. The authors of that study accounted for educational differences by dividing participants into two groups (either more than 12 years of education or less than 12 years of education; Hester et al., 2005). Hashimoto et al. (2006), in developing normative data for Japanese elderly, also found results suggesting the influence of level of education on TMT-B performance. In particular, they found that the time to complete both TMT-A and TMT-B was shorter for those individuals with a much higher education.

TMT: South African studies

Normative data has not yet been published on the performance of South African individuals on the TMT. However, Thornton (2007) provided unpublished normative data for Coloured participants in South Africa. These individuals came from rural disadvantaged areas in the Northern Cape and thus had all experienced a low quality and few years of education. As shown in Appendix A (Table A1), there is a significant difference between the means obtained by Thornton (2007) and as presented by Strauss et al. (2006, p.663). The means obtained from Thornton (2007) are much lower and, again, can at least partially be attributed to the lower quality and level of education of participants in that study.

CLOX Executive Clock Drawing Task

The *CLOX Executive Clock Drawing Task* (Royall et al., 1998) assesses executive control, visuospatial and constructional abilities (Lezak et al., 2004; Strauss et al., 2006). This task initially requires participants to draw a clock (CLOX 1). This clock must be set to a time of 1:45 and must be comprehensible enough for a child to read it. After the individual has completed this clock they are required to copy a clock that the examiner draws (CLOX 2). A 15-point system is used to score the participant's two drawings. Patients with Alzheimer's Disease (AD) perform poorly relative to healthy older patients on a CLOX total score, and they perform better on the CLOX 2 compared to the CLOX 1 (Lezak et al., 2004).

A study conducted by Royall et al. (2003), on a large sample (1309 individuals) of Mexican-American older adults, examined the significance of cross-cultural effects on a Spanish translated version (Royall, Cordes & Polk, 1998) of the CLOX. Results showed that cross-cultural effects were significant even when stratified for age, gender, income and language. However, the authors concluded that the effects of culture were not important and that the Spanish version of the CLOX was validated.

Yap, Tze-Pin, Niti, Yeo & Henderson (2007) tested the usefulness of the CLOX amongst the Chinese Singaporean population. They created an optimal cut-off score, stratified by education, based on data derived from 73 dementia patients and 75 healthy patients. They concluded that the CLOX is a useful cognitive screening measure amongst the Chinese Singaporeans. Further, Yap, Tze-Pin, Niti, Yeo & Henderson (2007) noted that the CLOX may help to differentiate between patients with varying degrees of dementia.

No published studies reveal the effect of level and quality of education on the performance on the CLOX Executive Clock Functioning Task in South Africa.

Neuropsychological Testing in a Multi-Cultural context

The empirical data reviewed above clearly indicate that neuropsychological test performance is heavily influenced by level and quality of education. Most of the neuropsychological tests commonly used today were developed by Western middle-class individuals, with access to a high quality and level of education. Therefore, individuals from outside those cultures might be at a disadvantage on those tests because their educational systems have not placed value on the same factors that the tests value (e.g., speed of response). Researchers should therefore either create new culturally fair tests applicable to the current test situations or use the current tests despite implications of culture. However, the most practical solution seems to be that normative data be stratified according to level and quality of education. Studies are currently underway to try and minimize this gap in the literature and, in so doing, to provide normative data for the South Africans of all ages.

SPECIFIC AIMS/HYPOTHESES

This project is part of a larger project, headed by researchers from the Albertina and Walter Sisulu Institute of Ageing in Africa (IAA; part of the Division of Geriatric Medicine at the University of Cape Town), aimed at developing normative data for the South African older adult population. The main purpose of this larger research project is to collect normative data for the South African population in order to describe how demented and healthy individuals perform on the IAA neuropsychological test battery. A related aim is to assess whether the IAA neuropsychological battery is useful in predicting/detecting AD within the South African population.

The aim of my smaller research study is to assess the effects of level and quality of education on three commonly used neuropsychological tests (the AVLT, the TMT, and the CLOX) that are a part of the IAA battery. No data in South Africa has been published focusing specifically on the effects of both level and quality of education on performance on these tests.

The following hypotheses were tested:

Hypothesis 1: Healthy younger adults will perform better on the neuropsychological tests than will healthy older adults.

Hypothesis 2: Individuals with more years of education will, regardless of age, perform better than individuals with fewer years of education on the neuropsychological tests

Hypothesis 3: Individuals from higher quality educational backgrounds will, regardless of age, perform better than individuals from lower quality educational backgrounds on the tests of interest

Hypothesis 4: Notwithstanding the findings from Hypothesis 3, differences in performance between individuals from low- and high-quality educational backgrounds will be more pronounced in older adult groups than in younger adult groups. This anomaly, if present, will suggest that the Apartheid schooling had a negative effect on the older adult participants, and would suggest that cohort effects should be taken into account when judging the likely impact of quality of education on neuropsychological test performance.

Additionally, in order to confirm that the neuropsychological test score differences between the YA and OA groups were related to normal declines in age-related cognition and not due to any disease processes, I will compare the performance of participants in the OA group to the performance of age-matched participants who had previously been diagnosed with Alzheimer’s Disease (AD) at the IAA Memory Clinic. This final comparison will serve to check that the three neuropsychological tests of interest were sensitive to AD-related neuropsychological decline.

DESIGN & METHODOLOGY

Design

In order to describe the differences in test performance that occur due to normal ageing, and to explore how much of the variance in test performance might be attributed to level and quality of education, I used a quasi-experimental cross-sectional design. This design compared the performance of two groups of individuals (healthy young adults (YA) healthy older adults (OA)) on the three specific tests of interest. Participants in each group were administered the same Memory Clinic neuropsychological battery of tests under standardized conditions.

Participants

Participants in the YA group were 56 (29 from a data archive; 27 personally collected) healthy volunteer male and female participants ranging from 18 to 25 years of age. Participants in the OA group were 53 (25 from a data archive; 28 personally collected) healthy volunteer male and female participants above 60 years of age. Participants in the AD group were 24 male and female Groote Schuur Hospital Memory Clinic patients individually diagnosed with possible/probable Alzheimer's disease (AD). Table 1 shows demographic characteristics of the participants.

The young adult participants were drawn from the UCT community. The majority came from the Department of Psychology's Student Research Participant Programme. The older adult participants were recruited from local communities outside of UCT. Personal contacts were used to encourage suitable individuals to take part in the study. The IAA neuropsychological database was used to obtain data for individuals previously diagnosed with possible/probable AD.

Exclusion Criteria

The following exclusion criteria were used to determine eligibility to participate in the study.

Mini-Mental State Examination (*MMSE*). Participants from the healthy younger and healthy older groups who obtain a score of 24 or less on the MMSE (Folstein, Folstein, & McHugh, 1975) are considered to be either cognitively impaired or at high risk for dementia (Lezak et al., 2004). Individuals who scored below this cut-off were excluded to ensure the integrity of our normative data. Although using such a cut-off may seem unfair given the effects of level and quality of education on cognitive test performance, I decided to err on the side of caution (Black et al., 1999; Lezak et al., 2004). Three potential older adult participants were excluded from this study based on this criterion.

Depression. Depression negatively affects neuropsychological test performance (Hertell, 2000, as cited in Lezak et al., 2004). Therefore any participants with a Beck Depression Inventory - II (Beck, Steer, & Brown, 1996) score of more than 20 (indicating at least moderate levels of depression) were excluded. Six potential participants (four younger adults and two older adults) were excluded from this study based on this criterion.

Other. Participants with a history of any of the following were also excluded from the data: neurological disorders, memory/ learning difficulties, multiple head injuries and psychological disorders. Three potential older adults and two potential younger adults were excluded from this study based on this criterion.

Table 1
Demographic Characteristics of Participants in the Current Study

		Group	
Variable	YA (*n* = 56)	OA (*n* = 53)	AD (*n* = 24)
Age (years)			
Range	18-24	60-91	69-85
Mean (SD)	20 (1.37)	72.47 (6.55)	75.7(4.87)
Sex			
Male	22	19	10
Female	34	34	14
Race			
White	41	31	5
Black African	7	0	0
Indian	1	1	1
Coloured	7	19	18
Other	0	2	0
Education			
Quality (High:Low)	32:24	11:42	5:19
Level (years)	13.89 (1.32)	12.45 (2.94)	10.42 (2.96)

Note. For Age and Education Level, means are presented with standard deviations in parentheses.

Measures

Screening Measures

A *demographic questionnaire* (see Appendix B) was used to obtain the participant's following information: age, sex, date of birth, home language, other spoken languages, handedness, SES (measured by the total monthly household income), education (both level and quality) and health. Information on an individual's level and quality of education forms the majority of the demographic questionnaire. Level of education was measured by the highest level of education received, e.g., 12 years represents a matric certificate. Quality of education was measured differently for the young adult and older adult groups. Participants in the YA group were assigned a quality of education rating of "high" if the individual was educated at a private school or at a highly-ranked public school (www.education.gov.za).

Participants in the YA group were assigned a quality of education rating of "low" if the individual was educated at a rural public school or a low-rated urban public school. Participants in the OA group were assigned a quality of education rating of high if the individual was White. Other participants in the OA group were automatically assigned a quality of education rating of "low" (i.e., every Black African, Coloured, Indian or 'Other' participant was assumed to have experienced a low quality of education due to the Apartheid system's forced segregation of individuals into high or low quality schools according to their race).

The *BDI-II* (Beck et al., 1996) assesses an individual's current level of depression. It consists of 21-items that indicate whether an individual is severely of moderately depressed (as depicted by a score of 20 or more). The BDI-II has been found to be highly reliable in clinical studies (Lezak et al., 2004) and has been used in many South African studies (e.g., Faure & Loxton, 2003; Pillay, 2001).

The *MMSE* (Folstein et al., 1975*)* is a standardized test that is brief and easy to administer and score. It assesses a variety of mental functions, including basic memory functions, orientation, language (naming, repetition, comprehension, reading and writing), attention, construction and calculation abilities (Lezak et al., 2004; Strauss et al., 2006). Strauss et al. (2006) estimate the internal consistency of the MMSE to range from 0.31 to 0.96 for different samples of individuals. Test-retest scores fall within the range of 0.80 and 0.95. Lezak et al. (2004) report similar results whereby test-retest scores fall within the range of 0.83 and 0.89. No normative data for the South African population are currently available, although the test is widely used in clinical practice.

Neuropsychological Tests

The *Rey Auditory Verbal Learning Test (AVLT)* measure assesses memory (immediate and recognition) and verbal learning (Lezak et al., 2004). Strauss et al. (2006) report high internal reliability to be 0.90 and test-retest reliability to be between 0.60 and 0.70. Lezak et al. (2004) report similar results, with test-retest reliability ranging from 0.60 to 0.86.

The *Trail-Making Test (TMT*) assesses motor coordination, attention and visual search (Strauss et al., 2006). The TMT reportedly has high reliability coefficients, ranging between 0.60 and 0.90 (Lezak et al., 2004). The test-retest reliability varies with age ranging from between 0.55 for Part A and 0.75 for Part B (Strauss et al., 2006).

The *CLOX Executive Clock Drawing Task* (Royall et al., 1998) assesses executive control and visuospatial abilities. Strauss et al. (2006) report that the test-retest reliability for the CLOX Executive Functioning Task to be 0.78 for patients with AD. The inter-rater reliability was estimated at greater then 0.80. Royall et al. (1998) reported similar findings with an inter-rater reliability of greater then 0.9 for both CLOX 1 and CLOX 2. The internal consistency was also found to be high at 0.82.

Table 2
Order of Test Administration

Test Name	Outcome Variable
1. CLOX	CLOX 1
	CLOX 2
	CLOX Difference: (CLOX2 – CLOX1)
2. Verbal fluency (letter “F”)	Number of words
3. Semantic fluency (animals)	Number of words
4. Rey Auditory Verbal Learning Test (AVLT) – I	
Trials I to V	Total words; Learning over trials (LOT)
Trial VI	Short-Term Percentage Recall (STPR)
5. Rey- Osterrieth Complex Figure Test (ROCF)- Part I	Copy and Immediate Recall scores
6. Digit Span	
Forward	Length of longest successful sequence
Backward	Length of longest successful sequence
7. Trail Making Test (TMT)	
Part A	Time to completion (s)
Part B	Time to completion (s)
8. Boston Naming Test (BNT)	Number of pictures correctly identified
9. Judgment of Line Orientation (JLO)	Number of items correct
10. AVLT - II	
Trial VII	Long Term Percentage Recall (LTPR)
	Delayed Recall Index
Recognition	Adjusted Recognition Score
11. ROCF	Delayed Recall score

Procedure

Participants were individually tested either at either the University of Cape Town or at a place of residence. The room that the participants were tested in was relatively similar to that used in the IAA/GSH Memory Clinic: It contained two chairs separated by a desk, and was uncluttered and quiet, with no distracters present. The participant and researcher sat on either side of the desk during the testing procedure. When the researcher and participant were seated opposite one another, the researcher provided the participant with a consent form to read through and sign. That form explained the study to the participant along with all of its benefits and procedures. The testing then began; it took roughly 90 minutes to complete. The IAA test battery was administered to the participant according to the procedures outlined in the individual test manuals. The order of test administration is shown in Table 2. After the testing was completed, the researcher explained the aims and rationale of the study and then gave the participant the opportunity to ask any further questions about the study.

Data Analysis

In order to test Hypothesis 1, I compared the performance of participants in the younger adult group against those in the older adult group, using simple *t*-tests (paired comparisons), on each of the neuropsychological test outcome variables. This included calculating effect sizes for each of these variables. Further, a Bonferroni correction of $\alpha/4 = 0.0125$ was performed on the data in order to reduce the familywise error rate.

In order to test Hypotheses 2 and 3, that level of education and quality of education, regardless of age, will have an effect on test performance, a separate multiple regression analysis was performed for each neuropsychological test outcome variable using the combined data from the YA and OA groups. Each model generated from this analysis depicts the effect of (level or quality of) education on each test outcome variable. The correlation between level and quality of education was also calculated to test for collinearity.

In order to test Hypothesis 4 (that the differences, in terms of neuropsychological performance, between high quality of education individuals and low quality of education individuals would be greater in the OA group than in the YA group), I performed Mann-Whitney U tests (for non-normal data) on all of the neuropsychological test outcome variables.

In order to compare performance of the OA group and the AD group, simple *t*-tests were conducted on each of the neuropsychological test outcome variables. This included calculating effect sizes for each of these variables. Further, a Bonferroni correction of $\alpha/4 = 0.0125$ was performed on the data in order to reduce the familywise error rate.

Within the YA group there were no missing data; however, within the OA group, data were missing for two participants. One of those participants managed to complete only the CLOX test. The second completed all tests except the AVLT. The total number of participants that completed each test is shown in Table 3. Where there is missing data within the AD group, the participant was unable to complete the test. Scores were excluded from the final data analyses if the participant was unable to complete the test. The only exception was within the TMT, where participants who started but could not complete the test (either Part A or Part B) were assigned a score of 300 seconds for that Part. No participants were excluded as outliers. Statistica Version 7.0 statistical analysis software package (StatSoft, 2007) was used for data analysis.

RESULTS

Descriptive Statistics

Descriptive statistics were calculated for each relevant neuropsychological test outcome variable, within each of the three groups, and are reported in Table 3. Upon inspection of the means it appears that participants in the YA group performed better than those in the OA group on all three tests except CLOX 1. It then appears that participants in the OA group performed better than those in the AD group on all of the three tests in question.

Hypothesis 1: YA versus OA between-group comparison

My first hypothesis was that participants in the YA group would perform statistically significantly better than those in the OA group on all of the AVLT, TMT and CLOX outcome variables. Table 4 shows that this prediction was confirmed for all of the variables except CLOX1. Interestingly, effect sizes varied quite substantially even across statistically significant comparisons.

Table 3.
Descriptive Statistics

Test	YA *n* = 56	OA *n* = 53[a]	AD *n* = 24[b]
RAVLT			
Total words[c]	59.33 (6.80)	40.65 (9.52)	18.4 (8.21)
LOT[d]	18.89 (9.22)	15.16 (5.83)	8.21 (6.13)
STPR[e]	92.68 (12.52)	66.71 (20.10)	24.33 (31.53)
LTPR[f]	94.65 (13.99)	66.35 (21.041)	12.05 (19.73)
DRI[g]	25.70 (3.99)	14.08 (5.986)	1.86 (3.00)
Adjusted recognition[h]	14.09 (1.64)	9.16 (4.042)	-5.42 (7.86)
TMT			
Part A	29 (10.41)	41.98 (10.13)	142.35(97.64)
Part B	57.53 (14.55)	105.58 (39.98)	259.6 (60.87)
CLOX			
CLOX1	12.61 (1.88)	12.44 (1.77)	7.63 (4.93)
CLOX2	14.30 (0.74)	13.47 (0.93)	10.38 (4.96)
Difference[i]	1.70 (1.877)	1.04 (1.47)	2.75 (3.38)

Note. Means are presented with standard deviations in parentheses.
[a]*n* = 52 for TMT-A and TMT-B; *n* = 51 for all RAVLT measures.
[b]*n* = 21 for RAVLT – STPR and RAVLT – DRI; *n* = 20 for TMT-A, TMT-B, RAVLT – Total Words, and RAVLT - LTPR; n = 19 for RAVLT – LOT and RAVLT – adjusted recognition
[c]'Total words' is the sum of the words recalled over trials I to V.
[d]'Learning Over Trials' is calculated as follows: (Sum of words from trials I to V) - (5x words recalled on trial I).
[e]'Short Term Percentage Recall' is the percentage words recalled on trial VI compared with trial V.
[f]'Long Term Percentage Recall' is the percentage words recalled on trial VII compared with trial V.
[g]'Delayed Recall Index' is the sum of the short term (trial VI) and long term (trial VII) delayed recall trials.
[h]'Adjusted Recognition' calculated by subtracting false positives from true positives.
[i]'CLOX difference' is calculated by subtracting the raw score of CLOX1 from CLOX2.

Table 4

Results of t-tests for YA versus OA (paired comparison)

Test	*t*	*Df*	*p*	Cohen's *d*
RAVLT				
Total words	11.76	105	0.0001***	2.28
LOT	2.48	105	0.015*	0.48
STPR	8.09	105	0.0001***	1.57
LTPR	8.26	105	0.0001***	1.60
DRI	11.91	105	0.0001***	2.31
Adjusted recognition	8.42	105	0.0001***	1.63
TMT				
Part A	-6.56	106	0.0001***	-1.26
Part B	-8.41	106	0.0001***	-1.62
CLOX				
CLOX1	0.494	107	0.622	0.09
CLOX2	5.18	107	0.0001***	0.99
CLOX difference	2.03	107	0.044*	0.39

Note. Bonferroni correction: Because four statistics were calculated for each of the individual neuropsychological test variables, $\alpha/4 = 0.0125$, and therefore, the statistical significance level is set at $p < 0.0125$.

* $p < .05$; ** $p < .01$; *** $p < .001$

Hypothesis 2: Effects of level of education on neuropsychological performance

My second hypothesis was that, regardless of age, individuals with more years of education would perform statistically significantly better than those with fewer years of education on all of the AVLT, TMT, and CLOX outcome variables. Table 5 shows the results of simple linear regressions testing this prediction. As can be seen, even though p-values suggest statistical significance in many cases, the amount of variance in neuropsychological test performance explained by level of education is less than 10% for all of the tests apart from TMT-B, where level of education account for almost 12% of the variance in performance.

Table 5

Results of Simple Linear Regression (OA and YA) on level of education

Test	*B*	*SE B*	*Β*	R^2
RAVLT				
Total words	1.54	0.51	0.28	0.08**
LOT	0.26	0.34	0.07	0.005
STPR	1.34	0.88	0.15	0.022
LTPR	0.93	0.96	0.09	0.009
DRI	0.73	0.34	0.22	0.047**
Adjusted recog	0.45	0.16	0.26	0.069*
TMT				
Part A	-0.37	0.51	-0.07	0.005
Part B	-5.64	1.50	-0.34	0.117***
CLOX				
CLOX1	0.121	0.07	0.157	0.025
CLOX2	0.06	0.04	0.156	0.024

* $p < .05$; ** $p < .01$; *** $p < .001$

Hypothesis 3: Effects of quality of education on neuropsychological performance

My third hypothesis was that, regardless of age, individuals with a higher quality of education would perform statistically significantly better than those with a lower quality of education on all of the AVLT, TMT, and CLOX outcome variables. Table 6 shows the results of simple linear regressions testing this prediction. As can be seen, the amount of variance in neuropsychological test performance explained by quality of education is small as none of the variables explain more then 5% of the variation.

Table 6

Results of Simple Linear Regression (OA and YA) on quality of education

TEST	B	*SE B*	*B*	R^2
RAVLT				
Total words	0.21	2.45	0.01	0.0006
LOT	1.77	1.56	0.11	0.0120
STPR	-5.23	4.10	-0.12	0.015
LTPR	-5.23	4.42	-0.12	0.013
DRI	-0.91	1.51	-0.06	0.003
Adjusted recog	0.05	0.77	0.01	0.0003
TMT				
Part A	-2.48	2.36	-0.10	0.0103
Part B	-10.58	7.38	-0.14	0.019
CLOX				
CLOX1	0.72	0.35	0.19	0.038*
CLOX2	-0.14	0.18	-0.07	0.0053

* $p < .05$; ** $p < .01$; *** $p < .001$

Comment [KGFT1]: Format like previous table.

Combined Effect of Level and Quality of Education: Multiple Regression

Multiple regression analysis was performed to assess the effect that both level and quality of education have on each test variable. Table 7 shows the results of these regressions. In general, it can be seen that level and quality of education have a larger effect on test performance when combined as a single variable. Large increases in explained variation occurred when combining level and quality of education on majority of the variables. Further, in order to test whether level and quality of education were independent, a test for collinearity was performed. A score of 0.36 was found depicting that level and quality of education are related. It is essential therefore to include both level and quality of education as a single predictor variable in order to explain much more of the variation in the data.

Table 7

Results of Multiple Regression for level and quality of education

	Level of education			Quality of education			
Test	B	*SE B*	*β*	B	*SE B*	*β*	R^2
RAVLT							
Total words	1.84	0.56	0.34	-3.34	2.57	-0.13	0.10**
LOT	0.12	0.37	0.03	1.53	1.72	0.10	0.014
STPR	2.20	0.95	0.24	-9.46	4.42	-0.22	0.063*
LTPR	1.70	1.04	0.17	-8.55	4.82	-0.19	0.04
DRI	0.98	0.35	0.29	-2.8	1.60	-0.18	0.075*
Adjusted recognition	0.54	0.18	0.32	-0.99	0.81	-0.13	0.083*
TMT							
Part A	-0.20	0.55	-0.04	-2.12	2.57	-0.09	0.012
Part B	-5.6	1.64	-0.34	-0.37	7.64	-0.004	0.12***
CLOX							
CLOX1	0.08	0.08	0.10	0.58	0.37	0.16	0.05
CLOX2	0.08	0.04	0.21	-0.28	0.19	-0.15	0.04

* $p < .05$; ** $p < .01$; *** $p < .001$

Hypothesis 4: Magnitude of Quality of Education Effects

My fourth hypothesis was that differences in performance between individuals from low- and high-quality educational backgrounds would be more pronounced in the OA group than in YA group. To test this prediction, I conducted a between-groups comparison of the mean effect size estimates across all neuropsychological test variables (see Table 8). I used the Mann-Whitney U test, a non-parametric method, to perform this analysis because the data were not normally distributed. Results showed that the mean effect size (i.e., the magnitude of the difference between individuals from high- versus low-quality educational backgrounds) was statistically significantly larger in the OA group (M = .22, SD = .34) than in the YA group (M = -.11, SD = .35), U = 23.5, p = .043 (one-tailed).

Table 8

Between-groups comparison of mean effect sizes for level of education

TEST	Effect sizes (Cohen's d) for YA	Effect sizes (Cohen's d) for OA
RAVLT		
Total words	-0.05	0.78
LOT	-0.48	0.56
STPR	-0.33	0.37
LTPR	-0.09	0.17
DRI	-0.16	0.47
Adjusted recog	-0.57	0.13
TMT		
Part A	0.36	-0.07
Part B	0.26	0.16
CLOX		
CLOX1	-0.41	-0.38
CLOX2	0.37	-0.03

Magnitude of Level of Education Effects

As level of education is stratified by more or fewer years of education, the magnitude of effect size could not be calculated due to the presence of only higher levels of education within the YA group. Typically, a high level of education represents 12 or more years of education and a low level of education represents less than 12 years of education.

Table 10.

Comment [KGFT2]: Format exactly like the YA-OA comparison table.

Results of T-tests for OA versus AD (paired comparisons)

TEST	*t*	*df*	*p*	*Cohen's d*
RAVLT				
Total words	9.19	69	0.0001***	2.42
LOT	4.37	68	0.00043***	1.18
STPR	6.83	70	0.0001***	1.77
LTPR	9.98	69	0.0001***	2.62
DRI	8.88	68	0.0001***	2.30
Adjusted recog	10.19	70	0.0001***	2.74
TMT				
Part A	-7.39	70	0.0001***	-1.95
Part B	-12.57	70	0.0001***	-3.31
CLOX				
CLOX1	6.30	75	0.0001***	1.55
CLOX2	4.41	75	0.00034***	1.08
CLOX difference	-3.11	75	0.0026**	-0.76

*Note.**Bonferroni correction: Since four statistics were calculated for each of the individual neuropsychological test variables, $\alpha/4=0.0125$, and therefore, for significance $p < 0.0125$.
* $p < .05$; ** $p < .01$; *** $p < .001$

Adjunct Analysis: OA versus AD between-group comparisons

My hypothesis here was that participants in the OA group would perform statistically significantly better than those in the AD group on all of the AVLT, TMT and CLOX outcome variables. Table 10 shows that this prediction was confirmed. It also showed that the performance of individuals on the three tests in question is related to normal declines in age-related cognition and not due to any disease processes.

DISCUSSION

Status of the Hypotheses

Hypothesis 1. My first hypothesis was that participants in the YA group would perform statistically significantly better than those in the OA group on all of the AVLT, TMT and CLOX outcome variables. In general it has been seen that the means of the younger adults were greater than those of the older adults except within CLOX 1 where hardly any difference was noted. It was further seen that the younger adults performed significantly better than the older adults on all of the neuropsychological tests, except no differences in performance were found on CLOX 1. This result was unexpected because CLOX 1 is generally regarded as much more demanding task than CLOX 2; certainly, individuals with age-related cognitive impairment (e.g., vascular dementia or Alzheimer's disease) are more likely perform poorly on CLOX 1 than on CLOX 2 (Royall et al., 1998), and thus having a statistically significant between-group difference on CLOX 2 but not CLOX 1 is extremely unusual and perhaps indicative of random variation within the current sample.

Hypothesis 2 and 3. The two hypotheses state that, regardless of age, individuals with more years of education would perform statistically significantly better than those with fewer years of education on all of the AVLT, TMT, and CLOX outcome variables; and that, regardless of age, individuals with a higher quality of education would perform statistically significantly better than those with a lower quality of education on all of the AVLT, TMT, and CLOX outcome variables. Generally, it has been reported that level and quality of education affect performance on neuropsychological tests (Ardila, 1996; Ardila et al., 2000; Hooren et al., 2007; Manly et al., 2000; Shuttleworth-Jordan, 1996; Shuttleworth-Edwards et al., 2004; Strauss, Sherman, & Spreen, 2006). Within this study however, due to confounding factors and specific cohort effects, performance on the three tests was generally found to be unaffected by level and quality of education. These effects will be addressed later.

The only variable that was significantly affected by level of education was TMT-B. The effect of level of education on TMT-B (as opposed to TMT-A) was found and confirmed by studies conducted by Hashimoto et al (2006) and Hester et al. (2005). None of the variables were found to be significantly affected by quality of education.

To calculate the effect of level and quality of education on test performance we combined the performance of the YA and OA groups. This was done in order to test whether cohort effects of Apartheid exist within the groups. After the rule of Apartheid ended the educational set up within the country changed. Individuals within the younger adult population were given educational opportunities at a high governmental standard and therefore majority of the younger adult population performed equally well regardless of their level or quality of education. This gap in education that originally existed due to the effects of Apartheid, narrowed causing speculation that differences should not exist between a low and high level and quality of education within the YA group, yet should exist within the OA group. Keeping this in mind, it was decided to combine the YA and OA group as we expect that the large differences in the OA group and small differences within the YA group would cancel each other out, leaving no significant effect of level and quality of education on test performance. In order to assure that this cohort effect of Apartheid exists within the OA group we expected the differences in performance between individuals with a low or high quality and level of education to be more pronounced in the OA group as opposed to the younger adult group (hypothesis 4).

. *Hypothesis 4.* My fourth hypothesis was that differences in performance between individuals from low- and high-quality educational backgrounds would be more pronounced in the OA group than in YA group. This predication was confirmed as significant differences were found between the effect sizes of the two groups. This indicated that differences between an individuals quality of education were more pronounced in the OA groups as opposed to the younger adult groups. Differences in performance between individuals with either a high or low level of education could not be performed. This occurred because there was no range of level of education within the YA group.

Taking the above into account, it is noted that the large differences found within the OA group can be attributed to the effects of Apartheid. It was shown that when combining the YA and OA groups, the effects of level and quality of education were insignificant on all three tests. It was further shown that when the effects of these two groups we separately taken into account, that differences in performance where found. These findings suggest that the Apartheid schooling had a negative effect on the older adult participants, and would suggest that cohort effects should be taken into account when judging the likely impact of quality of education on neuropsychological test performance

OA versus AD between-group comparisons. In general, it has been seen that the means of the older adults were greater than those of the AD patients. It was further seen that the older adults performed significantly better than the AD patients on all of the neuropsychological tests. Therefore overall it can be concluded that the IAA Memory Clinic battery is sensitive to difference in test performance due to Alzheimer's disease (Nield, 2007).

Limitations and Directions for Future Research

There were four primary limitations in this study. The first limitation depicted that the sample of data used within this study was not representative of the South African population. In particular, there appeared to be no large variation in biological or socio-cultural variables (such as language, race and SES) within the sample. Therefore it is essential for future research to collect a much larger sample of normative data that is more representative of the South African population.

The second limitation concerned the range of level and measure of quality of education within the YA group. For level of education, all of the participants had acquired more then 12 years of education depicting only a high level of education. This restricted our understanding of the effects of level of education within this group of individuals. Therefore for future research more normative data should be collected to develop a better range of level of education within the YA group. For quality of education, no real measure of this variable was used as it was speculated according to the rating of the school by the government as to whether or not an individual had a low or high quality of education. This was different for the OA group whereby a clear measure was used based on South Africa's historical struggle of Apartheid. Future research should try to find a better measure of quality of education amongst the younger adult population.

The third limitation concerned the measure of quality of education within the South African context. It is still unclear as to the sensitivity of the concept of quality of education in South Africa, as limited research has been conducted within this area. Therefore it is unclear as to whether the measure of quality of education used in this study is sensitive enough and encompasses the entirety of the variable quality of education. Future research should therefore consider developing a more sensitive measure of quality of education within the South African context.

Finally, concerning the issue of verbal and non-verbal tests, it can be understood that the traditional designations, preferring to define 'non-verbal' tests as those with neither expressive nor receptive language demands, and with no demands on knowledge of the alphabet or any other speech/language-based ability where not adhered to in this study. The non-verbal tests used in this study largely revolved around whether or not a test requires verbal output for successful completion. As these tests are then confounded by the effects of education, it would be much more effective to use non-verbal tests that are not confounded by these effects of education.

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APPENDIX A

Normative Data for the AVLT and TMT

Table A1

AVLT and TMT Normative Data: South African versus International Populations

Tests		Thornton (2007)	Strauss, Sherman and Spreen (2006)
RAVLT			
	Trial I	5.46	6.5
	Trial II	7.81	9.2
	Trial III	9.31	10.9
	Trial IV	9.62	11.82
	Trial V	10.27	12.35
	Recall after interference	8.08	10.6
	Delayed Recall	7.77	10.5
	Interference trial	5.12	6.1
TMT			
	TMT-A	50.28 seconds	29 seconds
	TMT-B	121.05 seconds	63 seconds

APPENDIX B

Demographic Questionnaire

1. **Age:** __________
2. **Date of Birth (d/m/y):** ______________
3. **Sex (circle one):** Male Female
4. **Race (circle one):** White Black Coloured
   Indian Other: specify:________________
5. **Handedness (circle one):** Left Right Ambidextrous
6. **Is anyone in your immediate family left handed?** YES NO
   If yes, which family member(s)?

____

7. **Home Language**:

   ____

8. **Do you speak any other languages**? Please specify:

   ____

9. **Who was/were your primary caregiver(s) during your childhood?** (E.g., parents, mother, father, grandmother, grandfather, uncle, aunt, etc.)

   ____

10. **What is the total monthly income of the household in which you live? If you are a student please take care to put your immediate caregivers monthly income not your own (circle one):**

R0 – R499	R500 – R999	R1000 - R2499
R2500 – R5499	R5500 – R9999	R10 000+

SECTION A. EDUCATION

11. **What are the names of the schools you attended during your schooling career?**
    Junior school

    ____

    High School

    ____

12. If you attended multiple schools in high school, how many months/years roughly did you spend at each and which schools were they?

____

13. Was most of your school education completed in a rural or urban setting (circle one)?

RURAL URBAN

14. In which language was most of your school education completed?

____

15. Did you have to repeat any grades? YES NO

If yes, please specify which grade(s):

____

16. Did you receive a matric certificate? ______________________

17. If so, at which school did you complete your matric? ______________________

18. Did you matriculate from a public high school or a private high school (circle one)?

PUBLIC PRIVATE

19. Roughly how many students were there per teacher in high school (that which you matriculated from)?

____

20. Did you, or are you presently, attending any tertiary education? YES NO

If yes, what are you studying?

____

Where are you studying?

____

Please only answer the following questions if you currently are NOT receiving any level of education

21. Did you receive any further education post-matric? YES NO

If yes, please specify at which institution/college etc. this was received:

____

22. How many years of education did you receive post-matric? _______________

23. What field of study was this in? ___________________________

24. Education (highest degree or grade completed as of 2008):

____

SECTION B. HEALTH
(Please circle the appropriate answer for each of the questions below)

25. Would you say your birth was: NORMAL ABNORMAL DON'T KNOW

26. Have you ever experienced a head injury? (e.g., being hit on the head with an object and losing consciousness as a result)
YES NO

If yes, please specify:

____

27. Have you ever been involved in a motor vehicle accident? YES NO
If yes, how old were you at the time?

____

28. Have you ever had surgery? YES NO
If yes:

What type of surgery?

____

How old were you at the time of surgery?

____

29. Do you now, or have you ever, experienced any of the following medical conditions:

29.1. Allergies YES NO
If yes, please specify:

____

29.2. Asthma YES NO

29.3. Tuberculosis YES NO

29.4. Hypertension (high blood pressure) YES NO

29.5. Epilepsy (i.e., seizures or fits) YES NO

29.6. Neurological problems YES NO
If yes, please specify:

____

29.7. Depression YES NO

29.8. Treated for/ diagnosed with any memory problems or disorders YES NO

If yes, please specify:

____

29.9. Learning difficulties (dyslexia, ADD/ADHD) YES NO

If yes, please specify:

____

29.10. Problems with your vision YES NO

If yes, please specify:

____

29.11. Problems with your hearing YES NO

If yes, please specify:

____

30. Do you have any family history of any of the above medical conditions? YES NO

If yes, please specify:

____

____

31. Are you currently taking any prescription medication(s)? YES NO

If yes, what medication(s)?

____

Plagiarism Declaration

1. I know that plagiarism is wrong. Plagiarism is using another's work and to pretend that is one's own.

2. I have used the American Psychological Association as the convention for citation and referencing. Each significant contribution to, and quotation in, this report from the work, or works of other people has been attributed and cited and referenced.

3. This report is my own work.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Signature: _________________

Date: _____________________