PSYCHOMETRIC PROPERTIES OF A VASCULAR NEUROPSYCHOLOGICAL BATTERY FOR ASSESSING COGNITIVE FUNCTIONS AMONG STROKE SURVIVORS IN SOUTH-WEST NIGERIA

BY

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CERTIFICATION

I certify that this work was carried out by Adedayo, Oluyinka Abiodun in the Department of Epidemiology and Medical Statistics, University of Ibadan, Nigerian.

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SUPERVISOR

DR J.O. AKINYEMI

DECLARATION

I hereby declare that this research is original. This work has neither been presented to any other Faculty for the purpose of the award of degree nor has it been submitted elsewhere for publication purposes.

Signature ……………………………   Date ………………….

ADEDAYO, Oluyinka Abiodun

DEDICATION

This research work is dedicated to Almighty God and to my late mother-in-law, Late (Mrs.) Mogbonjubola Adunni Oladimeji in honour of her memory.

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ABSTRACT

Background: Nigeria, the most populous black nation in the world, stands to risk the further straining of its resources as a result of the increasing prevalence of stroke and other cardiovascular diseases. After stroke, very many survivors encounter issues bordering on cognitive impairments which are assessed by neuropsychological battery. However, Psychometric properties explain the reliability and validity of these instruments used to assess the consistency, dependability and accuracy of the test results obtained. Several studies have investigated the psychometrics of these neuropsychological batteries among stroke survivors. However, none has investigated the psychometrics of the instruments used in the COGFAST – NIGERA (Memory After Stoke) Study. Therefore, this study primarily assesses the psychometric properties of a vascular neuropsychological test battery for memory function among stroke survivors.

Methodology: Secondary data was obtained from two referral hospitals from the records of 381 consecutively presenting stroke patients who are 45 years old or older made up of 244 stroke survivors and 137 healthy controls who were also clinically diagnosed by experienced physician neurologists were recruited from stroke registers of the two specialist hospitals in Abeokuta and Ibadan. The COGFAST-NG Study was conducted between July, 2010 and June, 2012. The psychometric properties of the test battery were investigated by assessing the internal consistency reliability using the Cronbach's Alpha model and the Nunnaly's criterion. Validity of the instrument was assessed using the Receiver Operating Characteristic curve analysis and the spearman's correlation coefficients. The factor structure of the test battery was described using

the principal components analysis through the varimax rotation method. Analyses of data were performed using the SPSS Version 25 software.

Results: There was no statistically significant difference between the ages, gender and education years between the two groups. Scores recorded after administering the tests on participants of the study showed that there were significant differences in the mean score of some tests except with a few showing no significance. The stroke survivors and the control group had Cronbach's Alpha of 0.750 and 0.647 respectively. The Area under the Receiver Operating Characteristic curve (AUC) ranged between 0.480 and 0.722. The sensitivity and specificity of the statistically significant tests ranged between 51.4 – 69.7% and 56.9 – 65% respectively with reasonable cut-points. Correlations between the MMSE and majority of the tests proved to be moderately strong ranging from 0.339 – 0.651. A three-factor solution accounting for 56.1% of the total variance for all the participants while also, a three-factor solution was recorded for the study group with 56.8% of the total variance explained. The control group showed a four-factor solution with 62.8% of the variance explained.

Conclusion: The study has shown that the V-NB demonstrated good internal consistency reliability. The validity study of the test battery has some attributes of accuracy and usefulness for screening individuals suspected to have cognitive impairment. The test battery also demonstrated an acceptable internal structure with reasonable factor loadings. Very importantly, this study proposed cut-points for some tests in the battery for the purpose of screening patients for cognitive impairments but cautioned that the cut-points might not be necessarily useful for diagnostics.

CHAPTER ONE

1.1 Background of the Study

Psychometrics is the construction and validation of measurement instruments and assessing if these instruments give reliable and valid measurement. (Ginty, 2013). Psychometric properties explain the accuracy of instruments in terms of their usefulness in research. The reliability of such instruments deals with its consistency and dependability. While on the other hand, validity of instrument delves into explaining the accuracy of the test result obtained. The quality of information obtained from measurement instruments depends on their psychometric properties. Hence, researchers have to be mindful when choosing or designing measurement instrument to ensure best result from a study. An Aspect of Medicine which deals with behaviours has made progressive attempts to measure knowledge, ability, personality, and other characteristics (Ginty, 2013). Checking the accuracy of a tool is centered on minimizing errors as much as possible (Kimberlin & Winterstein, 2008).

Various techniques in psychometric properties commonly employed in analyzing the concept of reliability and validity are briefly described. Construct Validity – this is the degree of precision measurement in relation to what was meant to measure in a bid not to measure something else. Content Validity explains if the measuring tool reflects the particular attribute it is expected to measure done in a systematic manner. For instance, a questionnaire intended to rate intelligence must have a wide range of queries bordering on intelligence. In Criterion validity, comparison of a measuring tool is made with another which is believed to be similar in terms of what they both estimate. This is a special type of Concurrent Validity which provides information with regards to the extent of association between the estimates (scores) of the instruments being compared. This also, in other terms simply explains the existing relationship among the estimates. There is also the possibility of a validity not measuring what it is not expected to estimate. This refers to Discriminant validity which is often times useful in differentiating between groups while trying to establish classification of the groups with specific conditions. In practice, some traits are supposed to be related in terms of what they measure. Therefore, Convergent Validity is employed as a form of technique for such measure of accuracy. Face validity has an element of subjectivity in its deployment for measuring a construct to be estimated. The pertinence of a test is usually exemplified by the face validity.

It is important to ascertain the extent of agreement that exists between scores obtained when interviewers extract information through the administering of questionnaire on the subjects. In light of this, the Inter-rater reliability gives an insight into how much such results can be relied upon while the Test-Retest Reliability elucidates on the concord that is observed with outcomes when an interviewer uses an instrument for more than once to measure some constructs. Provision has always been made by Inter-method reliability to reliably measure the same attribute and compare results to see if they agree using more than two instruments. Internal Consistency Reliability provides a measure on how total score will be different for items in a particular test instrument whenever the items are minimally varied. In general, statistical techniques involving correlational analysis as well as factor analysis are commonly used for measuring and evaluating validity and reliability. I have therefore made an attempt at evaluating the psychometric properties of a vascular neuropsychological battery to measure cognitive functions in stroke survivors.

Cognitive functioning provides a means of evaluating intelligence and a structure for identifying certain components of a measurable scale. Moreover, it is worthy of note that the measure of intelligence which cognitive functioning depicts assumes a variety of components of intellect. In addition, many criticisms have trailed cognitive functioning as a result of inadequacies in assessments for measurement. While measurable intelligence is the same as cognitive functioning, intelligence, according to the American Psychological Association, can be defined as "a person's ability to grasp complex concepts, environmental adaptation, experiential learning, and decision-making with logical reasoning in both new and familiar situations". In the quest to appropriately quantify cognitive functioning, experts in neurosciences and cognitive assessments have come up with diverse approaches in an attempt to provide quantitative measure. Psychological assessment has assisted in evaluating an individual's functional space especially within the domain of cognitive functioning. The term cognitive functioning holistically captures a variety of competencies which include intellect, concentration, processing speed, visual ability, language and communication tendencies, and memory. However, the foregoing skills and abilities cannot be adequately evaluated in the absence of standardized psychometric assessment.

For the reasons of patients' limitations to correctly report their cognitive functioning state and clinicians having to totally depend on clinical interviews due to the lack of neuropsychological test culminating into poor assessment of measurable intelligence, cognitive evaluation is basically a means to establish severity of cognitive disabilities which makes it a vital component of neuropsychological assessment.

1.2 Problem Statement

Stroke accounts for majority of diseases and eventual death globally while its likelihood of aggravating effects are experienced more in the developing countries like Nigeria based on the predictions of the World Health Organization (WHO) (Wahab, 2008). Bearing in mind the current prevalence of HIV/AIDS in the midst of other communicable diseases living with us which have proved over the years becoming more resistant to interventions, Nigeria being the most populous black nation in Africa and the entire globe experiencing the severe risk dwindling resources owing to the high prevalence of cardio-vascular diseases and stroke. In Nigeria, verified records showed that the prevalence of stroke is 1.14 in every one thousand persons and a death rate of 40% for cases documented in 30 days. (Wahab, 2008). Poor handling of the disease and inadequate funding has contributed negatively to this in terms of good research.

About 64% of stroke survivors will manifest some degrees of cognitive malfunctioning (Hachinski *et al*., 2006). In addition, close to about 30% or thereabout of these survivors will definitely end up having dementia in a lifetime (Hachinski *et al*., 2006). However, epidemiological transition is currently trending in the sub-Saharan region of Africa and stroke mortality remains very high especially in the region. In developing countries, the significance of stroke is fast becoming appreciated in the light of the recent update from the "Global Burden of Disease Study" where it was revealed that approximately 80% of deaths arising from stroke are from the less income-generating nations of the world. Another projection that was made showed that the neurological diseases such as stroke and other heart-related problems have the capacity to keep growing in the next ten years for poor countries owing to the anticipated demographic and health changes which culminate into the leading cause of disability and death.

Nigeria has a record of 26.0 (12.8–39.0) /100,000 person-years for the crude incidence of stroke, while the rate was evidently higher among men with 34.1 (9.7–58.4) /100,000 than what obtained women with figures standing at 21.2 (7.4–35.0) /100,000 (Adeloye *et al*., 2019). Stroke survivors in Nigeria have a record of 6.7 (5.8–7.7) /1000 being the pooled crude prevalence. This was also seen more in men with 6.4 (5.1–7.6) /1000 and 4.4 (3.4–5.5) /1000 in women when compared. Between year 2000 and 2009, Nigeria's figure for the incidence of stroke was 24.3% which progressively increased to 27.4% beginning form the year 2010 and beyond. In the same vein, stroke survivors recorded an increase of about 13. 4% in the Niger-Delta zone of Nigeria and 10.8% prevalence among people who live the rural areas.

Some neuropsychological battery has been proposed to measure memory/cognitive function among stroke survivors in south-west Nigeria. However, the psychometric properties of these scales have not been clearly documented.

1.3 Justification

Measurement of memory/cognitive function is very important because about 30% of all stroke survivors progress into full-blown cognitive malfunctioning (Teasell & Cotoi, 2017). For a proper understanding of the measurement of cognitive function, attention should be drawn to the three components, namely: memory, recall, and recognition. As stated earlier, various neuropsychological test battery used in this study encompasses these three components. Memory deals with the consistence in the acquisition of knowledge in a period of time by converting storage and extracting information. While recall measures memory functions whereby a subject is required to extract information gathered in the past. Recognition also being a measure of cognition requires that an individual only identify objects earlier learned.

Regular assessment of cognitive function in stroke survivors is crucial to overall well-being because they orchestrate a personalized standard of brain health for future comparison. Measurement of memory function also tends to help detect early indicators of memory impairment in order to take appropriate action. This has also assisted in providing a basis to measure against in the event of problems as it enhances focus on identified aspects of dysfunctionality when developing an intervention plan. Another important advantage of measuring memory function is that data obtained from subjects (stroke survivors) who have been tested using different instruments can be investigated and studied in the light of similar measurement of relatively associated cognitive functions.

1.4 General Objective

This study is aimed at assessing the psychometric properties of a vascular neuropsychological test battery for memory function among stroke survivors in south-west Nigeria.

1.5 Specific Objectives

1. To assess the internal consistency of the vascular neuropsychological test battery.
2. To assess the discriminant validity of the vascular neuropsychological test battery.
3. To evaluate the concurrent validity of the vascular neuropsychological test battery.
4. To describe the factor structure of the vascular neuropsychological test battery.

CHAPTER TWO

LITERATURE REVIEW

2.1 Internal Consistency of Vascular Neuropsychological Battery

As noticed in practice, high internal consistency forms an important basis for high validity usually indicated by the coefficient alpha also known as the Cronbach's Alpha. The specific psychometric properties at the new Luria Nebraska NB –III was examined. (Teichner, Golden, Bradley, & Crum, 1999). Two different groups making up a total sample of 288 was utilized. The result of administering the LNNB – III on the two groups revealed clearly that the Cronbach's alpa was high ($\alpha \geq .70$) which suggested a good internal consistency. The Psychometric Properties of the Spanish version of the Screen for Cognitive Impairment in Psychiatry (SCIP) (Pino *et al*., 2008) was a brief subscale created to identify psychological irregularities in a few psychotic issues. A sample of 126 stable patients previously determined to have Schizophrenia and Schizo-affective disorder or Schizophreniform together with 39 subjects as controls was recruited. (Pino et al., 2008). As a measure of psychometric properties of the SCIP protocol, Cronbach's alpha of 0.73 was recorded for internal consistency which quite agreed with other forms of reliability tests conducted using the protocol. The neuropsychological profile of three groups namely: visuo-perceptive disorders, attention disorders and numerical factors; as emphases were laid on how they match the Clock Drawing Interpretation Scale (CDIS) definitions in elderly people with mild to moderate cognitive disorder was conducted by (Colombo, Vaccaro, Vitali, Malnati, & Guaita, 2009). Results observed for the three groups mentioned above revealed that irrespective of the differentials, the internal consistency (>0.7) recorded for each of the groups was adequate for the reliability of the protocol.

Another neuropsychological battery is the "Brazilian version of the Cambridge Cognitive Examination Reversal (CAMCOG – R)" (Paradela, Lopes Cde, & Lourenco, 2009). This protocol was designed to an upgrade of the "Cambridge Examination for Mental Disorders of the Elderly (CAMDEX – R)" (Paradela *et al*., 2009). The CAMCOG – R was dev eloped to incorporate few screening tools for cognitive disturbances generally utilized in epidemiological research such as the Mini-Mental State Examination (MMSE) among others. Therefore an empirical investigation aimed at evaluating reliability of the Brazilian version of the CAMCOG – R was initiated (Paradela *et al*., 2009) being an important step in the evaluation process of the reliability and accuracy of the instrument. Study which was conducted in an outpatient clinic a public geriatric hospital in Brazil ended up having a total of 123 participants who reformed at the end of the selection process. In addition, inclusion and exclusion criteria were formed through selection process. The result showed that the Cronbach's alpha coefficient was 0.89 which suggested high reliability which meant that the instrument evaluated one same construct. This also indicated that well translated protocols could be as very reliable as the original protocol.

Stroke-specific health-related quality of life in Stroke Patient (HRQOLISP-26) was multifaceted, concise, and flexible (HRQOLISP-26) being adapted from the existing HRQOLISP-102 to have excellent psychometric properties (Ojo Owolabi, 2011). 100 (Ibadan, Nigeria) and 103 (Berlin, Germany) stroke patients contrasted with 100 (Ibadan) and 50 (Berlin) clearly solid grown-ups. The 26-thing comprised of restoratively important physical, mental, intellectual, and eco-social areas was generated. Internal consistency ($\alpha = 0.81, 0.89$) was revealed. The development of a practical information-based scale for the provision of a valid estimate of premorbid cognitive abilities (Apolinario *et al*., 2013) among low-educated populations revealed that the Premorbid Cognitive Abilities Scale (PCAS) had been proven and established to be a reliable easy-to-use instrument as findings consistency was supported among other measures of consistency having Cronbach's Alpha in the interval 0.85 and 0.90. A total of 132 participants drawn from a geriatric memory clinic at the "University of Sao Paulo Medical School in Brazil" *(Apolinario et al*., 2013). "Cognitive complaints in bipolar disorder rating assessment also known as the COBRA was developed in Barcelona" (Rosa *et al*., 2013) for the detection of cognitive complaints experienced by bipolar participants. It is a 16-item self-reported NB based on 4-point scale (Rosa *et al*., 2013), recruiting 215 subjects out of which 124 who did not meet the eligibility criteria were used as the controls. All the subjects were recruited into the Programme for people with bipolar condition at the Clinic. The COBRA protocol revealed an internal consistency with a coefficient of 0.913 which adequately to suggested that the protocol was very reliable thereby affirming the use fullness and applicability of the instrument for assessing cognitive impairment with focus on executive function, verbal learning and memory, attention, processing speed, working memory and mental training being the major cognitive inadequacies common with bipolar patients. While also trying to understand the concept of cognitive reserve emerging from the observed discrepancies between brain pathology and clinical symptoms, (Leon, Garcia-Garcia, & Roldan-Tapia, 2014) among a total of 117 healthy individuals using the Cognitive Reverse Scale (CRS) in an attempt to explain, in better terms, the neuropsychological performance in healthy individuals; the CRS had a very satisfactory internal consistency of coefficient 0.77 to establish the reliability of the scale. The Stroke Impact Scale (SIS 3.0) was translated from English into Hausa and was tested for its psychometric properties using a stratified random sample involving adult stroke survivors who attended the rehabilitation services at stroke referral hospitals in Kano, Nigeria (Mohammad, Al-Sadat, Siew Yim, & Chinna, 2014). The internal consistency assessed using the Cronbach's alpha revealed that components such as Hand function, Mobility, ADL/IADL, Memory and thinking, Communication, Emotion, and Social participation of the instrument had these values: 0.80, 0.92, 0.90, 0.78, 0.84, 0.89, 0.58, and 0.74, respectively.

The psychometric properties of a neuropsychological battery of three protocols (Chen *et al*., 2015) was recommended by the NINOS – Canadian Stroke Network to diagnose Vascular Cognitive Impairment (VCI). Factors such as difference in culture and language barrier prevented the direct use of the protocols which was then translated into Chinese language for use in China. Case – Control study was adapted in the investigation whereby 50 cases were post – stroke patients who were 50 years or older. The 50 cases were recruited three months after the ictus having satisfied other eligibility criteria. Similarly, 50 controls were enrolled into the study through advertisement. It was ensured that none of the controls had an history of stroke or temporary ischemic attack. The protocols recommended were a 60 – minute, 30 – minute and 5 – minute administered on the subject together with the Montreal Cognitive Assessment (MoCA) and the Mini – Mental State Examination (MMSE). An important point to note from the outcome showed the consistency of the study with other studies previously conducted as the reliability assessment performed on the data revealed Cronbach's alpha of 0.87 depicting a very good internal consistency for all subjects.

The Telephone Interview for Cognitive Status (TICS) was originally developed and adapted from the Mini-Mental State Examination (MMSE) known as the gold standard. (Castanho *et al*., 2016) This explored the applicability of the Telephone Interview Screening for Cognitive Status with a delayed recall item being a modified version against a wider assessment using a neuropsychological battery (Castanho *et al*., 2016). The modified version was a further improvement on the TICS which is a 13 – item test with score ranging from 0 to 39. A total number of 142 participants were drawn from a local health centre in Braga, Portugal. The reliability of the instrument was assessed using the internal consistency gave a Cronbach's alpha of 0.705. The informant AD8 was examined in Government subsidized primary healthcare centres in Singapore. 1082 informants completed AD8 assessment at two primary healthcare countries while 309 out of them who were patient – informants' dyads were further assessed using the Mini – Mental Slate Examination (MMSE), Montreal Cognitive Assessment (MoCA), Clinical Dementia Rating (CDR) and a locally validated formal neuropsychological battery in a tertiary hospital. The analyses of the data gathered demonstrated a high internal consistency with Cronbach alpha of 0.85 to affirm the reliability of the instrument (Shaik *et al*., 2016). The Patient Evaluation Scale (PES) was designed to be used by Nigerian primary health care. 300 patients who attended 28 primary health centres across eight states in Nigeria participated in the study. The full and shortened version of PES with 27 and 18 items, respectively, were also developed (Ogaji, Giles, Daker-White, & Bower, 2017). The shortened version of PES which was of interest had Cronbach's alpha of 0.87. However, both the PES and shortened version of PES were characterized with items relevant to the needs of patients in Nigeria.

The Alzheimer's Disease Assessment Scale - Cognitive (ADAS-Cog) was used to assess the feasibility of a low-literacy adaptation in rural sub-Saharan Africa (SSA) for interventional studies in dementia (Paddick et al., 2017). Validation took place in a cross-sectional sample of 34 rural-dwelling older adults with mild/moderate dementia alongside 32 non-demented controls in Tanzania. Internal consistency was high (Cronbach's α 0.884). The diagnosis of executive dysfunction front temporal dementia and Alzheimer disease was a studied by (Bahia *et al*., 2018) when an attempt was made to examine the internal consistency of the Brazilian version of the INECO frontal Screening (IFS), 18 patients already diagnosed with Alzheimer disease and 15 healthy controls were all recruited for the study. In addition, patients and healthy controls were subjected to clinical evaluation and screening tests for dementia. It was interesting to note that the IFS showed an acceptable internal consistency with Cronbach's alpha of 0.714. The psychometric properties of the University of California San Diego Performance – Based Skills Assessment (UPSA) was used in the assessment of Parkinson's disease (Holden *et al*., 2018). 100 patients with idiopathic Parkinson's disease were recruited from a Movement Disorders Center of the University of Colorado. The UPSA, a performance – based measure of cognitively demanding activities of daily living as well as a neuropsychological battery and motor examination were all administered on the participants. Of interest to this literature review was the strong internal consistency with Cronbach's alpha of 0.82 of the UPSA in PD. The National Institute of Neurologic Disorders and Stroke (NINDS) and the Canadian Stroke Network (CSN) developed a 30-minute neuropsychological battery while trying to have a better understanding of how important is cognitive assessment in the rehabilitation of in-patient rehabilitation (Jaywant, Toglia, Gunning, & O'Dell, 2018). The psychometric properties of this a 30-minute protocol was investigated. Only 100 inpatient stroke completed the NINDS-CSN battery which represented 24% of the original 423 individuals recruited for the study. The NINDS-CSN battery demonstrated a strong internal consistency with Cronbach's alpha of 0.85. Translation and cross-cultural adaptation of the Motor Activity Log (MAL) into Hausa Language was performed (Sada, Abdullahi, & Hassan, 2019). The internal consistency of the final version of the instrument assessed using 68 stroke survivors yielded a Cronbach's alpha values 0.97 and 0.93 between its individual items. The development of a Word Accentuation Test (WAT) was aimed at predicting cognitive performance in Portuguese-speaking populations (Gil *et al*., 2019). 206 older adults completed the final 40 – items Brazilian version of the WAT also known as WAT-Br. The subjects were made to complete the WAT-Br and a standardized neuropsychological battery. The result indicated that the WAT-Br version displayed an excellent internal consistency (Kuder-Richardson Formula 20 = 0.95) which affirmed the reliability of the instrument and proved valuable as a tool for estimating cognitive performance. The psychometric properties of the Brazilian version of the Montreal Cognitive Assessment MoCA-BR tool was used in screening mild cognitive impairment and Alzheimer disease (Pinto *et al*., 2019). The MoCA-BR was compared with the MMSE as a gold standard in the detection of cognitive dysfunction. The transversal study was conducted in four different referrals medical centres in Brazil which had 229 elderly individuals recruited. All the subjects/patients were 65 years and older. The outcome showed an acceptable Cronbach's alpha of 0.77 for the MoCA-BR suggesting reliability of the instrument.

2.2 Discriminant Validity of Vascular Neuropsychological Battery

The Cognitive complaints in bipolar disorder rating assessment also known as the COBRA was developed in Barcelona for the detection of cognitive complaints experienced by bipolar participants. It is a 16-item self-reported NB based on 4-point scale (Rosa *et al*., 2013), recruiting 215 subjects out of which 124 who did not meet the eligibility criteria were used as the controls. All the patients were enrolled in the Bipolar Disorders Programme at the Hospital Clinic. The discriminative capacity between patients and controls was assessed by the Receivers' Operating Characteristics (ROC) curve with area under the curve (AUC) 0.748. 95% CI: (0.679– 0.816). The discrimination between the cases and controls indicated a very good balance between sensitivity (68.1%) and specificity (68.5%). The psychometric properties of a neuropsychological battery of three protocols (Chen *et al*., 2015) was recommended by the NINOS – Canadian Stroke Network to diagnose Vascular Cognitive Impairment (VCI). Factors such as difference in culture and language barrier prevented the direct use of the protocols which was then translated into Chinese language for use in China. Case – Control study was adapted in the investigation. Similarly, 50 controls were enrolled into the study through advertisement. It was ensured that none of the controls had an history of stroke or temporary ischemic attack. The protocols recommended were a 60 – minute, 30 – minute and 5 – minute administered on the subject together with the Montreal Cognitive Assessment (MoCA) and the Mini – Mental State Examination (MMSE). The discriminant validity assessed by the AUC for the 60-min protocol, 30-min protocol and the 5-min protocol were 0.88, 0.88 and 0.86 respectively. This revelation confirmed the discriminative capacity of the neuropsychological battery.

The Telephone Interview for Cognitive Status (TICS) was originally developed and adapted from the Mini-Mental State Examination (MMSE) known as the gold standard. This explored the applicability of the Telephone Interview Screening for Cognitive Status with a delayed recall item being a modified version against a wider assessment using a neuropsychological battery (Castanho *et al*., 2016). The modified version was a further improvement on the TICS which is a 13 – item test with score ranging from 0 to 39. A total number of 142 participants were drawn from a local health centre in Braga, Portugal. The area under the curve of the ROC was 0.870 which was considered adequate to discriminate between the normal group and the cognitive impairment group while the sensitivity and specificity were 90.6 and 73.7 respectively. The Alzheimer's Disease Assessment Scale - Cognitive (ADAS-Cog) was used to assess the feasibility of a low-literacy adaptation in rural sub-Saharan Africa (SSA) for interventional studies in dementia (Paddick et al., 2017). Validation took place in a cross-sectional sample of 34 rural-dwelling older adults with mild/moderate dementia alongside 32 non-demented controls in Tanzania. The ROC curve indicated a phenomenal capacity for differentiating between dementia patients from controls using this adapted ADAS-Cog with optimal cu-off point less than 19. While the sensitivity yielded100%, the specificity was 94.0% and the AUC curve was 0.973 suggesting excellent criterion (discriminant) validity. The psychometric properties of the HRQOLISP-E based on the subscale of the Hospital Anxiety and Depression Scale (HADS-D) as a meaningful criterion was investigated. This instrument was useful for identifying post-stroke depression (PSD) (Ojagbemi, Owolabi, Akinyemi, & Ovbiagele, 2017). Data obtained from 387 recent stroke survivors indicated a direct correlation between the HRQOLISP-E and HADS-D with sensitivity = 73.7%, specificity = 79.3%. The AUC was 0.81suggesting that HRQOLISP-E had a cut-off of 20/21 while the HADS-D score was less than 8, was 20/21.

The diagnosis of executive dysfunction front temporal dementia and Alzheimer disease (AD) using the Brazilian version of the INECO frontal Screening (bvIFS) was examined (Bahia et al., 2018) when 18 patients already diagnosed with Alzheimer disease and 15 healthy controls were all recruited for the study. In addition, patients and healthy controls were subjected to clinical evaluation and screening tests for dementia. The IFS had the potency to differentiate patients with dementia from healthy controls (AUC = 0.768, cutoff = 19.75, sensitivity = 0.80, specificity = 0.63). However, there was a low accuracy to differentiate bvFTD from AD (AUC = 0.594, cutoff =16.75, sensitivity = 0.667, specificity = 0.600). This indicated a limitation using the instrument. The psychometric properties of the University of California San Diego Performance – Based Skills Assessment (UPSA) was used in the assessment of Parkinson's disease *(Holden et al.*, 2018). 100 patients with idiopathic Parkinson's disease (PD) were recruited from a Movement Disorders Center of the University of Colorado. The UPSA, a performance – based measure of cognitively demanding activities of daily living as well as a neuropsychological battery and motor examination were all administered on the participants. Total UPSA score demonstrated a discriminatory capacity by differentiating any cognitive impairment (PD-MCI or PDD) from normal cognition with an AUC of 0.87. Further, it detected a cut-off score of 78 for any cognitive impairment with a sensitivity of 84% and specificity of 80%. The psychometric properties of the Brazilian version of the Montreal Cognitive Assessment MoCA-BR tool was used in screening mild cognitive impairment and Alzheimer disease (Pinto *et al*., 2019). The MoCA-BR was compared with the MMSE as a gold standard in the detection of cognitive dysfunction. The transversal study was conducted in four different referrals medical centres in Brazil which had 229 elderly individuals recruited. Also, the ability of the MoCA-BR and the MMSE to discriminate between the cognitive impaired and the normal control indicated that the area under the curve (AUC) for the three groups were 0.95, 0.94 and 0.99 using the MoCA-BR tool as against the MMSE which indicated AUC of 0.86, 0.82 and 0.97. There was a clear indication that the MoCA-BR was a better tool in terms of its discriminatory capacity compared to the MMSE which showed lower AUC's.

2.3 Concurrent Validity of Vascular Neuropsychological Battery

The Screen for Cognitive Impairment in Psychiatry (SCIP) is a brief scale designed for detecting cognitive deficits in several psychotic and affective disorders. A sample of 126 stable patients with schizophrenia were recruited from consecutive admissions to 40 psychiatric outpatient clinics in Spain (Pino et al., 2008). Correlation coefficients between the subscales of the SCIP and test scores from established standardized neuropsychological instruments sensitive to each relevant domain were all statistically significant, and ranged from a low of 0.38 (WMT and WAIS III Letter/Number Sequencing) to a high of 0.60 (PST and WAIS III Symbol Search), suggesting that the SCIP subscale scores provide a valid quantification of their underlying cognitive domains. A multidimensional, brief, and flexible stroke-specific health-related quality of life in Stroke Patient (HRQOLISP-26) was developed from the existing HRQOLISP-102 to have excellent psychometric properties (Ojo Owolabi, 2011). 100 (Ibadan, Nigeria) and 103 (Berlin, Germany) stroke patients compared to 100 (Ibadan) and 50 (Berlin) apparently healthy adults. The 26-item made up of therapeutically relevant physical, psychological, cognitive, and eco-social domains was compared to the HRQOLISP-63 being a well-established instrument using the Spearman's Rank Correlation Coefficient (rho = 0.90 to 0.97, P < 0.000001) thereby indicating strong correlation between the two instruments. This was a clear explanation of the concurrent validity of the HRQOLISP-26.

The Cognitive complaints in bipolar disorder rating assessment also known as the COBRA was developed in Barcelona for the detection of cognitive complaints experienced by bipolar participants. It is a 16-item self-reported NB based on 4-point scale (Rosa *et al*., 2013), recruiting 215 subjects out of which 124 who did not meet the eligibility criteria were used as the controls. All the patients were enrolled in the Bipolar Disorders Programme at the Hospital Clinic. The Frankfurt Complaint Questionnaire scores was also obtained and compared to the COBRA using the Spearman's correlation coefficient which showed a remarkably strong relationship (rho= 0.888, po0.001) between the two tools thereby suggesting a very good concurrent validity of the COBRA. The informant AD8 was examined in Government subsidized primary healthcare centres in Singapore. 1082 informants completed AD8 assessment at two primary healthcare countries while 309 out of them who were patient – informants' dyads were further assessed using the Mini – Mental Slate Examination (MMSE), Montreal Cognitive Assessment (MoCA), Clinical Dementia Rating (CDR) and a locally validated formal neuropsychological battery in a tertiary hospital (Shaik *et al*., 2016). Concurrent validity, as measured by the correlation between total AD8 scores and CDR global ($R = 0.65$, $p < 0.001$), CDR sum of boxes ($R = 0.60$, $p < 0.001$), MMSE ($R = -0.39$, $p < 0.001$), MoCA ($R = -0.41$, $p < 0.001$), as well as the formal neuropsychological battery ($R = -0.46$, $p < 0.001$), was good and consistent with previous studies.

The Alzheimer's Disease Assessment Scale - Cognitive (ADAS-Cog) was used to assess the feasibility of a low-literacy adaptation in rural sub-Saharan Africa (SSA) for interventional studies in dementia (Paddick *et al.*, 2017). Validation took place in a cross-sectional sample of 34 rural-dwelling older adults with mild/moderate dementia alongside 32 non-demented controls in Tanzania. Concurrent validity assessment indicated very high correlation between the ADAS-Cog score and the IDEA cognitive screen score ($r = 0.833$, $p<0.001$) and CDR score ($r = 0.795$, $p<0.001$).

The psychometric properties of the HRQOLISP-E based on the subscale of the Hospital Anxiety and Depression Scale (HADS-D) as a meaningful criterion was investigated. This instrument was useful for identifying post-stroke depression (PSD) (Ojagbemi *et al.*, 2017). Data obtained from 387 recent stroke survivors indicated that each HRQOLISP-E item ($r= -0.40$ to -0.53, all $p < 0.001$), as well as the total HRQOLISP-E score (-0.53, $p < 0.001$) showed significant correlation with the HADS-D which was an already validated instrument. The HRQOLISP-E scores also correlated significantly with age and stroke severity. The psychometric properties of the University of California San Diego Performance – Based Skills Assessment (UPSA) was used in the assessment of Parkinson's disease (PD) (Holden *et al.*, 2018). 100 patients with idiopathic Parkinson's disease were recruited from a Movement Disorders Center of the University of Colorado. The UPSA, a performance – based measure of cognitively demanding activities of daily living as well as a neuropsychological battery and motor examination were all administered on the participants. Total UPSA scores correlated strongly with global cognition measured by total DRS-2 score. The correlation even remained strong when adjusting for age and education thereby establishing a concurrent validity of the UPSA IN PD. Translation and cross-cultural adaptation of the Motor Activity Log (MAL) into Hausa Language was performed The Forward and backward translations of the questionnaire were done by independent language experts who are fluent in Hausa and English language respectively. The translation process according to Beaton's guidelines was reviewed and the psychometric properties of the final version were assessed using 68 stroke survivors (Sada *et al*., 2019). The concurrent validity assessed using the Spearman's Rank Correlation Coefficient indicated significantly ($p<0.01$) strong correlation ranging from $r = 0.932$ to $r = 0.921$ between the Hausa version and English version of MAL. The psychometric properties of the Brazilian version of the Montreal Cognitive Assessment MoCA-BR tool was used in screening mild cognitive impairment and Alzheimer disease (Pinto *et al*., 2019). The MoCA-BR was compared with the MMSE as a gold standard in the detection of cognitive dysfunction. The transversal study was conducted in four different referrals medical centres in Brazil which had 229 elderly individuals recruited. All the subjects/patients were 65 years and older. The MoCA-BR scores present an elevated correlation with MMSE scores, with Spearman's rho = 0.750 ($p < 0.001$). The correlations between the MoCA-BR and MMSE scores and the diagnostic gold standard for the cognitive state of the elderly demonstrated that MoCA-BR and MMSE present statistically significant correlations with the gold standard ($p < 0.001$) and MoCA-BR was superior to MMSE (Spearman's rho = 0.804 and 0.681 respectively).

2.4 Factor Structure of Vascular Neuropsychological Battery

Understanding the factor structure of the Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery (CERAD – NP), 100 normal healthy Yoruba-speaking subject completed the battery (Guruje et al., 1995). Exploratory Factor Analysis revealed that

54.7% of the total variance was explained in a one factor solution measuring a general cognitive factor in the total sample. The Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery (CERAD – NP) explored by (Strauss & Fritsch, 2004) revealed that previous studies had proposed that the battery was multi-dimensional in 3 or 5 dimensions. A principal factor analysis was adopted in this study with the use of contemporary quantitative method. The CERAD sample had a total of 569 cases that were randomly divided into two – a derivation sample and a validation sample. There was one common factor in the variable matrix which identify the hidden trait structure of the CERAD – NP battery. Factor structure of the CERAD – NP battery studied using the data obtained from clinical series of military veteran patients referred for neuropsychological assessment of suspected dementia and using a total of 135 cases were selected over a period of years from a clinical series of referrals yielded only one factor model which accounted for the demented patients while it yielded only two factors among the total sample (Jones & Ayers, 2006).

The executive dysfunction is a distinguishing factor of both dementia of the Alzheimer's Disease (AD) and vascular dementia (VAD) as claimed by (Hall & Harvey, 2008). The Behavioural Dyscontrol Scale (BDS) was supposed to be a measure of executive function that addressed control over voluntary motor behavior. 206 outpatients recruited between 2002 and 2006. The exploratory factor analysis was performed with an orthogonal design and varimax rotation showed a two – factor solution which accounted for 53% of the total variance. As of May 5, 2008 a total of 14,428 participants had completed the initial assessment batteries (Hayden *et al*., 2011). As well, the Mini-Mental State Examination was administered on the subjects as a gold standard used as an indicator for dementia severity, so was the Clinical Dementia Rating (CDR) administered. The EFA yielded a five – factor solution that fit the data best. An informant-based instrument that would provide a valid estimate of premorbid cognitive abilities in low-educated populations named Premorbid Cognitive Abilities Scale (PCAS) was developed. Methods: The validation sample was composed of 132 older Brazilian. Three components had eigenvalues over Kaiser's criterion of 1, but the scree plot showed an ambiguous inflection (Apolinario *et al*., 2013). A two factor solution which accounted for 50.0% of the total variance was obtained.

The Cognitive complaints in bipolar disorder rating assessment also known as the COBRA was developed in Barcelona for the detection of cognitive complaints experienced by bipolar participants. It is a 16-item self-reported NB based on 4-point scale (Rosa *et al*., 2013), recruiting 215 subjects out of which 124 who did not meet the eligibility criteria were used as the controls. All the patients were enrolled in the Bipolar Disorders Programme at the Hospital Clinic. The internal factor structure of the instrument revealed a two factor solution which had the second factor being loaded with one item. However, the first factor was preferable due to its 43.77% accountability for the total variance. The Brief Examination of Alcohol-Related Neuropsychological Impairment (BEARNI) was invented to assess the motor and cognitive functions alcoholic patients (ALs). (Ritz et al., 2015) a total of 254 health controls completed the BEARNI. The EFA showed a five factor structure accounting for 60.08% of the total variance. This led to a conclusion that the BEARNI was a useful screening tool in clinical settings for detecting alcoholic patients' motor and cognitive impairments. Using the Everyday Memory Questionnaire (EMQ) was specifically investigated by (Avila-Villanueva *et al*., 2016). The controls were 776 while the study had 78 MCI. The five factor solution instrument yielded up to 50% which explained the total variance. However, the exploratory factor analysis of the EMQ with component loadings of each item yielded only four (4) factors which highly recommended the EMQ for quantifying subjective decline and to monitor the longitudinal progression of individuals who report those cognitive complaints. The Patient Evaluation Scale (PES) was designed to be used by Nigerian primary health care. 300 patients who attended 28 primary health centres across eight states in Nigeria participated in the study. The full and shortened version of PES with 27 and 18 items, respectively, were also developed (Ogaji *et al*., 2017). The shortened version of PES using the principal component extraction method with varimax rotation showed that the three-component solution explains 56.6% of the common variance of perceived quality of PHC in Nigeria.

The psychometric properties of the HRQOLISP-E based on the subscale of the Hospital Anxiety and Depression Scale (HADS-D) as a meaningful criterion was investigated. This instrument was useful for identifying post-stroke depression (PSD) (Ojagbemi *et al*., 2017). For the factor structure of the HRQOLISP-E, a one factor model containing 6 of the 7 psycho-emotional domain items explained 67.9% of the total variance. The Chronic Effects of Neuro-trauma Consortium (CENC) was developed to explore the effects of concussion among Service Members and Veterans in a Multicentre observational study which began in September, 2014 (Hirsch *et al*., 2018). 492 participants who survived the 11 September, 2001 attack on the United States of America. The scree plot from the exploratory factor analysis suggested that the number of factors to be extracted was between 4 and 5. Furthermore, the However, the exploratory factor analysis gave rise to a five – factor model. The study came to a conclusion that the CENC could be reduced to five (5) clinically useful factors.

CHAPTER THREE

METHODOLOGY

3.1 Study Design Secondary data was used in this case-control study. The settings of the study were two referral hospitals – the Federal Medical Centre, Abeokuta and the University College Hospital, Ibadan which were located in the South-Western region of Nigeria predominantly populated by the Yoruba-speaking people.

3.2 Cogfast – Nigeria (Memory After Stroke Study): Neurological Assessment

Consecutively presenting stroke patients who are 45 years old or older, also clinically diagnosed by experienced physician neurologists were recruited from stroke registers of the two specialist hospitals – Federal Medical Centre, Abeokuta and the University College Hospital, Ibadan. The COGFAST-NG Study was conducted between July, 2010 and June, 2012.

The stroke-free controls who were apparently healthy having been clinically adjudged not to have history of stroke were recruited from representative pool of community-dwelling volunteers participating in a community health literacy program.

Among the controls recruited were the spouses and unrelated caregivers of stroke survivors as previously done in some studies. Broadly, only these two groups were considered for the purpose of this project.

3.3 Inclusion Criteria for Stroke Patients

Patients with the following features were excluded from the study

1. Age less than 45 years
2. Subarachnoid hemorrhage
3. Significant physical illness and motor impairment that precluded paper and computer-based neuropsychological evaluation.
4. Any co-morbid psychiatry or neurologic illness
5. Any systematic disease that could impair cognition
6. Failure to give consent

3.4 Exclusion Criteria for Stroke-Free Controls

Individuals with the following features were excluded from the study

1. Background dementia and psychiatric disorders
2. Background neurological disorders
3. Inability to give consent and/or information

3.5 Study Instruments

The vascular neuropsychological battery that was evaluated in this study consists of the following tests. These test were administered on the study participants.

3.5.1 Mini-Mental State Examination (MMSE)

Among the various neuropsychological battery for the assessment of cognitive functions is the Mini-Mental State Examination (MMSE). The MMSE is usually a paper-oriented test with a maximum score of 30 points. A lower score indicates a severe cognitive abnormality. For normalcy, the cut-off point was set at 24 which is an indication that the respondent may not be having any problem associated with cognitive function. Without any loss of generality, several works of literature have set a score of 24 to depict normalcy. In addition, the use of the MMSE as a test battery has actually formed part of the process for determining if a respondent suffers from cognitive malfunctioning. However, the outcome of the test should be interpreted in a general perspective of the individual in question such as personality behavior and how they are managing in daily life. In this study, quite a number of test battery will be examined and explained in the light of various cognitive dysfunctioning the measure and as well detect.

The Mini-Mental Status Examination is a neuropsychological screening instrument that offers a quick and simple way to quantify cognitive function and screen for cognitive loss. It tested the individual's orientation, attention, calculation, recall, language and motor skills. Each section of the test involved a related series of questions or commands. The individual received one point for each correct answer. To give the examination, individual were sat in a quiet, well-lit room. He or She was asked to listen carefully and to answer each question as accurately as he or she could. The individual could only receive a maximum score of 30 points. A score below 20 usually indicated cognitive impairment. Every participant was made to complete the MMSE and score was recorded accordingly.

3.5.2 Cambridge Cognition Examination (CAMCOG)

The Cambridge Cognitive Test (CAMCOG) is a useful tool in the screening for dementia, but it has limited ability to depict milder cognitive deficits, as in Mild Cognitive Impairment (MCI). The CAMCOG is a concise neuropsychological test assessment of cognition impairment in elderly people. It was designed specifically to assist in the diagnosis of dementia at an early stage. CAMCOG assesses a broad range of cognitive function, as is required for the diagnosis of dementia. These cognitive functions include memory, language, attention, perception, praxis and thinking (now called executive functioning). Some standard neuropsychological items which are included in the CAMCOG are verbal fluency, similarities and the identification of objects.

3.5.3 Executive Functions

3.5.3.1 Language/Lexical Retrieval Domain: - In measuring the language/lexical retrieval of the participants, the Boston Naming (2^{nd} Version) Test (BNT) was used in this regard. It is a picture test that assesses noun naming. For the usefulness of this study, the second edition of the Boston Naming Test with 15 items in each trial was employed.

3.5.3.2 Memory/Learning Domain: - This consists of the Word List Test, (WLT) (Learning, Recall, Recognition). The subsets (Learning, Recall, Recognition) of this evaluation give credence to the measure of learning and memory in the subjects who are assessed through this means. Another constituent of the Memory/Learning is the Delayed

Recall of Stick Design (DRSD) and Word List Recognition (WLR) with higher score indicating better performance.

3.5.3.3 Visuospatial/Visuoconstruction Domain: - The Stick Design Test (SDT) is a representation of an arrangement of four wooden matches is printed on a page. It is a simple nongraphomotor test of visuospatial/visuoconsructional ability. It has little dependence from educational levels.

3.6 Assessment of Cognition

The Vascular Neuropsychological Battery [V-NB] was designed following the NINDS–CSN Harmonization Standards 60-minute neuropsychological protocol with little adjustments to guarantee adaptability to the language and culture of the study population. The V-NB comprised multiple validated test items examining specific cognitive domains (executive function, memory/learning, language, visuospatial/visuoconstructive skills). Executive function/activation and mental speed were assessed using the category (animal) fluency test, phonemic (letter) fluency test, verbal reasoning and visual reasoning tests which were modified using the Cambridge Cognitive Examination (CAMCOG) battery previously used for the CogFAST-Newcastle Study. The number of animals recorded in the first 15's of the animal fluency test presented an assessment of mental speed while all the tests differently assessed mental adaptability and diverse thinking. The 10-item word list learning test and delayed recall of stick design were utilized for assessing Memory/learning. The word list learning is a 3-trial, 10-item test with free recall taken following each learning trial and after a little delay. The total number of words recalled across the three trials makes up the total score (range 0–30) such that the delayed recall is scored 0–10, with higher scores indicating better performance. The 15-item Boston Naming Test was needed to asses Language following validation study of the CERAD battery among Yoruba Nigerians. Participants were required to name line drawings of common and uncommon objects. Items that exhibited more cultural tendencies were substituted with four of the items having low frequency in the standard CERAD-NB.

Visuospatial/visuoconstructive functioning was assessed using the Stick Design Test which is a non-graphomotor test of visuo-spatial/visuoconstructive ability. Each subject is requested to use match sticks to reproduce four different graphical shapes with specific attention to the correctness of the relative orientation of the match heads. Thereafter the respondent reproduces the four shapes without any form of help. The test is importantly useful in older adults with limited formal education.

In summary, a total number of fourteen (14) tests were assessed in this study namely: MMSE – Mini-Mental State Examination, AFT - Animal Fluency Test, LFT – Letter Fluency Test, VRT – Verbal Reasoning Test, VisRT – Visual Reasoning Test, IFT – Ideational Fluency Test, BNT – Boston Naming Test, WLLT – Word List Learning Test, WLR – Word List Recognition (Yes), WLR – Word List Recognition (No), DRSD – Delayed Recall of Stick Design, SDT – Stick Design Test, WLLT_I – Word List Learning (Recall) Test and Delayed Recall of Word List (DRWL).

3.7 Data Collection

Data was collected between July, 2010 and June, 2012 from the stroke registers at the two specialist hospitals – Federal Medical Centre, Abeokuta and the University College Hospital, Ibadan. Subjects together with their family/caregivers were invited for participation in the study upon discharge from the hospital or during initial outpatient visit. Demographic information on the subjects and the control group was obtained. The identified cognitive tests were administered on subjects and the control group while the total score of each test was carefully recorded.

Data was analyzed using the SPSS Software Version 25.

3.8 Sample Size

A total number of 381 records was extracted from the data and this consisted 244 stroke survivors and 137 control group.

3.9 Statistical Analysis

Demographic data of the participants was described based on the information gathered on age, gender and level of education. Therefore, appropriate statistical techniques such as frequency tables, percentages, mean, standard deviation and range were employed for the description. The Mann Whitney U test and Chi-square were used to compare the continuous variable and the nominal variable respectively.

Due to the non-normal distribution of the data, non-parametric analyses were adopted in this study. To simplify presentation of the results, all questions were scored so that higher scores indicated better cognitive function. Also, the internal consistency of the of the test battery which was used to give an estimate of the equivalence sets of items from the same test was assessed by running an analysis of the Cronbach's Alpha with cutoff point of 0.7 being the Nunnally's Criterion (Nunnally, 1978). In the same vein, the Receiver Operating Characteristics Curve was used to evaluate the discriminant validity of the instrument using the group outcomes (survivors and controls) as dichotomous variable while the state variable are the stroke-survivors (study group) with the outcome of interest. The Union of Index method (Unal, 2017) was used to propose cut-points ofr some of the tests for screening purpose. The concurrent validity was used to measure the relationship between each test scores and the MMSE. The Spearman's Rank Correlation Coefficient was adopted in the analysis due to the non-normality of the distribution of the scores.

Exploratory Factor Analysis (EFA) was included in the methodology of this study as it provided insight into the factor structure of the neuropsychological battery. This was described using the Principal Component Analysis (PCA) factor solution and the VARIMAX criterion as the method of rotation for the extraction of underlying factors. The PCA provided the variance explained by each of the components derived.

S/N	Specific Objective	Cognitive Test/Variable	Statistical Analysis
1.	To assess the reliability of the neuropsychological battery by measuring the internal consistency of the various tests identified in this study.	AFT, LFT, VRT, VisRT, IFT, BNT, WLLT, WLLT_I, WLRY, WLRN, DRSD, SDT and DRWL	The Cronbach's Alpha (α) with cut-off point of 0.7 as the Nunnally's Criterion
2.	To assess the discriminant validity of the neuropsychological battery defined by the potency of the battery in differentiating stroke survivors from the controls	AFT, LFT, VRT, VisRT, IFT, BNT, WLLT, WLLT_I, WLRY, WLRN, DRSD, SDT and DRWL	The Receiver Operating Characteristics Curve (ROC) Analysis
3.	To evaluate the concurrent validity defined by the inter-correlations between battery summary scores recorded in the study	MMSE, AFT, LFT, VRT, VisRT, IFT, BNT, WLLT, WLLT_I, WLRY, WLRN, DRSD, SDT and DRWL	Spearman's Rank Correlation Coefficient to measure the relationship of each test with the MMSE

4.	To describe the factor structure of the test battery	AFT, LFT, VRT, VisRT, IFT, BNT, WLLT, WLLT_I, WLRY, WLRN, DRSD, SDT and DRWL	The exploratory factor analysis (EFA) – Principal Component Analysis (PCA)

Table A – Analysis plan

3.9a INTERNAL CONSISTENCY

The reliability was measured using the method of internal consistency through the Cronbach's alpha given by the following equation:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\Sigma Vi}{Vtest}\right)$$

- n = number of questions
- Vi = variance of scores on each question
- Vtest = total variance of overall scores (not %'s) on the entire test
-

High alpha is good. High alpha is caused by high variance.

3.9b DISCRIMINANT VALIDITY

The receiver operating characteristic curve analysis model: This model was used in the eventual computation of the specificity and sensitivity. This model however explained how the true positive, false positive, false negative and true negative are contributing to the classification of statuses of the groups concerned. Ultimately, this model was able to correctly distinguish between the two groups.

TEST	MEDICAL CONDITION Yes	No
Positive	True Positive (TP)	False Positive (FP)
Negative	False Negative (FN)	True Negative (TN)

Sensitivity $= \frac{\textit{Total Number of subjects with positive medical condition}}{\textit{Total number of sujects with the medical condition}} = \frac{TP}{TP+FN}$

Specificity$= \frac{\textit{Total No.of subjects without medical condition with negative test}}{\textit{Total Number of subjects without the medical condition}} = \frac{TN}{TN+FP}$

3.9c CONCURRENT VALIDITY

In order to assess concurrent validity, the Spearman's Rank Correlation Coefficient was used. The Spearman's Rank Correlation Coefficient adopted has the following mathematical formula:

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{N(N^2 - 1)}$$

Where d_i is the difference in the ranks of each pair, N is the number of pairs and ρ is the coefficient of correlation.

3.9d FACTOR STRUCTURE

Principal Component Analysis: The Measurement Model

$$\mathrm{D}_i = \Lambda \mathrm{F}_i + \mathrm{e}_i$$

$$\begin{pmatrix} D_{i,1} \\ D_{i,2} \\ D_{i,3} \\ D_{i,4} \\ D_{i,5} \\ D_{i,6} \\ D_{i,7} \\ D_{i,8} \end{pmatrix} = \begin{pmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \\ \lambda_{31} & \lambda_{32} \\ \lambda_{41} & \lambda_{42} \\ \lambda_{51} & \lambda_{52} \\ \lambda_{61} & \lambda_{62} \\ \lambda_{71} & \lambda_{27} \\ \lambda_{81} & \lambda_{82} \end{pmatrix} \begin{pmatrix} F_{i,1} \\ F_{i,2} \end{pmatrix} + \begin{pmatrix} e_{i,1} \\ e_{i,2} \\ e_{i,3} \\ e_{i,4} \\ e_{i,5} \\ e_{i,6} \\ e_{i,7} \\ e_{i,8} \end{pmatrix}$$

$$D_{i,1} = \lambda_{11}F_{i,1} + \lambda_{12}F_{i,2} + e_{i,1}$$

$$D_{i,2} = \lambda_{21}F_{i,1} + \lambda_{22}F_{i,2} + e_{i,2} \quad \text{etc.}$$

The lambda values are called factor loadings (indicating the strength of relationship between the items and components in the solution) where D and F are the observable variables and factors respectively. The goal of the Principal Component Analysis used in this study was to reduce the dimensionality of a vector of random variables. In other words, variables/tests are reduced to a few components which explains the relationship among the tests.

3.10 Ethical Consideration

Each subject was required to complete an informed consent form. Institutional Review Board of the two specialist hospitals – Federal Medical Centre, Abeokuta and the University College Hospital, Ibadan, granted ethical approval for the study (Akinyemi *et al.*, 2014).

CHAPTER FOUR

RESULTS

4.1 Socio-Demographics and Vascular Neuropsychological Battery Characteristics

The socio-demographic attributes of the study and control groups were compared using the Mann Whitney U and the Chi square tests (Table 1). There was no statistically significant difference between the mean ages of the two groups – 60.61 for the stroke survivors and 60.73 for the control group with p-value = 0.879. The ages of the groups in terms of percentages were categorized into four with the category 45 to 59 accounting for 47.5% and 43.1% for the stroke survivors and control group respectively while the category of age between 60 and 74 accounted for 44.3% and 50.4% for the stroke survivors and control groups respectively, of the entire total sample. There was equally no statistically significant difference between the gender of the two groups with females in the stroke survivors accounting for 37. 3%, females accounting for 36. 5% in the control group, males accounting for 62.7% in the study group and 63.5% of males in the control group. In the same vein, the numbers of years of education showed that the mean year was 10.16 for the stroke survivors and 9.32 for the control group. However, there was no statistically significant difference between the two groups using the Mann Whitney U Test Having observed that the data grossly violated the condition for normality. In addition, the result revealed that participants with tertiary education had the largest percentage with 37.8% and 33. 6% for the stroke survivors and the control group respectively. Table 1 further showed the characteristics of all 14 Vascular Neuropsychological Battery (V-NB) being studied with the mean, standard deviation and the range of all scores recorded for both groups. The Verbal Reasoning Test, Visual Reasoning Test, Word List Learning Test – Recall and the Word List Recognition (No) scores between the two groups were demonstrated not to be statistically significant with p-values far greater than 0.05. Meanwhile, all other test scores were statistically significant including the MMSE.

Table 1. Sociodemographic and Vascular Neuropsychological Battery Characteristics:

Variable	Study Group (n=244)	Control Group (n=137)	Test of Significance
Age			p = 0.879 NS
Mean	60.61	60.73	
Standard Deviation (SD)	9.44	9.52	
Range	50	48	
45-59	116 (47.5%)	59 (43.1%)	
60-74	108 (44.3%)	69 (50.4%)	
75-89	19 (7.8%)	8 (5.8%)	
≥ 90	1 (0.4%)	1 (0.7%)	
Gender			$\chi^2 = 0.24$
Female	91 (37.3%)	50 (36.5%)	p = 0.877 NS
Male	153 (62.7%)	87 (63.5%)	
Education Years			p = 0.170 NS
Mean	10.16	9.32	
Standard Deviation (SD)	5.29	6.15	
Range	20	32	
0 (None)	25 (10.4%)	24 (17.5%)	
1-6 (Primary)	60 (24.9%)	34 (24.8%)	
7-12 (Secondary)	65 (27%)	33 (24.1%)	
≥ 13 (Tertiary)	91 (37.8%)	46 (33.6%)	
Mini-Mental State Examination (MMSE)			p = 0.001
Mean	25.18	26.92	
Standard Deviation	5.03	3.10	
Range	29	15	
CAMCOG-Executive			
Animal Fluency Test(AFT)			p = 0.000
Mean	2.51	3.31	
Standard Deviation	0.89	0.90	
Range	5	4	
Letter Fluency Test (LFT)			p = 0.000
Mean	13.69	21.68	
Standard Deviation (SD)	11.44	15.31	
Range	59	57	
Verbal Reasoning Test (VRT)			p = 0.652 NS
Mean	4.19	4.31	
Standard Deviation (SD)	2.06	2.22	
Range	9	8	
Visual Reasoning Test (VisRT)			p = 0.266 NS
Mean	2.71	2.89	
Standard Deviation (SD)	1.55	1.52	

Range	6	6	
Ideational Fluency Test (IFT)			p = 0.000
Mean	3.55	4.7	
Standard Deviation	1.83	1.56	
Range	10	9	
Boston Naming Test (BNT)			p = 0.004
Mean	10.41	11.36	
Standard Deviation (SD)	3.30	2.95	
Range	15	12	
Word List Learning Test (WLLT)			p = 0.000
Mean	14.63	16.70	
Standard Deviation (SD)	4.69	3.90	
Range	26	22	
Word List Learning Test (Recall)(WLLT_I)			p = 0.113
Mean	1.04	1.04	
Standard Deviation (SD)	1.85	1.40	
Range	12	8	
Word List Recognition (Yes) (WLRY)			p = 0.006
Mean	7.78	8.56	
Standard Deviation (SD)	2.48	1.60	
Range	10	8	
Word List Recognition (No) (WLRN)			p = 0.399 NS
Mean	9.34	9.56	
Standard Deviation (SD)	1.79	0.76	
Range	10	3	
Sick Design Test (SDT)			p = 0.002
Mean	10.31	11.35	
Standard Deviation (SD)	3.19	1.85	
Range	12	8	
Delayed Recall of Stick Design (DRSD)			p = 0.002
Mean	4.55	5.57	
Standard Deviation (SD)	2.86	2.96	
Range	11	12	
Delayed Recall of Word List (DRWL)			p = 0.000
Mean	4.59	5.68	
Standard Deviation	2.38	2.10	
Range	11	14	

statistically significant at α = 0.05;

NS: Not Significant

4.2 Internal Consistency

The Internal consistency was a measure of the reliability of the V-NB using the Cronbach's Alpha as a model. In this model, the MMSE was excluded because it was actually used as a gold standard for other tests sued in this study. The Cronbach's Alpha of the V-NB for the stroke survivors and the control group revealed that the Internal Consistency coefficients were 0.750 and 0.647 respectively. However, the reliability coefficient for the control group did not meet the Nunnally's Criterion (Nunnally, 1978). On the other hand, the Internal Consistency coefficient for the stroke survivors proved to fulfil the Nunnally's Criterion as shown in Table 2.

Table 2. Reliability: Internal Consistency of the Vascular Neuropsychological Battery:

Variable	**Cronbach's Alpha value (α)**
Stroke Survivors	0.750
Controls	0.647

The model of reliability used here is the Cronbach's Alpha. MMSE was excluded from the analysis

4.3 Discriminant Validity

Table 3 shows the Area Under the Curve (AUC) and the Confidence Interval (CL) of each of the Test's Receiver Operating Characteristic as displayed in the diagrams labelled figure 1 to 13 with the exclusion of the MMSE. Only WLRN exhibited an AUC that is less than 0.5. Tests such as VRT, VisRT, and WLLT_I however have AUC that are greater than 0.5 fail to be statistically significant at $\alpha = 0.05$. It is also worthy of note to observe that only AFT has an AUC that is in the neighborhood of 0.7 which suggest its discriminatory capacity compared to other tests in the study.

Of the 13 tests that made up the V-NB, only seven of them had proposed cut-points, sensitivity and specificity as shown in Table 4. A cut-point of 16.5 for LFT (Sensitivity = 65.2%; Specificity = 62.0%), 4.5 for IFT (Sensitivity = 69.7%; Specificity = 54.7%), 11.5 for BNT (Sensitivity = 54.1%; Specificity = 61.3%), 15.5 for WLLT (Sensitivity = 55.3%; Specificity = 65.0%), 8.5 for WLRY (Sensitivity = 51.4%; Specificity = 57.4%), 5.5 for DRSD (Sensitivity = 59.1%; Specificity = 58.8%) and also 5.5 for DRWL (Sensitivity = 63.8%; Specificity = 57.4%). The method of Index of Union (IU) as proposed by (Unal, 2017) was used for determining the cut-point for each of the test. The purpose of the cut-point was to set a benchmark for each for screening using the tests. The cut-point defined by the IU method should satisfy two conditions: (1) sensitivity and specificity obtained at this cut-point should be simultaneously close to the AUC value; (2) the difference between sensitivity and specificity obtained at this cut-point should be minimum. The second condition was not compulsory, but it was an essential condition when multiple cut-points satisfy the equation.

Table 3. Discriminant Validity of Vascular Neuropsychological Battery: AUC & CL

Test	AUC	CL	Test of Significance
CAMCOG-Executive Animal Fluency Test(AFT)	0.722	0.670- 0.775	p = 0.000
Letter Fluency Test (LFT)	0.650	0.590-0.711	p = 0.000
Verbal Reasoning Test (VRT)	0.514	0.451-0.576	p = 0.657 NS
Visual Reasoning Test (VisRT)	0.534	0.474-0.594	p = 0.274 NS
Ideational Fluency Test (IFT)	0.685	0.631-0.738	p = 0.000
Boston Naming Test (BNT)	0.589	0.530-0.649	p = 0.004

Word List Learning Test (WLLT)	0.627	0.570-0.684	p = 0.000
Word List Learning Test (Recall)(WLLT_I)	0.544	0.485-0.604	p = 0.152 NS
Word List Recognition (Yes) (WLRY)	0.583	0.524-0.641	p = 0.008
Word List Recognition (No) (WLRN)	0.480	0.419-0.540	p = 0.509 NS
Sick Design Test (SDT)	0.576	0.518-0.635	p = 0.013
Delayed Recall of Stick Design (DRSD)	0.596	0.537-0.655	p = 0.002
Delayed Recall of Word List (DRWL)	0.628	0.571-0.685	p = 0.000

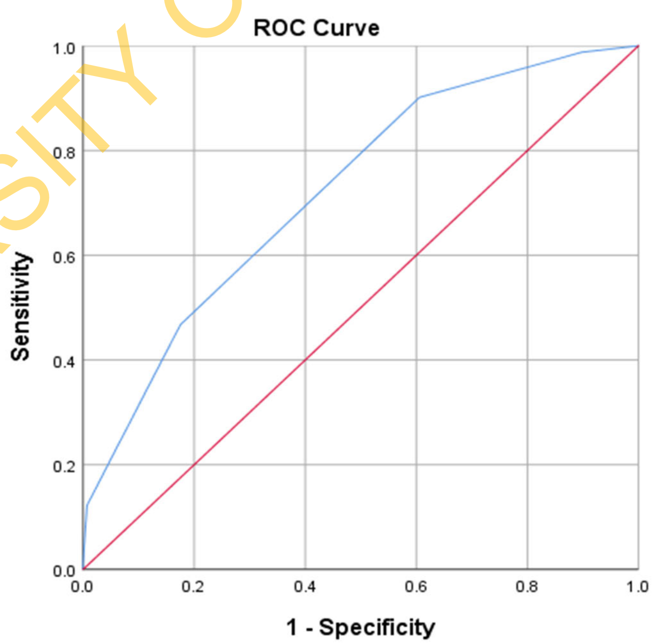
**statistically significant at α = 0.05;*
NS: Not Significant

AUC = Area Under the Curve
CL = Confidence Interval

Table 4. Receiver Operating Characteristic of Vascular Nueropsychological Battery: Sensitivity, Specificity and Cut-Points

Test	Proposed Cut-Point	Sensitivity (%)	Specificity (%)
CAMCOG-Executive Animal Fluency (AFT)	----	-----	----
Letter Fluency Test (LFT)	16.5	65.2	62.0
Verbal Reasoning Test (VRT)	----	-----	-----
Visual Reasoning Test (VisRT)	----	-----	-----
Ideational Fluency	4.5	69.7	54.7

Test (IFT)			
Boston Naming Test (BNT)	11.5	54.1	61.3
Word List Learning Test (WLLT)	15.5	55.3	65.0
Word List Learning Test (Recall)(WLLT_I)	-----	-----	-----
Word List Recognition (Yes) (WLRY)	8.5	51.4	57.4
Word List Recognition (No) (WLRN)	----	-----	-----
Sick Design Test (SDT)	----	-----	-----
Delayed Recall of Stick Design (DRSD)	5.5	59.1	58.8
Delayed Recall of Word List (DRWL)	5.5	63.8	57.4



Diagonal segments are produced by ties.

Figure 1: ROC curve between stroke survivors - AFT

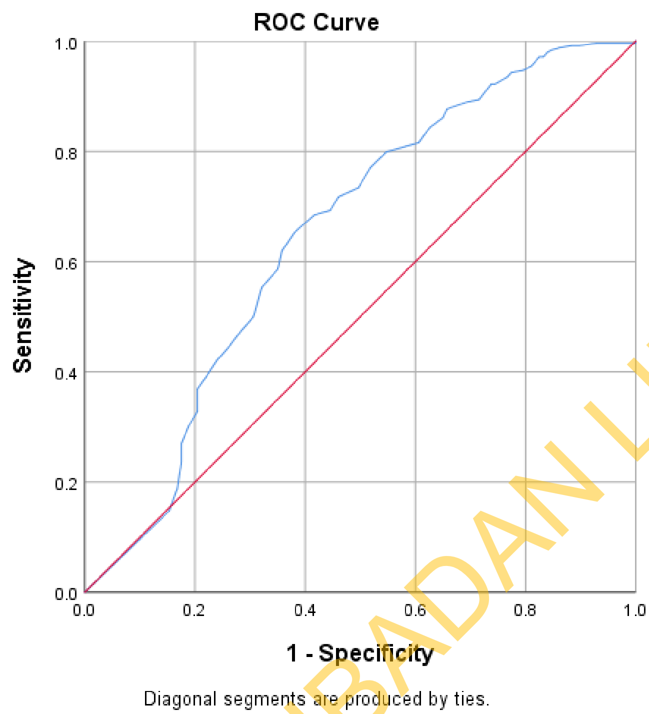


Figure 2: ROC curve between stroke survivors - LFT

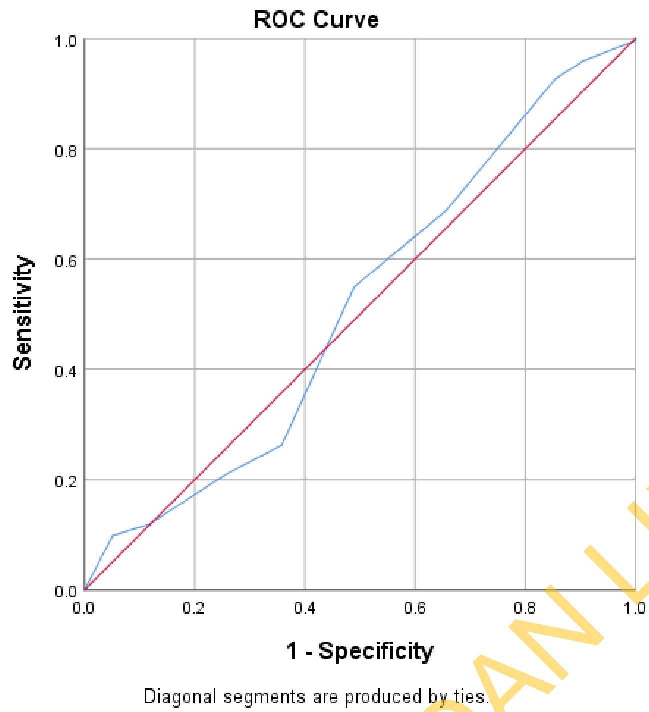


Figure 3: ROC curve between stroke survivors - VRT

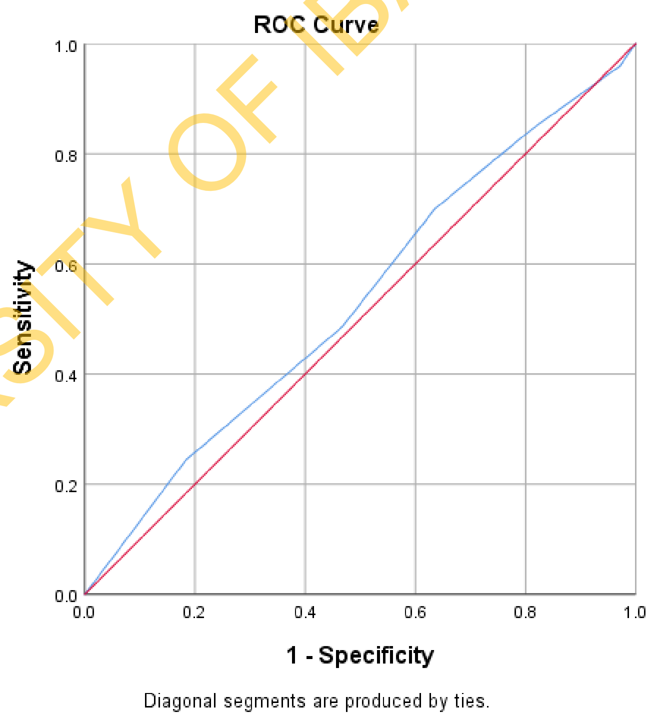


Figure 4: ROC curve between stroke survivors - VisRT

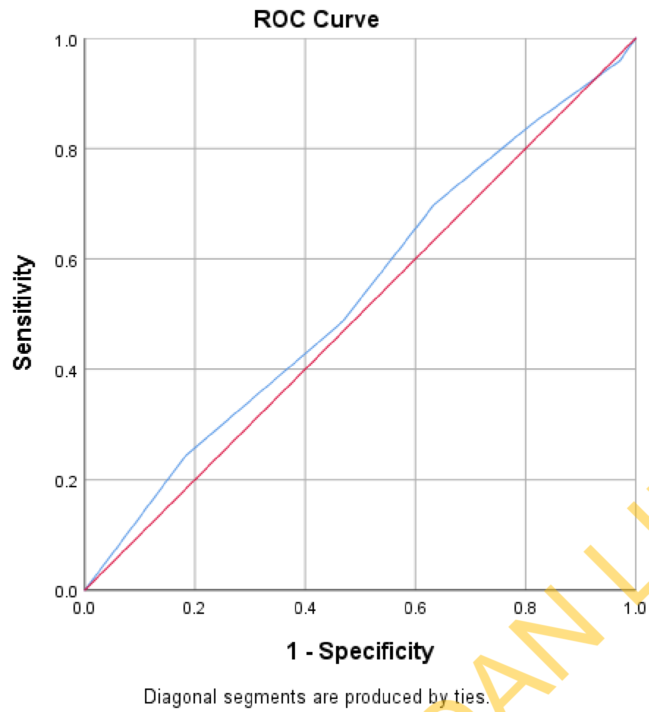


Figure 5: ROC curve between stroke survivors - IFT

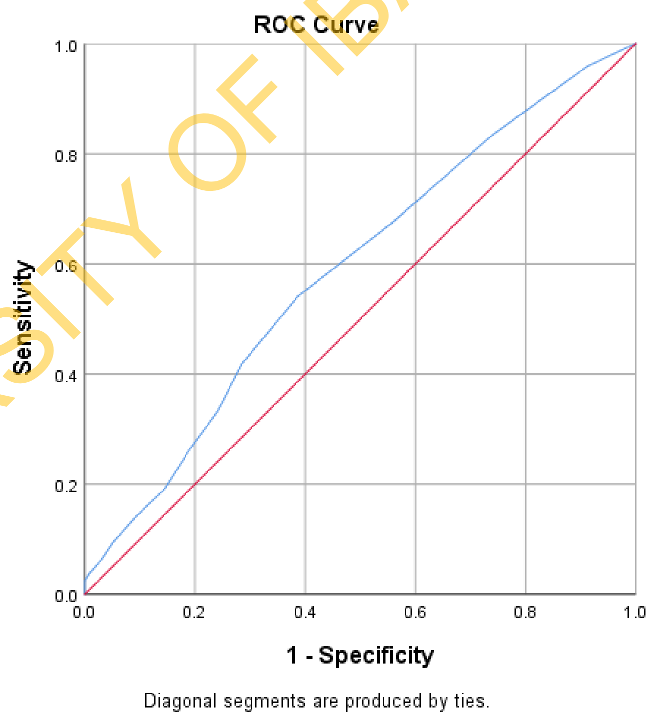


Figure 6: ROC curve between stroke survivors - BNT

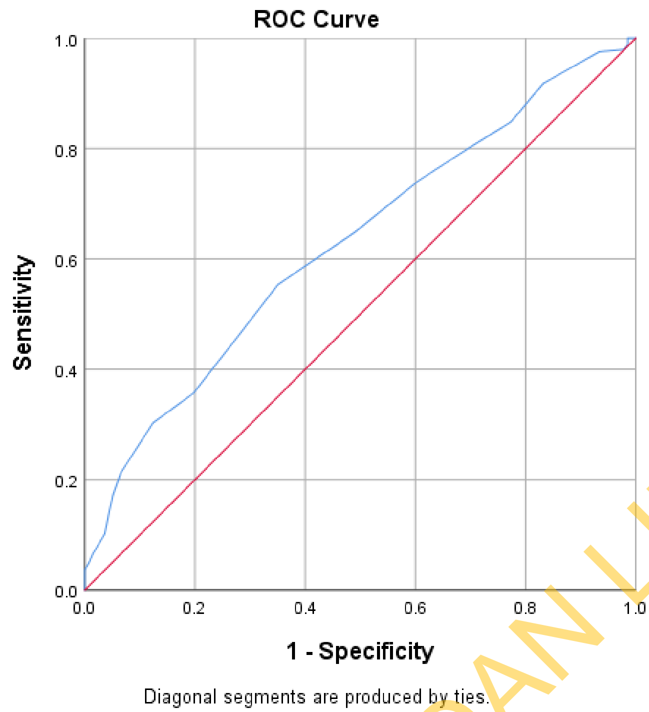


Figure 7: ROC curve between stroke survivors and controls - WLL

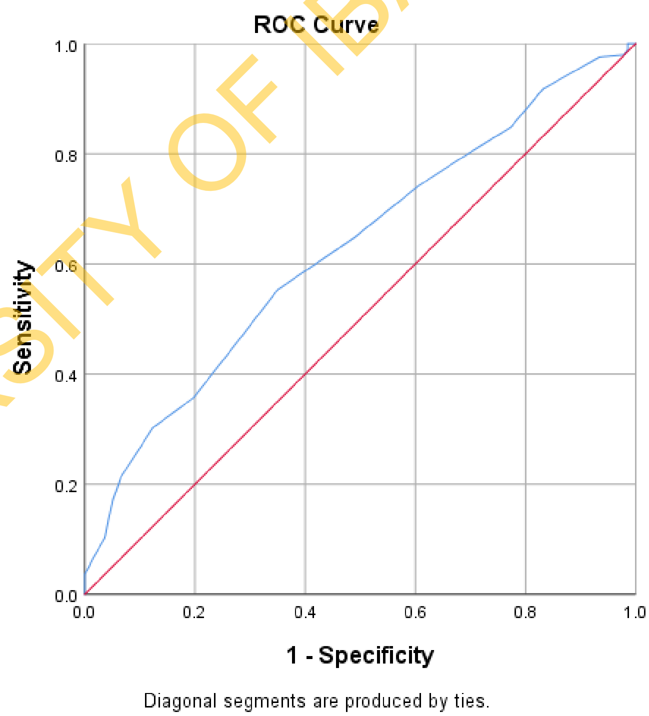


Figure 8: ROC curve between stroke survivors and controls – WLL_I

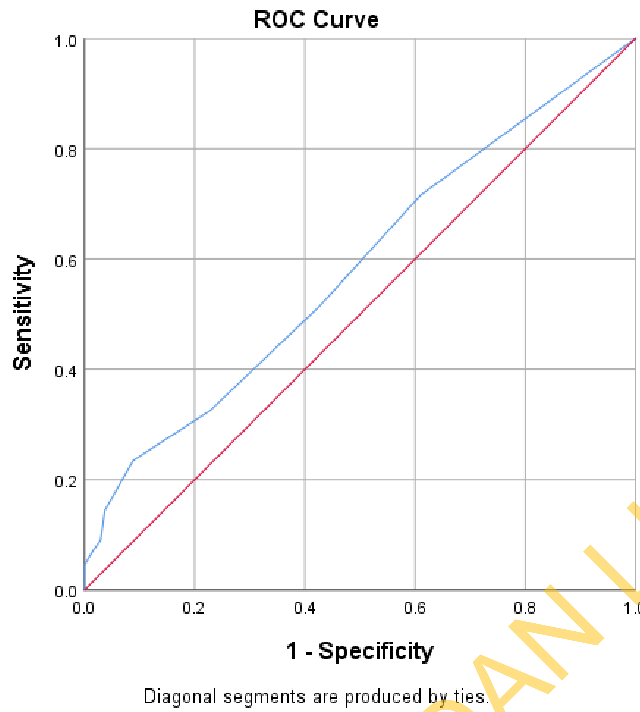


Figure 9: ROC curve between stroke survivors and controls - WLRY

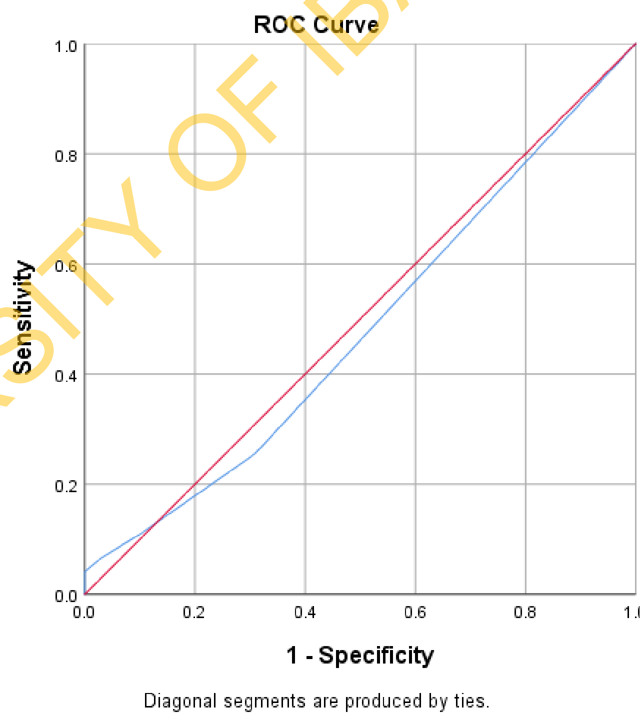


Figure 10: ROC curve between stroke survivors and controls - WLRN

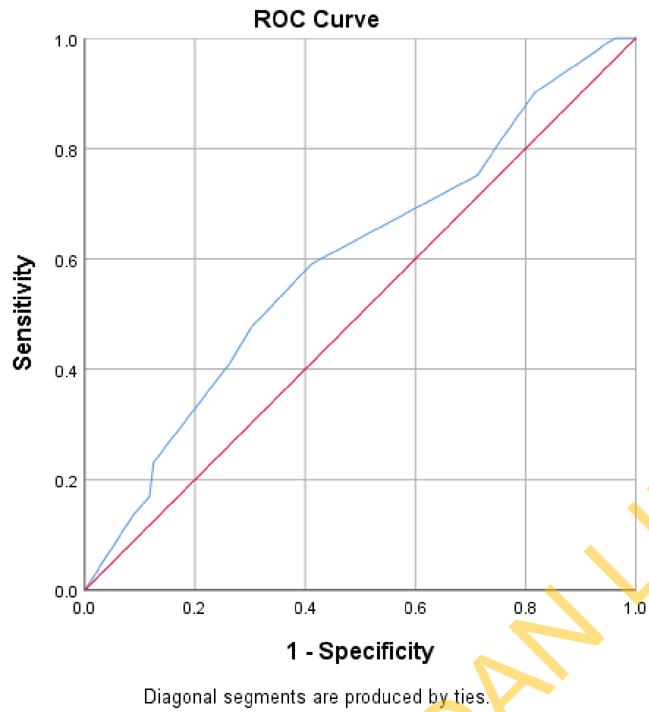


Figure 11: ROC curve between stroke survivors and controls - RSD

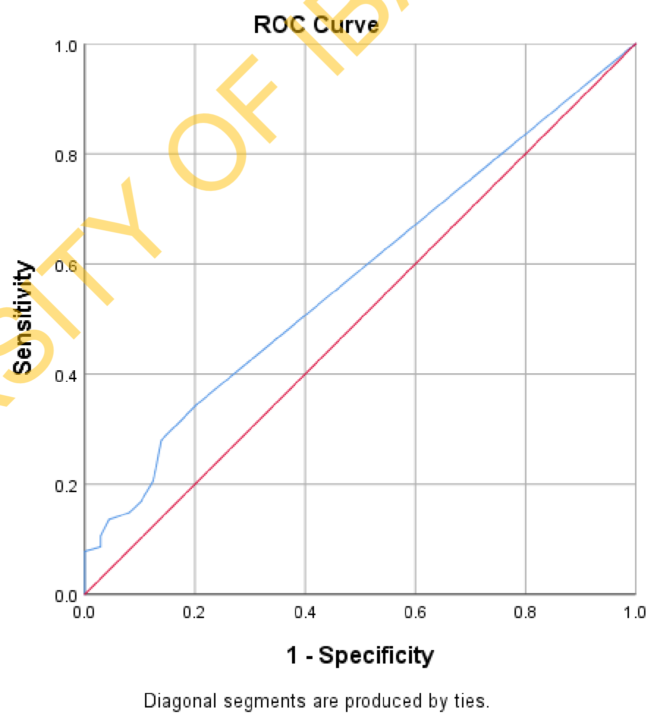


Figure 12: ROC curve between stroke survivors and controls - SDT

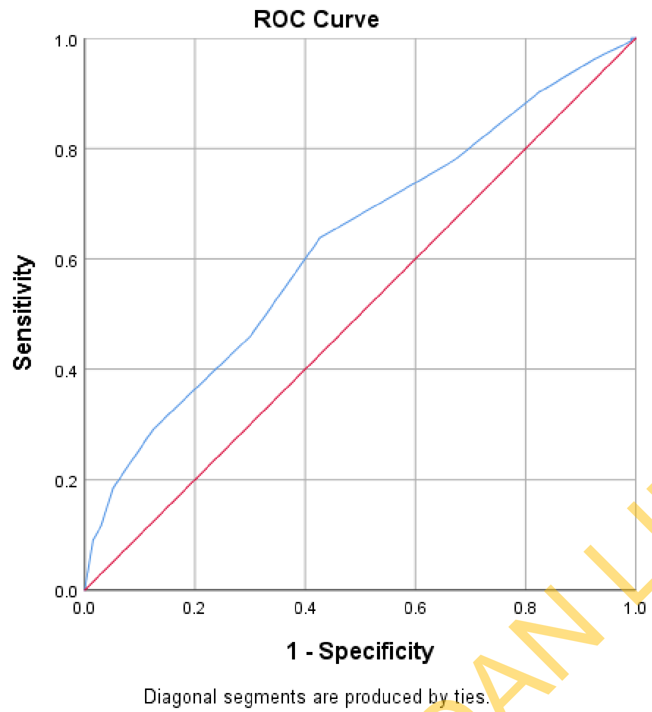


Figure 13: ROC curve between stroke survivors and controls - RWL

4.4 Concurrent Validity

Table 3 shows how each of the test in the V-NB correlates with the MMSE which was used as a well-established instrument for the validation of the V-NB. It was observed that all the tests in the study correlated significantly with the MMSE. However, the WLL_I (-0.121), WLRN (0.261) and IFT (0.202) – all presented a weak correlation for the validation of the V-NB. On a more general perspective, there seemed to be a moderate correlation between each test of the battery.

Table 5: The Spearman's Correlation Coefficients between the Vascular Neuropsychological Battery and the MMSE for both Groups

Test	Correlation Coefficient	p-value
Animal Fluency Test (AFT)	0.394**	0.000
Letter Fluency Test (LFT)	0.651**	0.000
Verbal Reasoning Test (VRT)	0.477**	0.000

Visual Reasoning Test (VisRT)	0.500**	0.000
Ideational Fluency Test (IFT)	0.202**	0.000
Boston Naming Test (BNT)	0.614**	0.000
Word List Learning Test (WLLT)	0.496**	0.000
Word List Learning Test (Recall) (WLLT_I)	-0.121*	0.000
Word List Recognition (Yes) (WLRY)	0.339**	0.000
Word List Recognition (No) (WLRN)	0.261**	0.000
Stick Design Test (SDT)	0.581**	0.000
Delayed Recall of Stick Design (DRSD)	0.523**	0.000
Delayed Recall of Word List (DRWL)	0.492**	0.000

**statistically significant at α = 0.05;*
***statistically significant at α = 0.01*

4.5 Factor Analysis (Principal Components Analysis)

The study of the factor structure of the V-NB after rotation using the Varimax method determined a three-factor structure when all participants in the study were taken into account with the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.887 and Barttlett's Test of Sphericity being statistically significant (p-value = 0.000) which ensured that all the tests of the V-NB were significantly correlated. For all the participants, the three components retained accounted for 56.1% of the total variance which is good in practice. Only 56.8% of the total variance was accounted for in the stroke survivors. The stroke survivors indicated a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.882 with a statistically significant Barttlett's Test of Sphericity (p-value = 0.000). However, the model for the stroke survivors produced a three-factor solution. In the control group, the KMO value was 0.834 which was adequate in terms of sampling with a statistically significant Barttlett's Test of Sphericity (p-value = 0.000). The result in the control group appeared slightly different because of its four-factor solution which explained 62.8% of the total variance.

Results of the Rotated Component Matrix for all the participants in Table 6 showed that six items loaded on the first factor, five items loaded on the second factor and only one item loaded on the third factor. This same result obtained for all participant was observed for stroke survivors having the same factor loadings (Table 7). The result for the control group was also similar to the groups earlier mentioned except for the third and fourth factors having only one loading each (Table 8). The scree plots were presented in figures 14-16.

Table 6: The factor loadings obtained from the Rotated Component Matrix for all participants

Test	Components/Factors		
	1	2	3
AFT	0.275	0.664	-0.051
VRT	0.649	0.189	0.271
VisRT	0.689	0.081	-0.111
BNT	0.782	0.199	-0.102
WLL	0.339	0.742	-0.252
WLL_I	-0.107	-0.038	0.905
SD_Total	0.691	0.232	-0.138
WLR_Yes	0.241	0.659	-0.031
WLR_No	0.418	0.187	-0.047
RSD_Total	0.687	0.288	-0.077
LFT_TOTAL	0.642	0.386	0.038
RWL_TOTAL	0.329	0.749	-0.046
IF_TOTAL	0.026	0.624	0.292

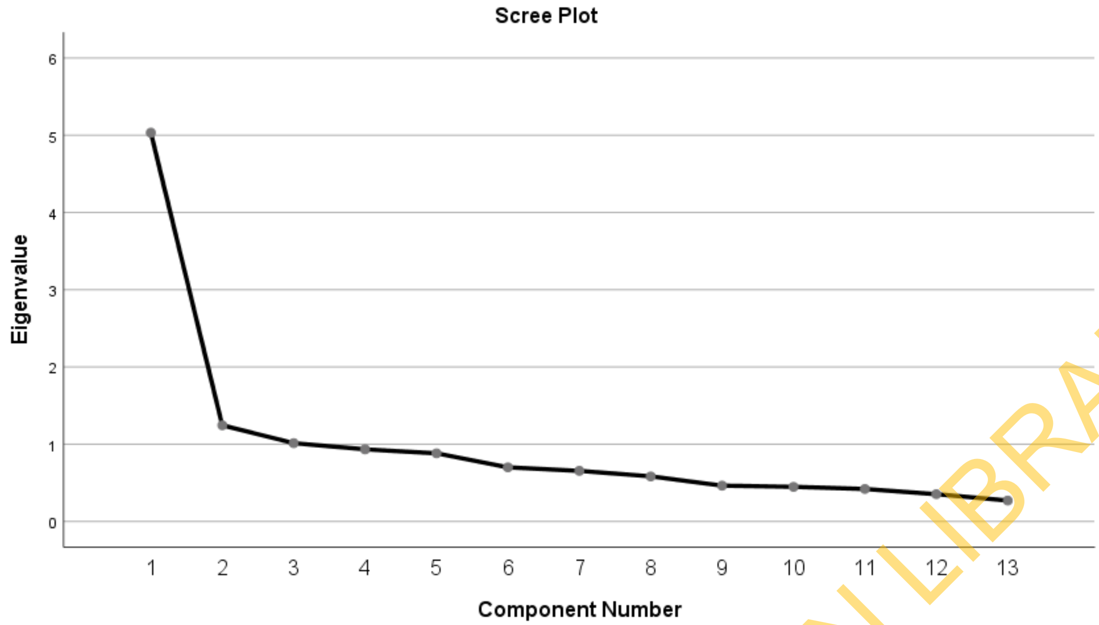


Figure 14: The Scree Plot of all participants

Table 7: The factor loadings obtained from the Rotated Component Matrix for the Stroke Survivors

Test	Components/Factors		
	1	2	3
AFT	0.303	0.669	-0.078
VRT	0.522	0.257	0.488
VisRT	0.681	0.097	-0.062
BNT	0.789	0.209	-0.062
WLL	0.374	0.764	-0.133
WLL_I	-0.205	-0.059	0.859
SD_Total	0.741	0.168	-0.136
WLR_Yes	0.222	0.658	-0.020
WLR_No	0.446	0.282	-0.045
RSD_Total	0.722	0.210	-0.054
LFT_TOTAL	0.637	0.336	0.136
RWL_TOTAL	0.366	0.739	0.024
IF_TOTAL	-0.062	0.615	0.248

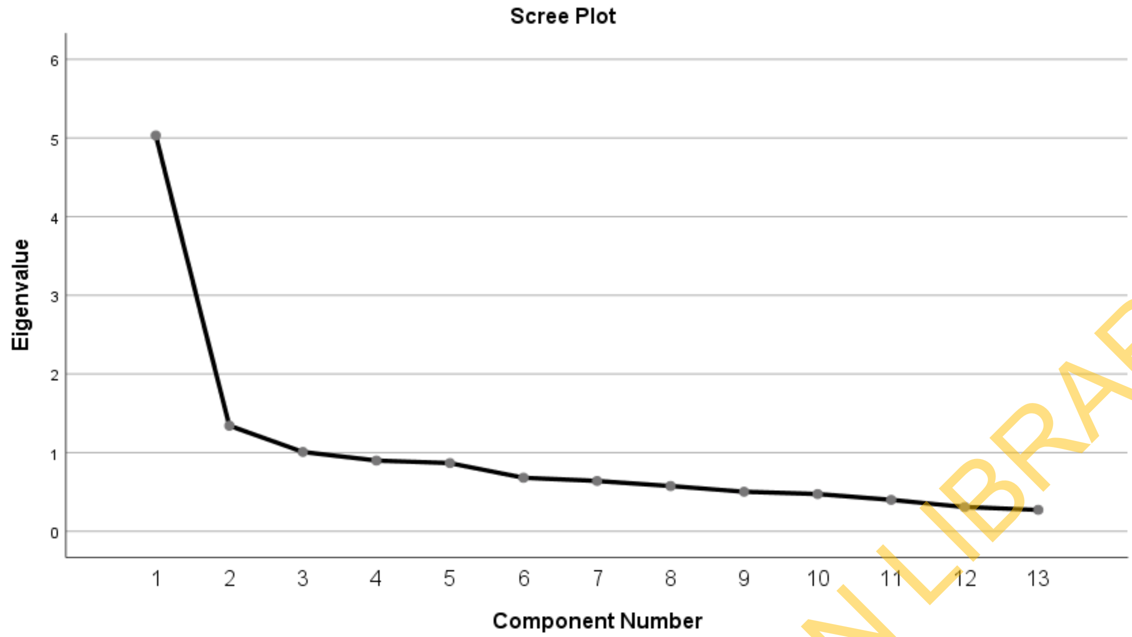


Figure 15: The Scree Plot of stroke survivors

Table 8: The factor loadings obtained from the Rotated Component Matrix for the control group

Test	Components/Factors			
	1	2	3	4
AFT	0.336	0.299	0.370	0.061
VRT	0.779	0.154	-0.147	0.233
VisRT	0.638	0.269	-0.048	-0.279
BNT	0.764	0.126	-0.031	0.173
WLL	0.295	0.763	-0.181	-0.150
WLL_I	-0.187	-0.069	0.867	0.008
SD_Total	0.596	0.288	0.328	0.205
WLR_Yes	0.268	0.592	0.035	0.398
WLR_No	0.410	-0.258	0.365	-0.545
RSD_Total	0.562	0.478	0.123	0.073
LFT_TOTAL	0.750	0.283	0.000	0.017
RWL_TOTAL	0.162	0.865	0.081	0.053
IF_TOTAL	0.283	-0.044	0.118	0.697

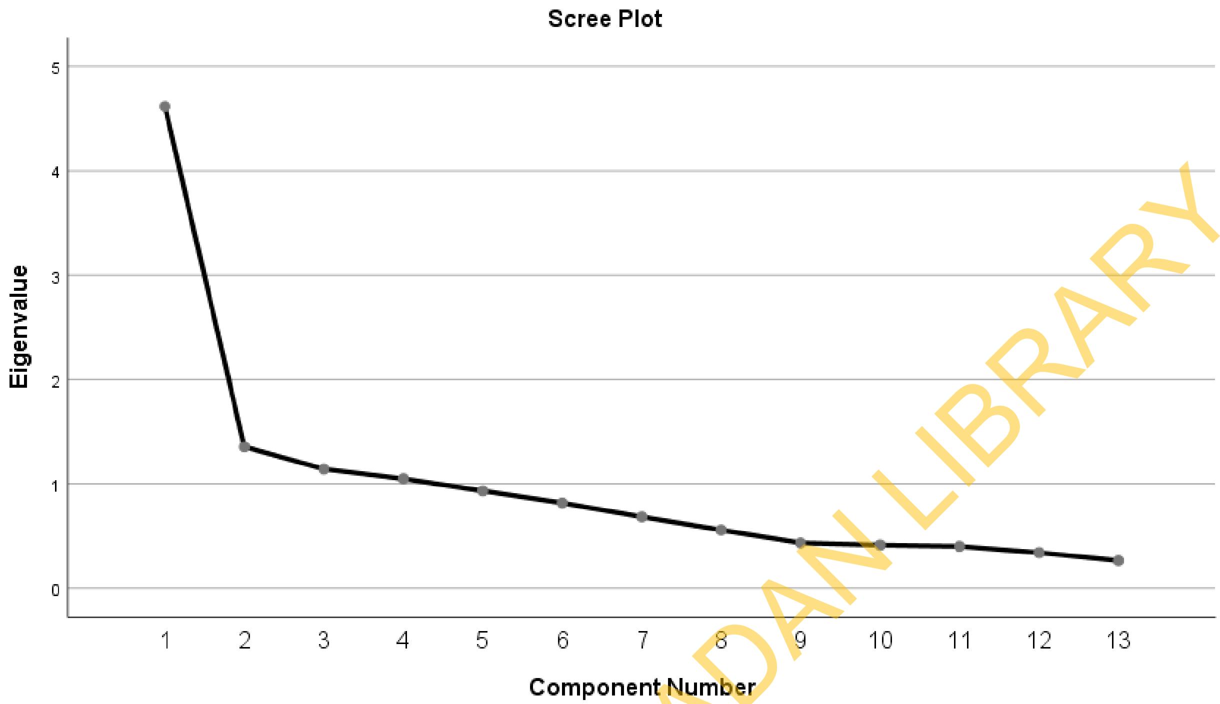


Figure 16: The Scree Plot for the control group

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

This is the first study of the psychometric properties of the of the V-NB used for assessing cognitive functions among stroke survivors in South-Western Nigeria based to the data obtained from the COGFAST – Nigeria (Memory after Stroke Study) Neuropsychological Assessment with special emphases on the executive function, language, memory/learning and visuospatial/visuoconstructive domains of the V-NB (Akinyemi *et al*., 2014). However, this present study made an attempt to assess the psychometrics of the V-NB in terms of its reliability and validity as well as the internal structure of the instrument. Specifically, I delved into assessing the internal consistency, discriminant validity, concurrent validity and the factor analysis of the test battery. This study had a sample size of 381 with the study group being 244 and 137 control group. This was essentially a case-control study with the case being stroke survivors and the control group being healthy participants who had met and satisfied all the inclusion/exclusion criteria. The sample size was in agreement with a few studies (Ogaji *et al*., 2017; Ojagbemi *et al*., 2017; Ojo Owolabi, 2011; Pinto *et al*., 2019; Teichner *et al*., 1999) similar to the one being presently reported. From the previous studies, I observed that most validation studies did not require large sample size as evident by some available literatures on the psychometric properties.

The socio-demographic characteristics of the study participants showed a similarity in age, gender and number of years of education which may be useful in terms of the homogeneity of the sample population. This was empirically confirmed by the Mann Whitney U test and chi square test. In effect, there was no statistically significant difference in age, gender education years between the two groups. The choice of the test statistics for the continuous variables was based on the violation of the normal distribution assumptions. Age and education years of the study participants were categorized and each class was described using percentages. It was observed that participants in both groups with the age range of 45 to 74 had the highest proportion. Similar observation was made for number of years of education. Also, this study has more male (240) than female (141). As presented in Table 1, this study described the characteristics of the MMSE and the V-NB in which scores from VRT, VisRT, WLLT_I and WLRN between the two groups were not statistically significant.

5.1.1 Reliability

In this study, the V-NB statisfied the Nunnaly's criterion for internal consistency reliability which recommended a benchmark of 0.7. Internal consistency reliability was investigated for stroke survivors and control group. The model of choice for assessing this particular psychometric characteristic being the Cronbach's Alpha was adequate to explain the reliability of the V-NB which ensures the reproducibility of the result under same condition. This study was able to deduce that Cronbach's Alpha for the control group did not satisfy the Nunnaly's criterion. This could be attributed to the fact that the control group was homogenous in terms of cognition of the participants in the group. It should also be noted that the MMSE was excluded from the analysis because of its possible interference with the internal consistency of the V-NB having known that the reliability of the MMSE had been established in many previous studies. Reviewed literatures in this study (Apolinario *et al*., 2013; Gil *et al*., 2019; Mohammad *et al*., 2014; Ojo Owolabi, 2011;

Paradela *et al*., 2009; Shaik *et al*., 2016) corroborated the essentiality of satisfying the Nunnaly's criterion when assessing the internal consistency of the test battery.

5.1.2 Discriminant Validity

A very important feature of the Receiver Operating Characteristic (ROC) curve was to correctly classify participants in the study to the group they belong. This discriminating capacity of the ROC curve was used specifically in the study to assess the discriminant validity of the V-NB. The Area Under the Curve was also an important tool used in this study for proposing some cut-point for each of the test in the battery except for some test that failed to achieve statistical significance following analysis. The affected tests included the VRT, VisRT, WLL_I and WLRN which all had AUC>0.5 except the WLRN with an AUC = 0.48. For the test battery to be validated in this regard, analysis had shown that the affected tests did not contribute meaningfully to the effectiveness of V-NB as an instrument for assessing cognitive functions in the study group. This study further investigated the sensitivity and specificity of each of the test in the battery to correctly identify participants with cognitive impairment and also to correctly classify those without the post-stroke conditions. The cut-points proposed in this study was performed using the method of Index of Union, (Unal, 2017).

5.1.3 Concurrent Validity

In this study, the Mini-Mental State Examination was used as a gold standard while assessing the concurrent validity of the test battery. Correlational analysis using the Spearman's Correlation Coefficient by comparing each test with the MMSE to measure the degree of correlation. The result of the analysis evidently showed that all the tests in the V-NB correlated significantly with the MMSE except for tests such as WLLT_I, IFT and WLRN which had weak correlations with the gold standard. The correlation statistic was chosen based on the non-parametric nature of the test scores. It was also observed that all the test had a positive correlation with MMSE but for WLLT_I which indicated a negative correlation with MMSE at α = 0.05. However, statistical significance was evaluated at α = 0.01 (for others) which was considered as one of the defaults in SPSS. Concurrent validity measures how well a new test compares to a well-established test which in this regard was the MMSE (Ojo Owolabi, 2011; Paddick *et al*., 2017; Pino *et al*., 2008; Pinto *et al*., 2019; Rosa et al., 2013; Sada *et al*., 2019; Shaik *et al*., 2016).

5.1.4 Factor Structure

Exploratory Factor Analysis assessed the internal structure of the V-NB with the exclusion of the MMSE. Specifically, I used the Principal Component Analysis (PCA) to analysis the factor structure of the test battery, Factor analysis is a data reduction technique for explaining relationship among the tests in the battery using the smallest number of variables/test that can explain the correlations. PCA performed in this study was sectioned into three categories – for all participants in the study, for the study group and the control group. The varimax as a method of orthogonal rotation was used (Guruje *et al*., 1995; Ogaji *et al*., 2017; Ojagbemi *et al*., 2017; Sarfo *et al*., 2016; Strauss & Fritsch, 2004). The results showed that while there was a three-factor solution for all participants and the study group, a four-factor solution emerged for the control group. In addition, the KMO and the Bartlett's Test of Sphericity were acceptable thereby giving indicating a valid factor structure for the V-NB. The variance explained in each of the categories were also acceptable in practices. The factor loadings as explained by the rotated component matrix showed sufficiently high loadings on the retained factors/components.

5.2 Conclusion

This study has shown that the V-NB demonstrated good internal consistency reliability among the stroke survivors. The validity study of the test battery has some attributes of accuracy and usefulness for screening individuals suspected to have cognitive impairment in which the discriminant validity presented results which correctly distinguish between the two groups. The concurrent validity showed its usefulness for validating the data as evident by the moderate degree of relationship between the tests and the MMSE. Lastly, the test battery also demonstrated an acceptable internal structure with reasonable factor loadings as explained by the variances for two groups.

5.3 Recommendations

The discriminant validity of the of the V-NB required more work especially for proposing cut-points for some tests in the battery. These cut points could be used for the purpose of screening only and not for diagnostic tendencies. Also, tests which failed to be statistically significant in terms of their respective AUC's could be removed from the battery while using it for screening purposes.

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