



# Establishing a Measure of Educational Attainment: Using the Zambia Neurobehavioural Test Battery

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**How to cite this paper:** Chirwa, E., Mpolomoka, D.L., Muvombo, M. and Chikopela, R. (2024) Establishing a Measure of Educational Attainment: Using the Zambia Neurobehavioural Test Battery. *Open Access Library Journal*, **11**: e11870.  
<https://doi.org/10.4236/oalib.1111870>

**Received:** June 25, 2024

**Accepted:** August 11, 2024

**Published:** August 14, 2024

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## Abstract

This study is aimed at establishing a suitable measure of educational attainment in the process of validating the Zambia Neurobehavioural Test Battery. We explore the function of education in three different contexts: reading ability which from literature presented, has proved to be a better measure; literacy as measured by how often people engage in tasks such as reading and writing; and quality of education measured by access to books. The components conducted under methods and results include, neuropsychological tests administered for each cognitive domain, and hierarchical regression analysis for effects of age, education and reading level on neuropsychological tests. Other components under methods included, multiple regression analyses: predictors of neuropsychological test, performance per domain, and partial correlation values: age, reported years of education and reading ability. Under the results, hierarchical regression was used, which is a type of regression model in which the predictors are entered in blocks. Each block represented one step or model. The teacher pupil ratio and other factors that may affect quality of education offered. It is hypothesised that reading ability, literacy and quality of education serve as an appropriate measure of educational attainment than reported years of schooling. This is predominantly because these will take into account the assessment of the knowledge, strategy and skills needed to perform well on traditional neuropsychological tests. In summary, this study advocates for the integration of reading ability in neuropsychological evaluations to enhance the validity and reliability of cognitive assessments in diverse populations. For recommendations, there is a need to adopt reading ability tests, such as the Zambia Achievement Test Reading

Recognition subtest, in neuropsychological evaluations to better predict cognitive performance and enhance diagnostic accuracy. Another recommendation was that, stakeholders should validate neuropsychological test batteries tailored to the cultural and educational context of Zambia, tools accurately reflect the cognitive abilities of the population of the country.

### **Subject Areas**

Special Education, Psychology

### **Keywords**

Neurobehavioural Test Battery, Neuropsychological Test, School, Education

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## **1. Introduction**

Neuropsychological Assessment Battery (NAB) is a comprehensive, integrated, modular battery of 33 neuropsychological tests developed to assess a wide array of neuropsychological skills and functions in adults who have known or suspected neurocognitive dysfunction [1]. The relationship between education and performance on neuropsychological tests has been established by many researchers [2]-[4] to the extent that poorly educated but cognitively stable individuals get lower scores than mildly impaired but better educated patients [5] [6].

The notion that education is an important construct that affects neuropsychological test performance cannot be overlooked. However, it is a great challenge to find an accurate estimate of educational attainment. Moreover, this is even more problematic in an African country like Zambia with few psychometrically sound assessment tools to measure this construct [3] [4] [7] [8].

The Ministry of Education has reported a drop in the quality of education being offered in Zambia today. There is a report of reduced numbers of teachers in schools resulting in high pupil to teacher ratios, and inadequate facilities such as books and desks to facilitate the learning process [9]. With these problems being cited in the Zambian education process it may be expected that individuals going through school may complete the required years of schooling but that does not guarantee that the knowledge acquired in those years is corresponding with the number of years they have spent in school. This therefore implies that a person may have had 12 years of schooling but will perform at the level of a 10th or 11th grader. This then poses a challenge of interpretation of test results based on reported years of schooling. Recent research, however, has shown that reading ability has proved to be a better measure of educational attainment than reported years of education [10]-[12].

Ref. [13] observed that African Americans scored lower than European Americans on neuropsychological tests; however, these differences nearly vanished when T-scores were adjusted based on the reading level of the groups. This

underscores the importance of considering literacy as a more reliable predictor of cognitive performance. Similarly, ref. [14] found that years of education and literacy levels significantly predicted cognitive test performance among older adults from diverse ethnic backgrounds. Their findings on the Selective Reminding Test indicated that both literacy levels, as measured by the Wide Range Achievement Test-3 (WRAT-3), and reported years of schooling affected performance, but literacy levels had a stronger impact on delayed recall [2] [15].

Fittingly, [16] carried out a study on validation of the European Cross-Cultural Neuropsychological Test Battery (CNTB) for the assessment of mild cognitive impairment due to Alzheimer's disease and Parkinson's disease. Their findings were similar to those of ref. [17] who examined the relationship between literacy and cognitive test performance in diverse older adults. They determined that reading level was a more accurate predictor of performance on neuropsychological tests than either age or reported years of education across three domains: language, memory, and executive functions. Ref. [17] found that reading proficiency, rather than years of education, better indicated cognitive functioning, supporting the notion that literacy levels should be a primary consideration in neuropsychological assessments.

Literature abounds depicting differences in reading levels, proficiency and aptitude among diverse learners [18]. Interestingly, reading level has also been found to reduce differences observed among HIV+ individuals. [1] emphasized that relying solely on reported years of education can overestimate impairment levels among minority groups. They found that incorporating reading ability into neuropsychological assessments significantly reduced these discrepancies, aligning with findings from ref. [13] who conducted a systematic review validating various neuropsychological test batteries, and this was equally supported by the findings of [13].

Cementing the reading levels and other similar aspects, plus supported by the findings of ref. [1] [19] investigated the accuracy of reading ability versus years of schooling in diagnosing HIV-associated neurocognitive impairment. Their results demonstrated that using reading ability as a determinant of neuropsychological impairment not only provided a better prediction but also increased both specificity and sensitivity among Caucasian participants and increased specificity among African Americans. This supports the broader conclusions drawn by ref. [20], who established the construct validity of neuropsychological tests through factor analysis, highlighting the importance of reading ability in accurate cognitive assessment. Ref. [19] further studied the accuracy of reading ability versus years of schooling in diagnosing HIV-associated neurocognitive impairment. Results revealed that using reading ability as a determinant of neuropsychological impairment was not only a better predictor but also increased both specificity and sensitivity among Caucasian participants and increased specificity among African Americans in determining neurocognitive impairment [15] [18].

## 2. Research Methods

A total of 324 Zambians were recruited in the study. They consisted of HIV negative Zambian adults from the ages of 20 to 65 years ( $M = 38.48$ ,  $SD = 12.8$ ), from both rural and urban areas of Zambia. They were about equally distributed in terms of gender and had a range of 5 years of education to 19 years of education ( $M = 11.02$ ,  $SD 2.8$ ). Participants were assessed for depression using the Beck Depression Inventory (BDI) [21]. Personal function and Daily living were also assessed using the Patients Assessment of Own Functioning Inventory (PAOFI) [22] and Activities of Daily Living (ADLs) [13] [23].

### 2.1. Inclusion and Exclusion Criteria

#### 2.1.1. Inclusion

- HIV negative—confirmed by means of a rapid HIV-1 antibody test carried out study site clinics.
- Educational level with a minimum of Grade 5, Demographic Questionnaire.
- Age range of between 20 - 65, Demographic Questionnaire.
- Ability to speak and understand English—Assessed by means of the Wide Range Achievement Test-3 (WRAT-3) and the Zambia Achievement Test (ZAT).

#### 2.1.2. Exclusion

- History of neurological problems (Epilepsy, closed head injury, coma etc.)—Neurobehavioural Medical Screen which assesses past medical and neurological histories.
- History of drug abuse—Assessed by the substance use and Chinese substance use history questionnaire which captured the units of alcohol consumed. Moderate alcohol consumption for males = 21 units of alcohol per week and 4 units per day. While moderate alcohol consumption in females is measured as being = 14 units of alcohol per week and 3 units per day [1].
- History of Psychiatric illness—Use of the Composite International Diagnostic International Interview (CIDI). It is a structured questionnaire using the DSM-IV and ICD-9 diagnosis.

#### 2.1.3. Neuropsychological Assessment

All participants completed a comprehensive Neuropsychological test battery developed for the Zambian population (Zambia Neurobehavioural Test Battery). **Table 1** below lists the tests included in the 4-hour battery which assesses seven cognitive domains. The domains include: Speed of Information Processing, Verbal Episodic Memory, Visual Episodic Memory, Verbal Fluency, Working Memory Executive functioning and Motor Dexterity The battery was administered by nine trained Master of Science in Clinical Neuropsychology students as part of a larger validation study of the test battery.

#### 2.1.4. Reading Ability

Reading ability was assessed using the Zambia Achievement Test Reading Recognition subtest [24]. This is an individually administered test constructed to

quantify academic achievement for the purpose of identifying academic difficulties. It has a total of 20 items with each item containing four words. A correct item is the ability to read and pronounce all four words correctly. The words are listed in order of decreasing familiarity and increasing phonological difficulty.

**Table 1.** Neuropsychological Tests Administered for each cognitive domain.

Speed of Information Process
WAIS Digit Symbol and Symbol Search
Trail Making Test, Part A
Colour Trails 1
Stroop Colours Task
Visual Episodic Memory
Brief Visual-Spatial Memory Test—Learning
Brief Visual-Spatial Memory Test—Delayed Recall
Verbal Episodic Memory
Hopkins Verbal Learning Test—Learning
Hopkins Verbal Learning Test—Delayed Recall
Verbal Fluency
Controlled Word Association Test—FAS
Category Fluency Test (Animal and Actions)
Stroop Word Task
Executive Functioning
Colour Trails 2
Halstead Category Test—Total Errors
Stroop Colour/Word Task
Wisconsin Card Sorting Test (64 Item)
Working Memory
Paced Serial Addition Test
WMS Spatial Span
Motor Dexterity
Grooved Pegboard Test (Dominant & Non-Dominant Hands)

### 2.1.5. Statistical Procedure

Hierarchical multiple regression to determine which index of education will serve as a better predictor of performance on neuropsychological tests. Partial correlations were also used to show how much each index will contribute to predicting performance on neuropsychological tests.

Overall the methods section, it has provided a thorough demographic breakdown of the study participants, comprising 324 HIV-negative Zambian adults aged 20 to 65 years ( $M = 38.48$ ,  $SD = 12.8$ ), equally distributed across gender and

recruited from both rural and urban areas of Zambia. Participants had varying levels of education ranging from 5 to 19 years ( $M = 11.02$ ,  $SD = 2.8$ ). Inclusion criteria ensured participants were proficient in English, confirmed by the Wide Range Achievement Test-3 (WRAT-3) and Zambia Achievement Test (ZAT). Exclusion criteria included histories of neurological problems, substance abuse, and psychiatric illness. The comprehensive neuropsychological assessment, administered by trained Master of Science in Clinical Neuropsychology students, included tests across seven cognitive domains. Meanwhile, despite these details, the methods section could potentially benefit from the additional socio-economic background information to better contextualize participants' educational attainment. This can include even its implications on neuropsychological performance as a whole.

### 3. Results

The results shown in **Table 2** show that all three predictors were significant with  $P < 0.0001$  in predicting performance on the neuropsychological test battery.

**Table 2.** Model One—Hierarchical regression Analysis for effects of age, education and reading level on neuropsychological tests.

Variable	B	SEB	$\beta$	B	SEB	$\beta$	B	SEB	$\beta$
	Step 1			Step 2			Step 3		
Age	-0.064	0.007	0.442*	-0.055	0.006	0.838*	-0.058	0.006	0.401*
Years of Schooling				0.309	0.032	0.431*	0.203	0.034	0.283*
Reading Level							0.185	0.029	0.307*
R <sup>2</sup>	0.195			0.378			0.450		
$\Delta R^2$	0.195			0.183			0.072		

\* $P < 0.001$ .

In step three, age accounted for the highest beta weight recording 0.401 and 19.5% of the variance, while reading level showed more significance than reported years of education with a beta weight of 0.307 and an additional 0.72% of the variance over and above age and reported years of schooling. The results also indicate that when all three variables are entered in the analysis an  $R^2$  0.450 is obtained implying that when all three variables are entered the variance accounted for is up to 45%. This is more than what is obtained when only age (Step 1) was entered or age and schooling (Step 2) were included accounting for 19.5% and 37.8% of the variance respectively.

In order to find the effects of reading, schooling and age on the different test domains of neuropsychological functioning, hierarchical multiple regression analyses were run (**Table 3**) following the design of model 1 (**Table 2**). Effects of schooling were strongest on the tests of verbal fluency, followed by speed of in-

formation processing and working memory. Minimal effects of schooling were found on the visual and verbal episodic memory domains, executive functioning and motor domains. Additional variance accounted for by ZAT scores over and above age and schooling was greatest for tests of verbal fluency, speed of information processing and working memory. However, ZAT scores did not account for any additional variance on the motor domain. Effects of age were strongest on speed of information processing followed by Visual Episodic Memory then Executive Functioning. It is important to bear in mind that age in Step 1 is still confounded with effects of schooling and reading level.

**Table 3.** Multiple regression analyses: Predictors of neuropsychological test performance per domain.

Variable	B	SEB	B
<b>Visual Episodic Memory</b>			
Age	-0.092	0.012	-0.390*
Schooling	0.104	0.067	0.088
Reading Level	0.199	0.056	0.200*
	<b>Step 1</b>	<b>Step 2</b>	<b>Step 3</b>
R <sup>2</sup>	0.162	0.196	0.227
ΔR <sup>2</sup>	0.162	0.034	0.031
<b>Verbal Episodic Memory</b>			
Age	-0.061	0.011	-0.272*
Schooling	0.169	0.065	0.153*
Reading Level	0.189	0.054	0.203*
	<b>Step 1</b>	<b>Step 2</b>	<b>Step 3</b>
R <sup>2</sup>	0.087	0.149	0.181
ΔR <sup>2</sup>	0.087	0.062	0.032
<b>Verbal Fluency</b>			
Age	-0.207	0.008	-0.153*
Schooling	0.303	0.044	0.345*
Reading Level	0.260	0.037	0.352*
	<b>Step 1</b>	<b>Step 2</b>	<b>Step 3</b>
R <sup>2</sup>	0.041	0.302	0.398
ΔR <sup>2</sup>	0.041	0.261	0.096
<b>SIP</b>			
Age	-0.076	0.008	-0.420*
Schooling	0.198	0.046	0.175*
Reading Level	0.199	0.038	0.263*

Continued

	Step 1	Step 2	Step 3
R <sup>2</sup>	0.204	0.323	0.376
ΔR <sup>2</sup>	0.204	0.119	0.053
<b>Executive Functioning</b>			
Age	-0.052	0.008	-0.320*
Schooling	0.141	0.046	0.175*
Reading Level	0.139	0.038	0.204*
	Step 1	Step 2	Step 3
R <sup>2</sup>	0.119	0.192	0.224
ΔR <sup>2</sup>	0.119	0.073	0.032
<b>Working Memory</b>			
Age	-0.040	0.010	-0.207*
Schooling	0.188	0.055	0.195*
Reading Level	0.230	0.046	0.282*
	Step 1	Step 2	Step 3
R <sup>2</sup>	0.056	0.164	0.225
ΔR <sup>2</sup>	0.056	0.108	0.061
<b>Motor</b>			
Age	0.066	0.011	-0.300*
Schooling	0.294	0.063	0.270*
Reading Level	0.023	0.053	0.025
	Step 1	Step 2	Step 3
R <sup>2</sup>	0.114	0.192	0.192
ΔR <sup>2</sup>	0.114	0.078	0.000

\*P &lt; 0.05.

Partial correlation analyses were run to explore the relationship between age, reported years of education and reading ability and the different domains of the neuropsychological tests. The associations obtained were generally low as shown in **Table 4** below. However, all the correlations were significant at 0.01. All the domains correlated negatively with age with the highest correlation being obtained in the Speed of Information processing domain with  $r = -0.465$ . In the reported years of schooling domain, the highest correlation obtained was in the fluency domain with  $r = 0.361$ . Reading ability correlated the highest with the Fluency domain as well with  $r = 0.370$ . All associations between reported years of schooling, reading ability and all seven domains were positive and significant with  $P < 0.01$ .

**Table 4.** Partial correlation values: Age, reported years of education and reading ability.

Domain	Age	Reported Years of Schooling	Reading Ability
Visual Episodic Memory	-0.400**	0.087**	0.196**
Verbal Episodic Memory	-0.285**	0.145**	0.193**
Verbal Fluency	-0.192**	0.361**	0.370**
Speed of Information Processing	-0.465**	0.237**	0.281**
Executive Functioning	-0.338**	0.170**	0.199**
Working Memory	-0.226**	0.189**	0.271**
Motor	-0.313**	0.253**	0.024**

\*\*Correlation Significant at 0.01 levels (2-tailed).

### Statistical Analysis Rationale Justification

In justifying the statistical analysis section as to why hierarchical multiple regression was chosen over other statistical methods that could be more appropriate given the data structure, was sorted by the following narrowed explanation. By realty of this article, the hierarchical multiple regression was selected as the primary statistical method in this study due to its suitability for examining the unique contribution of predictor variables such as age, reported years of schooling, and reading ability. This was due to neuropsychological test performance and results obtained. For example, this method allows for the sequential entry of predictors into the regression equation, thereby assessing their incremental predictive power [25]. Given the complex interplay between demographic factors and cognitive performance, hierarchical regression was deemed appropriate for delineating how age, schooling, and reading ability individually and collectively influence cognitive outcomes across different domains. However, this approach facilitates the interpretation of how each predictor contributes to the variance in test scores while controlling for potential confounding effects [26] [27]. Justifiably, the alternative statistical methods such as structural equation modelling or latent variable analysis, while powerful, may require more assumptions about the underlying data structure and were not chosen here to maintain clarity as well as transparency in the aspect interpretation of result themselves [28].

### 4. Discussion

In the hierarchical regression carried out, it was observed that both age and reported years of schooling served as predictors of performance on neuropsychological tests. However, over and above this, reading ability as measured by the ZAT reading recognition subtest accounted for a higher variance than the previous two predictors.

The importance of using reading ability as a measure of educational attainment and as a predictor of performance on neuropsychological tests has been

highly supported in the literature [1] [13]-[15] [29]-[32]. It establishes that although age and schooling are both important in obtaining more sensitive and specific results on neuropsychological tests, reading ability adds more predictive power as it takes into account extraneous variables that are not reflected in the other variables, especially reported years of schooling in this case. The results also showed that reading ability had consistent predictive power in almost all domains with the exception of motor ability, where reading ability was not a significant predictor of performance.

In fitting the findings, using reading ability as a measure of educational attainment will not only give an indication of levels of performance but is more likely to provide better diagnosis in conditions such as HIV-related dementia, as reported by ref. [19] and ref. [25]. They argue that using test results corrected for reading ability will increase the specificity and sensitivity of the tests and reduce levels of reported impairment, a conclusion also supported by the findings of ref. [17]. In cases where only reported years of schooling were used as a measure of educational attainment, results tended to inflate the levels of impairment, resulting in wide variations among individuals of different backgrounds. With the understanding that HIV is a growing epidemic in Zambia, a sensitive and specific method of diagnosis would be needed. Although the participants in the study were HIV negative, these results will serve as a guide in the diagnosis of HIV-related dementia.

It was hypothesized that reading level would have more effects on verbal tests such as the Hopkins Verbal Learning Test-Revised, the COWAT (FAS), Category Fluency test and the Stroop Word test. The hypothesis was confirmed with the results indicating that reading ability was significant and accounted for more beta weight than reported years of schooling in the Verbal Episodic Memory. The results obtained in this analysis as indicated in **Table 2** show that tests affected the most by reading ability are in the fluency domain which include the COWAT (FAS) (animals and actions) and the Stroop word. These showed an  $R^2$  of 39.8% with reading ability on its own accounting for a beta weight of 0.352, higher than both age with  $-0.153$  and reported years of schooling with 0.345. However, it is important to note that reported years of schooling also accounted for additional variance over and above reading. Comparing models 1 and 2 we see that when the last predictor entered in Step 3 is reading level indexed by the ZAT score an additional 7% of the variance is accounted for, whereas when the last predictor entered is years of schooling as additional 6% is accounted for. This suggests that both variables make an equally important contribution to scores in the neuropsychology test battery [18] [20].

These results are consistent with other research which shows that the ability to read affects how individuals perform on neuropsychological tests [1] [13] [18]. In their work, it is suggested that the ability to read influences automatic word production and phonological abilities crucial for performance on tests like the Stroop Word. Previous research has equally established how education affects

performance on verbal tests [19] [32] [33] and functional skills [25] [34].

Similarly, the results obtained in this study support findings of many other studies thereby highlighting the importance of correcting test results based on reading ability to account for factors such as automatic reading and phonetic abilities not fully captured by reported years of schooling [11] [33] [35]-[37]. Given that English is not the native language for most people in Zambia, and the tests in the Zambia Neurobehavioural Battery are in English, correcting for reading ability would yield more specific results by accounting for English phonological abilities, which may otherwise confound the results.

### **Justification on Integration of Tables and Figures in Discussion**

Pertaining to the discussion of findings section, specific references to tables and figures, such as **Table 2** and **Table 3**, are essential for providing a cohesive link between the reported findings and their visual representation. In line with **Table 2**, it illustrates the results of hierarchical regression analyses, demonstrating the significant contributions of age, schooling, and reading ability to neuropsychological test performance. For instance, through referring to these tables, the discussion can effectively contextualize the magnitude of these contributions across different cognitive domains. Similarly, it highlights how reading ability, as measured by the Zambia Achievement Test (ZAT). This accounted for the additional variance beyond age and reported years of schooling, particularly in tests of verbal fluency and speed of information processing. To add on, this approach not only reinforces the main findings but also enhances clarity by connecting theoretical interpretations with empirical data. In the end, referencing specific figures and tables aids readers in navigating complex statistical outcomes and strengthens the overall coherence of the discussion section. As mentioned, integrating these references more prominently will provide a more structured and understanding discussion of the study's implications and findings inclusively.

## **5. Conclusion**

The findings of this study have given the critical role side of reading ability in predicting performance on neuropsychological tests, highlighting its superior predictive power over reported years of schooling. This aligns with previous research which shows that reading ability effectively accounts for extraneous variables not captured by mere educational attainment, particularly in contexts where the quality of education is variable and English is not the native language. As a result, by incorporating reading ability into assessments, we achieve a more accurate diagnosis, particularly in conditions like HIV-related cognitive impairment, where sensitivity and specificity are paramount. To add on, this study advocates for the integration of reading ability in neuropsychological evaluations to enhance the validity and reliability of cognitive assessments in diverse populations. In summary, this includes those in Zambia, ultimately contributing to more equitable as well as precise diagnostic practices as a whole.

## 6. Recommendations

From the findings and discussions of the study, the following recommendations were made:

- 1) There is a need to adopt reading ability tests, such as the Zambia Achievement Test Reading Recognition subtest, in neuropsychological evaluations to better predict cognitive performance and enhance diagnostic accuracy.
- 2) Stakeholders should validate neuropsychological test batteries tailored to the cultural and educational context of Zambia, tools accurately reflect the cognitive abilities of the population of the country.
- 3) To address the reported drop in education quality by increasing the number of trained teachers and providing adequate educational materials and facilities to improve overall educational attainment.
- 4) Use standardized measures of educational attainment, such as reading ability, across different populations to minimize discrepancies and biases in neuropsychological test results.
- 5) The government should regularly monitor and evaluate the effectiveness of educational interventions and neuropsychological assessments to ensure they meet the evolving needs of the population and maintain high standards of validity and reliability.
- 6) To encourage more studies on the relationship between education and neuropsychological performance in various cultural contexts to better understand the impact of educational quality and literacy on cognitive assessments.

## Conflicts of Interest

The authors declare no conflicts of interest.

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