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Montreal Cognitive Assessment (MoCA): Normative Data for a South African Sample

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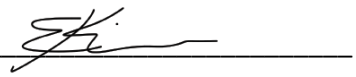
Signed: 

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List of Abbreviations

AD	Alzheimer's Disease
ANI	Asymptomatic Neurocognitive Impairment
ANOVA	Analysis of Variance
CI	Confidence Interval
GLM	General Linear Model
HAD	HIV-Associated Dementia
HAND	HIV-Associated Neurocognitive Disorder
HDS	HIV-Dementia Scale
HIV	Human Immunodeficiency Virus
IHDS	International HIV Dementia Scale
LS	Least Squares
MCI	Mild Cognitive Impairment
MND	Mild Neurocognitive Disorder
MoCA	Montreal Cognitive Assessment
MP	Mood/Psychosis
NCD	Neurocognitive Disorder
PLWH	People living with HIV
SD	Standard Deviation
SES	Socioeconomic Status

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Abstract

Valid, brief, and easily administered cognitive screening and diagnostic tests, such as the Montreal Cognitive Assessment (MoCA), can be of significant benefit in resource limited settings such as South Africa. This study aimed to explore the influence of demographic variables (age, years of education and gender) on total MoCA score, calculate the psychometric properties (internal consistency and discriminant validity) of the MoCA, and provide normative data for a well-defined sample of South African adults (≥21 years) who are English second- or third-language speakers and who attained public education. All participants completed the English MoCA version 8.1. Secondary data from 70 patients with human immunodeficiency virus (HIV) and comorbid psychiatric disorder, 13 patients with HIV and comorbid neurocognitive disorder (NCD), and 89 unaffected controls were compared. Total MoCA scores were significantly correlated with years of education ($p<0.001$) and age ($p=0.007$), but not gender. Cronbach's alpha was 0.64 revealing moderate internal consistency of the MoCA in this study. According to regression, belonging to psychiatric or NCD groups, respectively, was significantly predicted by age and years of education, rather than total MoCA scores, indicating poor discriminant validity of the MoCA. Although the MoCA showed suboptimal psychometric properties in this study, the preliminary norms presented may offer useful guidelines for healthcare practitioners to determine whether a patient's cognitive performance on the MoCA is in accordance with other non-English first language speaking South Africans with the same age and education, or whether the patient requires further evaluation.

Keywords: assessment; human immunodeficiency virus; Montreal Cognitive Assessment; neurocognitive disorder; psychiatric disorder; psychometrics; screening

1. Literature Review

Valid, brief and easily administered cognitive screening and diagnostic tests, such as the Montreal Cognitive Assessment (MoCA), can be of significant benefit to clinical researchers and practitioners, particularly in resource limited settings such as South Africa (Robbins et al., 2013). The MoCA is a brief neurocognitive test that fits neatly on a single-sided A4 page and can be administered in approximately 15 minutes (Nasreddine et al., 2005). The MoCA evaluates a wide variety of cognitive domains including memory, language, executive functioning, arithmetic ability, visuospatial skills and orientation. The maximum score is 30 points, where higher scores indicate higher cognitive function (Nasreddine et al., 2005). The MoCA was originally developed in Montreal, Canada to assist clinical practitioners to distinguish between age-related cognitive decline within the normal range from mild cognitive impairment (MCI), a clinical state which presents no noticeable impairment in everyday life, but which can be a precursor to dementia in geriatric populations (Nasreddine et al., 2005).

The MoCA has subsequently been used globally in various socioeconomic, cultural and linguistic contexts, including global north countries such as Portugal (Duro et al., 2010; Freitas et al., 2011), Italy (Milanini et al., 2016; Santangelo et al., 2015), and the United States (Hoops et al., 2009; Rossetti et al., 2011), as well as global south countries such as Brazil (Cecato et al., 2016; Sobreira et al., 2015), China (Tu et al., 2013; Zhang et al., 2016), Egypt (Rahman & El Gaafary, 2009), and South Africa (Rademeyer & Joubert, 2016; Robbins et al., 2013). The MoCA has been translated into nearly 100 languages (https://www.mocatest.org/faq/) which has promoted its widespread use. Beyond its original scope, the potential of the MoCA has also been explored in a variety of clinical samples including human immunodeficiency virus (HIV, Janssen et al., 2015; Robbins et al., 2013), HIV-associated neurocognitive disorder (HAND, Hakkers et al., 2018; Joska et al., 2016), Huntington's Disease (Bezdicek et al., 2013; Videnovic et al., 2010), traumatic brain injury (de Guise et al., 2014; Whitney et al., 2012), schizophrenia (Rademeyer & Joubert, 2016), and various forms of dementia including vascular dementia (Duro et al., 2010; Freitas et al., 2012c), frontotemporal dementia (Freitas et al., 2012b) and Parkinson's Disease dementia (Ozdilek & Kenangil, 2014; Tumas et al., 2016). These studies have all reported varying psychometric properties of the MoCA compared to the original validation study.

1.1. Psychometric Properties of the MoCA

Psychometric properties refer to statistical calculations of the degree to which a test instrument, such as the MoCA, can be interpreted consistently across different samples and contexts (i.e., reliable) and accurately measure what it was designed to measure (i.e., valid; de Souza et al., 2017). In order to ensure the accuracy of the instrument, it needs to be both reliable and valid (Bajpai & Bajpai, 2014).

1.1.1. Reliability

1.1.1.1. Internal Consistency of the MoCA.

Internal consistency is a form of reliability referring to the statistical estimate of the degree to which items on a test scale, or items within a subscale of the test, measure the same characteristic (Bajpai & Bajpai, 2014). It is calculated as the sum of the true variability among respondents (i.e., true variance) plus the variability due to error (i.e., random error variance; Gignac, 2014).

The most common statistical method of assessing internal consistency is Cronbach's alpha (α) coefficient (de Souza et al., 2017). Alpha values range between zero and one, the closer to one, the higher the reliability (Cronbach, 1951). Typically, a coefficient of ≥ 0.80 is considered acceptable for a diagnostic test (Kline, 1999). However, there is debate regarding the interpretation of alpha coefficients, whereby some researchers establish that values of ≥ 0.60 are satisfactory (de Souza et al., 2017; Kline, 1999). Alpha coefficients substantially lower indicate an unreliable scale where random errors in measurement largely determine the observed score, such that items on the instrument may be measuring different constructs or that responses to items are inconsistent amongst respondents (de Souza et al., 2017).

A summary of internal consistency data on the MoCA is presented in table 1. The original MoCA validation study in Canada reported high internal consistency ($\alpha=0.83$) in a sample of 90 controls, 94 patients with MCI and 93 patients with Alzheimer's Disease (AD; Nasreddine et al., 2005). Other studies have reported alpha coefficients as low as 0.55 for the MoCA in a sample of 110 Australians at risk for MCI due to cardiovascular disease (McLennan et al., 2011) and as high as 0.90 for the MoCA in Portuguese samples (Duro et al., 2010; Freitas et al., 2012a; Freitas et al., 2012b; Freitas et al., 2012c; Freitas et al., 2012d). In South Africa, Beath et al. (2018) reported moderate internal consistency of the MoCA ($\alpha=0.62$) in a sample

of 370 cognitively healthy subjects. Cronbach's alpha tends to be higher in clinical samples compared to controls (Janelidze et al., 2017; Pike et al., 2017). For example, Freitas et al. (2012a) reported a high Cronbach's alpha (α=0.88) for the MoCA in the clinical sample and a lower alpha (α=0.67) in the control sample. The majority of MoCA studies, however, calculated Cronbach's alpha for the overall sample (Dagenais et al., 2013; Gil et al., 2015; Tsai et al., 2012).

Reliability is a precondition for validity; if a test is not reliable, it is not possible for it to be valid, but it is possible for a test to be reliable yet invalid (Gignac, 2014). Important to note is that reliability and validity estimates are not fixed properties of a test instrument and can differ according to the sample characteristics and context in which it is administered (Bajpai & Bajpai, 2014). It is therefore important to evaluate both the reliability and validity of a diagnostic instrument to determine its accuracy within a particular context with particular sample characteristics (de Souza et al., 2017).

Table 1

Internal consistency of the MoCA in the literature

			Cronbach's α		
First Author	Year	MoCA version	Overall Sample	Clinical Sample	Control Sample
Beath et al.	2018	N/S	0.62		
Bezdicek et al.	2013	Czech		0.82 (HD)	0.56
Chen et al.	2015	Beijing	0.73		
Chu et al.	2015	Cantonese	0.85		
Costa et al.	2012	German	0.84		
Dagenais et al.	2013	French	0.87		
Duro et al.	2010	Portuguese	0.90		
Freitas et al.	2012a	Portuguese	0.90	0.88	0.67
Freitas et al.	2012b	Portuguese	0.90	0.84 (FTD); 0.83 (AD)	
Freitas et al.	2012c	Portuguese	0.90	0.82 (VaD); 0.80 (AD)	
Freitas et al.	2012d	Portuguese	0.78		
Gil et al.	2015	Spanish	0.84		
Janelidze et al.	2017	Georgian		0.92 (aMCI); 0.89 (AD)	0.86
Julayont et al.	2015	Thai	0.81		
Kaya et al.	2014	Turkish	0.81		
McLennan et al.	2011	N/S	0.55		
Nasreddine et al.	2005	English; French	0.83		
Ozdilek et al.	2014	Turkish		0.66 (PD)	0.75
Pike et al.	2017	N/S		0.80 (CHD)	0.72
Rahman et al.	2009	Arabic	0.83		
Tsai et al.	2012	Taiwanese	0.86		
Tu et al.	2013	Changsha	0.88		
Yu et al.	2012	Beijing	0.88		
Zheng et al.	2012	Chinese-Los Angeles	0.79		

Note. MoCA=Montreal Cognitive Assessment; N/S=Not Specified; HD=Huntington's Disease; FTD=Frontotemporal Dementia; AD=Alzheimer's Disease; VaD=Vascular Dementia; aMCI=amnestic Mild Cognitive Impairment; PD=Parkinson's Disease; CHD=Congenital Heart Disease; α=alpha coefficient.

1.1.2. Validity

1.1.2.1. Discriminant Validity of the MoCA.

Discriminant validity refers to the degree to which the scores obtained on an instrument, such as the MoCA, can be used to correctly distinguish independent groups, such as cognitively impaired groups from cognitively unimpaired groups (Bajpai & Bajpai, 2014). For this purpose, screening and diagnostic tests often use a cut-off point in which test results equal to or greater than this threshold value is considered positive (i.e., no cognitive impairment), otherwise they are negative (i.e., cognitive impairment; Habibzadeh et al., 2016).

The chosen cut-off point determines the rates of true positive (TP), false positive (FP), true negative (TN) and false negative (FN) test results (Habibzadeh et al., 2016). Sensitivity (Se) refers to the ability of the test to correctly identify those with cognitive impairment (i.e., true positive rate) and is calculated using the formula Se=TP/(TP+FN) (Habibzadeh et al., 2016). Specificity (Sp) refers to the ability of the test to correctly screen out those without cognitive impairment (i.e., true negative rate), calculated using the formula Sp=TN/(TN+FP) (Habibzadeh et al., 2016). Theoretically, a perfect test has both sensitivity and specificity equal to 1.00 (i.e., 100%; Habibzadeh et al., 2016). However, sensitivity and specificity do not increase in tandem; specificity decreases as sensitivity increases and vice versa (Habibzadeh et al., 2016). The optimal cut-off point is determined by the value that yields the optimum balance between sensitivity and specificity, ideally with both greater than 80 percent (Habibzadeh et al., 2016).

A summary of the discriminant validity of the MoCA in the literature (including cut-off points, Se and Sp) is provided in table 2. The original MoCA validation study recommended a cut-off point of 26 out of 30, whereby scores of ≤25 indicates cognitive impairment and ≥26 indicates no cognitive impairment (Nasreddine et al., 2005). At this threshold, the MoCA was capable of distinguishing cognitively unimpaired controls from the MCI group with a high sensitivity (90%) and specificity (87%; Nasreddine et al., 2005). The same cut-off value could distinguish controls from patients with AD with a perfect sensitivity (100%) and acceptable specificity (87%; Nasreddine et al., 2005). In a South African study by Joska et al. (2016), the recommended cut-off value of ≥26 revealed a high sensitivity (89%) but extremely poor specificity (22%) to distinguish controls from individuals affected by HAND. The low specificity of the MoCA in this case indicates a high false positive rate in which the MoCA

may misclassify 78 percent of patients with HAND who are unaffected (Habibzadeh et al., 2016; Joska et al., 2016). In another South African study, Beath et al. (2018) demonstrated a high sensitivity (94%) but extremely low specificity (28%) for the MoCA for identifying MCI using the recommended cut-off score of ≥26. Lowering the cut-off value to ≥24 demonstrated a slightly lower sensitivity (84%) but improved specificity (52%; Beath et al., 2018). Thus, it may be necessary to use a lower cut-off score than originally recommended in order to reduce rates of misclassification (Elkana et al., 2020; Wong et al., 2015).

Table 2

Discriminant validity of the MoCA in the literature

First Author	Year	Country	MoCA version	Type of Impairment	Cut-off	Se (%)	Sp (%)
Beath et al.	2018	SA	N/S	MCI	23	75	66
Bezdicek et al.	2013	Czech Republic	Czech	HD	25	94	84
Bosco et al.	2017	Italy	Italian	AD	14	87	92
Chen et al.	2015	China	Beijing	OSAHS	26	54	70
Chu et al.	2015	China	Cantonese Chinese	aMCI	22	78	73
				AD	19	94	92
Costa et al.	2012	Germany	German	MCI	26	93	62
				AD	22	97	97
Cumming et al.	2013	Australia	N/S	Stroke	23	92	67
Freitas et al.	2012a	Portugal	Portuguese	MCI	22	81	77
				AD	17	88	98
Freitas et al.	2012b	Portugal	Portuguese	FTD	17	78	98
Freitas et al.	2012c	Portugal	Portuguese	VaD	17	77	97
Gierus et al.	2015	Poland	Polish	CI	23	82	70
Gil et al.	2015	Colombia	Spanish	MCI	23	89	79
Goldstein et al.	2014	USA	N/S	MCI	24	95	63
				DEM	22	96	88
Hoops et al.	2009	USA	N/S	PDMCI	26	90	53
Janelidze et al.	2017	Georgia	Georgian	aMCI	22	100	69
Janssen et al.	2015	Netherlands	Dutch	HIV-1	26	56	63
Joska et al.	2016	SA; USA	N/S	HAND	26	89	22
Julayanont et al.	2015	Thailand	Thai	MCI	24	81	86
Kwok et al.	2015	Canada	N/S	CI	25	84	50
McLennan et al.	2011	Australia	English	aMCI	24	100	50
Nasreddine et al.	2005	Canada	English; French	MCI	26	90	87
				AD	26	100	87
Ng et al.	2015	Singapore	Chinese	MCI	28	64	36
Oudman et al.	2014	Netherlands	Dutch	KS	23	100	96
Ozdilek et al.	2014	Turkey	Turkish	PD	21	59	89
Pirrotta et al.	2015	Italy	Italian	CI	15	83	97
Smith et al.	2007	UK	N/S	MCI	26	83	50
				DEM	26	94	50
Sobreira et al.	2015	Brazil	Brazilian	PDMCI	26	84	27
Tsai et al.	2012	Taiwan	Chinese/Taiwanese	MCI	23	92	78
				AD	21	98	95
Whitney et al.	2012	USA	N/S	CI	23	72	75
Yu et al.	2012	China	Beijing	MCI	21	68	63

Note. MoCA=Montreal Cognitive Assessment; Se=Sensitivity; Sp=Specificity; N/S=Not Specified; SA=South Africa; USA=United States of America; UK=United Kingdom; CI=Cognitive Impairment; MCI=Mild Cognitive Impairment; aMCI=Amnestic Mild Cognitive Impairment; PD=Parkinson's Disease; PDMCI=Mild Cognitive Impairment caused by Parkinson's Disease; AD=Alzheimer's Disease; DEM=Dementia; FTD=Frontotemporal Dementia; VaD=Vascular Dementia; HIV=Human Immunodeficiency Virus; HAND=HIV-Associated Neurocognitive Disorder; KS=Korsakoff's Syndrome; OSAHS=Obstructive Sleep Apnoea Hypopnea Syndrome; HD=Huntington's Disease.

1.1.2.2. Construct Validity of the MoCA.

A second type of validity, known as construct validity, refers to a calculation of the degree to which the items on the test reflect the broader construct/s that the instrument is designed to assess (de Souza et al., 2017). Construct validity is established when scores obtained by two different instruments designed to measure the same construct/s are highly correlated (also known as convergent validity; Bajpai & Bajpai, 2014).

For a summary on the construct validity of the MoCA in the literature, see table 3. The original validation study by Nasreddine and colleagues (2005) demonstrated good construct validity of the MoCA through a strong correlation with the Mini-Mental State Examination (MMSE, Folstein et al., 1975), r=0.87, p<0.001. Contrastingly, a study conducted in South Africa using a shorter, supposedly more language and culture neutral version of the MoCA (MoCA-Basic, Robbins et al., 2013) demonstrated poor construct validity via a weak correlation (r=0.36, p<0.05) when compared to a 'gold standard' neuropsychological assessment (Hakkers et al., 2018). Thus, when a test is adapted, translated or used in a particular sample or context, the construct validity needs to be established relative to another 'gold standard' neuropsychological test or battery in order to ensure that the test is accurately measuring the construct/s that it is intended to measure.

Table 3

Construct validity of the MoCA in the literature

			Correlations (r)					
First Author	Year	MoCA version	MMSE	DRS	NPA	RBANS	CAMCOG	Strength
Beath et al.	2018	N/S				0.51**		Moderate
Bezdicek et al.	2013	Czech			0.81**			High
Brito-Marques et al.	2019	N/S	0.63**					Moderate
Chen et al.	2015	Beijing	0.41*					Low
Chu et al.	2015	Cantonese Chinese	0.91**					High
Costa et al.	2012	German	0.86**					High
Duro et al.	2010	Portuguese	0.82**					High
Freitas et al.	2012c	Portuguese	0.74**					High
Gierus et al.	2015	Polish			0.92**			High
Gil et al.	2015	Spanish	0.75					High
Hakkers et al.	2018	Basic			0.36*			Low
Lam et al.	2013	N/S	0.66**	0.77**				Moderate/High
McLennan et al.	2011	N/S	0.49**					Low
Nasreddine et al.	2005	English; French	0.87**					High
Rahman et al.	2009	Arabic					0.93**	High
Stewart et al.	2012	N/S	0.90**					High
Tsai et al.	2012	Chinese/Taiwanese	0.91**					High
Yu et al.	2012	Beijing	0.83**					High

Note. *p-value significant at <0.05; **p-value significant at <0.01.
N/S=Not Specified; MoCA=Montreal Cognitive Assessment; MMSE=Mini-Mental State Examination; DRS=Mattis Dementia Rating Scale; NPA=Neuropsychological Assessment battery; RBANS=Repeatable Battery for the Assessment of Neuropsychological Status; CAMCOG=Cambridge Cognition Examination; r=correlation coefficient.

Reliability and validity of neuropsychological tests, such as the MoCA, are not universal and need to be determined in the context, sample and nature of impairment in which it is intended to be used (Bajpai & Bajpai, 2014). Whilst the original MoCA validation study in Canada yielded excellent psychometric properties (Nasreddine et al., 2005), four studies in South Africa have demonstrated poor psychometric properties, particularly as a screening tool for HIV and HAND (Beath et al., 2018; Hakkers et al., 2018; Joska et al., 2016; Robbins et al., 2013). This is partly attributable to the different sample characteristics, including demographic variables (e.g., age, years of education, gender) and contextual factors (e.g., language, culture, socioeconomic background; Freitas et al., 2012d).

1.2. Impact of Demographic Variables on MoCA Psychometrics

The most significant demographic variables found to affect performance on the MoCA are age and years of education, with older age and less years of education associated with lower total MoCA scores (Kaya et al., 2014; Malek-Ahmadi et al., 2015; Pinto et al., 2018; Robbins et al., 2013; Zheng et al., 2012). According to Freitas et al. (2011), age and education explained 49 percent of the variation in total MoCA scores. Similarly, in Santangelo et al.'s (2015) study, the final regression model for total MoCA score included age and education, accounting for 48 percent of the total variance. On the other hand, Konstantopoulos et al. (2016) found that age, education as well as gender explained 35.8 percent of the variance in total MoCA scores.

The effect of gender is more ambiguous in the literature, with some studies reporting significant gender differences on the MoCA (Beath et al., 2018; Borland et al., 2017; Konstantopoulos et al., 2016), whereas others do not (Conti et al., 2015; Freitas et al., 2012d; Luis et al., 2009; Ng et al., 2015; Robbins et al., 2013; Rossetti et al., 2011; Santangelo et al., 2015). In Konstantopoulos et al.'s (2016) study, females scored a mean 0.3 points higher on the MoCA than males. In a multivariate regression model, Borland et al. (2017) found that the effect size of gender on total MoCA score (standardised beta [β]=0.12) was nearly half that of age (β=–0.20) and education (β=0.23). Therefore, whilst these studies found a significant effect of gender on total MoCA scores, the impact of gender is marginal in comparison to age and education (Borland et al., 2017; Konstantopoulos et al., 2016).

Despite finding statistically significant gender effects on the MoCA, Borland et al. (2017) reported cut-off values for the MoCA stratified by age and education only. Other studies have also reported cut-off scores and/or normative data stratified for age and/or education, excluding gender (Conti et al., 2015; Freitas et al., 2011; Innocenti et al., 2017; Kaya et al., 2014; Thomann et al., 2018; Wong et al., 2015). This reinforces the notion that age and education are highly significant and consistent predictors of performance on the MoCA, underscoring the need for cut-off points and normative data to be stratified by at least these two variables.

1.3. Neuropsychological Assessment in South Africa

The impact of demographic and contextual variables on neuropsychological test performance is particularly relevant to consider in South Africa with its culturally and linguistically diverse population (Foxcroft et al., 2004). South Africa also has high socioeconomic and educational inequalities, where approximately one-fifth of the population have completed 12 years of education (Robbins et al., 2013). This is largely a consequence of South Africa's complex history of apartheid (Foxcroft, 1997; Laher & Cockcroft, 2014).

During apartheid (1948-1994), educational facilities for Black and Coloured (i.e., mixed race) South Africans under the Department of Education and Training (DET) were largely under-resourced (i.e., disadvantaged) in comparison to those afforded to White South Africans (Laher & Cockcroft, 2013). Following the dismantling of apartheid after the first democratic elections in 1994, more Black and Coloured South Africans have gained access to better educational opportunities (Cockcroft et al., 2015; Shuttleworth-Edwards et al., 2004). It is important to note that younger generations born post-1994 will have benefited from the transformation more so than older generations who underwent disadvantaged schooling during apartheid (Watts & Shuttleworth-Edwards, 2016). Despite notable efforts at reform, the effects of apartheid remain evident in South Africa which have resulted in significant biases in neuropsychological testing, affecting in particular those who are not first-language English speakers and who received a lower quality of education (Cockcroft et al., 2015; Shuttleworth-Edwards et al., 2004; Watts & Shuttleworth-Edwards, 2016).

Quality of education is an umbrella term used to encapsulate a multiplicity of interrelated factors. A higher quality of education is characterised by well-resourced, urban and private schooling versus a lower quality often associated with under-resourced, rural and public schooling (Laher & Cockcroft, 2013). Both the quality and years of formal education are important to take into consideration when administering and interpreting neuropsychological assessments, such as the MoCA, in South Africa (Shuttleworth-Edwards et al., 2004).

1.4. Screening for Cognitive Impairment Associated with HIV in South Africa

In South Africa, approximately seven million people over the age of 15 years are living with HIV (UNAIDS, 2019) and its frequent comorbidities including psychiatric disorders and neurocognitive disorders (Jonsson et al., 2013). According to revised Frascati diagnostic criteria, HAND ranges from mild forms such as asymptomatic neurocognitive impairment (ANI), mild neurocognitive disorder (MND), and more severe forms such as HIV-associated dementia (HAD, Antinori et al., 2007; Vally, 2011). Joska et al. (2011b) found high prevalence rates of HAND in a South African sample whereby 42.4 percent experienced MND whilst 25.3 percent were diagnosed with HAD. The prevalence of psychiatric illness in the general South African population is around 12.6 percent, whilst the prevalence is increased in people living with HIV (PLWH) at around 26 to 38 percent (Jonsson et al., 2013).

Several screening tools for neurocognitive disorders associated with HIV have been designed and validated for use in South Africa; including the HIV Dementia Scale (HDS, Ganasen et al., 2008; Power et al., 1995), International HIV Dementia Scale (IHDS, Joska et al., 2011a; Sacktor et al., 2005) and cognitive assessment tool-rapid (CAT-rapid, Joska et al., 2016; Witten, 2015). However, questions have been raised regarding the efficacy of these measures in screening for milder forms of HAND, such as ANI and MND (Joska et al., 2016). The MoCA is increasingly being used in South Africa and has shown promise in assessing MCI associated with HIV (Beath et al., 2018). However, the MoCA was standardised in a global north context and normative data does not yet exist for the MoCA in South Africa (Rademeyer & Joubert, 2016; Robbins et al., 2013). Interpretation of tests such as the MoCA relies on the availability of reliable, up-to-date normative values with which an individual can be compared (Kenny et al., 2013).

Robbins et al. (2013) compared a South African sample of 39 HIV-negative participants to published North American MoCA normative data (no impairment, MCI and AD). Despite the South African sample being significantly younger than the North American sample (>70 years), the South African HIV-negative controls did not perform significantly better on any of the subtests, and performed similarly to the North American AD group on several tasks (Robbins et al., 2013). These results elucidate the pitfalls of applying internationally published normative data in South Africa.

Watts and Shuttleworth-Edwards (2016) have cautioned against the use and interpretation of neuropsychological data obtained from tests which were standardised in global north contexts and highlight that when it comes to normative data, "generally representative is representative of none" (p. 1305). Therefore, general population-based normative data are not appropriate for the diversity of South African demographics where more culturally-specific locally-derived norms are of necessity (Laher & Cockcroft, 2014; Watts & Shuttleworth-Edwards, 2016). Whilst some researchers have advocated for the development of suitable local tests (Laher & Cockcroft, 2014), Shuttleworth-Jordan (1996) argues against the abandonment of tests purely because they have been standardised and normed for western populations. Rather, extensive research to translate and adapt existing neuropsychological tests appropriately to improve their utility in less westernised populations is more feasible (Shuttleworth-Jordan, 1996).

2. Rationale

The MoCA should not be used in South Africa to make diagnostic claims without extensive knowledge of its reliability and validity, and without the use of appropriate normative data, as this compromises accurate interpretations of test results (Joska et al., 2016; Rademeyer & Joubert, 2016). In particular, the MoCA is sensitive to age and years of education and require culturally relevant norms that are stratified using at least these two variables (Elkana et al., 2020). The present study heeds the calls of Robbins et al. (2013) and Hakkers et al. (2018) for more research in South Africa to examine the reliability and validity of the MoCA for identifying cognitive impairment in PLWH with comorbidities, and to collect local normative data. In so doing, the study contributes towards improved neuropsychological assessment in South Africa.

3. Research Aims

The present study aims to explore the influence of demographic variables (age, gender and years of education) on performance on the MoCA in three independent diagnostic groups; a clinical group with HIV and comorbid psychiatric disorder, a second clinical group with HIV

and comorbid neurocognitive disorder (NCD) and an unaffected control group. A comparison between diagnostic groups will determine the discriminant validity of the MoCA in this sample. Furthermore, the study aims to calculate the internal consistency of the MoCA and to consider which stratifications are appropriate for local norms in a well-defined sample of adults (≥21 years of age), English second or third language speakers who attained public primary and secondary education.

4. Research Questions

i. Which variables (e.g., age, years of education and gender) affect total MoCA scores?
ii. Can total MoCA scores accurately discriminate between the HIV-positive group with comorbid psychiatric disorder, HIV-positive group with comorbid neurocognitive disorder and unaffected control group?
iii. Does the MoCA have acceptable internal consistency in this sample?
iv. Which stratifications for the control sample are appropriate for norms?

5. Materials and Methods

5.1. Research Design

This secondary study of pre-existing data will utilise a non-experimental ex-post facto design with no manipulation of independent variables or random assignment into groups (Ary et al., 2010). It has a cross-sectional, between-subjects design (Ary et al., 2010).

5.2. Procedure

The present study conducted secondary analyses of MoCA data collected from two studies in which the supervisor was the principal investigator (PI). The procedure used for each study will be described separately.

The data for the clinical sample was obtained from a study for which the primary aim was to determine the diagnostic utility of the MoCA and the Rey Auditory Verbal Learning Test (RAVLT) in a clinical sample and matched healthy control group, as well as explore the relationship between age, years of education and test performance on the two measures. This study utilised both retrospective and prospective data. Only data from the retrospective arm was used in the current study. As part of the retrospective data collection procedure, the PI obtained formal permission from the Chris Hani Baragwanath Hospital in order to have access to the relevant files, including demographic data and MoCA data (see appendix A and B). Retrospective data of the test scores were obtained from the patients' medical files that have prior authorisation for use for research purposes. Two research assistants (Psychology Honours students) were hired and trained by the PI to assist in the process of data mining.

The control group data was obtained from a study for which the principal aim was to identify and describe the neurocognitive profiles of five individuals with Huntington Disease-Like 2 (HDL2) by means of comparisons to a matched unaffected control sample. Prospective participants were given full disclosure about the aims of the study and the conditions of their participation via an information sheet (appendix C). Data was collected from participants who provided formal written consent (appendix D). Assessments were conducted individually under standardised conditions in a room with adequate ventilation and illumination and low noise levels. A smooth desk and at least two chairs, as well as a pencil and paper were provided. A demographic questionnaire was initially administered (appendix E), followed by the MoCA (appendix F).

The data provided for this study involves a database in Microsoft Excel for Windows (version 16.0) including the following elements: research identification number of each participant, chronological age, gender (female or male), years of education, individual item MoCA scores, total MoCA scores, and the research group to which each participant belongs (i.e., control or clinical group).

5.3. Ethical Considerations

Ethics permission was provided by the Human Research Ethics Committee-Medical (HREC-M) of the University of the Witwatersrand (Wits) for the two studies for which the data was

collected. Appendix G provides the ethical clearance certificate for the clinical group data (protocol number M190819) and the ethical clearance certificate for the control group data (protocol number M140872) is provided in appendix H. Ethics approval for secondary analyses of the data for control and clinical groups, respectively, was granted by Wits HREC-M (protocol number M200631) and is provided in appendix I.

Anonymity is guaranteed because the researcher of the present study did not have access to any identifying information from any of the participants. Confidentiality is guaranteed by keeping the database as a password protected file in a password protected computer, whereby only the student and supervisor have access. Analyses will be undertaken in groups, therefore, no individual data is presented at any stage of the reporting.

5.4. Instruments

5.4.1. Demographic Questionnaire

Demographic data for the control group (including chronological age, gender, language experience, handedness and years of education) were obtained from a demographic questionnaire (appendix E). Demographic data for the clinical group (including chronological age, gender, years of education, language experience, handedness and clinical diagnosis) were collected from the patients' medical files.

5.4.2. Montreal Cognitive Assessment (MoCA)

All participants completed the same MoCA English version 8.1 (appendix F). Administration and scoring were done by multiple health professionals who were allowed within their respective scopes to administer this test. Certification in the MoCA is mandatory as of September 2019 (https://www.mocatest.org/mandatory-moca-test-training/).

The MoCA brief screening test can be administered in approximately 10 to 15 minutes and measures several domains of neurocognitive function out of a maximum score of 30 points, where higher scores indicate better cognitive function (Nasreddine et al., 2005). Visuospatial abilities are measured using a three-dimensional cube copy drawing (one point) and clock

drawing task with a specified time (three points). Multiple aspects of executive functioning are measured using the alternating trail-making task (one point), two-item verbal abstraction (similarities-type) task (two points) and phonemic fluency task (one point). The phonemic fluency task generally assesses aspects of executive functioning as well as language ability. Furthermore, the MoCA measures short-term memory through a five-item delayed word recall task (five points) and attention/concentration and working memory are assessed through a digit span forwards and backwards task (two points), tapping test (one point) and serial seven subtraction task (three points). Language ability is assessed via a sentence repetition task (two points), three-item animal naming task (lion, camel, rhinoceros; three points) as well as the aforementioned phonemic fluency task. Finally, level of conscious awareness of temporal and spatial orientation is assessed using the orientation task by asking the participant to name the current date, month, year, day of the week, place location, and city (six points). As noted in the manual, an additional point was added to the total score for participants with less than 12 years of formal education (Nasreddine et al., 2005).

5.5. Sample and Sampling

Both the clinical and control sample was formed by means of purposive sampling because it allowed for the identification of participants who met the criteria under study (Etikan, 2016). The criteria for inclusion for the overall sample are adults over the age of 21 years whose first language is not English (second or third language), attended public primary and secondary schooling, did not abuse illicit drugs and/or alcohol and who provided formal consent. Participants were included in the control group if they had no history of any motor, psychiatric or cognitive symptoms. Participants were included in the clinical group if they had a dual clinical diagnosis of HIV with comorbid disorder. For the purposes of the present study, the clinical group was classified into two groups: (1) participants with HIV and a comorbid psychiatric disorder, consisting of mood disorder (including bipolar mood disorder and major depressive disorder), psychosis (including schizophrenia), or mood and psychosis disorders (henceforth referred to as the ‘MP’ group); and (2) HIV participants with comorbid NCD including HAND, HAD and MND, with or without an additional psychiatric disorder (henceforth referred to as the ‘NCD’ group). The rationale behind this classification is to determine whether the level of severity of cognitive impairment, where NCD is more severe

than psychiatric disorder, influences MoCA performance and/or the ability of MoCA to discriminate between these two clinical groups.

Patients' medical files with incomplete and/or contradictory data (such as age, years of education and/or date of administration) were excluded from data collection which had a negative impact on the sample size. Participants who had a clinical diagnosis unrelated to HIV and comorbidity of psychiatric disorder and/or NCD (N=16) and those with ≤6 years of education (N=3) were excluded from data analyses. The final sample comprised 172 participants overall: control (N=89), MP (N=70), NCD (N=13). The descriptive characteristics for each of the study variables, overall and by diagnostic group, are summarised in table 4.

Table 4

Descriptive statistics characterising sample demographics and total MoCA scores, overall and per diagnostic group

		Group			
Variables	Statistics	Overall (N=172)	Control (N=89)	MP (N=70)	NCD (N=13)
Age (years)	Mean	44.3	47.5	40.5	43.5
	SD	9.4	9.2	8.9	5.3
	Median	45	50	40	43
	Minimum	26	30	26	37
	Maximum	61	60	61	55
Gender					
Female	N (%)	112 (65.1)	48 (53.9)	53 (75.7)	11 (84.6)
Male	N (%)	60 (34.9)	41 (46.1)	17 (24.3)	2 (15.4)
Education (years)	Mean	11.8	12.6	11.1	10.2
	SD	2.4	2.6	1.6	2.2
	Median	12	12	11	10
	Minimum	7	7	7	7
	Maximum	19	19	15	15
Total MoCA Score	Mean	22.0	22.5	21.4	22.2
	SD	4.1	3.8	4.4	3.6
	Median	22	23	22	22
	25th pctl	19	20	18	22
	75th pctl	25	25	25	25
	Minimum	9	14	9	13
	Maximum	30	30	30	26

Note. MoCA=Montreal Cognitive Assessment; SD=standard deviation; pctl=percentile; MP=mood psychosis; NCD=neurocognitive disorder.

5.6. Data Analysis

This study utilised a quantitative design involving analysis of archival data. The data were cleaned and coded in preparation for statistical analyses. Statistical analyses were conducted using the IBM Statistical Package for the Social Sciences (SPSS) version 26.0 for Windows

(version 16.0) using a five percent significance level. Prior to conducting the statistical analyses that will address the aims of the study, the assumptions for each statistical test were checked in order to ensure the correct use and interpretation of the results.

Descriptive analyses of the study variables age, gender, years of education and total MoCA score (table 4) were conducted to characterise the sample.

The distribution of continuous data (age, years of education and total MoCA score) for the control group (N=89) was checked using histograms and the Shapiro-Wilk test of normality to determine whether the data were normally distributed (Altman & Bland, 1995; Ghasemi & Zahediasl, 2012).

To determine whether diagnostic groups were matched, the association between diagnostic groups and continuous variables (age and years of education, respectively) was determined by one-way analysis of variance (ANOVA, N=172). The association between categorical variables (gender and diagnostic group) was determined by the chi-square (χ^2) test of association (N=172).

Non-parametric Spearman's rank order correlations were used to further explore the associations between total MoCA score, age and years of education (N=89) because the data were not normally distributed (Schober et al., 2018). The association between total MoCA score and gender (females and males) was determined by one-way ANOVA (N=89).

For the comparison of means between three groups by one-way ANOVA, the detection of a small (f=0.1), medium (f=0.3) or large (f=0.5) effect size with 80 percent power at five percent significance level requires a sample size of 969, 159 or 69, respectively, assuming balanced groups. The actual sample size of 89 and 172, respectively, is thus adequate for the detection of a small to medium effect size, which is appropriate for the purposes of the study. However, the group sizes are unbalanced and inference about the smallest group (N=13) is likely to be poor. Sample size calculations were carried out in G*Power (Faul et al., 2007).

The association between total MoCA score (dependent variable) and diagnostic group, age, years of education and the interaction between age and years of education (independent variables), was assessed using a General Linear Model (GLM).

Predictive models for each diagnosis (vs. the control group) based on total MoCA score, age, years of education and the interaction between age and years of education were developed using multinomial logistic regression. Non-significant covariates and interaction terms were removed from the model to avoid over-fitting. For logistic regression, the rule of thumb given by Peduzzi et al. (1996) was used, which states that the number of parameters estimated in the model should be less than or equal to 10*the number of cases in the smallest outcome group. In this study, the smallest outcome group has 13 cases, thus limiting the number of parameters to one, although for the purposes of this research, four parameters were estimated.

Internal consistency reliability analyses were conducted using Cronbach's (1951) alpha coefficient, item-total statistics and inter-item correlations (Ferketich, 1991) to determine whether the MoCA has acceptable internal consistency in this sample.

To determine which stratifications for the control sample are appropriate for the normative data, arbitrary stratifications were tested for age and years of education, respectively, using independent samples t-test for two groups and one-way ANOVA for three or more groups (N=89). Once significant stratifications were identified, descriptive analyses were conducted to be reported as psychometric norms.

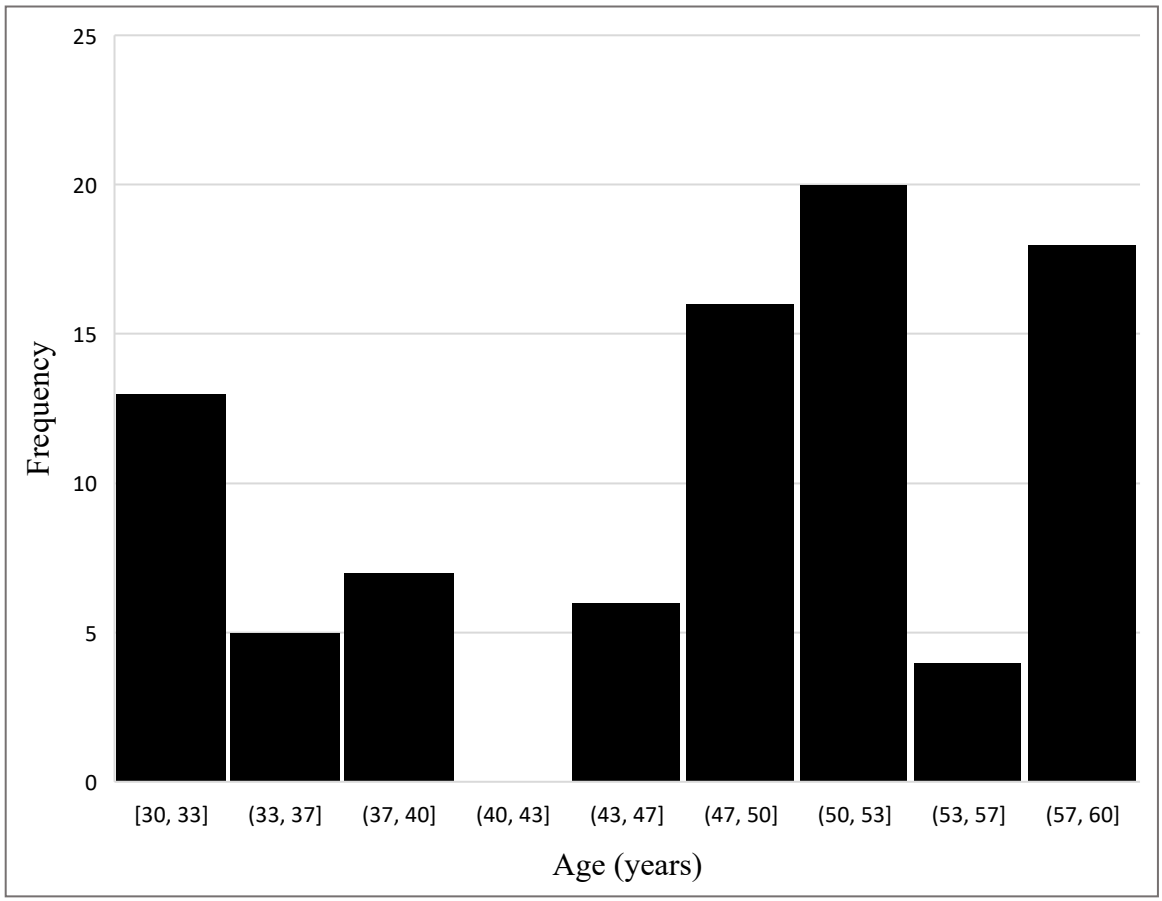
6. Results

The present study aimed to, firstly, explore the influence of variables age, gender and years of education on total MoCA scores. In addition, it aimed to calculate the psychometric properties of the MoCA, specifically discriminant validity and internal consistency. Finally, it aimed to present normative data for the MoCA for a well-defined South African population.

Prior to addressing these aims, the assumption of normality was checked for age, years of education and total MoCA score for the control group (N=89) to determine whether the data were normally distributed (Ghasemi & Zahediasl, 2012). The distribution of data for age is illustrated in figure 1. Visually, the age distribution appears abnormal (Park, 2008). The highest frequency of control participants is between the ages of 50 to 53 years, whilst the lowest frequency is between 53 to 57 years of age. There is no data for participants aged 40 to 43 years. Overall, the majority of participants are between 43 to 60 years of age.

Figure 1

Distribution of data for age (years)

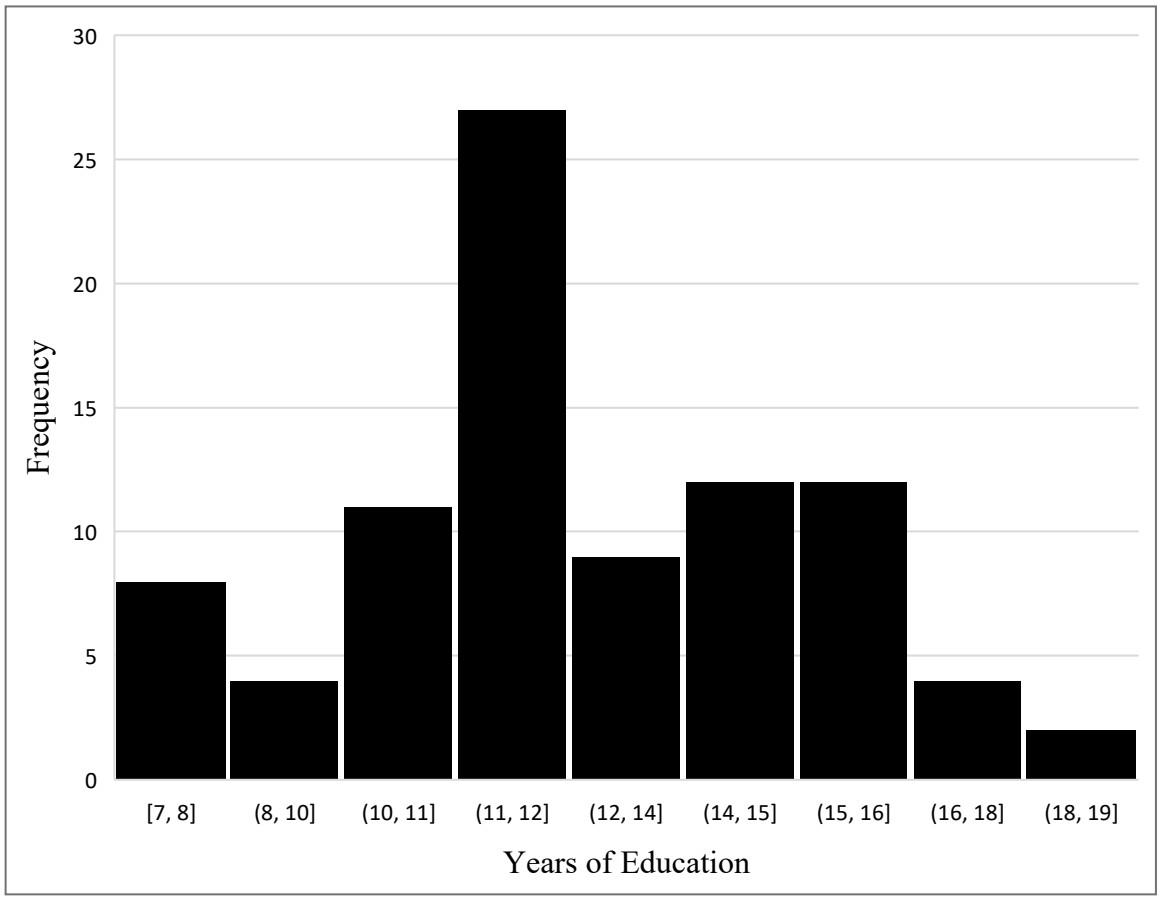


Note. N=89.

The distribution of data for years of education for the control group (N=89) is illustrated in figure 2. Visually, the distribution appears slightly skewed to the right (Park, 2008). The highest frequency of control participants has between 11 to 12 years of education, whilst the lowest frequency of participants has between 18 to 19 years of education. Overall, the majority of participants have 11 or more years of education.

Figure 2

Distribution of data for years of education

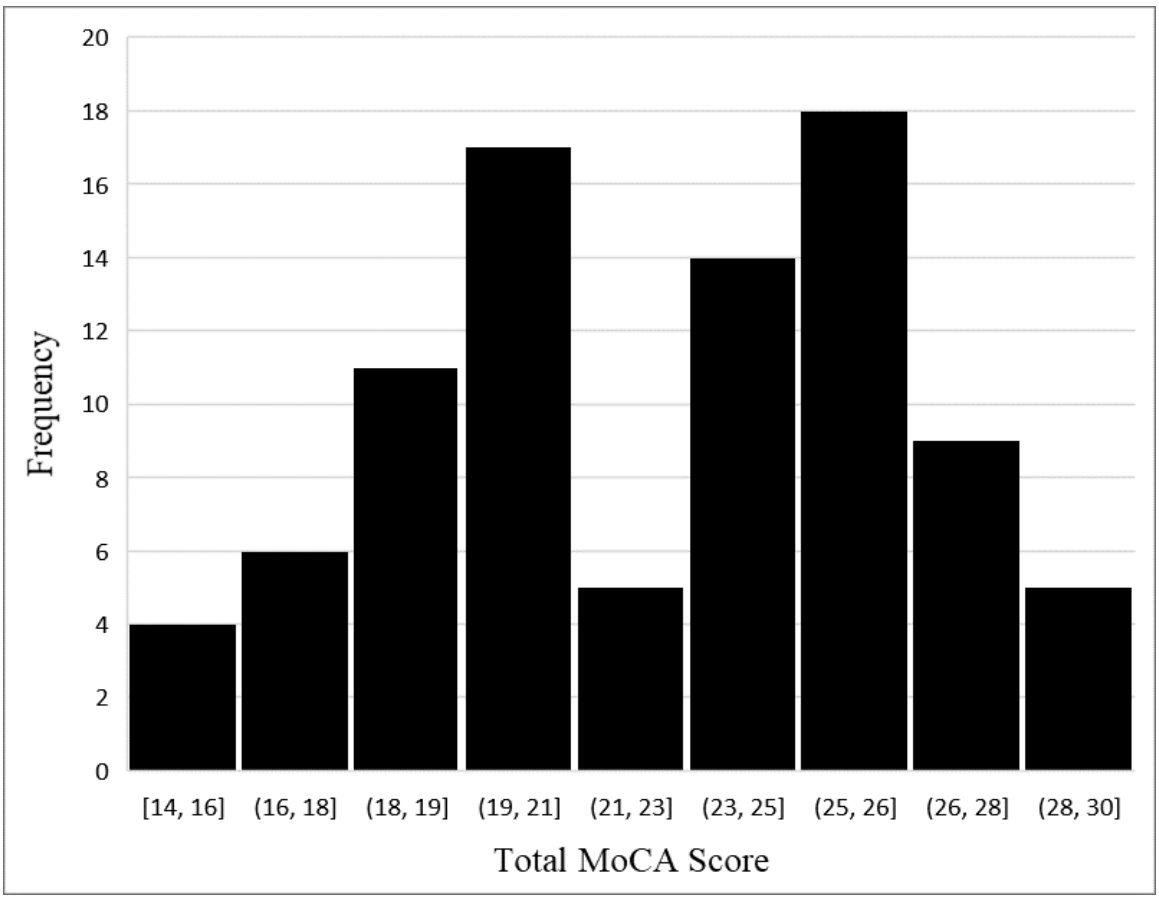


Note. N=89.

The distribution of data for total MoCA score for the control group (N=89) is illustrated in figure 3. Visually, the distribution appears approximately normal and bimodal (Park, 2008), with the two peaks for total MoCA scores between 19 to 21 points and 25 to 26 points, respectively. The lowest frequency of control participants scored between 14 to 16 points on the MoCA.

Figure 3

Distribution of data for total MoCA score



Note. N=89.

Visual inspection of the distribution of data using histograms provide a quick and easy illustrative method for checking for normality, however, it can be subjective (Altman & Bland, 1995). As such, it is recommended that the more objective Shapiro-Wilk (SW) test of normality (table 5) be used to supplement visual inspections (Ghasemi & Zahediasl, 2012). According to the SW test, total MoCA scores for the control group (N=89) were normally distributed ($p=0.072$), whilst age and years of education for the control group (N=89) were significantly non-normal ($p<0.001$ and $p=0.006$, respectively), thus confirming the results of the visual inspections. Logarithmic transformations failed to normalise the distributions (Leydesdorff & Bensman, 2006). Therefore, non-parametric statistical procedures were performed (Altman & Bland, 1995; Mishra et al., 2019).

Table 5

Shapiro-Wilk test of normality

	Shapiro-Wilk	
	Statistic	*p* -Value
Age (years)	0.91	**0.000**
Education (years)	0.96	**0.006**
Total MoCA Score	0.97	0.072

Note. N=89, df=89.

6.1. Effects of Gender, Age and Years of Education on Total MoCA Scores

One-way between subjects' ANOVA for age and years of education, and a χ^2 test of association for gender were conducted to examine how well the diagnostic groups (control, MP and NCD) were matched on these variables. The results of the χ^2 test (table 6) indicate that controls were not well matched to the clinical groups in terms of gender. The proportion of males in the control group (N=41) was significantly higher than in the MP (N=17) and NCD (N=2) groups, $\chi^2(2, N=172)=10.5$, p=0.005. Females constitute the highest frequency overall (65.1%) as well as in each diagnostic category; controls (53.9%); MP (75.7%); NCD (84.6%). Therefore, gender is unequally represented in each group.

Table 6

Chi-square test of association for gender by diagnostic group

	df	Statistic	*p*
Pearson Chi-Square	2	10.5	**0.005**
Likelihood Ratio	2	10.9	0.004
Linear-by-Linear Association	1	10.0	0.002

Note. N=172, df=degrees of freedom. 1 cell (16,7%) has an expected count less than 5, the minimum expected count is 4,53.

The controls were not well matched to the clinical groups in terms of age and years of education according to one-way ANOVA (table 7). There was a statistically significant difference in the mean age of the three groups, $F(2)=12.39$, $p<0.001$. Post hoc comparisons using the Bonferroni test (table 8) revealed that the mean age (in years) of the control group (M=47.5, standard deviation [SD]=9.2) was significantly higher than that of the MP group (M=40.5, SD=8.9), $p<0.001$. However, the mean age of the NCD group did not differ significantly from the control group (M=43.5, SD=5.3), $p=0.402$. In addition, there was a statistically significant difference in the mean years of education of the three groups, $F(2)=13.65$, $p<0.001$. Bonferroni post-hoc comparisons (table 8) revealed that the mean years of education of the control group (M=12.6, SD=2.6) was significantly higher than that of the MP (M=11.1, SD=1.6) and NCD group (M=10.2, SD=2.2), $p<0.001$ and $p=0.001$, respectively.

Taken together, these results indicate that diagnostic groups were not well-matched in terms of gender, age and years of education. Whilst matching may enhance comparability between cases and controls and improve statistical efficiency, variability in the factors of interest is necessary in studies such as this to evaluate the effect that these variables have on total MoCA scores (Bland & Altman, 1994). The logical next question, therefore, is what the association between these variables is.

Table 7

One-way analysis of variance for age and years of education by diagnostic group

	Source	*df*	*SS*	*MS*	*F*	*p*
Age (years)	Between Groups	2	1926.1	963.0	12.30	**0.000**
	Within Groups	169	13230.0	78.3		
	Total	171	15157.1			
Education (years)	Between Groups	2	135.1	67.5	13.65	**0.000**
	Within Groups	169	836.2	4.9		
	Total	171	971.3			

Note. N=172, df=degrees of freedom; SS=sum of squares; MS=mean square.

Table 8

Bonferroni post hoc test for age and years of education by diagnostic group

	Diagnostic Group		Mean			95% Confidence Interval	
Dependent Variable	(I)	(J)	Difference (I-J)	Std. Error	*p*	Lower	Upper
Age (years)	Control	MP	6.99	1.41	**0.000**	3.58	10.41
		NCD	3.96	2.63	0.402	-2.4	10.31
Education (years)	Control	MP	1.57	0.36	**0.000**	0.71	2.43
		NCD	2.48	0.66	**0.001**	0.88	4.07

Note. N=172. Bold values represent the mean difference is significant at the 0.05. level.

Given that the data for age and years of education were non-normally distributed, a non-parametric Spearman's rank-order correlation (table 9) was conducted for the control group (N=89) in order to determine the strength (magnitude), direction (positive or negative) and significance of associations between continuous variables age, years of education and total MoCA scores (Taylor, 1990). Age and years of education were statistically significantly correlated (r_s=-0.41, $p<0.001$). The strength of the association was moderate and the direction was negative, indicating that younger individuals in the sample are better educated. There was a statistically significant correlation between total MoCA score and age (r_s=-0.28, $p=0.007$). The association was negative and weak, indicating that total MoCA scores decrease as age increases. A positive and moderate significant correlation was found between total MoCA score and years of education (r_s=0.38, $p<0.001$), suggesting that total MoCA scores increase as years of education increase.

Table 9

Spearman correlations between age, years of education and total MoCA score

		Age (years)	Education (years)	Total MoCA Score
Age (years)	Correlation Coefficient	1.000		
	Sig.			
Education (years)	Correlation Coefficient	-0.412	1.000	
	Sig.	**0.000**		
Total MoCA Score	Correlation Coefficient	-0.283	0.382	1.000
	Sig.	**0.007**	**0.000**	

Note. N=89. Bold values represent correlations significant at the 0.01 level (2-tailed).

When comparing the performance of males and females on the MoCA, males obtained slightly higher mean total scores on the MoCA (M=22.17, SD=3.72) compared to females (M=21.92, SD=4.26). However, the mean difference of 0.25 points was marginal and not statistically significant according to one-way ANOVA (table 10), F(1,87)=0.82, p=0.368. These results indicate that MoCA performance was not affected by gender in this sample.

Table 10

One-way analysis of variance for gender by total MoCA score

Source	*df*	*SS*	*MS*	*F*	*p*
Between Groups	1	11.97	11.97	0.82	0.36
Within Groups	87	1272.28	14.62		
Total	88	1284.25			

Note. N=89, df=degrees of freedom; SS=sum of squares; MS=mean square.

A GLM (table 11) was conducted to further explore the associations between total MoCA score (dependent variable) and diagnostic group, age, years of education and the interaction between age and years of education (independent variables). Prior to this, the homogeneity of variance (i.e., homoscedasticity) assumption was checked visually using the scatterplot of standardised residuals against standardised predicted values (appendix J). There

is sufficient evidence to suggest equality of variance, thereby reducing the risk of a large type I error (Caudill, 1988; Field, 2009).

When constructing the GLM, only the variables found to be significantly associated with total MoCA scores (i.e., age and years of education) were entered into the model as covariates and thereby statistically controlled. Gender was excluded from the model given that it did not exert a significant effect on MoCA performance. According to the results (table 11), the interaction between age and years of education was not statistically significant and therefore removed from the model. Only the effect of years of education [F(1)=7.1, p=0.009] was significant, whereas the effect of age [F(1)=3.2, p=0.077] and diagnostic group [F(2)=0.9, p=0.416] was not significant. This finding supports the significance of the relationship between years of education and MoCA performance, and further indicates that the effect of diagnostic group status on total MoCA score is insignificant, likely due to the control and clinical groups obtaining similar mean total MoCA scores.

Table 11

Summary of the General Linear Model with the total MoCA score as the dependent variable

Source	*df*	Type III *SS*	*MS*	*F*	*p*
Model	4	244.2	61.0	4.2	0.003
Age (years)	1	46.0	46.0	3.2	0.077
Education (years)	1	103.1	103.1	7.1	**0.009**
Diagnostic group	2	25.7	12.9	0.9	0.416
Error	166	2416.7	14.6		
Total	171	86042.0			
Corrected Total	170	2660.9			

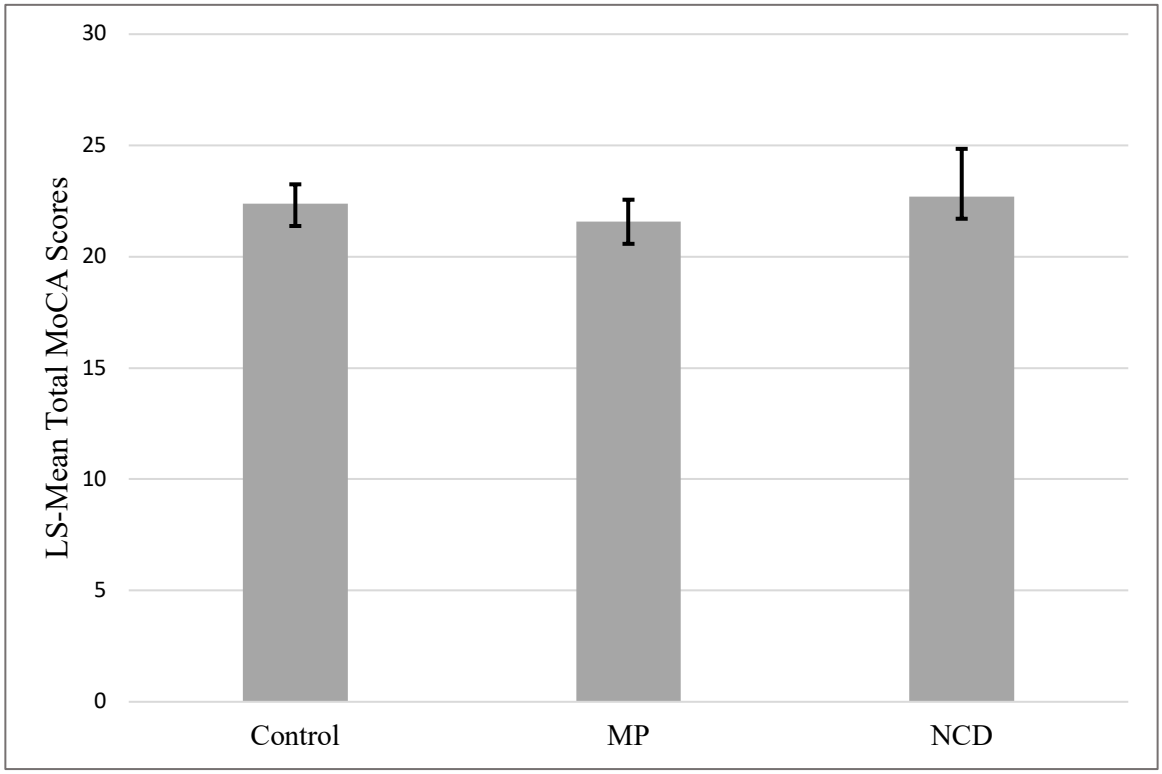
Note. N=171, one outlier removed based on model diagnostics. R-Squared=0,092, Adjusted R-Squared=0,070. df=degrees of freedom, SS=sum of squares, MS=mean square.

Given the unbalanced diagnostic group sizes and demographic heterogeneity of the sample, the resultant raw mean total MoCA scores may not be representative (Cai, 2014). Therefore, least squares (LS) means (also referred to as estimated marginal means; Lenth et al.,

2021) for total MoCA scores were derived from the GLM to provide means adjusted for the unequal observations in each group (Cai, 2014). These adjusted means were identical to the raw means, indicating that the results of the total MoCA scores cannot be attributed to the unbalanced group sizes. The adjusted means for the controls (22.5 points) was only slightly higher than the MP (21.5 points) and NCD (22.2 points) groups (figure 4) and not statistically significantly different, $F(2)=1.14$, $p=0.321$ (see appendix K). However, as illustrated by the error bars (figure 4) representing the 95 percent confidence interval (CI) for the mean (Mishra et al., 2018), the NCD group (95% CI: 20.0-24.3) had the greatest variability in total MoCA scores compared to the MP group (95% CI: 20.6-22.5) and controls (95% CI: 21.7-23.3).

Figure 4

Least squares mean total MoCA scores per diagnostic group



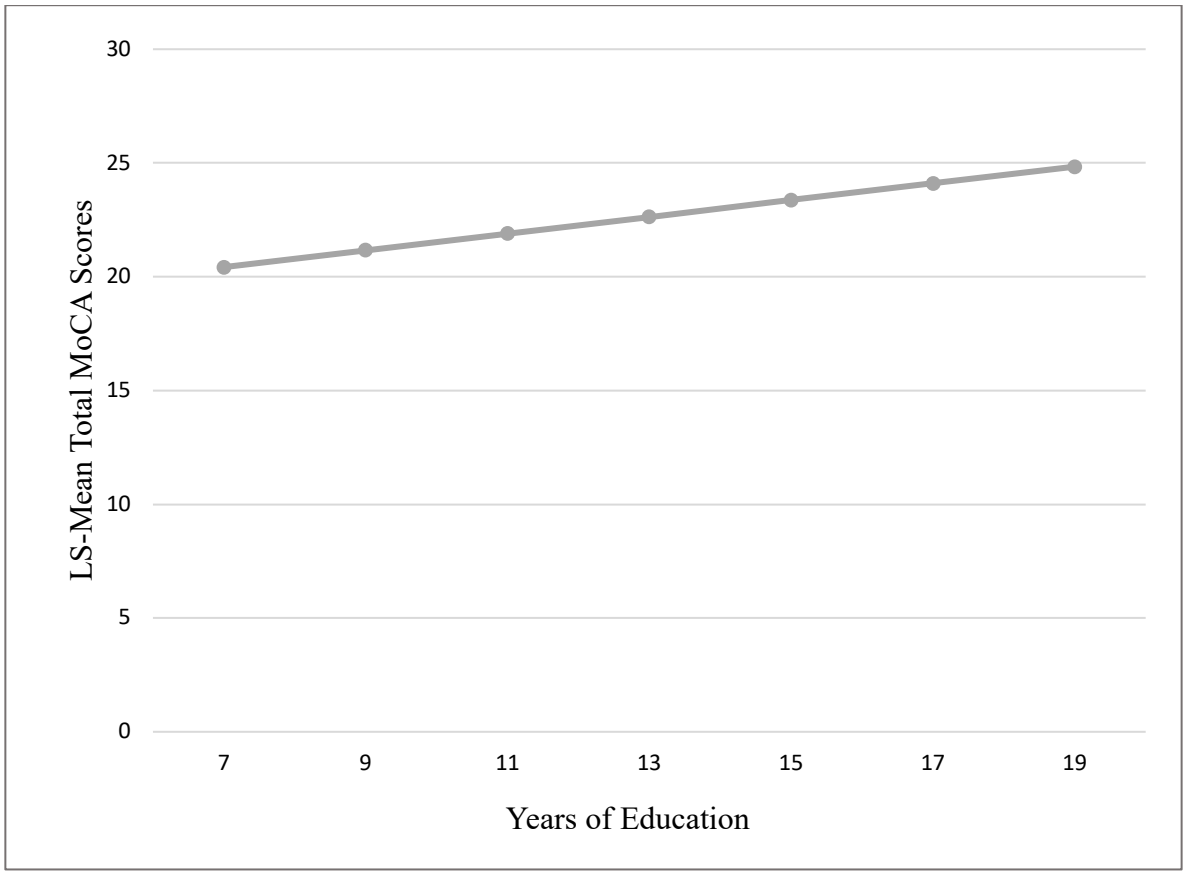
Note. N=171. One outlier removed based on model diagnostics. Error bars denote the 95% confidence interval for the mean.

Given the significant effect of level of education relative to age on total MoCA scores, LS means (Cai, 2014) for years of education were derived from the control group (N=89) and

plotted in figure 5. The adjusted mean total MoCA scores increased by an estimated 0.37 points for every additional year of education. The positive slope illustrates that as years of education increases, so do total MoCA scores, reinforcing the results of the Spearman's correlation. Adjusted mean total MoCA scores ranged between 20.4 points for individuals with the least years of education (7 years) to 24.8 points for individuals with the highest years of education (19 years) at an average age of 47.5 years.

Figure 5

The effect of years of education on total MoCA scores



Note. N=89. Illustrated for the control group at an average age of 47.5 years.

6.2. Discriminant Validity of the MoCA

In addressing the second research question, multinominal logistic regression (table 12) was used to develop predictive models for each diagnosis (vs. the control group) based on total

MoCA score, age and years of education. This was done in order to determine whether diagnostic group belonging can accurately be predicted by total MoCA scores when controlling for the effects of known covariates (i.e., age and years of education). Non-significant covariates (i.e., gender) and the interaction between age and years of education were excluded from the model to avoid over-fitting.

For the MP versus control group, the full regression model (with all terms) reveals that the effect of total MoCA score was not significant (β=-0.05, p=0.285), whilst age (β=-0.12, p<0.001) and years of education (β=-0.50, p<0.001) were significant independent predictors. Similarly, for the NCD versus control group, the full regression model shows that only the effect of age (β=-0.11, p=0.007) and years of education (β=-0.73, p<0.001) were significant, whilst the effect of total MoCA score was not significant (β=0.01, p=0.916).

These results indicate that belonging to control, MP and NCD groups, respectively, could not be predicted by total MoCA scores. Rather, age and years of education were significant independent predictors of diagnostic group belonging. These results signify the poor discriminant validity of the MoCA and highlight the importance of taking demographic variables into consideration when administering and interpreting the MoCA. Given these findings, sensitivity, specificity, and cut-off values for the MoCA were not subsequently calculated. These results may be attributable to the finding that total MoCA scores did not differ significantly between control, MP and NCD groups, even when adjusted for the unbalanced group sizes. Three possible explanations are explored in the discussion. Having determined the validity of the MoCA in this sample, the internal consistency reliability will be determined next.

Table 12

Regression analysis of parameters for each clinical group versus the control group

Model	Parameter	β	Standard Error	Wald Chi-Square	*p*
MP vs Control	Intercept	12.16	2.29	28.15	0.000
	Age (years)	-0.12	0.02	27.13	**0.000**
	Education (years)	-0.50	0.12	18.74	**0.000**
	Total MoCA Score	-0.05	0.05	1.14	0.285
NCD vs Control	Intercept	10.94	3.95	7.67	0.006
	Age (years)	-0.11	0.04	7.24	**0.007**
	Education (years)	-0.73	0.20	13.43	**0.000**
	Total MoCA Score	0.01	0.08	0.01	0.916

Note. N=172, df=1.

6.3. Internal Consistency of the MoCA

In addressing the third research question, reliability analyses using Cronbach's (1951) alpha coefficient were conducted to determine whether the MoCA has acceptable internal consistency in this sample. Cronbach's alpha was 0.64 indicating moderate internal consistency of the MoCA in this sample.

Inter-item correlations (table 13) are a way of analysing internal consistency by measuring whether items on the full scale or items within a subscale correlate well with one another (Ferketich, 1991). Unrelated items that do not measure the same construct will have a low correlation ($r \leq 0.30$; Ferketich, 1991). According to the results (table 13), the highest correlation is between the trail-making task and tapping task ($r=0.34$), indicating that all items are weakly correlated and therefore do not measure the same construct (de Souza et al., 2017). This is to be expected given that the MoCA represents a multidimensional scale designed to measure a variety of cognitive functions as opposed to one unified cognitive function, and does not contain any subscales (Nasreddine et al., 2005).

Table 13

Inter-item correlation matrix for the 12 items of the MoCA

MoCA Items	1	2	3	4	5	6	7	8	9	10	11	12
1. Trail Making	1.00											
2. Cube Drawing	0.19	1.00										
3. Clock Drawing	0.11	0.20	1.00									
4. Digit Span	0.22	0.10	0.06	1.00								
5. Tapping	0.34	0.31	0.09	0.24	1.00							
6. Serial Subtraction	0.17	0.30	0.24	0.16	0.21	1.00						
7. Naming	0.08	0.06	0.16	0.04	0.09	0.03	1.00					
8. Repetition	-0.09	0.09	0.16	0.22	0.03	0.15	0.17	1.00				
9. Fluency	0.10	0.02	0.18	0.24	0.19	0.23	0.18	0.33	1.00			
10. Abstraction	0.10	-0.02	0.20	0.09	0.07	0.01	0.30	0.19	0.29	1.00		
11. Delayed Recall	0.04	0.16	0.17	0.10	0.14	0.23	0.23	0.30	0.26	0.26	1.00	
12. Orientation	0.06	0.08	0.04	0.10	-0.05	0.07	0.05	0.01	0.010	0.15	0.19	1.00

Note. N=172.

Item-total statistics of the MoCA are summarised in table 14. There is substantial variability in corrected item-total correlations, reinforcing the results of the abovementioned inter-item correlations (de Souza et al., 2017). Furthermore, with reference to the column titled 'Cronbach's alpha if item deleted', all item values are less than or equal to the overall reliability of 0.64, indicating that all items are positively contributing to the overall reliability of the scale, and the scale would not be improved if any MoCA items were to be removed (Field, 2009). Having determined the reliability and validity of the MoCA, as well as the associations between total MoCA scores, age, gender and years of education, normative data can now be reported.

Table 14

Item-total statistics for the 12 items of the MoCA

MoCA Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
1. Trail Making	21.13	16.79	0.20	0.18	0.63
2. Cube Drawing	21.35	16.43	0.28	0.21	0.62
3. Clock Drawing	19.43	15.21	0.31	0.13	0.61
4. Digit Span	20.30	15.89	0.26	0.16	0.62
5. Tapping	20.98	16.70	0.29	0.24	0.63
6. Serial Subtraction	19.80	14.30	0.34	0.21	0.61
7. Naming	19.24	15.70	0.28	0.14	0.62
8. Repetition	20.63	15.03	0.35	0.22	0.61
9. Fluency	21.38	15.80	0.43	0.25	0.61
10. Abstraction	20.51	15.54	0.32	0.21	0.61
11. Delayed Recall	19.06	10.68	0.41	0.22	0.62
12. Orientation	15.88	17.24	0.18	0.08	0.64

Note. N=172.

6.4. Normative Data for the MoCA

Prior to reporting normative values that will address the fourth and final aim of the study, relevant stratifications for the norms needed to be determined. Given that age and years of education (but not gender) had a significant effect on MoCA performance, the norms were stratified by these two variables only. Subsequently, a series of independent sample's t-tests (tables 15 and 16, respectively) were conducted for the control group (N=89) in order to determine the relevant stratifications for age and years of education.

In terms of the stratifications for age (table 15), results indicate that the 47 participants aged 50 years or younger obtained significantly higher mean total MoCA scores (M=23.34, SD=3.74) compared to the 42 participants aged 51 years or older who obtained a mean total MoCA score of 21.55 points (SD=3.72), $t(87)=2.26$, $p=0.026$.

Table 15

Independent samples t-test for age

	df	t	*p* (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
						Lower	Upper
Equal variances assumed	87	2.26	**0.026**	1.79	0.79	0.22	3.37
Equal variances not assumed	85.99	2.26	0.026	1.79	0.79	0.22	3.37

Note. N=89. Bold values represent the mean difference is significant at the 0.05 level.

Regarding the stratifications for years of education (table 16), the 23 participants with 11 or less years of education obtained significantly lower mean total MoCA scores (M=20.35, SD=4.14) compared to the 66 participants with 12 or more years of education (M=23.24, SD=3.43), t(87)=-3.30, p=0.001.

Table 16

Independent samples t-test for years of education

	df	t	*p* (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
						Lower	Upper
Equal variances assumed	87	-3.30	**0.001**	-2.90	0.88	-4.64	-1.15
Equal variances not assumed	33.13	-3.01	0.005	-2.90	0.96	-4.85	-0.94

Note. N=89. Bold values represent the mean difference is significant at the 0.05 level.

The results of the independent samples t-tests for age and years of education were subsequently used in the stratification of normative data (table 17). Note that whilst the performance of the sample aged between 30 to 50 years with between seven to eleven years of education were used in the calculation of normative values, the number of observations in this category was small (N=3) and therefore cannot be reported as part of the norms.

Table 17

South African norms for the MoCA stratified by age and years of education

Age (years)	Education (years)	N	Mean	SD	Median	Min	Max	Percentiles						
								5	10	25	50	75	90	95
30-50	≥12	44	23.41	3.53	24.00	15	30	16.25	19.00	21.00	24.00	26.00	28.50	29.00
51-60	7-11	20	20.05	3.69	19.50	15	28	15.00	15.10	17.25	19.50	21.50	26.80	27.95
	≥12	22	22.91	3.27	23.50	17	29	17.15	18.30	20.00	23.50	25.00	27.70	28.85

Note. N=89. The performance of the samples between 30 to 50 years of age with 7 to 11 years of education cannot be taken as normative due to small subgroup size (N=3).

7. Discussion

The present study aimed to determine the influence of age, gender and years of education on total MoCA scores. In addition, to explore the internal consistency and discriminant validity of the MoCA. Finally, to present normative data for a well-defined South African population. The results addressing these aims will be discussed.

7.1. Influence of Age, Years of Education and Gender on Total MoCA Score

In the present study, total MoCA scores were negatively correlated with age and positively correlated with years of education, suggesting that older age and less years of education are associated with lower total MoCA scores. In another South African study of 370 cognitively healthy participants, Beath et al. (2018) also found that total MoCA scores were significantly negatively correlated with age ($r=-0.20$, $p<0.01$) and significantly positively correlated with years of education ($r=0.33$, $p<0.01$). In a large population-based sample (N=2653) in North America aged 18 to 85 years (M=50.30 years) with a mean 13.4 years of education, total MoCA scores were significantly negatively correlated with age ($r=-0.21$, $p\leq0.001$) and significantly positively associated with education ($r=0.42$, $p\leq0.001$; Rossetti et al., 2011). Despite the differences in sample demographics between these studies, age and years of education are consistently found to be associated with performance on the MoCA (Freitas et al., 2012d; Pinto et al., 2018; Zheng et al., 2012).

Gender did not exert a significant effect on total MoCA scores in this study. Whilst this could be a product of the unequal representation of females and males in the sample, the overall proportion of females (65.1%) is consistent with other MoCA studies in which females constitute 60 to 68 percent of the sample, yet significant gender differences also did not emerge (Malek-Ahmadi et al., 2015; Rossetti et al., 2011; Santangelo et al., 2015). Some studies, however, did report significant gender effects on the MoCA (Kaya et al., 2014; Larouche et al., 2016; Lu et al., 2011).

Significant gender effects may be attributed to differences in educational attainment or, by proxy, other socioeconomic factors. In a Turkish sample of 474 participants with AD (N=114, 57.0% female), MCI (N=114, 42.9% female) and controls (N=246, 60.1% female), Kaya et al. (2014) found a significant gender-group interaction in which females obtained lower MoCA scores compared to males in the AD group. No significant gender differences emerged in the MCI and control groups. The AD group had lower levels of education compared to MCI and control groups (Kaya et al., 2014). Similarly, in a large community-based sample of elderly Chinese participants with MCI (N=1687, 56.3% female), dementia (N=441, 68.7% female) and controls (N=6283, 52.1% female), Lu et al. (2011) also found that males obtained higher mean MoCA scores relative to females among individuals with less education. These results suggest that gender differences may be more pronounced in less educated groups (Kaya et al., 2014; Lu et al., 2011).

Another trend that can be observed in these studies is that females obtained lower mean MoCA scores than males (Kaya et al., 2014; Lu et al., 2011). Using data from the Brazilian Aging Brain Study Group, Farfel et al. (2013) found that individuals without formal education were older, more likely to be female and have a lower socioeconomic status (SES). Lu et al. (2011) also notes that in the Chinese context, women tend to have a lower SES than their male counterparts, particularly among older generations, which negatively impacts their test-taking abilities. These findings suggest a strong interplay between gender and social factors such that studies conducted in contexts where women are, on average, less educated and have a lower SES than their male counterparts, gender differences on neuropsychological tests become evident (Larouche et al., 2016; Lu et al., 2011; Zhang et al., 1990). Therefore, the effects of gender can be attributed to other factors such as age and particularly education (Borland et al., 2017; Konstantopoulos et al., 2016; Larouche et al., 2016; Lu et al., 2011).

When the association between total MoCA scores, age and years of education were further explored in the GLM, it was found that years of education was significantly associated with total MoCA score whilst age was not. The effect of age is more ambiguous in the literature, with some studies finding that total MoCA scores decrease as age increases (Beath et al., 2018; Rossetti et al., 2011), whilst other studies find no association (Luis et al., 2009; Robbins et al., 2013). This could be due to the interactive effect between age and years of education. According to the cognitive reserve hypothesis, more years of formal education may delay the onset and severity of cognitive decline in geriatric populations (Stern, 2009). Higher levels of formal education are associated with greater preservation of cognitive functions and later onset of dementing illnesses (Amieva et al., 2014; Bourgeois et al., 2020; Cross et al., 2013). As such, older but more educated individuals may obtain higher total MoCA scores versus younger but less educated individuals (Pinto et al., 2018).

In this study, a significant negative correlation was found between age and years of education. This inverse relationship suggests that younger individuals in the sample are better educated. This finding may be indicative of the current post-apartheid era in which younger generations of English second- or third-language speakers are gaining increasing access to better educational opportunities and are obtaining higher levels (i.e., more years) of education (Laher & Cockcroft, 2013; Watts & Shuttleworth-Edwards, 2016).

The contribution of level of education on MoCA performance in this study was such that total MoCA scores increased by an estimated 0.37 units for every additional year of education. Adjusted mean total MoCA scores ranged between 20.4 points for the controls with 7 years of education to 24.8 points for subjects with 19 years of education. The control group displayed a performance that was well below the originally recommended cut-off point of 26, despite being considerably younger. This cut-off was derived from a predominantly homogenous, Caucasian, western and well-educated sample (Nasreddine et al., 2005). The performance of the current control sample was comparable with an ethnically diverse population-based sample in Texas (N=2653, M=50.30 years of age, M=13.35 years of education), whereby mean total MoCA scores ranged between 20.5 points for individuals with the least years of education (<12 years) to 24.8 points for individuals with the highest level of education (>12 years; Rossetti et al., 2011). Rossetti et al. (2011) also found that Caucasians had significantly more years of education and obtained significantly higher mean total MoCA scores than Black, Hispanic and Other groups. Therefore, differences in mean MoCA scores

cannot be attributed on the basis of ethnicity as ethnicity is associated with socioeconomic inequalities, which, as in South Africa, are linked to access to resources and quality of education (Ardila, 1995; Brickman et al., 2006; Laher & Cockcroft, 2013; Manly, 2005; Rossetti et al., 2011; Shuttleworth-Edwards et al., 2004; Shuttleworth-Jordan, 1996).

Numerous studies with differing sample characteristics and contextual factors have reported the original cut-off point of 26 to be too stringent, increasing the risk of misclassification and false positives (Conti et al., 2015; Freitas et al., 2011; Luis et al., 2009; Pinto et al., 2018; Wong et al., 2015). The most affected by misclassification are less educated individuals, however, even highly educated individuals with no cognitive impairment still obtain mean MoCA scores within the 'abnormal' range (Elkana et al., 2020; Rossetti et al., 2011). These findings were corroborated in the present study in which highly educated control subjects (19 years of education) still scored below the originally recommended cut-off of 26, on average. Therefore, low MoCA scores cannot be assumed to reflect cognitive impairment (Robbins et al., 2013). Given that the MoCA is increasingly being used in a variety of settings, these results highlight that one cut-off does not fit all and emphasise the importance of taking sociodemographic variables into account, such as age and particularly level of education, when administering and interpreting the MoCA in order to reduce instances of misclassification (Elkana et al., 2020).

7.2. Discriminant Validity of the MoCA

According to the regression model, both age and years of education were significant independent predictors of belonging to control, MP or NCD groups. However, total MoCA scores were not a significant predictor of belonging to these diagnostic categories, even when controlling for the effects of known covariates (i.e., age and years of education). These results suggest that the MoCA lacks adequate discriminant validity, as diagnostic group belonging is predicted by age and years of education rather than total MoCA score. These findings are likely a product of all three diagnostic groups obtaining similar mean total MoCA scores: control (M=22.5 points), MP (M=21.4 points), NCD (M=22.2 points). Contrary to expectations, the clinical groups did not perform poorer on the MoCA compared to the controls. These findings contrast with another South African study in which the HIV-positive group performed significantly poorer overall on the MoCA (M=18.62, SD=4.39) relative to the HIV-negative

controls (M=21.67, SD=2.00; Robbins et al., 2013). Three possible explanations for these results will be systematically explored.

First, in Robbins et al. (2013) study, the number of participants in the HIV-positive (N=39) and HIV-negative (N=39) groups were balanced, whereas in the present study diagnostic group sizes were unbalanced. However, the means adjusted for the unequal observations in each diagnostic category were identical to the raw observed means, suggesting that the total mean MoCA scores obtained are not a product of the unbalanced group sizes (Cai, 2014). In addition, Robbins et al.'s (2013) study did not account for common comorbidities in the HIV population, such as depression and psychosis, thereby reducing the representativeness of the sample. Participants with these comorbidities were included in the present study, thus improving the generalisability of findings to PLWH with comorbidities.

The 95 percent CIs indicated that the control group had the smallest variability in total MoCA scores, followed closely by the MP group, whilst the NCD group showed the greatest variability. The MP and control groups may have had a similar variability in total MoCA scores because psychiatric disorders may not have a major impact on MoCA test performance. Bourgeois et al. (2020) found that cognitive impairment (as assessed via a total MoCA score <26) was not associated with psychiatric illness in PLWH. In accounting for the greater variability observed in the NCD group, the severity of cognitive impairment among individuals diagnosed with NCDs can differ substantially (Haddow et al., 2016). Some may experience asymptomatic or mild cognitive impairment and therefore score similar to controls, whilst others, particularly those diagnosed with HAD, may experience more substantial cognitive impairment and hence obtain lower scores on the MoCA (Vally, 2011). The study did not distinguish participants based on the severity of NCD and may have included individuals ranging from mild, moderate to severe cognitive impairment, which could explain the greater variability observed in total MoCA scores amongst the NCD group.

Further to the severity of cognitive impairment inflicted by different diagnoses, it is well established that cognitive functioning as assessed by the MoCA can be influenced by age and years of education (Elkana et al., 2020). Due to age-related cognitive decline, total MoCA scores decrease as age increases (Freitas et al., 2012d). The age of the sample in Robbins et al.'s (2013) study was considerably younger compared to the present sample, ranging between 19 to 46 years (M=29.62), which could explain why Robbins et al. (2013) did not find any

significant age effects on the MoCA. Furthermore, the effect of age on total MoCA scores is attenuated by educational attainment. The cognitive reserve hypothesis maintains that more years of formal education contribute to greater cognitive preservation which can mitigate the effects of age-related cognitive decline in healthy subjects (Stern, 2009). In clinical subjects, Amieva et al. (2014) found that subtle impairment in some cognitive domains is detectable up to 20 years prior to the onset of full-blown dementia in highly educated subjects and up to seven years earlier in less educated subjects. Whilst the present sample have at least seven years of formal education, Farfel et al. (2013) concluded that even a few years of formal education contributes to cognitive reserve. Whilst Robbins et al.'s (2013) sample also had at least seven years of education (range 7-13 years), the present study includes more highly educated individuals (range 7-19 years), thus potentially experiencing greater cognitive preservation and hence minimal cognitive impairment.

The severity or extent of cognitive impairment could also be influenced by extraneous variables, such as the length of time since the onset of illness and adherence to treatment (Crum-Cianflone et al., 2013). Length of time since the onset of illness is important to consider because HIV-associated cognitive symptomatology becomes progressively more severe over time, particularly as is the case with HAD (Amieva et al., 2014; Heaton et al., 1995). Cole et al. (2007) found that cognitive functions remain generally stable over the first five years in HIV patients undergoing highly active antiretroviral therapy. Thus, the extent of cognitive impairment can be maintained or even improved by adherence to treatment factors (Awori et al., 2018; Bourgeois et al., 2020; Cysique et al., 2011; Haddow et al., 2016; Joska et al., 2010). If patients were diagnosed early and receiving appropriate treatment and care, the severity of cognitive impairment may be minimal and manageable (Crum-Cianflone et al., 2013). The minimum of seven years of formal education in conjunction with the relatively young age of the sample (≤61 years) could also indicate greater cognitive preservation and hence minimal impairment, even in patients diagnosed with HAD (Amieva et al., 2014).

In the present study, total MoCA scores were not a significant predictor of diagnostic group status because the groups did not obtain significantly different mean total scores on the MoCA. Contrastingly, in Robbins et al.'s (2013) study, HIV status was a significant predictor of total MoCA scores because the HIV-positive group obtained significantly lower mean MoCA scores relative to the HIV-negative controls. However, Robbins et al. (2013) conducted

multiple comparisons without corrections, which may have resulted in high Type I error and thus any significant differences that emerged may be false discoveries.

The MoCA was originally validated in a well-educated North American sample of adults over the age of 70 years with either no cognitive impairment, MCI or AD (Nasreddine et al., 2005). Other studies in samples with different characteristics have highlighted the inadequacy of the MoCA in screening for more severe forms of HAND, such as HAD (Awori et al., 2018; Brito-Marques et al., 2019; Joska et al., 2016; Kim et al., 2016; Robbins et al., 2013). For instance, Kim et al. (2016) found that the MoCA and its subtests are not sufficient in screening for HAND in a South Korean sample comprising 51 HIV patients diagnosed with HAND (M=44.39 years old; M=12.8 years of education) and 143 HIV patients without HAND (M=45.38 years old; M=13.6 years of education). Joska et al. (2016), using combined data from North America and South Africa, found that the MoCA yielded excellent sensitivity (100%) but poor specificity (22%) in screening for HAD. Joska et al. (2016) stated that "a screener used in the USA [United States of America] should also be useful in Africa […]" (p. 3). Whilst this may be true for well-educated, highly acculturated first language English speakers, the same may not apply to less westernised English second- or third-language speaking populations (Laher & Cockcroft, 2013; Nyamayaro et al., 2019). Robbins et al. (2013) identified culturally and linguistically biased test items on the MoCA, therefore modifying the MoCA in an attempt to improve its utility in less educated South Africans. However, Hakkers et al. (2018) demonstrated the poor utility of this version of the MoCA for screening for HAND in South Africa. The third possibility is therefore that the discriminant validity of the MoCA (Nasreddine et al., 2005) does not extend to populations with different socio-demographic characteristics and/or to PLWH experiencing psychiatric and NCD comorbidities.

In sum, it is not likely that the results obtained were a product of the unbalanced group sizes as the means adjusted for these unequal observations were identical to the raw observed means (Cai, 2014). Another possibility is therefore that the patients may not have experienced significant cognitive impairment, due to factors contributing to greater cognitive reserve (Stern, 2009). These factors include variables that were measured in the study, such as the minimum of seven years of education (at least primary school) as well as the relatively young age of the sample (≤61 years). However, it may also be explained by extraneous variables that were not measured in the study, such as the length of time since the onset of illness and adherence to treatment (Crum-Cianflone et al., 2013). The final possibility pertains to the idea that the utility

of the MoCA does not extend beyond its original scope for MCI and AD in samples with different clinical diagnoses and demographic characteristics, as other studies have demonstrated (Brito-Marques et al., 2019; Kim et al., 2016; Robbins et al., 2013).

7.3. Internal Consistency of the MoCA

Having addressed the discriminant validity of the MoCA, the internal consistency of the MoCA will be discussed. In the present study, the MoCA showed modest internal consistency via a Cronbach's alpha coefficient of 0.64. This is comparable to a previous South African study which reported a Cronbach's alpha of 0.62 for a sample of 370 cognitively healthy adults (Beath et al., 2018). In contrast, the original validation study in Canada reported a high internal consistency reliability of 0.83 for the MoCA (Nasreddine et al., 2005).

The present findings might suggest that the MoCA lacks acceptable internal consistency when measured against the criterion that a value of 0.80 is the minimum acceptable for a diagnostic test (Field, 2009). However, Kline (1999) notes that values below 0.70 can realistically be expected when dealing with diverse psychological constructs. This is particularly true regarding the MoCA as it represents a multi-construct scale intended to measure multiple aspects of cognition (Nasreddine et al., 2005). Alternatively, the moderate internal consistency could be a result of inconsistent responses to items amongst the sample (de Souza et al., 2017). This may be due to different levels of English proficiency amongst the respondents, which was not measured in this study (Laher & Cockcroft, 2013).

The MoCA is a brief, multi-construct, inexpensive and easily administered pen-and-paper test (Nasreddine et al., 2005). These characteristics render it particularly useful in rural and under resourced clinical contexts to make neuropsychological assessment more accessible for individuals who cannot afford expensive full assessments (Robbins et al., 2013). Given the moderate internal consistency reliability and poor discriminant validity of the MoCA, the MoCA cannot substitute full neuropsychological assessment batteries (Brito-Marques et al., 2019). Rather than a screening or diagnostic tool, the MoCA may be better used to assess global cognitive capacity and provide significant clinical data to assist healthcare professionals in directing further clinical evaluation (Musso et al., 2018). When used for this purpose, the alpha coefficient of 0.64 may be considered acceptable.

7.4. Normative Data for the MoCA

Although the MoCA showed moderate internal consistency and poor discriminant validity in this study, these preliminary norms may offer useful guidelines for healthcare practitioners to determine whether a patient's cognitive performance on the MoCA is in accordance with other English second- or third-language speaking South Africans with the same age and education, or whether the patient may require more extensive evaluation to determine a clinical diagnosis (Brito-Marques et al., 2019).

Given the significant effect of age and years of education on total MoCA scores, the normative data reported in this study were stratified by these two variables only. Whilst there was a significant correlation between age and years of education, the significance of the interaction between these variables was not maintained in the GLM. However, the normative data supports the correlation. For instance, the norms showed that older individuals aged 51 to 60 years with less than 12 years of education scored a total mean of 20.05 points, whereas younger participants aged 30 to 50 years old with 12 or more years of education scored three points higher with a total mean of 23.41 points on the MoCA. This emphasises the need for stratified norms that include both age and education (Elkana et al., 2020). Numerous other studies have chosen to stratify normative data and/or cut-off scores for the MoCA by age and years of education (Borland et al., 2017; Conti et al., 2015; Freitas et al., 2011; Kenny et al., 2013; Konstantopoulos et al., 2016; Pinto et al., 2018; Rossetti et al., 2011; Santangelo et al., 2015; Sink et al., 2015; Wong et al., 2015).

The present study reports age- and education- corrected normative data as opposed to cut-off scores. One advantage of cut-off scores is that they are accompanied by sensitivity and specificity values which provide good indications of the ability of the test to discriminate individuals with cognitive impairment from those without (Malek-Ahmadi et al., 2015). However, cut-off values do not usually account for significant covariates, thus increasing the risk of misclassification (Malek-Ahmadi et al., 2015). On the other hand, normative scores stratified for age and level of education may reduce the occurrence of misclassification by allowing clinicians to be more confident in determining whether the patient's cognitive performance may be related to their age or level of education, or whether they require further assessment (Elkana et al., 2020).

7.5. Study Limitations and Recommendations

This study notes some limitations on the basis of which to provide recommendations for future research. One of the limitations of using archival data is that it reduces the researchers control over some aspects of the research, such as sampling and group matching (Jones, 2010). While groups were matched in terms of having public education and English not as a first language, diagnostic groups were not well-matched in terms of study variables age, gender and years of education. However, archival data facilitates preliminary studies such as this which could otherwise not be conducted during times of elevated risk, such as during a pandemic. In addition, variability in age, gender and years of education is necessary in studies such as this in order to evaluate the effect that these variables have on total MoCA scores (Bland & Altman, 1994).

By including individuals under the broad concept of public education, the study may have overlooked the underlying qualitative diversity accommodating this category, such as well-resourced versus under-resourced education (Shuttleworth-Edwards et al., 2004). The effects of variables that were not measured in the study, such as quality of education, SES and language proficiency should also be explored in future research on the MoCA, as these variables have been known to influence performance on neuropsychological tests (Bourgeois et al., 2020; Brickman et al., 2006; Chan et al., 2019; Hackman & Farah, 2009; Laher & Cockcroft, 2013; Robbins et al., 2013; Shuttleworth-Jordan, 1996).

South African populations are diverse, therefore, the characteristics of the sample may limit generalisability to dissimilar populations (Murad et al., 2018). The relatively small size of the subgroups also limits the accuracy of inferences that can be drawn, especially of the NCD group (N=13). Future studies on the MoCA in South Africa should recruit larger samples, including participants younger than 30 years and older than 61 years, as well participants with less than seven years of formal education. Longitudinal studies may also help identify whether the MoCA can be used to evaluate cognitive changes relating to disease progression in people with dual diagnoses (Caruana et al., 2015). Nevertheless, findings from this study may assist researchers and healthcare practitioners working with similar populations.

The MoCA data used in the present study was obtained by different administrators. Therefore, some degree of variability may have existed between examiners resulting in high inter-rater reliability (Bajpai et al., 2015). This form of reliability was not assessed, therefore, future research should explore the extent to which administration from different examiners affect MoCA scores. Convergent validity of the MoCA should also be evaluated against other screening tools specialised in HIV and dual diagnoses, such as the HDS and IHDS (Bajpai & Bajpai, 2014).

Whilst the present study did not conduct item analyses, Robbins et al. (2013) identified culturally and linguistically biased MoCA test items in a non-English speaking South African sample. Future research utilising methods of item analysis may contribute towards the accurate translation and cultural adaptation of the MoCA in the South African context (Robbins et al., 2013). Moreover, adapting the suitability of the items for HIV populations with dual diagnoses may serve to improve the utility of the MoCA for PLWH in South Africa (Hambleton & Kanjee, 1995; Joska et al., 2016).

The present study derived preliminary normative data for total MoCA score using the traditional method (i.e., percentiles calculated from a mean and SD only). Larouche et al. (2016) comment that a limitation of this method pertains to the use of arbitrary categories to obtain comparison means and SDs. However, the present study analysed a variety of arbitrary categorisations to determine which were statistically significant. Therefore, the normative data are based on statistically significant categories rather than arbitrary ones. One advantage of regression-based norms, however, is that the method requires smaller total and subgroup sample sizes (Oosterhuis et al., 2016). It may therefore be advantageous for future studies to utilize regression-based normative data. More extensive analyses of the psychometric properties of the MoCA (e.g., inter-rater reliability, convergent validity and item analysis) and the development of a more substantive body of local normative data may contribute towards the improved utility of the MoCA in South Africa.

7.6. Study Strengths and Practical Implications

Despite its limitations, the present study has significant implications for practice in South Africa. The MoCA should not be used in diverse South African populations for which no

normative data exists and little is known about its reliability and validity in this context. This preliminary study contributes to the limited body of research regarding the psychometric properties of the MoCA in the South African context (Beath et al., 2018; Joska et al., 2016; Robbins et al., 2013), and represents a practical and relevant starting point for establishing MoCA norms in an understudied and well-defined South African population to assist healthcare practitioners working with similar populations.

Whilst the MoCA was originally developed to screen for MCI and AD in geriatric populations (Nasreddine et al., 2005), the present study enables the use of norms for clinicians investigating cognitive impairment occurring in disorders other than MCI or AD in younger, local populations. This is highly relevant in South Africa with a large population of PLWH (UNAIDS, 2019). Whilst other studies tend to exclude HIV-patients with dual comorbidities (Haddow et al., 2016; Robbins et al., 2013), resulting in an unrealistically 'clean' sample, these patients were included in this study thus improving generalisability to PLWH with dual diagnoses. The present findings have important implications in the diagnosis and treatment of PLWH with psychiatric and NCD comorbidities.

Whilst the prevalence of HIV in Sub-Saharan Africa is high, screening and testing for neurocognitive impairment among PLWH is limited (Nyamayaro et al., 2019). Early and accurate diagnoses of cognitive impairment can lead to better intervention efforts and treatment outcomes, whilst the impact of undiagnosed and untreated cognitive impairment on health outcomes may be substantial (Jonsson et al., 2013). Severe psychiatric and neurocognitive disorders increase one's risk of mortality and often leads to poor functional outcomes, such as higher risk of acquiring and transmitting HIV, suboptimal adherence to treatment, employment difficulties and impaired daily living activities (Nyamayaro et al., 2019). Secondary neurocognitive and psychiatric disorders associated with HIV can improve with treatment, especially if diagnosed early and the patient receives integrated care of both conditions (Jonsson et al., 2013). It is vital that healthcare practitioners treating HIV-positive individuals routinely screen for, diagnose and manage neuropsychological symptoms in this population (Jonsson et al., 2013). However, healthcare practitioners in South Africa are often constrained to do so, particularly in rural and resource limited settings, as many patients cannot afford expensive full neuropsychological assessment (NPA) and clinics have a shortage of trained professionals to administer and interpret lengthy NPAs (Nyamayaro et al., 2019). As such, healthcare practitioners in South Africa require reliable, inexpensive, quick and easily

administered screening and diagnostic tools. The MoCA may be a suitable candidate, however, more research is needed.

7.7. Concluding Remarks

The present study has contributed to neuropsychological research and assessment in South Africa by investigating the influence of age, gender and level of education on the MoCA, calculated its internal consistency and discriminant validity, and is the first study to provide preliminary normative data for the MoCA in a South African sample. Statistical analyses found that MoCA performance was significantly associated with age and years of education, but not gender. Furthermore, the MoCA showed unfavourable psychometric properties; internal consistency reliability was moderate whilst discriminant validity was poor. This suggests that the MoCA may not be useful as a screening or diagnostic tool for cognitive impairment associated with HIV and psychiatric or NCD comorbidities in populations with similar sample characteristics. Normative data are reported as the MoCA may be useful as a brief, inexpensive and easily administered tool to assist healthcare practitioners in assessing global cognitive capacity to direct further evaluation. Further research on the MoCA in South Africa is recommended.

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Appendix A. Request for permission to conduct research in C. H. Baragwanath Hospital I (Clinical Group)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT
PSYCHOLOGY

Johannesburg, October 2019

To Whom It May Concern
Chris Hani Baragwanath Hospital

RE: Permission to conduct research

Good day. We are a group of clinicians and academics currently developing a study titled '*Psychometric properties and norms of the Montreal Cognitive Assessment screening tool and the Rey Auditory Verbal Learning Test'*. The aim of this study is to explore the validity of these commonly used assessment tools for the assessment of cognitive functions in patients that have English as a second language and have attended public schools and achieved different levels of education. This study is motivated by the frequent use of neuropsychological tools that are not appropriate for our context and/or have not been assessed in terms of their diagnostic validity. We are hoping this investigation will provide empirical evidence of the use (or limitation thereof) of two specific tests: the Montreal Cognitive Assessment (MoCA) and the Rey Auditory Verbal Learning Test (RAVLT).

Since the MoCA and the RAVLT are frequently used in clinical practice, we would like to have your permission to obtain the scores of these tests from the users of several clinical services at Chris Hani Baragwanath Hospital. This will involve 1) a review of files in order to obtain minimal demographic data (please see appendix A) and the scores of these tests for each patient that has them. We are specifically looking to develop several clinical groups (e.g. HIV, Traumatic Brain Injury, Psychosis, etc.) and 2) invitation of potential participants during their attendance to the clinics (please see appendix E and F).

If you grant us permission to conduct research in the hospital premises, we will approach the Heads of Departments of the respective Clinics (e.g. in the Neurology and the Psychiatry Departments) that use these tests in order to ask them for permission to access the data in the files or to invite the potential participants during the clinics. If no previous agreement to use data for research purposes was given by the patients, we will approach the patients during the clinics in order to invite them to take part in this investigation.

We are currently applying for ethics clearance from the University of the Witwatersrand (Medical). Please be assured that all data will be treated confidentially and will be anonymised at data capture. If you grant us permission, we will need to have access to the files for review and data capturing.

Thank you for considering this request and please feel free to contact us if you have any questions regarding the study.

Sincerely,

Dr. Aline Ferreira Correia (PhD)
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Appendix B. Request for permission to conduct research in C. H. Baragwanath Hospital II (Clinical Group)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT
PSYCHOLOGY

Johannesburg, October 2019

Prof Yasmien Jeenah
Chris Hani Baragwanath Hospital
Department of Psychiatry

Dear Prof Yasmien Jeenah:

We are currently developing a study titled '*Psychometric properties and norms of the Montreal Cognitive Assessment screening tool and the Rey Auditory Verbal Learning Test*'. The aim is to explore the validity of these commonly used assessment tools for the assessment of cognitive functions in patients that have English as a second language and have attended public schools and achieved different levels of education. This study is motivated by the frequent use of neuropsychological tools that are not appropriate for our context and/or have not been assessed in terms of their diagnostic validity. We are hoping this investigation will provide empirical evidence of the use (or limitation thereof) of two specific tests: the Montreal Cognitive Assessment (MoCA) and the Rey Auditory Verbal Learning Test (RAVLT).

Since the MoCA and the RAVLT are frequently used in clinical practice, we would like to have your permission to obtain the scores of these tests from the users of your clinical services at Chris Hani Baragwanath Hospital. This will involve a review of files in order to obtain minimal demographic data (please see appendix A) and the scores of these tests for each patient that has them. We are specifically looking to develop several clinical groups (e.g. HIV, Traumatic Brain Injury, Psychosis, etc.) in order to assess the discriminant validity of the tests. Please be assured that all data will be treated confidentially and will be anonymised at data capture. If you grant us permission, we will need to have access to the files for review and data capturing.

Thank you for considering this request and please feel free to contact us if you have any questions regarding the study.

Sincerely,

Dr. Aline Ferreira Correia (PhD)
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Appendix C. Participant Information Sheet (Control Group)

Psychology

School of Human & Community Development

Private Bag 3, Wits 2050, South Africa. Telephone: +27 11-717-4500/2/3/4. Fax: +27-11-717-4559

Participant Information Sheet (control group)

Introduction

Good day. My name is Aline Ferreira Correia and I am a Doctoral (PhD) student at the School of Human and Community Development, at the University of the Witwatersrand. For the purpose of my studies, I am required to undertake research. I would like to invite you to participate in my research entitled: *The Cognitive Profile of Huntington Disease (HD) and Huntington Disease Like 2 (HDL2).*

You have been contacted by me or by other member of the research team because you are a healthy adult that has not been diagnosed with HD or HDL2.

Purpose and significance of the research

HD and HDL2 are genetic and neurodegenerative disorders associated with mood and behavioral changes, cognitive deterioration and movement dysfunction. Generally HD and HDL2 have been thought to be clinically identical, that is, it is impossible to tell them apart on the basis of a

neurological and cognitive examination. However there is some information to suggest this may not be the case. Hence, my research aims to identify the differences and similarities between the cognitive profiles of individuals with HD and HDL2. This project is the neuropsychological section that belongs to big research that also includes genetic, hematological, and neurological assessment.

This research might be able to identify key differences between the two disorders, which it might suggest differences in the disease pathways underlying the conditions and this might help us understand the processes causing them and could provide with clues to develop new treatments.

For the cognitive assessment, the comparison between HD and HDL2 will be only meaningful when compared to a group of healthy adults with similar demographic characteristics (age, level of education, gender, etc).

Procedure

If you agree to participate, you will be invited part of a neuropsychological testing that different types of activities, from answering questions, do drawings, remembering information and solve different types of problems. These tools are frequently used by psychologists all over the world when conducting psychological assessments. The assessment will include a brief interview to gather demographic details. This process will take between 2 hours to 2 and half hours. This testing will take place at a time and place of your convenience.

Research agreement

You will not receive any compensation, monetary or otherwise, for participating in the study. There will be no other benefits to participation in this research. No risks to participation in this study are anticipated. However, the cognitive testing might elicit distress if some of the tasks are perceived as difficult, however, I would therefore like to stress that your participation in this research is entirely voluntary and you may withdraw from it at any point. You may also refrain from answering any particular question with no negative consequences. If you experience any distress associated with the assessment process, please note the following free counselling service: South African Depression and Anxiety Group: 011 262 6396.

Your identity as a participant will be only known to myself and my supervisor. The test protocols will be stored in a locked file cabinet and the results stored in a password protected computer. Only my supervisor and I will have access to these files. To protect confidentiality, your name or other personal identification data will not be used. Instead, an identification number will be used in each protocol.

Prior to participating in the study it is required that you completed the attached consent form. This will be kept separately from the rest of the data for the purpose of confidentiality. The consent form will only be made available to the University authorities should a random audit process require this.

The PhD thesis resulting from this research will be available in the library of the University of the Witwatersrand, which offers access to material on the world-wide web. The findings will also potentially be published in scientific journals. If you wish to have access to the results, you may request so by contacting me. The results are expected to be ready in 2019.

Enquiries

Should any matters require further clarification please do not hesitate to call me at 072 200 9292 / 011 717 4527 or email me at Aline.FerreiraCorreia@wits.ac.za.

You may also contact my research supervisor, Prof. Kate Cockcroft, telephonically at 011 717 4511 or via email at Kate.Cockcroft@wits.ac.za

Appendix D. Consent Form (Control Group)

Psychology

School of Human & Community Development

Private Bag 3, Wits 2050, South Africa. Telephone: +27 11-717-4500/2/3/4. Fax: +27-11-717-4559

Informed Consent Form (control group)

I am an adult person above the age of 21 years and I confirm that I have read and understand the information provided in the information sheet in relation to the research entitled: *The Cognitive Profile of Huntington Disease (HD) and Huntington Disease Like 2 (HDL2).* I have been informed about what the research entails and what is required from me. I also understand that:

- My participation is completely voluntary.
- I may withdraw from the research at any time with no negative consequences for me
- My results and identity will be kept anonymous and the information will be kept in a password secure file in a password secure computer and the protocols of the tests will be kept in a locked cabinet, both only accessible to the researcher and the supervisor.
- My participation will be treated with confidentiality
- No rewards will be offered or provided for my participation
- No risks are associated with participation, however I have been given a number for free counselling services if I experience any distress as a result of the cognitive assessment
- I have received the contact details of the researcher (Aline Ferreira Correia) and the supervisor (Prof. Kate Cockcroft)

Participant's name: _____

Participant's signature: _____

Researcher's name: _____

Researcher's signature: _____

Date: _____

Appendix E. Demographic Questionnaire (Control Group)

Study Identity Number:

Age:

Gender:

Have you undergone neuropsychological testing before? Yes____ No____

Which is your home language?: _____

Languages you know in order of dominance:

1	2	3	4	5
6	7	8	9	10

Languages you use on daily basis:

1	2	3	4	5
6	7	8	9	10

Language/s educated in (years): _____
_____

How many years of formal education do you have?

What is the highest level of formal education you have achieved?

School history

Level	School 1/type	School 2/type	School 3/type
Primary School			
Highschool			
University			
Others			

Profession:

Occupation:
Current:
Past:

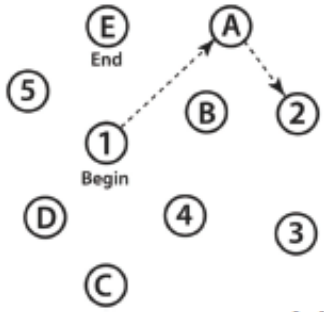
Special Hobbies/ Talents:

Appendix F. Montreal Cognitive Assessment

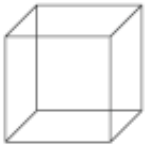
MONTREAL COGNITIVE ASSESSMENT (MOCA®)
Version 8.1 English

Name:
Education: Date of birth:
Sex: DATE:

VISUOSPATIAL / EXECUTIVE — POINTS



[ ] [ ]



Copy cube

Draw CLOCK (Ten past eleven)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

__/5

NAMING

[ ]

[ ]

[ ]

__/3

MEMORY — NO POINTS

Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1ST TRIAL					
2ND TRIAL					

ATTENTION

Read list of digits (1 digit/sec.). Subject has to repeat them in the forward order. [ ] 2 1 8 5 4

Subject has to repeat them in the backward order. [ ] 7 4 2

__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Serial 7 subtraction starting at 100. [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65

4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**

__/3

LANGUAGE

Repeat: I only know that John is the one to help today. [ ]

The cat always hid under the couch when dogs were in the room. [ ]

__/2

Fluency / Name maximum number of words in one minute that begin with the letter F. [ ] _____ (N ≥ 11 words)

__/1

ABSTRACTION

Similarity between e.g. banana - orange = fruit [ ] train - bicycle [ ] watch - ruler

__/2

DELAYED RECALL

	(MIS)	Has to recall words WITH NO CUE	FACE	VELVET	CHURCH	DAISY	RED	Points for UNCUED recall only
Memory Index Score (MIS)	X3		[ ]	[ ]	[ ]	[ ]	[ ]	
	X2	Category cue						MIS = ____/15
	X1	Multiple choice cue						

__/5

ORIENTATION

[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City

__/6

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Administered by:_____

Training and Certification are required to ensure accuracy

MIS: /15
(Normal ≥ 26/30)
Add 1 point if ≤ 12 yr edu

TOTAL __/30

Appendix G. Ethics Clearance Certificate (Clinical Group)

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Post Graduate Affairs)

TO: Dr A Ferreira-Correia
School of Human and Community Development
Department of Psychology
University

E-mail: Aline.FerreiraCorreia@wits.ac.za

CC: Supervisor: Not applicable <>
and <HREC-Medical.ResearchOffice@wits.ac.za>

FROM: Iain Burns
Human Research Ethics Committee (Medical)
Tel: 011 717 1252

E-mail: Iain.Burns@wits.ac.za

DATE: 2019/11/06

REF: *R14/49*

PROTOCOL NO: **M190819** *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

PROJECT TITLE: *Psychometry properties and norms of the Montreal Cognitive Assessment screening tool and the Rey Auditory Verbal Learning Test*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to the Government funding of the University.

MSWorks2000/Iain0007/Clearscan.wps

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Dr A Ferreira-Correia

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M190819

NAME: (Principal Investigator)	Dr A Ferreira-Correia
DEPARTMENT:	School of Human and Community Development Department of Psychology University
PROJECT TITLE:	Psychometry properties and norms of the Montreal Cognitive Assessment screening tool and the Rey Auditory Verbal Learning Test
DATE CONSIDERED:	2019/08/30
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Not applicable
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2019/11/06

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **August** and will therefore reports and re-certification will be due early in the month of **August** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

Appendix H. Ethics Clearance Certificate (Control Group)

R14/49 Dr David Graham Anderson et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M140872

NAME: (Principal Investigator)	Dr David Graham Anderson et al
DEPARTMENT:	Neurology Wits Donald Gordon Medical Centre Charlotte Maxeke Johanesburg Academic Hospital Bloemfontein, Polokwane and Northen Gauteng
PROJECT TITLE:	The Phenotype of Huntington Disease Like 2 (HDL2)
DATE CONSIDERED:	29/08/2014
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof A Krause
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	09/10/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.
I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix I. Ethics Clearance Certificate (Present Study)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Miss Elisabeth Kirkbride

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200631

NAME: (Principal Investigator)	Miss Elisabeth Kirkbride
DEPARTMENT:	School of Human and Community Development Department of Psychology
PROJECT TITLE:	Montreal Cognitive Assessment (MoCA): Normative data for a South African Sample
DATE CONSIDERED:	26/06/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Aline Ferreira Correia
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	21/07/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

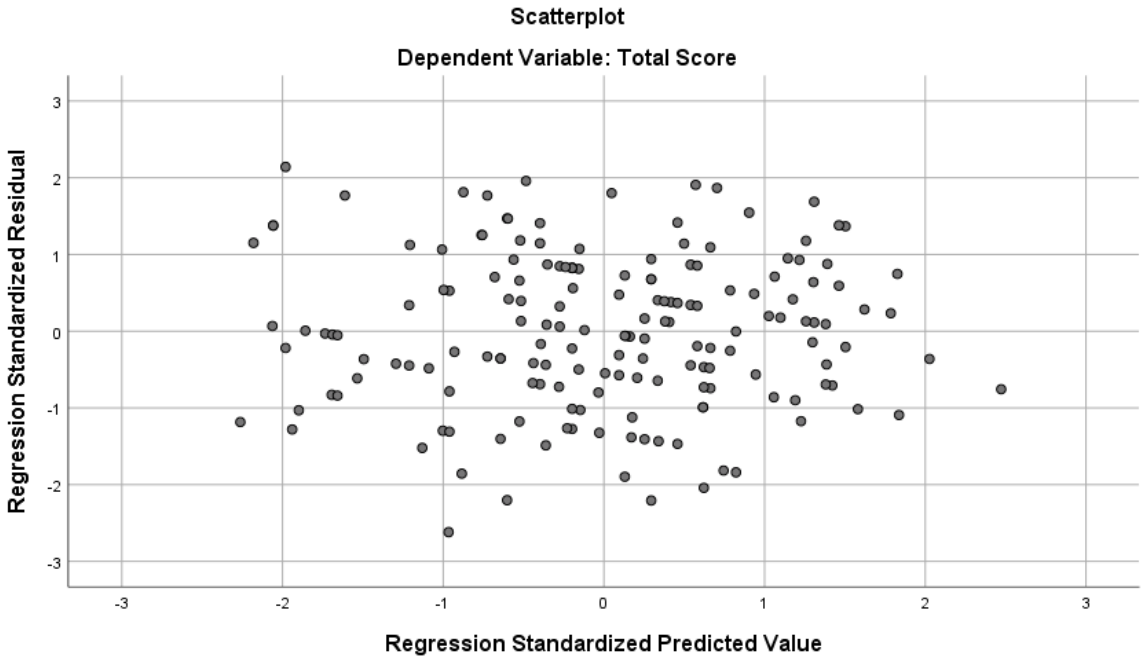
DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I **agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **June** and will therefore be due in the month of **June** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature — Date: 23 July 2020

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix J. Scatterplot of Standardised Residuals Against Standardised Predicted Values



Appendix K. One-way ANOVA Based on LS-mean MoCA Total Scores per Diagnostic Group

Source	*df*	*SS*	*MS*	*F*	*p*
Contrast	2	25.70	12.85	0.88	0.416
Error	166	2416.67	14.56		

Note. df=degrees of freedom; SS=sum of squares; MS=mean square