UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT
PSYCHOLOGY

Preliminary Normative Data for the Hooper Visual Organization Test for a South African sample

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Submitted in fulfilment of the requirements for the Degree of Master of Arts in Social and Psychological Research (PSYC7022) in the Department of Psychology, School of Human and Community Development, Faculty of Humanities, at the University of the Witwatersrand, Johannesburg.

Masters in Social and Psychological Research –Declaration

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ABSTRACT

The Hooper Visual Organization Test (HVOT) is an instrument designed to measure an individual's ability to organize visual stimuli and assess visual-spatial abilities and synthesis. The current investigation aimed to explore the psychometric properties of the HVOT and develop normative data for South Africans who do not speak English as a first language and who received primary and secondary public education. The research design was cross-sectional and the HVOT was administered to healthy adults (n=111) and a clinical group (n=17) whose age range between 19-70 years and had an education of between 6-22 years. The clinical group was made up Huntington's Disease patients. The reliability analysis of the 30-item scale indicated good levels of internal consistency and reliability (McDonalds ω_t of .90). Item difficulty analyses indicated a potential cultural bias in the South African population. Pearson's correlation coefficient showed a significant positive association ($p<0.005$) between HVOT total score and gender and years of education. Additionally, a significant negative association ($p<0.005$) was observed between HVOT total score and age. There were significant, positive correlations between the HVOT total scores and different subtests of the Montreal Cognitive Assessment. The clinical group performed worse than the control group when mean total HVOT scores were compared. Preliminary norms stratified by age, gender and years of education were presented. Future studies should include larger sample sizes and additional research on the influence of gender on the total HVOT score is needed.

ACKNOWLEDGEMENTS

I am grateful to my supervisor, Dr. Ferreira-Correia for the time and effort she dedicated to meetings, and for the valuable advice and guidance she offered, that allowed me to complete this thesis during a global pandemic. I would also like to thank Prof. C. van Zyl, for his assistance with the Item Response statistical analysis. Lastly, I would like to thank my husband, daughter and parents for their support which enabled me to complete my research.

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1 INTRODUCTION

The Hooper Visual Organization Test (HVOT) (Hooper, 1958) has been considered a neuro-psychological test of visual spatial function and visual organization. In the past, it was used as a screening tool to detect neuropathology (Boyd, 1981), however, this has been contested (Rathbun & Smith, 1982). Even though its screening potential has been challenged, it has been shown to have credibility with regard to its sensitivity to detecting brain dysfunction (Boyd, 1981) and has been used in the assessment batteries of patients who suffer from a wide spectrum of pathologies (Booth & Happé, 2018; Eberson, 2014; Ferreira-Correia et al., 2020; Gasparini et al., 2008; Mitolo et al., 2016; Paxton et al., 2007; Sanz Cortés et al., 2011; Stamenovi et al., 2004; Zakzanis et al., 2001).

Reliability and validity of the HVOT has been found to be good in studies from diverse countries (Campagna & Ferreira-Correia, 2021; Giannakou & Kosmidis, 2006; Greve et al., 2000; Lin et al., 2012; Lopez et al., 2003), although differences in the cultural item appropriateness and item ranking in various contexts have been noted (Merten & Beal, 1999; Su et al., 2013). Moreover, achievement on the test seems to be influenced by age (DeVries, 2005; Miller et al., 2015; Su et al., 2013), level of education and gender (Campagna & Ferreira-Correia, 2021; Elias et al., 2011; Giannakou & Kosmidis, 2006; Merten & Beal, 1999). It is for this reason that the clinical potential of the HVOT should be determined with the development of country-specific norms which may allow for the amalgamation of demographic variables into the data analyses. This will allow for adaptation of items which reduces the risk of Type I errors ("Type I error occurs when there is belief that there is a genuine effect in a population, when in fact there is none." (Field, 2018)), and enhance the diagnostic value of a test for a specific context (Crawford & Garthwaite, 2012). Country-wide norms are, however, not appropriate given the diversity of the South African population. Consequently, this study aims to explore the psychometric value, demographic variability, and normative performance on a selected sample of South Africans who do not speak English as a first language and who attended public schooling. With regard to exploring the psychometric properties, it is noted that, even though validity studies with the HVOT have been done (Ferreira-Correia et al., 2020; Pena et al., 2008), the HVOT was not correlated with the MoCA indicating a lack of data in this regard. Specifically, the objectives of the study include: a) to determine which demographic variables (age, years of education and/ or gender) have a significant correlation

with the HVOT total score; b) to describe the normative data for the HVOT in an demographically homogeneous South African sample; c) to determine the concurrent validity of the HVOT with regard to the correlation of the total score of the Montreal Cognitive Assessment (MoCA); d) to determine the construct validity of the HVOT in relation to the visuo-constructive and confrontational naming items of the MoCA; e) to determine the diagnostic validity of the HVOT in terms of its capacity to discriminate controls from a clinical group; f) to determine the reliability of the HVOT; and g) to investigate the item difficulty of each item of the HVOT for the South African sample.

This project presents, in the first chapter a brief literature review which explains the current availability of South African normed neuropsychological tests in general, and the importance of developing context-relevant norms. Furthermore, the historical and psychometric background of the HVOT is described. The second chapter incorporates the methodological aspects of the study, including the sampling, procedure, instruments used, ethical considerations and data analyses. It is a retrospective study done on secondary data (Ferreira-Correia, 2019) which provides preliminary norms that have been stratified by age, gender and level of education. In the results chapter, each research question is addressed and linked to statistical analyses. Lastly these findings are integrated in the discussion chapter and compared to the existing literature and debated in terms of its generalizability and applicability to the South African population. Limitations of the study are explored and ideas for future research are proposed with the intention of guiding the next steps in the development of normative studies on the HVOT in South Africa.

2 LITERATURE REVIEW

2.1 Neuropsychological Assessment in South Africa

Sociocultural and socioeconomic disparities constitute a significant challenge for practitioners and researchers who are responsible for developing and selecting norms that are truly representative instead of enacting a socio-cultural bias that enhances the disadvantage, instead of mitigating it (Lucas, 2013). It is sometimes the case where normative studies are developed based on samples that do not consider variables relevant for cognitive assessment, such as years and quality of education and language, and have therefore been criticized (Shuttleworth-Edwards, 2017). Furthermore, some of the available South African norms are dated and no longer applicable to the South African population. An example of this in noted in a letter from the Health Professions Council of South Africa (HPCSA) stated that the Individual Scale for Zulu speaking (ISZSP) children is obsolete and practitioners are required to make use of an alternative test (Khati, 2017). Another illustration of inappropriate standardization and norming, is that of the Wechsler Adult Intelligence Scale (WAIS- IV ^{SA}) developed by Jopie Van Rooyen (JVR) Psychometrics group in conjunction with Pearson (Pienaar et al., 2017), in which people with diverse cultural, linguistic and educational background formed an heterogenous sample that has been criticized for being representative of no one and have dubious clinical applicability (Pienaar et al., 2017). “The South African adaptation was conducted on the basis of population (i.e. countrywide) norming, and population-based norms are increasingly being called into question on scientific grounds.” (Shuttleworth-Edwards, 2017, p.3).

Nevertheless, some users of psychological tests sources are often left with little choice but to make use of tests that have not been adapted to our context and having to use international standardized norms (Lucas, 2013; Truter et al., 2018), which are inadequate because they are not representative of the South African population. Bias is accentuated when using norms obtained from Western, Educated, Industrialized, Rich and Democratic (WEIRD) societies, which represent only 12 percent of the world’s population (Beth, 2010). Tests need to be contextually sensitive and applicable for the assessment to generate valid and reliable results, which can then be applied to make clinical decisions and plan interventions. There is an increasing need to reflect on our cultural diversity and inform the growth and adaptation of western orientated assessment measures so that they are culturally appropriate and create valid

results in a multicultural African context (Duncan et al., 2007; Foxcroft & Roodt, 2018; Mpofu et al., 2012).

A way in which psychological test users could potentially overcome this is for adequate training to be provided to graduates. Experts explain that test development is highly specialised (Foxcroft, 2004) and that inadequate training has been provided to graduates. Furthermore, research agencies such as the Human Sciences Research Council (HSRC) ceased to prioritise the development of psychological tests and experienced test developers took on new roles (Foxcroft, 2004). Other agencies like Psytech, JVR and Saville and Holdsworth (SHL), among others then took on the responsibility of adapting international tests and norming them for the South African context, however, some of these efforts were successful, while others, unsuccessful (Lucas, 2013; Watts & Shuttleworth-Edwards, 2016).

Some examples of successful normative studies which have been conducted in South Africa include norms for the Senior South African Individual Scale – Revised (SSAIS-R) test which has been developed for Afrikaans-speaking and English-speaking learners between the age of 7 years and 16 years and 11 months. It has been noted that socio-economic deprivation does, however, have a negative influence on performance (van Eeden, 1991). Therefore, there are norms available for environmentally disadvantaged learners of the same age which can be used for participants with English or Afrikaans as a mother tongue, irrespective of socio-economic status (van Eeden, 1991). Another example of a test for which preliminary norms have been developed for the South African population is the Trail Making Test (TMT). Participants comprised of 33 Black, isiXhosa – speaking unskilled workers, who formed part of a non-clinical sample and had an educational level of Grade 11 or Grade 12, and were from Black township schools with a relatively disadvantaged quality of education (Andrews et al., 2012). While there are many available norms for Afrikaans speakers, some for isiXhosa speakers, etc., the problem is that these efforts need to be extended to many other tests while controlling for the effects of relevant covariates in the South African context, such as type of education (advantaged groups vs disadvantaged group, English proficiency, urbanization levels, etc.). Unfortunately, these adaptations and norms are scarce.

Norming is often challenging due to the multicultural and multilingual nature of our population as it implies incorporating into the study design several variables, such as South African's multilingualism, varying levels of quality of education, wide differences in socio-economic status, divergent cultures and acculturation, all enmeshed with a historical

background of political and socio-economic inequality (Lucas, 2013). The process of developing a psychological test is indeed a complex and lengthy one, because it requires complex designs, large samples to control for relevant demographic variables, which becomes expensive and requires extremely large studies. Even though sociocultural and socioeconomic disparities are known to hinder the development of neuropsychology in many ways, it should not be a limitation for norming or for practitioners to make use of adequate tools. Given that clinicians use these tools to make diagnoses, efforts to overcome the challenges are needed. One way to reduce the biases is to develop local norms. Therefore, local norming of psychometric tests has become a priority in neuropsychological research to mediate valid assessment practices in the country (Watts & Shuttleworth-Edwards, 2016).

Research suggests that, variables such as cultural practice, languages spoken and used for assessment, as well as years and quality of education have an impact on test performance (Foxcroft & Roodt, 2018). Therefore, it is unjust to expect clients/patients who speak English as a second language and who have attended public school, to complete neuropsychological tests which are then compared to a reference group that does not consider the aforementioned variables. Various authors concur that when South African scores are juxtaposed with international normative data, the scores which are locally produced are less than the prototypical standardised scores, producing a high number of errors in diagnosis and increased biases (Anderson, 2001; Jinabhai et al., 2004; Lucas, 2013).

Although developing new tests that are culturally relevant would be ideal, it is often expensive and lengthy. It is, however, important that we do not “re-invent the wheel” (Shuttleworth-Jordan, 2016, p.96). Therefore, an efficient option is to understand the effects of the cultural and demographic variables in tests that are available in order to understand the limitations and potential of those tools that are already being used (Shuttleworth-Edwards, 2017). Findings should then guide the use of the available tools, their adaptation and/or development of better ones. Other countries facing similar challenges have implemented guidelines in the use of international tools, such minimum levels of education (New Zealand Psychologists Board, 2013).

We have to develop better norms of tests that are available (as to not “re-invent the wheel”). These tests need to be sensitive, inexpensive, quick and easy to administer. Clinical and research evidence (Robbins et al., 2013; Robertson et al., 2009) highlight the need for these tests that are quick and easy to administer, that are sensitive to neurological pathology or

cognitive deficits, and that have low language implications to accommodate for the linguistic diversity of South Africa. The Hooper Visual Organisation Test (HVOT) accommodates for some of these challenges. For example, it is easy to administer (Hooper, 1958), some argue that it has a low language load (Mason & Ganzler, 1964), it is able to identify cognitive dysfunction (Eisenman & Coyle, 1965; Mitolo et al., 2016), and it has minimal influence of education (Boyd, 1981). Therefore, it is a test with good potential for clinical use in South Africa.

2.2 The Hooper Visual Organisation Test (HVOT)

The Hooper Visual Organization Test (HVOT) (Hooper, 1958) was developed in 1958 and is one of the first neuropsychological tests to have been published. The test consists of 30 drawings of common objects and animals that are segmented into two or more pieces, requiring mental rotation in order for participants to identify and name each item (Giannakou & Kosmidis, 2006; Hooper, 1958; Lezak et al., 2012) and it is scored by awarding one point for a correct response. Some items allow for partially correct responses, which receive half a credit, and zero credit is given to incorrect responses (Hooper, 1958). The original manual provides tables which enable the test users to adjust scores in order to correct for the influence of age and years of education and provides norms where the raw scores are converted into T-scores. The Total Raw Score is obtained by adding the credits and half-credits for all the items. The Corrected Raw Score is used for adults between the age of 25 and 69 years old. The Corrected Score and the T-Score equivalent can be obtained from the appendices in the HVOT Manual (Hooper, 1958).

The HVOT was conceived as a screening tool for general brain pathology (Boyd, 1981; DeVries, 2005), however, more recent research argues that the HVOT is specific to determining visual organizational ability/visuo-constructive deficits (Merten & Beal, 1999). What was once understood as general brain damage, was attributed to the fact that visual spatial tasks involve a multitude of brain areas and cognitive function (Seydell-Greenwald et al., 2017; Walter & Dassonville, 2008), and it is for this reason that visuospatial tasks are often used as screening tests. Even though the HVOT's ability to act as a screening tool has been contested (Rathbun & Smith, 1982), it does have clinical potential as it is particularly sensitive to neurological impairment, and brain damage/dysfunction (Hooper, 1983; Boyd, 1981; Lezak et al., 2012). There are a multitude of studies that shows that the HVOT has been used in

assessment batteries of patients with different neurological pathologies (Booth & Happé, 2018; Eberson, 2014; Ferreira-Correia et al., 2020; Gasparini et al., 2008; Mitolo et al., 2016; Paxton et al., 2007; Sanz Cortés et al., 2011; Stamenovi et al., 2004; Zakzanis et al., 2001).

The HVOT task is possible to solve thanks to visual-organizational ability, which refers to the ability and capacity to organise visuospatial stimuli together in your mind (Boyd, 1981). Empirical evidence further suggests that the HVOT assesses components of confrontational naming (Higginson et al., 2011; Hooper, 1958), and visual attention and memory (Lin et al., 2012). Studies have shown that the HVOT is more sensitive to the identification of right brain lesions, although it has shown good sensitivity on bilateral injury too (Fitz et al., 1992; Lewis et al., 1997). A study on the neuroanatomic correlates of the HVOT through functional Magnetic Resonance Imaging (fMRI), showed that bold responses were found in many bilateral brain regions, although they were especially prominent in the parietal (right parietal lobe) and the occipital lobes (Moritz et al., 2004).

2.3 Psychometric properties of the HVOT

2.3.1 Norms

Norms have been defined as an illustration of a "score distribution of a test in a representative sample which provides a standard frame with which to relate individual scores". (Chien & Yao, 2014, p.190). It forms part of a collection of raw scores which are processed and grouped together which then serve as a comparison group (Foxcroft & Roodt, 2018). In order to evaluate, describe and make informed decisions, researchers transform the raw scores into meaningful data in the form of derived scores. These scores are then used to evaluate an individual's performance (Chien & Yao, 2014).

Several international studies on the psychometric properties of the HVOT are available (Boyd, 1981; Campagna & Ferreira-Correia, 2021; DeVries, 2005; Jefferson et al., 2006; Merten & Beal, 1999), however, these have not been done in South Africa. It will therefore be important to validate the HVOT for a South African population as clinical or research-based work has not been done. While these studies have demonstrated that the HVOT has good psychometric properties; this research study offers the opportunity to explore the clinical value of this test in South Africa.

The original standardization process of the HVOT was conducted in Torrance, California, with a sample of 30 junior high school students (mean age = 13,9), 166 college students (mean age = 21,8) and 28 residents in a voluntary home (mean age = 76,8) (Hooper, 1958). The means and standard deviations for each of the aforementioned groups were 25,43 (SD=5,04) for the junior high school students, 25,64 (SD=3,98) for the college students, and 18,57 (SD=4,31) for the normal aging group (Hooper, 1958). Since a credit had been given for each correct response, higher total raw scores suggested that participants had a greater ability to organize visual stimuli. Therefore lower scores suggested difficulty in this domain which in turn advocated possible organic impairment (Hooper, 1958). Using this hypothesis, degrees of impairment were suggested in the original manual where a raw score of 25-30 showed no impairment; 20-24 indicated mild impairment; 10-19 demonstrated moderate impairment; and a score of 0-9 suggested severe impairment. The standardized norms provided by Hooper (1958) were used to formulate cut-off scores that reduced the number of misclassification of individuals in each normative age group (Hooper, 1958) and cut-off scores of 20 to 25 were recommended (Hooper, 1958).

Other normative data for the HVOT which have been published includes a study on male veterans (Mason & Ganzler, 1964); Venezuelan adults (Campagna & Ferreira-Correia, 2021); Greek adults (Giannakou & Kosmidis, 2006); adults in Michigan (DeVries, 2005); Chinese children in Southern Taiwan (Lin et al., 2012); Caucasian adults in Boston (Miller et al., 2015); adults in Georgia (Tamkin & Jacobsen, 1984); geriatric population from Detroit (Walsh et al., 1997); and adults in New York City (Wentworth-Rohr et al., 1974).

Some studies have found only age to be an important contributor to HVOT performance (DeVries, 2005; Miller et al., 2015; Su et al., 2013), while in other studies have found both age and years of education to be important contributors (Campagna & Ferreira-Correia, 2021; Elias et al., 2011; Giannakou & Kosmidis, 2006; Merten & Beal, 1999). Furthermore, gender bias in the visuospatial functions which suggests that men perform better than women has been suggested for the HVOT (Hatta et al., 2015) but another study did not support this finding (DeVries, 2005).

It can be noted that not all the studies have similar stratifications, and the majority are from countries such as the United States of America (DeVries, 2005; Miller et al., 2015; Tamkin & Jacobsen, 1984; Walsh et al., 1997; Wentworth-Rohr et al., 1974), Taiwan (Lin et al., 2012) and Greece (Giannakou & Kosmidis, 2006). The study conducted by DeVries (2005)

concluded that, for the entire sample, HVOT scores were mildly and positively correlated with gender and number of years of education; and there was a mild and positive correlation between age and HVOT scores. Giannakou & Kosmidis (2006) stated that both age (moderate and negative correlation) and education (moderate and positive correlation) contributed significantly to test performance, where increased age were related to poorer performance, and lowered levels of education were related to lower HVOT scores. Gender, however, was not significant.

Tamkin and Jacobsen (1984) demonstrated that age significantly correlated with the HVOT scores and explained a significant amount of variance in the scores. There was a negative correlation observed from the youngest age group (20-29 years) with a mean HVOT score of 23,7 and the oldest age group (70-79 years) had a mean score of 14,09. When controlling for age and intellectual level, Wentworth- Rohr et al. (1974) found that education was unrelated to HVOT scores and there was no significant relationship between HVOT and education level. In a geriatric population group, Miller et al. (2015) showed that performance by the oldest-old individuals (90+ years) on the HVOT were significantly worse than young-old (85-89 years) performance. In this study the age group of 65-69 age group was used as a reference/referent group (Miller et al., 2015). There were significant differences in performance between the 85-89 age band and the referent group, and there were significant differences between the 90+ age band and the referent group and no significant differences were found with gender. In another study on the elderly (Walsh et al., 1997), age was found to be a significant predictor of the HVOT performance over and above the effect of education which was also correlated with the HVOT scores.

Lin et al. (2012) and Seidel (1994) developed norms for children. Specifically, Lin et al (2012) showed by way of an ANOVA that the main effect was on the age group; the Scheffe post hoc test indicated that 12–14-year-olds had the highest scores on the Chinese version (M=38,50); followed by 9–11-year-olds (M=37,00); then 7–8-year-old (30,39) and then 5–6-year-olds (M=24,13). Norms were stratified according to age. Increased age (in children) was related to better performance on the HVOT. Similarly, Seidel (1994) showed positive correlation between age and HVOT scores where children age 5 had a HVOT score mean of 18,4 while children age 11 had a mean score of 24,1.

The influence of certain demographic variables on the HVOT performance is different for each of this study, and also the mean performance is different, which accentuates the need

for context-specific data, especially given the argument presented above regarding the variables that have been considered important in cognitive performance in South Africa. There is a need for normative studies to be performed in South Africa while at the same time controlling for context-specific variables.

2.3.2 Validity

Test validity is defined as "the extent to which an instrument measures what it is intended to measure" (p. 114, Leedy & Ormrod, 2015). Test validity is classified in several types, including concurrent validity, construct validity and diagnostic validity, which are described in detail below. Concurrent validity is established when there is a sound correlation between a particular test and an alternative measure that was previously validated. It often involves the validation studies in which two measures are administered at the same time to the same group of people (Miller & Lovler, 2015).

When the HVOT was correlated with other measures, such as the Symbol Digit Modalities Test (SDMT) and Tower Test (Ferreira-Correia et al., 2020), it did not show any significant correlations and therefore supports the idea that the HVOT is mostly associated with other measures of visuo-constructional abilities, and cannot be considered to be screening tool, as debated previously. The debate regarding HVOT assessing one or more constructs, however, comes from the findings from different studies on concurrent validity, for example, the correlations of the HVOT was explored with a number of other tests (Pena et al., 2008). These tests include the Mattis Dementia Rating Scale (MDRS) total; Judgement of Line Orientation, Form (JLO); Scales of outcomes of Parkinson Disease (SCOPA-cog) figure composition subscale; SCOPAcog Total; Clock Drawing Task (1 and 2) CLOX1; CLOX2 (Pena et al., 2008). The MDRS for example is a multidimensional test that examines a multitude of areas, including attention, initiation construction, conceptualisation and memory (Spreen & Strauss, 1998), while the JLO is a purely visual, unidimensional test that is commonly used as a measure of visuospatial perception (Benton et al., 1983). From the study conducted by Pena et al (2008), it was concluded that even though correlations were evident, they were not strong as many of the tests did not primarily assess visuospatial functions (Pena et al., 2008). Therefore, it can be argued from the aforementioned findings that the HVOT is a primarily visuospatial test because it did not correlate with tests of other functions.

Another form of validity is construct validity. This is defined as the “degree to which an instrument measures a characteristic that cannot be directly observed but is assumed to exist” (Leedy & Ormrod, 2015, p. 115). For example, a study explored the influence of confrontational naming on the HVOT with 50 male veterans between the ages of 21 and 76 years (Ricker & Axelrod, 1995). This was analysed using hierarchical multiple regression analyses, where the HVOT was used in conjunction with the Wechsler Adult Intelligence Scale – Revised (WAIS-R) and Multilingual Aphasia Examination (MAE). The Verbal Comprehension (VC), Perceptual Organization (PO) and Freedom from Distractibility (FD) factor scores from the WAIS-R were used as a measure of overall cognitive function, and the Visual Naming Test (VNT) from the MAE was administered as a measure of object naming ability (Ricker & Axelrod, 1995). From this, PO was responsible for 48% of the variance in HVOT performance and confrontational naming accounted for 11%. It was concluded that the HVOT is a valid measure for perceptual organization and it is not necessarily influenced by naming ability (Ricker & Axelrod, 1995).

Correlations were done between the HVOT and the Wechsler scale subtests on 98 patients suffering from cerebrovascular accidents and, construct validity of the HVOT was investigated, with particular emphasis placed on the role of confrontational naming in HVOT performance (Greve et al., 2000). Each participant was administered the HVOT, WAIS-R and Cognistat. From this it was determined that the HVOT was a valid tool (Greve et al., 2000). Specifically, naming ability showed the highest correlation and accounted for less than 10% of the observed variance. In contrast, perceptual processes accounted for about 35%. Picture Completion and Object Assembly had the strongest relation with the HVOT (Greve et al., 2000).

Another study used a comprehensive neuropsychological test battery on 200 native German speaking, neurological in-patients (Merten, 2005). The sample was made up of 128 males and 72 females within the age range of 16-94 years old. Participants’ level of education fell within the range of 6-21,5 years. The test battery comprised of tests of visuospatial functions, memory, attention, executive functions, naming ability and vocabulary (Merten, 2005). Significant loadings of the HVOT was found on non-verbal cognitive functions (Merten, 2005). In summary, the difference between concurrent validity and construct validity can be explained, where, the former is done when data is recorded simultaneously using a new instrument and existing criteria (Field, 2018), and the latter refers to the degree to which

inferences can made which should demonstrate that scores on a test do predict the theoretical trait which it claims to examine (Ginty, 2013).

The diagnostic validity of a test alludes to "the test's ability to differentiate persons with and without a characteristic disorder" (Smith et al., 2003, p. 273). Given that cognitive abilities are differentially affected in Alzheimer's Disease (AD) and Dementia with Lewy Bodies (DLB), with the latter showing more decline, the assessment of cognitive function has been used a diagnostic marker. Studies have explored whether the HVOT is able to discriminate between these diagnostic groups. Despite similarities in the cognitive deficits associated with DLB and AD, visuospatial abilities seem to be more affected in DLB than in AD (Ala et al., 2001; Calderon et al., 2001; Johnson et al., 2005). For example, Mitolo et al. (2016) showed that the mean HVOT scores for the normal control group were 24,19, (SD=3,2), those with AD had a mean score of 19,1, (SD=5,6) and those with DLB had a mean HVOT score of 16,73, (SD=6,96). Therefore, when healthy controls were compared against the clinical sample, the visual perceptual organization ability of patients with dementia using the HVOT, showed greater impairment. Patients with DLB, scored significantly worse than equally demented patients with AD (Mitolo et al., 2016). Additionally, HVOT performance was more effective when differentiating individual DLB patients from the healthy controls, than it was at differentiating individual AD patients from the healthy controls (Mitolo et al., 2016).

A study in South Africa compared patients with Huntington's Disease (HD) and Huntington's Disease-Like 2 (HDL2) to matched control samples using a single case methodology. It was found that out of 10 cases (3 HDL2 patients; and 7 HD patients) in different stages of progression, presented with significant deficits in the scores of the HVOT scores (Ferreira-Correia et al., 2020), which highlighted the potential diagnostic validity of HVOT in South Africa.

Huntington's Disease (HD) and Huntington's Disease-Like 2 (HDL2), have genetic causes that involve specific mutations (Margolis & Holmes, 2004). Even though these mutations ensue in non-identical genes for HD and HDL2, there are significant commonalities between them in terms of the mechanisms and implications of the mutation (Margolis & Holmes, 2004). HD/HDL2 have a marked progressive triad of movement, psychiatric (emotional/behavioural), and cognitive disorders, that have a detectable clinical symptoms at about 30 years for HD patients and between 25 to 45 years for HDL2 patients (Margolis & Holmes, 2004; Santos et al., 2008). HD/HDL2 is marked by motor disturbances as well as

cognitive changes including slow processing of information (bradyphrenia), deficits in attention, memory and executive and visuospatial skills (Cummings & Benson, 1988; Eberson, 2000; Snowden, 2017). The literature on HD/HDL2 suggest that their clinical presentation, including neuropsychological function, are identical, therefore for the purpose of this study, HD/HDL2 they will be treated as a homogeneous clinical group.

HD/HDL2 patients commonly present with visuo-constructive deficits (Gómez-Tortosa et al., 1996), which represents a good clinical sample to test the diagnostic validity of the HVOT. The HVOT allows for the assessment of visuospatial ability/visual integration with minimal motor involvement thus, it is ideal to use in cases where the motor function is compromised such as in HD/HDL2 (Azambuja et al., 2012). Studies have shown that the HVOT is known to be able to discriminate cognitive dysfunction in patients, it is frequently used in HD research (Azambuja et al., 2012; Eberson, 2000; Ferreira-Correia, 2019). This study hopes to obtain the diagnostic validity of the HVOT in terms of its capacity to discriminate controls from a clinical sample of HD/HDL2 patients. In an attempt to provide as much differentiation between the control group and the clinical group, this study will provide cut-off scores which will aid in the interpretation of HVOT scores in the South African population.

2.3.3 Reliability

Reliability is defined as the "consistency with which a test measures what it says it measures" (Foxcroft & Roodt, 2018, p. 60). The first reliability data for the HVOT show a split-half correlation coefficient of 0,82 in a sample of college students and 0,78 in a clinical population. (Hooper, 1958). These statistics show good reliability and suggest that the HVOT consistently measures participants' ability to organize visual stimuli.

Another study showed that the HVOT had a reliability coefficient of r = 0,80. The result suggested good internal consistency (Gerson, 1974). A more recent study which used the HVOT on a sample of Greek participants yielded a Cronbach alpha of 0,85 (Giannakou & Kosmidis, 2006) and it was concluded that the original sequence of the HVOT is a reliable and valid neuropsychological tool for the Greek population. In addition, a study which explored the psychometric properties on a Venezuelan population, yielded an McDonalds omega of 0,86 which is considered to be good internal consistency reliability for the total HVOT score (Campagna & Ferreira-Correia, 2021).

2.4 Rationale

Efforts to norm neuropsychological tests in South Africa have been made. Specifically, these include the WAIS-IV, the SSAIS-R, and the Individual Scales for Zulu Speaking (ISZSP), among others. However, there has been no norming done on the HVOT. These efforts do not cover all the tests commonly used by neuropsychologists, and some of the methodologies used are not representative norms for all South Africans. Given that the HVOT is easy to administer, it aims to measure a unitary construct, it is sensitive to different pathologies, it has the potential to be used in multiple languages (where answers are accepted in any language), and it is widely used (Giannakou & Kosmidis, 2006; Hooper, 1958), it may be a good tool for the South African context.

The present study investigated the psychometric characteristics and normative performance of the HVOT in the multicultural context of South Africa, specifically in a sample of adults who do not speak English as a first language and attended public/government funded primary and secondary education. While some studies have made use of a "mixed bag of standardization for the entire country without any stratification for quality of education" (Watts & Shuttleworth-Edwards, 2016, p. 1319), this investigation aims to determine which demographic variables, namely age, gender, and years of education influence the performance on the HVOT in order to guide the stratification of norms. Research has demonstrated that the relationship between HVOT and education has been minimally significant (DeVries, 2005; Tamkin & Jacobsen, 1984), and this will be further explored in this research study.

South African multilinguals who attended public schooling in the year 2019. represent the majority of the country. Specifically, majority of students (96.88%) attended public schools (South African Market Insights, 2020), where classes are too large, there are a lack of books, school fees are considered to be too high, facilities at public school are considered to be substandard, teachers are scarce, and quality of teaching is poor (South African Market Insights, 2020). This results in an educational disadvantage that influences cognitive performance (Manly, 2005). A study by Shuttleworth-Edwards et al. (2004) attributed differences in neuropsychological test performance between Black and White South Africans to the differences in their quality of education. The study showed that Black African people who had been educated at the Department of Education and Training (DET) schools performed more poorly that did White individuals who had been educated at Model C schools. The effects of education on neuropsychological test performance have confirmed that individuals with poor

quality of education, perform more poorly than those with better quality education (Shuttleworth-Edwards et al., 2004).

The HVOT is a good test to use with this specific population in terms of its psychometric properties, and therefore this study hopes to contribute to the debate around its cultural appropriateness, its construct and discriminant validity. The findings hope to contribute to the unitary vs multi-construct debate by exploring the correlation between the HVOT and MoCA. It aims to determine the concurrent validity of the HVOT by correlating the total score of the HVOT and the total score of the Montreal Cognitive Assessment (MoCA). The MoCA is a quick to administer tool clinically used by clinicians in South Africa (Hakkers et al., 2018; Robbins et al., 2013) as well as globally (Nasreddine et al., 2005). It is considered to be a brief screening tool for mild cognitive impairment and is known to objectively assess a number of the cognitive domains in only ten minutes (Dautzenberg et al., 2019). Items on the HVOT can be said to be less prejudiced against participants first language (Giannakou & Kosmidis, 2006b) and level of education (Hooper, 1958).

Even though the HVOT has been previously validated, its validity for the specific sample which I am investigating has yet to be determined. In order to investigate this, neuropathologies in which the visuo-constructive function is affected, such as HD/HDL2, are compared to healthy groups.

In order to better assess reliability as compared to other studies, I make use of the McDonalds Omega ω_t. This form of reliability testing, i.e. McDonalds Omega, ω_t is based on a one factor model and it is a better way to assess reliability as it overcomes the deficiencies of Cronbach alpha, α (Deng & Chan, 2017). This study will determine reliability using McDonalds Omega. Furthermore, the current investigation further aims to carry out item analysis. Given that none of the previous studies have made use of Item Response Theory (IRT) item analysis, and, considering its strengths, this form of analysis in the current study makes an important contribution.

3 METHODS

3.1 Research Questions

a) Do demographic variables, such as age; number of years of formal education; and gender have a significant correlation with the HVOT total score?
b) What are the norms for the HVOT in a South African sample of participants that do not speak English as a first language and have attended a public school?
c) What is the concurrent validity of the HVOT in terms of the correlation of the total score of the MoCA?
d) What is the construct validity of the HVOT in relation to the visuo-constructive and confrontational naming items of the MoCA respectively?
e) What is the diagnostic validity of the HVOT in terms of its capacity to discriminate controls from patients with HD/HDL2?
f) What is the internal consistency/reliability of the HVOT?
g) What is the item difficulty of each item of the HVOT for this study specific sample, from an Item Response perspective?

3.2 Null Hypotheses

Demographic variables such as age, number of years of education and gender do not have a significant effect on the HVOT total score.

Normative data for the HVOT in a South African sample do not include stratifications by age, years of education and gender.

There is no concurrent validity between the HVOT and the total score of the MoCA.

There is no construct validity between the HVOT and the visuo-constructive and confrontational naming items of the MoCA.

There is no diagnostic validity in terms of the HVOT's capacity to discriminate controls from patients with HD/HDL2.

There is no internal consistency/reliability of the HVOT.

There is no change in item difficulty of each item of the HVOT for this study specific sample from an Item Response perspective.

3.3 Research Design

This investigation is non-experimental as none of the variables have been manipulated. It involves a cross sectional design because it investigates particular variables retrospectively, without directly interfering with it (Field, 2018).

3.4 Sample and Sampling

Secondary data obtained from the research titled *The Neurocognitive profile of Huntington's Disease-Like 2,* which was conducted by the supervisor of this study (Ferreira-Correia, 2019) from her PhD thesis, will be used.

The data used in this study (Ferreira-Correia, 2019) was collected in stages where participants with HD/HDL2 as well as control participants were recruited. Given the rarity of HD/HDL2 in the South African population within the stipulated demographics, only 18 patients participated in her study. Ten participants formed part of the HD group and eight were part of the HDL2 group. One participant from the HDL2 group was excluded for the current study as the participant did not complete the HVOT. The recruitment of the control sample aimed to match the HD/HDL2 participants in terms of language and education and age.

The original sample was obtained from a clinic established by Prof Krause at the University of the Witwatersrand (Wits) and the National Health Laboratory Service (NHLS) with the aim of providing health care services to patients with HD and HD-phenocopy diseases and their families, as well as collecting data for this research. It was located at the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Data collection occurred simultaneously for both the control and clinical group. Both groups were formed by means of purposive homogenous sampling (Leedy & Ormrod, 2015), so as to better match the demographics of the patients. The sample comprised of 111 healthy adults who did not meet the clinical diagnostic criteria for HD. Participants age, ranged from 19 years to 70 years and had an education of between 6 to 22 years of education. There were

more males (70,6%) than females (29,4%) in the clinical group, however, in the control group the opposite was true, where there were more females (56,8%) than males (43,2%).

For the purpose of the current investigation the scores obtained from the visuospatial items which include Trails, the Copy Cube and Clock Drawing; as well as items of confrontational naming (i.e., lion, rhinoceros, and camel) of the MoCA will be correlated with the total score of the HVOT to explore the construct validity. Data on concurrent and construct validity for the HVOT in South Africa is not available, which is a gap this study intends to fill.

Only participants who were able to speak English were included in the research study. Participants who had comorbid neurological or metabolic diseases, history of traumatic brain injury (TBI) with loss of consciousness, abuse of illegal drugs, and/or who did not give formal consent were excluded from participation. Demographic characteristics of the sample is illustrated in Table 1.

Table 1.

Demographic characteristics of the clinical (HD/HDL2) and control group

		Diagnosis Group	
Variables	Statistics	Clinical Group (HD/HDL2) (n=17)	Control Group (n=111)
Age (years)	Mean	43,94	47,37
	SD	9,57	9,33
	Min	32	19
	Max	61	65
Gender			
Male	N (%)	12 (70,6)	48 (43.2)
Female	N (%)	5(29,4)	63 (56.8)
Education (years)	Mean	12,65	12,28
	SD	2,47	2,77
	Min	9	6
	Max	18	22
HVOT score	Mean	11,29	18,14
	SD	6,56	5,45
	25th p,	4,50	14,50
	50th p,	10,00	17,50
	75th p,	17,25	22,00
	Min	3	5
	Max	21	29

3.5 Procedure

This study was conducted through the following sequence of events: ethics clearance was sought from Human Research Ethics Committee (Medical). Thereafter, participants were recruited and invited to participate in the neuropsychological assessment. The data was captured in Research Electronic Data Capture (REDCap ®) (Harris et al., 2009) and then analysed and reported on. A total of 16 neuropsychological tests formed part of the original assessment battery. For the purpose of the current project, the data obtained from the demographic questionnaire, the HVOT and the MoCA were used.

During administration, the neuropsychological assessment of control participants was conducted at different venues following the participants' convenience. The clinical sample of HD/HDL2, was assessed at a consulting room in the CHBAH or the DGMC (Ferreira-Correia, 2019). The testing room had a desk and chairs with light and ventilation. Good assessment conditions in terms of light and ventilation conditions, as well as furniture (desk and chair) availability were kept in all instances.

For the specific purpose of this thesis, the following procedure was followed:

a) Data was pre-selected by my supervisor, Dr Ferreira-Correia and was shared by a password-controlled file and a private link to the Dropbox® folder which was sent to me via email. This folder contains the database in excel and the scanned research protocols that have been anonymised and identified only by a research number.

b) Quality control of the data was conducted. Previously, the data of the respective tests, had been collected and scored by two researchers. I acted as a third independent individual who ensured precision and accuracy of the available data.

c) Statistical analysis and report writing were the final step of this master's research report.

3.6 Instruments

Demographic questionnaire (Ferreira-Correia, 2019)*:* The demographic questionnaire was the first to have been administered. Participants were given a questionnaire to determine variables such as age, level of education, occupation, language experience, gender, ancestry,

HD/HDL2 history (diagnosis, onset and symptomatology), general medical history and medication (Appendix A).

Montreal Cognitive Assessment (MoCA)- (Nasreddine., 2005) – In the original study, the MoCA was administered after the demographic questionnaire was filled out. Participants completed the tasks in the order it is presented in the original test following instructions given by the examiner. It includes the following subtests: Trails (one point), Copy Cube (one point), Clock Drawing (three points) and confrontational naming of the Lion, Rhinoceros and Camel (three points). It also includes other subscales such as attention (six points), language (three points), abstraction (two points), memory - delay recall (five points), orientation (six points). The total possible score which a participant can achieve is 30 points.

The neuropsychological domains measured by the aforementioned subscales of the MoCA comprise of executive function and visuospatial abilities, confrontational naming, short-term memory, attention and working memory, language, concentration, verbal abstraction and orientation (Nasreddine et al., 2005). Cognitive skills such as auditory and visual comprehension, concentration, visuospatial abilities, abstract conceptualization, executive control, and perseverative responses can also be determined from the Clock Drawing Test (CDT) (Ehreke et al., 2011; Lezak et al., 2012b).

Hooper Visual Organization Test (HVOT) (Hooper, 1958)- The HVOT consists of 30-line drawings that depicts uncomplicated objects which have been cut into pieces and placed in a puzzle-like manner. The HVOT was the sixth test in a battery of 16 neuropsychological tests given to participants. During administration, the original version of the test was used, and the following protocol was adhered to - the booklet of pictures was placed before the participants and instructions were read out. If the respondent could not answer item 1, a cue was provided. The pictures were presented in the order in which they appeared in the original booklet. There was no time limit. If participants were unable to respond in English, answers were accepted in other languages. Answers in other languages were later translated by a research assistant who was proficient in several South African languages. Furthermore, the research assistant accommodated for the familiarity with the objects. The scoring rules of the manual were adjusted for the same reasons noted above. Responses were recorded on the answer sheet (Hooper, 1958). Table 2 below illustrates the adapted scoring system.

Table 2.

Scoring system for the South African population

Item number	Score 1	Score 0,5	Score 0
1	Fish		
2	Saw		
3	Table, Bench		desk
4	Airplane, flying machine		flight
5	Baseball, other round ball	Football, rugby ball	egg
6	Hammer		Axe,crowbar, saw
7	Dog, Sheep,Lamb	Animal	Bear, pig
8	Truck, Lorry	Car, vehicle	Motorbike, machine for cement
9	Cup, Mug	Jug	kettle, iron, pot, handbag
10	Hand	Glove	Fingers, foot, palm
11	Apple, Peach, tomatoe, pumpkin, pear etc	Fruit	Mouth, umbrella
12	Basket		Net
13	Scissors		Hanger
14	Cane, Hockey stick, walking stick, stick		Pencil, knife, umbrella
15	Sailboat, Boat, Ship		dress, washing
16	Teakettle, kettle, teapot		
17	Chair, Couch	Sofa	
18	Candle		flower
19	Teapot, Kettle		
20	Cat	Animal	Rabbit, dog, lion
21	Flower, Pansy, etc.		Tree, Mountain, clouds
22	Mouse, rat, Guinea Pig, etc.	Animal	Hamster, pipe, pig, rabbit
23	Book, bible, dictionary		
24	Rabbit	Animal	dog, rat, cat
25	Block, cube		book, box, brick, dice, house, square
26	Lighthouse, house of the sea	Tower, Castle, watch tower, Church, Tower high place	house, pen, pencil
27	Shoe, boot		Iron, toilet seat
28	Key		cutting tool, knife, razor
29	Ring, diamond ring		Lock, padlock, handle
30	Broom		Mop, pumpkin

3.7 Ethical Considerations

Initially, external medical ethical clearance was obtained from the Human Research Ethics Committee (Medical), with a clearance certificate number: M140872 (Appendix B). For the purpose of the current study, additional ethical clearance was obtained from the Human Research Ethics Committee (Medical), with clearance certificate number: M200669. This study obtained ethical approval from the University of the Witwatersrand on the 21st of July 2020 (Appendix B). The secondary data was used in this study within the scope that was initially allowed by the Human Research Ethics Committee (Medical) when the original study was conducted. The current research report used the data to describe the controlled performance of the selected sample and make a comparison with a homogenous clinical sample of HD/HDL2 participants. The hard copies of the anonymised assessment protocols are kept locked at an office at the University of the Witwatersrand. Presently, the data is stored on my password protected computer, which will be deleted from this device on completion of this master's thesis. During the data collection process (Ferreira-Correia, 2019), and the present study, confidentiality was protected by anonymizing the data using research ID numbers and separating the consent forms (Appendix E and F) from the data.

There was minimal risk to participants when the study was conducted, however, the neuropsychological assessment process may have elicited anxiety and fatigue in participants. In order to mitigate the effect of these factors on the participants, they were reminded about their right to withdraw from the study at any time and/or refuse to answer specific questions. Moreover, participants were given a comprehensive information sheet (Appendix C and D) that explained the project and provided full disclosure with regard to what the research involved.

An independent genetic counsellor was responsible for describing the research to participants, provide information about the study to participants, and answer their questions regarding participation. Due to the varying levels of English proficiency, cognitive status and levels of education, the information was explained verbally in the presence of an accompanying person. Only participants with conversational English were invited to participate in the neuropsychological assessment. Participants signed an informed consent form prior to the commencement of the neuropsychological testing.

Participants were not misled nor were there any inducements, furthermore, there were no negative consequences (such as limited access to the clinic services) for those who chose not

to participate. Free counselling services at the CMJAH or at the HD clinic were provided for those participants who reported distress during their participation. Participants were financially compensated for their participation. Lunch was provided to those attending the clinic at the CMJAH.

Participants were given the choice to obtain information about the results of the study. Therefore, the contact details of the researcher and the supervisor were provided in the information sheet (Appendix C and D). The participants were also invited to contact the Ethics Committee and research supervisors in case they had concerns linked to the research project. It was also brought to their attention that the final products of this research (PhD thesis, journal articles, and conference presentations) was available on the World-Wide Web.

3.8 Data Analyses

In order to determine the psychometric properties of the HVOT, IBM SPSS Statistics 26 (IBM Corp., 2019) was used to run the statistical analysis. Descriptive analysis was performed for all variables. The sample was described through the use of frequency distributions (Table 6), measures of central tendency and variability in order to better define demographic variables and ranges to use for the normative data.

The second step was to explore the influence of demographic variables on the total score of the HVOT which was done using parametric statistics such as Pearson's correlation co-efficient. Initially, an ANOVA was performed, however, due to the small sample sizes in each of the groups, the analysis was not meaningful (Appendix C and D). These groups included age groups of 19-40 years; 41-60 years; and 61-70 years, and education groups of 2-11 years; 12-16 years; and 17-22 years.

Concurrent validity was determined by correlating the total score of the HVOT and the total score of the Montreal Cognitive Assessment (MoCA). Additionally, all items of the MoCA were correlated with the total score of the HVOT to explore the construct validity. Performance of control participants was correlated with the clinical sample of HD/HDL2 participants in order to determine the diagnostic validity of the HVOT.

Internal consistency/reliability was reported on by determining the Cronbach Alpha as well as McDonalds Omega. This involves a correlation between all the items on the HVOT.

Lastly, item analysis of the HVOT was performed where the item difficulty was determined such that they are appropriate for the South African population. This was done by checking the number of correct responses per item. The higher the number of correct responses the easier the item would be. During the item analysis, 8 participants from the control group were excluded due to poor legibility of the protocols and were regarding as missing data.

4 RESULTS

In order to explore the distribution of the data and decide whether parametric or non-parametric statistics would be required; tests of normality were run on the HVOT total scores the healthy participant group. From the analysis, it was evident that the data was fairly symmetrical as noted from the skewness statistic of 0,162. There was a lack of kurtosis and the distribution of scores was neither too flat nor too packed, as observed from the kurtosis statistic of -0,490 (Table 3). Kolmogorov Smirnov = 0,079, df (111), p = 0,089 and Shapiro Wilk = 0,981, df (111), p = 0,108 (Table 4) indicates a result that is greater than 0,05, therefore the data is normally distributed. Figure 1 is a histogram which depicts the normal distribution.

Table 3.

Skewness and Kurtosis of the HVOT

		Statistic	Std. Error
Mean		18,144	0,5176
95% Confidence Interval for Mean	Lower bound	17,118	
	Upper bound	19,170	
Median		17,500	
Variance		29,734	
Std. Deviation		5,4529	
Minimum		5,0	
Maximum		29,0	
Range		24,0	
Interquartile Range		7,5	
Skewness		0,162	0,229
Kurtosis		-0,490	0,455

Table 4.

Tests of Normality for the HVOT

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HVOT	0,079	111	0,089	0,981	111	0,108

a. Lilliefors Significance Correction

control group n=111

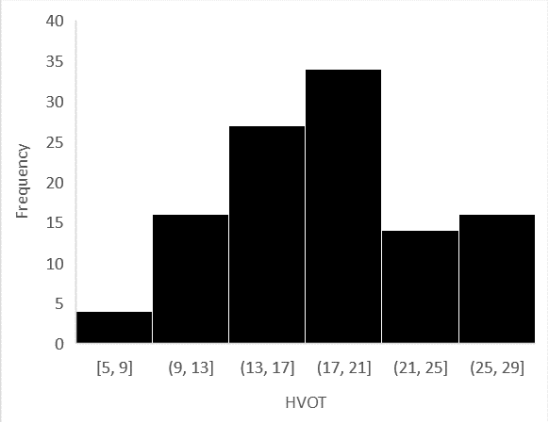

Figure 1.
Histogram for mean scores of the HVOT

Both the Cronbach alpha (0,87) and McDonald's omega (0,90) analysis of internal consistency reliability for the total score of the 30 HVOT items were good which suggests that every item in the HVOT measures various aspects of the same construct. An examination of the Cronbach alpha values if any of the 30 items were deleted showed no increase in reliability values ranging from 0,86 to 0,87 (Table 5). No items were removed as these values are acceptable.

Table 5.

Internal consistency reliability of the HVOT (Cronbach alpha coefficients)

HVOT Item	Scale Mean if item deleted	Scale variance if item deleted	Corrected Item-Total Correlation	Cronbach's Alpha if item deleted
1. Fish	17,153	29,695	0,029	0,871
2. Saw	17,171	29,452	0,144	0,871
3. Table	17,171	29,680	0,016	0,872
4. Airplane	17,324	28,148	0,351	0,868
5. Baseball	17,617	26,932	0,509	0,863
6. Hammer	17,369	28,035	0,343	0,868
7. Dog	17,257	28,872	0,233	0,870
8. Truck	17,495	28,048	0,335	0,868
9. Cup	17,329	28,216	0,346	0,868
10. Hand	17,297	28,329	0,362	0,867
11. Apple	17,212	28,975	0,274	0,869
12. Basket	17,450	28,441	0,218	0,872
13. Scissors	17,514	27,207	0,453	0,865
14. Cane	17,730	27,072	0,469	0,865
15. Sailboat	17,766	26,526	0,592	0,861
16. Teakettle	17,315	28,372	0,302	0,869
17. Chair	17,640	27,305	0,549	0,863
18. Candle	17,288	28,525	0,288	0,869
19. Teapot	17,396	27,305	0,491	0,864
20. Cat	17,545	26,871	0,522	0,863
21. Flower	17,748	26,799	0,529	0,863
22. Mouse	17,653	26,145	0,660	0,858
23. Book	17,315	27,881	0,428	0,866
24. Rabbit	17,680	27,204	0,454	0,865
25. Block	18,027	28,008	0,474	0,865
26. Lighthouse	17,932	27,393	0,564	0,863
27. Shoe	17,838	27,883	0,335	0,868
28. Key	18,027	28,408	0,355	0,867
29. Ring	17,973	27,881	0,428	0,866
30. Broom	17,946	27,652	0,456	0,865

Table 6 presents the frequency of full score, half scores and zero scores for each of the HVOT items. The difficulty values reveal that items 29 (Ring), 25 (Block), 28 (Key), 30 (Broom) and 26 (Lighthouse) are the most difficult. The easiest items were identified to be, 3 (Table), 1 (Fish), 2 (Saw), 7 (Dog), 11 (Apple). The discrimination values of the HVOT are variable and range between 0,5 to 2,53. The items with the best discriminating power in this sample are 19 (Teapot), 22 (Mouse), 26 (Lighthouse), 23 (Book), and 25 (Block).

Table 6.

Frequencies of full credit, half credit and no credit for each HVOT item

Item	1 credit		0,5 credit		0 credit		Frequent errors			Item Analysis	
	n	%	n	%	n	%	Answer	n	%	a	b1
1. Fish	102	99		0	1	1				0,63	-6,18
2. Saw	101	98		0	2	2				1,46	-2,80
3. Table	100	97		0	3	3				0,50	-6,20
4. Airplane	86	83		0	17	17				2,01	-0,90
5. Baseball	51	50	9	9	43	42	Kite	8	8	1,56	0,07
6. Hammer	79	77		0	24	23	Axe	12	12	1,15	-1,19
7. Dog	91	88	3	3	9	9			0	1,11	-1,66
8. Truck	54	52	16	16	33	32			0	1,17	-0,01
9. Cup	84	82	5	5	14	14	Kettle	5	5	1,49	-0,97
10. Hand	85	83	5	5	13	13			0	1,50	-1,05
11. Apple	95	92	3	3	5	5			0	1,99	-1,45
12. Basket	69	67		0	34	33	Net	10	10	0,78	-0,89
13. Scissors	66	64		0	37	36	Hanger	7	7	1,67	-0,40
14. Cane	44	43		0	59	57	Knife	15	15	1,44	0,50
		0		0		0	Umbrella	10	10		
15. Sailboat	39	38		0	64	62	Dress	7	7	1,72	0,39
		0		0		0	Washing	5	5		
16. Teakettle	83	81		0	20	19			0	1,41	-1,08
17. Chair	35	34	39	38	29	28			0	1,46	0,73
18. Candle	87	84		0	16	16	Flower[1]	9	9	1,31	-1,50
19. Teapot	72	70		0	31	30			0	2,53	-0,60
20. Cat	62	60	3	3	38	37	Rabbit	10	10	2,05	-0,22
21. Flower	42	41		0	61	59	Clouds	9	9	1,61	0,40
		0		0		0	Mountain	5	5		
		0		0		0	Tree[2]	32	31		
22. Mouse	52	50	3	3	48	47	Pipe[3]	11	11	2,36	0,13
23. Book	87	84		0	16	16			0	2,23	-1,06
24. Rabbit	44	43	7	7	52	50	Dog	7	7	1,33	0,43
		0		0		0	Cat	7	7		
25. Block	10	10		0	93	90	Box	11	11	2,13	1,62
		0		0		0	House	31	30		
26. Lighthouse	18	17	16	16	69	67	House[4]	11	11	2,24	1,32
27. Shoe	29	28		0	74	72	Iron	19	18	0,93	1,08
		0		0		0	Toilet seat[5]	19	18		
28. Key	19	18		0	84	82	Cutting tool	5	5	1,58	1,55
		0		0		0	Knife	23	22		
		0		0		0	Razor[6]	9	9		
29. Ring	11	11		0	92	89	Lock[7]	13	13	1,14	2,16
30. Broom	21	20		0	82	80	Pumpkin	21	20	1,70	1,34

n=103 (8 participants were excluded due to missing data)

Note. a=discrimination parameter; b1=difficulty parameter

[1] includes flowerpot

[2] includes tree with bird

[3] includes pipe for smoking; smoke pipe;smoking pipe

[4] includes rondavel; house with chimney

[5] includes toilet, toilet room; potty; seat for toilet; base for toilet

[6] includes razor blade

[7] includes padlock

Pearson's correlation reveals a significant moderate negative correlation between age and the total HVOT score (r=-0,368), suggesting lowered scores in older participants (Table 7). There is a weaker but significant positive correlation between gender and HVOT total score (r=0,268) which suggests that females performed better, (n=63, $\bar{x}$=19,413, SD=5,1223) than males (n=48, $\bar{x}$=16,479, SD=5,4762) (Table 8). There is a moderate positive correlation between years of education and HVOT total score (r=0,343) indicating that participants with a higher level of education (12-22 years) performed better that those with a lower level of education(2-11years).

Table 7.

Pearson's correlation between HVOT and sociodemographic variables (age, gender and years of education)

		Age	Gender	Years of education
HVOT Total	Pearson Correlation	-0,368**	0,268**	0,343**
	Sig. (2-tailed)	.000	.004	.000
	N	111	111	111

**. Correlation is significant at the 0.01 level (2-tailed).

Table 8.

Group normative statistics

Variables	Statistics		
	N	Mean	Std. Dev
Years of education			
2-11 years	40	15,663	4,8759
12-22 years	71	19,542	5,2893
Age			
19-40 years	28	20,661	4,6608
41-70 years	83	17,265	5,4785
Gender			
Male	48	16,479	5,4762
Female	63	19,413	5,1223

During the initial data analysis of this study, an ANOVA was performed (Appendix G and Appendix H) in order to determine the best stratification categories for the norms. These

groups, as previously mentioned included age groups of 19-40 years; 41-60 years; and 61-70 years, and education groups of 2-11 years; 12-16 years; and 17-22 years. In the end, however, two groups were created groups because further splitting would have made the groups too small. As a result, an independent samples t-test was performed.

The independent t-test showed that females had statistically significantly higher HVOT total scores (19,41 ± 5,122) compared to males (16,47 ± 5,48), *t*(109)=-2.901, *p*=0.004 (Table 9). Furthermore, participants aged 19-40 years performed significantly better (20,66 ±4,66) compared to participants aged 41-70 years (17,27 ±5,48), t(109)=2,92, p=0.004 on the HVOT. Lastly, individuals with an education of 12-22 years achieved a significantly higher HVOT total score (19,54 ±5,29) compared to those with an education of 2-11 years (15,66 ±4,88), t(109)=-3,81, p=0,000 (Table 9).

Table 9.

Independent samples t-test for age, gender and years of education and the HVOT total score

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
HVOT Total (Gender)	Equal variances assumed	0,137	0,712	-2,901	109	0,004	-2,9335	1,0112	-4,9376	-0,9294
	Equal variances not assumed			-2,875	97,652	0,005	-2,9335	1,0204	-4,9586	-0,9085
HVOT Total (Age)	Equal variances assumed	0,378	0,540	2,919	109	0,004	3,3655	1,1529	1,0805	5,6506
	Equal variances not assumed			3,159	54,005	0,003	3,3655	1,0655	1,2293	5,5018
HVOT Total (years of education)	Equal variances assumed	0,326	0,569	-3,814	109	0,000	-3,8798	1,0172	-5,8958	-1,8637
	Equal variances not assumed			-3,902	86,637	0,000	-3,8798	0,9942	-5,8559	-1,9036

The construct validity was explored by correlating the total scores of the HVOT with different domains of the MoCA (Table 10). There was a significant positive correlation between all the respective domains, except for the MoCA orientation total and the HVOT total score. A strong, positive correlation was noted between the HVOT and the MoCA language total (r=0,564, p=0,000). This means that participants who achieve a high score on the HVOT will likely achieve a high language total score on the MoCA. There was a moderate, positive correlation between the HVOT and the MoCA Delayed Recall Total (r=0,395, p=0,000).

Therefore, participants who obtain a high HVOT score are likely to get a high score on the MoCA delayed recall subtest, and *vice versa*. A moderate, positive strong correlation was also noted between the HVOT and the MoCA naming total (r=0,354, p=0,000). Consequently, high HVOT scores are likely to also produce high MoCA naming total scores.

Table 10.
Pearson Correlation Co-efficient showing the relationship between the HVOT total score and different subtests of the MoCA

	Pearson Correlation	Sig. (2-tailed)
MoCA Visuospatial Executive Total (trails, cube, clock) x HVOT Total	.193*	.042
MoCA Naming Total x HVOT Total	.354**	.000
MoCA Attention Total (digits, tapping, subtraction) x HVOT Total	.291**	.002
MoCA LanguageTotal (Naming, repetition, fluency) x HVOT Total	.564**	.000
MoCA Abstraction Total x HVOT Total	.296**	.002
MoCA delayed recall Total x HVOT Total	.395**	.000
MoCA orientation Total x HVOT Total	.044	.650

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The statistical findings suggest that the clinical group (n=17) had statistically significantly lower mean HVOT total scores (11,30 ± 6,56) compared to control group (18,14 ± 5,45) (Table 11), $t(126)=-4,693$, $p=0,000$ (Table 12). There is a difference in sample size between the clinical and control group, and that can affect the power of this claim and increase the chance of Type I errors. This difference in sample size may decrease the statistical power.

Table 11.

Mean HVOT scores and Standard Deviations for the clinical and control groups

Diagnosis Group	N	Mean HVOT	Std. Deviation
Clinical	17	11,294	6,5552
Control	111	18,144	5,4529

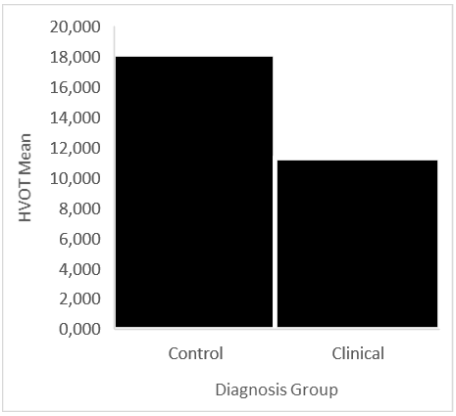

Figure 2.

Histogram showing the mean HVOT scores of the clinical and control group

Table 12.

Independent samples t-test for diagnosis group and the HVOT total score

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
HVOT Total (Diagnosis group)	Equal variances assumed	3,501	0,064	-4,693	126	0,000	-6,8500	1,4598	-9,7389	-3,9612
	Equal variances not assumed			-4,097	19,539	0,001	-6,8500	1,6720	-10,3430	-3,3570

Descriptive statistics of the HVOT scores were established once stratified by age, level of education and gender (Table 13). It is important to note that the age group 19-40 years, with an education of 2-11 years for both males and females were excluded due to the small sample sizes as this decreases the value of the data. The groups which showed the highest performance

were males and females between the ages of 19-40 years with an education of 12-22 years. Lowest performance was seen in male participants between the age of 41-70 years with an education of 2-11 years.

Table 13.

South African norms of the HVOT stratified by age, education and gender

Age Range	Education	Gender	N	Mean	SD	Median	Min	Max	5	10	25	50	75	90	95
19-40 years	12-22 years	Male	11	20,545	4,6393	20	13,5	28,5	13,5	14,1	17	20	24	28,2	
41-70 years	2-11 years	Male	17	12,412	3,4425	12,5	5	17,5	5	6,6	10,5	12,5	14,75	17,5	
41-70 years	12-22 years	Male	18	17,194	5,2332	15,75	9,5	29	9,5	9,5	14,375	15,75	22,125	24,05	
19-40 years	12-22 years	Female	15	20,533	5,11	18	11,5	28	11,5	13,3	17,5	18	26	27,4	
41-70 years	2-11 years	Female	21	17,667	4,397	18	9	25,5	9,2	11,2	14,5	18	21	22,9	25,25
41-70 years	12-22 years	Female	27	20,148	5,4664	19	10	29	10,6	13,5	16,5	19	25,5	28,2	29

5 DISCUSSION

The primary focus of the present study was to develop stratified HVOT norms for a South African sample of participants that do not speak English as a first language and who have attended a public primary and secondary school. Given that some studies have made use of a multiplicity of standardization for the entire country without any stratification for quality of education (Watts & Shuttleworth-Edwards, 2016) the present investigation mitigated these factors by stratifying the sample to participants who speak English as a second language and who have attended public school. In doing so, it hopes to limit linguistic bias. For this, I investigated the effects of sociodemographic variables (age, number of years of formal education and gender) on the HVOT total score. This study also provided evidence of predictive or concurrent validity, which is necessary for the evaluation of the clinical utility of this test in South Africa. Construct validity was determined in relation to the visuo-constructive and confrontational naming items of the MoCA. Furthermore, the diagnostic validity was explored in order to determine the capacity of the HVOT to discriminate controls from the clinical group of HD/HDL2 patients. Lastly, I explored the internal consistency and item appropriateness of this test for the South African multicultural and multilingual population.

Both the clinical and control groups comprised of small sample sizes. However, literature suggest that it is better to make use of well matched, small homogenous groups ($n \geq 5$) rather than large, heterogeneous groups (Crawford & Garthwaite, 2012). A well-defined and homogenous sample was selected for this project and is representative of a large proportion of the South African population. Therefore, this study may have significant value for clinicians using the HVOT in this context, despite the small sample numbers.

The results illustrate that younger people in the age group of 19-40 years performed better ($\bar{x}$ = 20,66, SD=4,66) than older ones in the age group of 41-70 years ($\bar{x}$=17,26, SD=5,47) and people with more years of education had a better performance ($\bar{x}$=19,54, SD= 5,28) than those with less ($\bar{x}$=15,66, SD=4,87). This is in line with what literature states, where it has been noted that increased age, and lowered levels of education were related to poorer HVOT performance (Campagna & Ferreira-Correia, 2021a; Giannakou & Kosmidis, 2006a). In brief, healthy adults with fewer years of education presented lower HVOT scores. Although this interaction suggests that education acts as a shielding factor against the decrease in the visuospatial function, it is important to keep in mind that the interaction between age and educational attainment and its impact on cognitive performance is complex (Ardila et al., 2000).

Educational attainment is known to have an impact on the development of specific abilities, on the access to higher socioeconomic levels (Ardila et al., 2000), and on health-related behaviours (Zahodne et al., 2015).

From the results it was established that gender had a significant correlation with the total score, with females performing better than males. Although a gender bias in the visuospatial functions has been suggested (Hatta et al., 2015; Parsons et al., 2004), our study challenges this notion, as other studies suggest that men outperform women (Campagna & Ferreira-Correia, 2021; Hatta et al., 2015), whereas another study did not find any significant relationship between gender and HVOT scores (Giannakou & Kosmidis, 2006). Future studies in South Africa should explore the potential contribution of gender towards the total score of the HVOT while controlling for age and years of education.

In this study, we presented the HOVT norms for the South African population stratified by age, gender and years of education. All these variables had a significant correlation to the total HVOT score. To our knowledge, no other norms for the HVOT are available in this country. When our normative data was compared to those of the Greek population (Giannakou & Kosmidis, 2006) which was also stratified by age and education level, the mean scores of the South African population was lower, and while the Greek population demonstrated significance for age and level of education, there was no significant association with HVOT score and gender. The mean HVOT scores which was stratified by age by Tamkin and Jacobsen (1984) for an adult population in Georgia, were similar to the mean scores which was obtained for the South African population. A more recent normative study conducted on the Venezuelan population demonstrated a significant association between age, gender and level of education (Campagna & Ferreira-Correia, 2021), much like the current study, although gender differences were noted. It is important to consider that the generalisability of the current norms may be questionable. One of the reasons, is that the use of quota sampling represented a limitation because some of the resulting subgroups were too small to be representative of a particular set of demographics (e.g., the age group of 19-40 years who had an education level of 2-11 years for both males and females). The data for these participants were excluded, as was noted in Table 13, as they do not provide reliable data for clinical comparisons.

The original test battery included a naming measure from the MoCA in order to explore a potential confounding association between naming abilities and performance on the HVOT, which has been previously noted (Greve et al., 2000). Some argue that naming difficulty of the

HVOT items are not sufficient to affect overall performance (Paolo et al., 1996), while others state that successful performance depends to some degree on intact object naming (Ricker & Axelrod, 1995). In the present investigation, a strong correlation was evident between the HVOT and the MoCA language total (r=.564, p=.000) and the MoCA naming total (r=.354, p=.000). Additional research should consider incorporating other psychometric measures apart from the MoCA in order to further validate the HVOT's association with naming ability.

In terms of the HVOT's ability to discriminate between the normal control and clinical group, it was apparent that the clinical group performed significantly worse than the healthy control group. This supports literature which states that patients with HD/HDL2 often present with visuo-constructive deficits (Gómez-Tortosa et al., 1996), and that the HVOT is known to be able to discriminate these cognitive dysfunctions in patients (Azambuja et al., 2012). Given that this study only made use of the HD/HDL2 clinical population, the generalisability on the results is limited. It is also noted that the sample size of the clinical group was small (n=17) in comparison to the control group (n=111), which is a limitation of this study and future research should take this into account. The HVOT therefore, has potential for clinical use in the assessment of these deficits, but need to be confirmed with other neuropathologies in our context.

Furthermore, the fact that answers can be accepted in different languages, it allows for assessment of linguistically diverse patients. However, this needs to be further explored in studies that better control for this. The results from the current investigation suggest that the HVOT has good internal consistency with a similar Cronbach's alpha as that found in previous studies (Giannakou & Kosmidis, 2006; Lopez et al., 2003; Merten & Beal, 1999) and good McDonalds Omega total reliability (Campagna & Ferreira-Correia, 2021).

There were differences noted with respect to item responses when the current results were compared to reports by DeVries (2005), as none of the items in our sample received 100% of correct responses. Item one (fish), however, was the easiest one with only 1% of the participants giving incorrect responses. Other examples include items 3 (table) and 2 (saw), which were among the ten easiest items, while 25 (block) was one of the ten most difficult ones. Hence, the administration order should follow empirical data that is context specific (Campagna & Ferreira-Correia, 2021). Presenting the items by order of difficulty opens the possibility of considering the application of a discontinuation rule, which has yielded good discriminatory power (Wetzel & Murphy, 1991; Campagna & Ferreira-Correia, 2021) and decreases

administration time and levels of fatigue for the patient. However, given the findings of the current study, no discontinuation rule should be applied when administering the HVOT in the South African context.

This study represents an important contribution to the literature on psychological assessment in South Africa, as it demonstrates the psychometric properties and potential of the HVOT and normative use for South African polyglot adults who speak English. However, it is not a definitive study and requires a more exhaustive psychometric study in terms of the discriminatory power of the HVOT items in the South African population. In the meantime, South African practitioners are encouraged to use the adapted version of the HVOT presented here, which along with stratified norms, can be used as a point of reference in order to minimize the limitations imposed by the use of foreign norms.

5.1 Limitations

The use of quota sampling was a limitation for this study as some of the subgroups were too small to be representative of a particular set of demographics. Given the small sample samples in a specific set of demographics, methodologies commonly used by psychologists to compare patients scores against norms such as z-scores may increase the risk for diagnostic errors. Therefore, single case study methodologies as defined by Crawford and Garthwaite (2012) take into consideration the sample size of the normative group. Additionally, future normative and psychometric studies should aim to control for linguistic and educational variables with more sophistication, such as measuring English proficiency and categorizing public education in rural and urban schools. The data from the age group of 19-40 years, with an education of 2-11 years for both males and females were excluded as they did not provide reliable data for clinical comparison. There is only one type of clinical group, and although they are considered to be two different pathologies have similar neurocognitive presentation.

5.2 Recommendations

There is a need for a South African study that involves a larger sample size for both clinical and control groups. Furthermore, the size of each age group should be considered for a more reliable normative study which has clinical utility. Future research should take this into

account and strive for equal-sized groups in order to maximise statistical power. Future normative and psychometric should aim to control for linguistic and educational variables with more sophistication, like measuring English proficiency and categorising public education in rural and urban schools. According to Crawford and Garthwrite (2012), normative groups of a minimum of five can be used especially if the sample size is taken into consideration when comparing scores, however, the author recommends that 20 is a better size, so future studies should aim for higher levels of homogeneity within demographics subgroups and samples between 20 and 30 people per subgroup to improve the reliability of the results (Crawford & Garthwaite, 2012).

Additionally, a more detailed psychometric normative study for the South African population should incorporate additional measures of visuo-construction and naming ability for more robust construct validity results. Moreover, South African studies should further explore the potential contribution of gender towards the total score of the HVOT while controlling for age and years of education.

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7 APPENDICES

Appendix A: Demographic Questionnaire

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 B. Human Research Ethics Committee (Medical) Clearance Certificate

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

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mrs Saleha Mahomed Kola

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200669

NAME: (Principal Investigator)	Mrs Saleha Mahomed Kola
DEPARTMENT:	School of Human and Community Development Department of Psychology
PROJECT TITLE:	Preliminary normative data for the Hooper Visual Organization Test (HVOT) for a South African sample
DATE CONSIDERED:	26/06/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Mrs A. 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

23/07/2020
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Information Sheet for HD/HDL2 Patients

National Health Laboratory Service
University of the Witwatersrand, School Of Pathology
Division Human Genetics

GENETIC COUNSELLING CLINIC

Hospital Street, Johannesburg 2001
Telephone: +27-11-489-9224/9223/9211

PO Box 1038, Johannesburg 2000
Fax: +27-11-489-9226

Prof A Christianson 011 489-9211 | Prof A Krause 011 489-9219 | Ms T Wessels 011 489-9243

Information and consent form

***Title*: The Phenotype of Huntington Disease Like 2**

***Investigators*: Dr David Anderson & Ms. Aline Ferreira Correia**

Department Human Genetics

&

The University of the Witwatersrand Donald Gordon Medical Centre

Good Day

We are Dr. Dave Anderson, a neurologist specializing in movement disorders and Ms. Aline Ferreira Correia, a clinical psychologist. We are currently doing PhDs in Huntington disease.

Introduction

We are asking you to take part in this study because you have been diagnosed with Huntington Disease (HD) or a disease believed to be similar to it called Huntington Disease Like 2 (HDL2). In this form we will explain what this study involves and why this study is being performed.

Those with HD may experience difficulty thinking and making choices as well as mood problems and involuntary movements that start in adulthood. HD and HDL2 are genetic diseases that affect the brain. The cells of the human body carry genetic material in the form of long molecules called DNA, which is then copied and passed on the next generation. Each DNA molecule contains thousands of coded instructions called genes that make the cells work normally. The abnormal genes for HD and HDL2 have been identified and are not the same. We have discovered that other genetic factors outside the 'disease gene' can affect when the disease starts and how the disease it looks.

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 examination. However there is some information to suggest this may not be the case. If we were able to tell the difference between the two it might suggest differences in the disease pathways underlying the conditions and this might help us understand the processes causing them and where to focus on treating them.

In order to see if there are any differences between HD and HDL2 we will be doing detailed physical examinations of patients with HD and HDL2 and comparing them. We will also compare their brain in the form of MRI scans and lastly we will do blood tests to compare their DNA. And what their blood cells look like.

What will the study involve?

The HDL2 Phenotype study will involve a visit to Area 256 at the Charlotte Maxeke Johannesburg Academic Hospital. This visit will last 3-4 hours. You will then be taken to the University of the Witwatersrand Donald Gordon Medical Centre (WDGMC) where you will be given lunch and the MRI scan will be done. This will take another hour.

What will happen during the study?

If you have consented to participate in this study you will receive a unique identification number at the beginning of the your visit. This number will replace your name and all your personal and identifying data. This number will be used to identify you afterwards and only the local research staff will know who you are.

1. We will record all your unique information (name, date of birth, home address etc) and assign you a study number.
2. We will ask you questions about yourself, your past medical history, medications and other members of your family that may be affected by similar symptoms.
3. A full neurological examination will be performed as part of the Unified Huntington's Disease Rating Scale (UHDRS). Part of this will be videoed for analysis later.
4. Your cognition or thinking ability will be tested. This will involve a variety of activities, such as answering questions and doing paper and pencil tasks.
5. We are interested in how you and your family are functioning at home and will ask you about how you are coping with every day things around the home.
6. Blood will be taken for two tests. One will be to test your genetic fault the other to look at the shape of the blood cells. Some studies have shown that HDL2 patients may have slightly different shaped red blood cells.
7. An MRI scan will be done at WDGMC. This is not a painful test but does take 30–40 minutes. This will allow us to see if there are any differences between the brains of patients with HD and HDL2.

Where will the data be kept and how will it be used?

All of the data collected will be coded and will be kept by Dr. Anderson at WDGMC. This information will only be used for the purposes of studying HD and HDL2. This research will only be done with the approval of The University of the Witwatersrand Human Ethics Committee. Under no circumstances will your personal identifying information be used and your rights to privacy will be respected at all times. The data will be used for research only and no financial benefits will be a gained from this research.

The PhD theses 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 and presented in scientific meetings or conferences. All identifying information (such as names) will remain confidential at every stage of the process. If you wish to have access to a summary of the results, you may request so by contacting any of the researchers in 2019 when the project is expected to be finished. The videos will be digitally stored by Dr. Anderson and kept in a safe. They opportunity may arise to show other doctors and scientists what this condition looks like at scientific meetings. If this happens you will be asked if your video can be shown.

What are the risks of me participating in the study?

Your individual results from your evaluation will not be told to you because they are not part of normal clinical care and will not affect your treatment at the clinic. If you are concerned about your health you are welcome to discuss it with the team and we will address it through the clinic structures. In the unlikely event that the evaluation does reveal something important we will inform you as soon as possible and assist as the need arises.

The questionnaires, examinations and UHDRS pose no more risk to you than a regular physical examination. These will take longer than usual. The blood sample is also a standard test that you may have had before. You can have some discomfort from the needle and bruising. The MRI scan takes 30-40 minutes. It is a safe procedure that allows us to see the structure of the brain. You need to lie in a tunnel and keep still for the duration of the test. Some people feel uncomfortable in closed spaces and do not tolerate the test. We can work around this if you think this is going to be a problem. The cognitive testing might elicit distress if some of the tasks are perceived as difficult, however, the psychologist will monitor how you are feeling and will refer you to a free counselling service if needed[24]. All these tests are paid for by the study.

What are the benefits of the study?

You will not receive any direct benefits from undergoing these evaluations. What this study will do is provide important information about HDL2.

What are the financial implications?

Participating in this study will not cost you anything. All tests will be paid for. Although you will not be paid for participating in the study we will offer you R100 for travel costs incurred on the day and a sandwich will be provided for you.

Do I have to participate?

You are not obligated to participate in the study. Should you choose not to participate it will not affect your access to the HD clinic or the treatment you receive. If you decide that you would like to join the study a consent form will need to be signed by you or your legal guardian. Once it is signed you are still free to withdraw at anytime without giving a reason and your information will not be used in the study.

Can I be taken out of the study?

You may be withdrawn from the study if you do not follow the directions of the study or your medical condition changes so that staying in the study may risk your health or the research.

Questions?

Should you have questions regarding the study please contact the project coordinator, Dr Anderson at 011-726-8741.

If there are any complaints you have regarding the way the study is being conducted The Human Research Ethics Committee (HREC) of the University of the Witwatersrand can also be contacted with any concerns. Prof Cleaton Jones is the chairman 011 717 2301 (Monday-Wednesday-Friday mornings) alternatively the Jennifer Palmer can be contacted. 011 274-9278 (E-Mail: jpalmer@witshealth.co.za

Appendix D: Information Sheet for Healthy Controls

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 E: Informed Consent Form for HD/HDL2 patients

National Health Laboratory Service
University of the Witwatersrand, School Of Pathology
Division Human Genetics

GENETIC COUNSELLING CLINIC

Hospital Street, Johannesburg 2001
Telephone: +27-11-489-9224/9223/9211

PO Box 1038, Johannesburg 2000
Fax: +27-11-489-9226

Prof A Christianson 011 489-9211 | Prof A Krause 011 489-9219 | Ms T Wessels 011 489-9243

Informed Consent to participate in the HLD2 Phenotype study for patients over 18 years of age

This study will be conducted according to the Declaration of Helsinki (2008) and the South African Good Clinical Practice (SA GCP) Guidelines. These ensure, among other things the protection of individuals participating in research studies.

I _____ hereby declare that I have read and understood the information document for the research report entitled The Phenotype of Huntington Disease Like 2

I _____

1. Have read (or been read to me) and understood the information in this consent ☐ form.
2. Have been encouraged to ask questions and am satisfied with the responses to my questions. ☐
3. Have been told I will receive a dated and signed copy of this consent ☐ form.
4. Understand all the data collected will be kept confidential and that the results are to be used for scientific ☐ objectives.
5. Understand that my participation in this study is voluntary and I am free to withdraw at anytime and that this will not affect the care and ☐ treatment I receive.
6. Understand that I am not waving my legal rights as a result of signing this consent ☐ form.

7. Understand that there is no guarantee that this study will provide any benefits to me. ☐
8. Do consent to participate in this study by signing this consent form. ☐
9. Agree to be examined and videoed as has been explained. ☐
10. Agree to being interviewed as has been explained. ☐
11. Agree to my blood being taken as has been explained. ☐
12. Agree to have an MRI scan as has been explained. ☐

_____	_____	_____
Signature of research Subject	Name Printed	Date
_____	_____	_____
Signature of Witness	Name Printed	Date
_____	_____	_____
Translator	Name Printed	Date
Dr David Anderson	_____	_____
Signature of Principal Investigator	Name Printed	Date

Appendix F: Informed Consent Form for Healthy Controls

Psychology

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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 G: ANOVA with Bonferroni adjustment for Age and HVOT Total score

(I) Age category	(J) Age category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
19-40 years	41-60 years	3.222*	1.1451	.017	.438	6.007
	61-70 years	10.411*	3.8233	.023	1.113	19.708
41-60 years	19-40 years	-3.222*	1.1451	.017	-6.007	-.438
	61-70 years	7.188	3.7389	.172	-1.904	16.281
61-70 years	19-40 years	-10.411*	3.8233	.023	-19.708	-1.113
	41-60 years	-7.188	3.7389	.172	-16.281	1.904

Based on observed means.
The error term is Mean Square (Error) = 27.286.
*The mean difference is significant at the ,05 level.

Appendix H: ANOVA with Bonferroni adjustment for years of education and HVOT Total score

(I) Education	(J) Education	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2-11 years	12-16 years	-3.471*	1.0134	.003	-5.936	-1.007
	17-22 years	-9.050*	2.3990	.001	-14.884	-3.216
12-16 years	2-11 years	3.471*	1.0134	.003	1.007	5.936
	17-22 years	-5.579	2.3459	.057	-11.284	.126
17-22 years	2-11 years	9.050*	2.3990	.001	3.216	14.884
	12-16 years	5.579	2.3459	.057	-.126	11.284

Based on observed means.
The error term is Mean Square (Error) = 25.578.
*The mean difference is significant at the ,05 level.