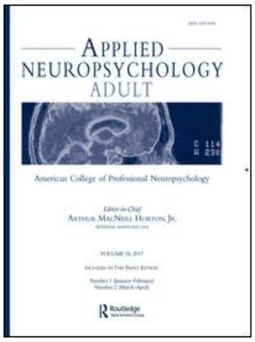

Applied Neuropsychology: Adult

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hapn21

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APPLIED NEUROPSYCHOLOGY: ADULT
https://doi.org/10.1080/23279095.2021.1882461

Hooper visual organization test: Psychometric properties and regression-based norms for the Venezuelan population

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ABSTRACT
The Hooper Visual Organization Test (HVOT) is used to assess visual organization and visual synthesis. Psychometric studies reveal cultural biases and associations between demographic variables and test performance capable of compromising the test's clinical utility. The present study aimed to adapt the HVOT, explore the psychometric properties of this test, and develop regression-based norms for the Venezuelan population. Using a cross-sectional design, the HVOT was administered to a stratified sample of 351 healthy adults (20–85 years of age and 0–23 years of education) from the Metropolitan Area of Caracas. The results revealed good levels of internal consistency and reliability. Confirmatory Factor Analysis suggests that the HVOT is unidimensional. Item difficulty, types and rate of errors and inappropriateness of some items indicated a potential cultural bias in our Venezuelan sample. Spearman's Correlation and Wilcoxon Rank test analysis ($p<.001$) showed a significant association between HVOT total score and age, education, and gender, but not with socioeconomic status. We present regression-norms stratified by age, years of education, and gender. Cultural biases were noted, which highlights the need for a revision of items in terms of inclusion, scoring, and order of presentation. Future studies of concurrent and predictive validity are needed.

KEYWORDS
Construct validity; Hooper; HVOT; norms; visuospatial ability

Introduction

The Hooper Visual Organization Test (HVOT) (Hooper, 1983) was designed to measure visual organization and visual synthesis. Test administration comprises the presentation of 30 pictures of objects that have been cut-up and rearranged; then asks the examinee to put the pieces together in their mind; and identify and name each object (Lezak et al., 2012). It relies on the individual's capacity for confrontational naming (Hooper, 1983), visual attention, and memory (Lin et al., 2012).

Historically, the HVOT has been used to discriminate between individuals with and without neurological pathologies (DeVries, 2005), and those with either right or left hemisphere lesions (Boyd, 1981). The HVOT's sensitivity is linked to its power to identify bilateral injury, although it is more sensitive for the identification of right hemispheric lesions (Fitz et al., 1992; Lewis et al., 1997). In support, a study using Functional Magnetic Resonance Image (fMRI) revealed that the HVOT recruits several bilateral brain regions but with preference for parietal and occipital lobes, and with significantly more involvement of the right parietal lobe (Moritz et al., 2004). Although its screening potential has been challenged on the grounds that "organicity" or "brain damage" do not constitute unitary constructs (Rathbun & Smith, 1982), the HVOT is very sensitive to brain dysfunction (Boyd, 1981). As a result, is frequently included in the assessment batteries of patients with a wide range of pathologies, such as Parkinson's Disease (Stamenović et al., 2005), stroke (Gasparini et al., 2008), brain tumors (Sanz Cortés et al., 2011), Alzheimer's disease (Paxton et al., 2007), Huntington's disease (Eberson, 2014), Huntington's disease-like 2 (Ferreira-Correia et al., 2020), Lewy bodies dementia (Mitolo et al., 2016), frontotemporal dementia, schizophrenia (Zakzanis et al., 2001), and autism (Booth & Happé, 2018).

The HVOT has been found to be valid (Greve et al., 2000; Johnstone & Wilhelm, 1997; Lin et al., 2012) and reliable (Giannakou & Kosmidis, 2006; Lopez et al., 2003) but significantly influenced by age and level of education (Merten & Beal, 1999). Variations in item appropriateness and ranking across different contexts suggest that the HVOT is not free from cultural bias (Merten & Beal, 1999; Su et al., 2013; Verma et al., 1993). Specifically, the value and cultural appropriateness of certain HVOT items has been criticized (Merten, 2002). Items 16 (teakettle) and 19 (teapot) have been at the center of this debate with certain studies supporting a strict scoring (DeVries, 2005), whereas

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Supplemental data for this article can be accessed at publisher's website.

Table 1. Descriptive statistics of the demographic characteristics of the sample.

Variables	Mean	SD	Median	Minimum	Maximum	Interquartile range
Age	45.59	16.0	45	20	85	32–58
Years of education	9.1	4.6	9	0	23	6–12
Gender	*N* (%)					
Female *n* (%)	194 (55.3)					
Male *n* (%)	157 (44.7)					
SES	*n* (%)					
I	5 (1.4%)					
II	26 (7.4)					
III	47 (13.4)					
IV	175 (49.9)					
V	98 (27.9)					

$n = 351$.

others have had a more flexible approach, accepting similar answers for both items (such as in this study). Regardless, their relevance has been questioned (Merten, 2002; Merten & Beal, 1999). Teakettles and teapots are uncommon in our country, especially in the lower and lower median classes which conform more than 75% of the population and thus of the sample. Venezuela, a coffee-drinking country, prepares tea infrequently and using different tools, which suggest that the use of these items in our country may be problematic.

Therefore, the HVOT's clinical potential is subject to the development of country-specific norms that facilitate the incorporation of demographic variables into the interpretation of results, and the adaptation of items in order to reduce the risk of Type I errors and improve the diagnostic value of the test for a particular context (Crawford & Garthwaite, 2012). The majority of the HVOT norms are stratified only by age (Miller et al., 2015; Su et al., 2013) or age and years of education (Elias et al., 2011; Giannakou & Kosmidis, 2006).

Previous norms published for Venezuela have shown significant discrepancies when compared against foreign norms, accentuating the need for local parameters that facilitate valid and reliable diagnosis (Ferreira Correia & Campagna Osorio, 2014). Our study aims to: (a) investigate if the items of the HVOT are appropriate in terms of adaptability and order of difficulty for the Venezuelan population; (b) to explore the influence of selected demographic variables (age, years of education, gender and socioeconomic status) on the HVOT total score, and (c) to present stratified norms of the HVOT for the population of the Metropolitan area of Caracas-Venezuela.

Methods

Participants

The sample was selected in the context of a larger project aiming to standardize and create norms for the population of the Metropolitan Area of Caracas in Venezuela for selected neuropsychological tests. Quota sampling (Neuman, 2000) was implemented following the stratification by age, years of education, gender, and socioeconomic status (SES) parameters obtained from the most recent official census (2001) in Venezuela. We measured education by number of approved years of formal education. The Venezuelan educational system includes six years of primary school, five years of high school, five years of university degree (three if it is a technical degree), three years for a master degree and five years for a PhD (when includes course work), therefore, participants can accrue more than 23 years.

Participants included healthy adults who met the stratification criteria and did not have a history of psychiatric, metabolic or neurological illness, were without subjective complaints of memory loss or cognitive symptoms, had no history of illegal substance use, abuse of alcohol consumption, or use of psychotropic medication. Three hundred and sixty participants were recruited but nine of them were excluded due to errors in administration and data capturing. The demographic characteristics of our sample are summarized in Table 1. In contrast to our sample, Venezuela's age average is 23 years and the majority of people are below 65 years of age (Ledezma et al., 2007). There is a high dropout rate in Venezuela (Lugo, 2013) and only 60% of the population completes the 9 years of basic education at the corresponding age (Freitez, 2010), which is consistent with the mean of years of education in our sample. Venezuelan's gender distribution is homogenous, so our sample is slightly over-representing women (Ledezma et al., 2007).

Procedure

The study was approved by the Ethics Committee of the University Hospital of Caracas (Hospital Universitario de Caracas). All participants gave informed consent prior testing. The researchers involved in the data collection were psychologists or psychology interns who took part in a training workshop on the data collection, administration, and scoring of the tests. We used a cross-sectional design (Levin, 2006) that included two phases. The first part of the data collection included a structured interview used to gather the demographic details, health history of each participant and included the administration of the Graffar-Mendez Castellanos method (Méndez-Castellano & Méndez, 1994). The latter is the most widely used instrument for exploring social stratification (SES) in Venezuela by evaluating the following variables: occupation of the head of the household, level of education of the mother, main source of income of the family, and type of housing. The total score is then classified in a scale from I to V, being I the highest socioeconomic level (Méndez-Castellano & Méndez, 1994). This part of the assessment aimed to facilitate the selection

Table 2. Scoring system adjusted for the Venezuelan population.

Item number	Score 1	Score 0.5	Score 0
1	Pescado, pez		
2	Serrucho		
3	Mesa, banco		
4	Avión		
5	Pelota		
6	Martillo		Hacha
7	Perro, oveja	Animal	Oso
8	Camión	Carro, vehículo, automóvil	Tractor
9	Taza	Jarrón, jarra, florero	
10	Mano	Guante	Dedos
11	Manzana, tomate	Fruta	Pera
12	Cesta		Malla, carrito supermercado
13	Tijera		
14	Bastón		Lápiz, cuchillo, palo
15	Velero, barco		Lancha, carpa, ropa
16	Tetera, cafetera	jarra	
17	Silla, sillón, mueble		
18	Vela, candelabro		Lámpara
19	Cafetera, jarra, tetera		Jarrón, azucarera, taza
20	Gato	Animal	Otros animales
21	Flor		Arbol, isla
22	Ratón, rata, rabipelao	Animal, hamster	Cochino, pipa
23	Libro, cuaderno		Escuadra, regla, triangulo
24	Conejo	Animal	Otros animales
25	Cubo, taco		Casa, caja, dado
26	Faro	Torre, castillo	Iglesia, edificio
27	Zapato		Plancha, cama poceta
28	Llave		Exacto, navaja, cuchillo
29	Anillo, sortija		Candado, cerradura
30	Escoba		Cepillo, bombillo, botella, lámpara

of participants in terms of the inclusion and exclusion criteria.

Those who met all the selection criteria took part in the second assessment phase, which included the Alternate Use Test, Stroop Test, Consequences Test, and the HVOT, in that order. The total duration of the assessment was approximately 40 minutes. The assessment was conducted in different settings but all with appropriate testing conditions, which included good ventilation and illumination, table, two chairs, low environmental noise, and privacy. The HVOT protocols were scored by the administrator and a senior neuropsychologist to correct for any scoring errors.

Administration and scoring

The administration of the HVOT followed the guidelines for individual administration outlined by the manual (Hooper, 1983). The instruction was translated into Spanish and piloted. The scoring rules of the manual were adjusted to accommodate for Venezuela's specific use of the language and familiarity with the objects. For example, "cafetera" and "tetera" were both acceptable answers for items 16 and 19 because kettles and teapots are not common objects in our country (hardly found in stores) and tea is not a usual drink. The adapted scoring system is presented in Table 2. Full and half scores were added for a maximum score of 30 points.

Data analyses

The data analysis was carried out using SAS version 9.4 for Windows. A 5% significance level was used. Descriptive statistics were included for all the demographic variables. For continuous variables, the median and the interquartile range were provided given the distribution of the data.

The McDonald's omega analysis was used to calculate the internal consistency of the HVOT. Confirmatory Factor Analysis (CFA) using a single-factor model was used to investigate the construct validity of the HVOT. Polychoric correlations produced a non-positive definite correlation matrix due to several items being linear combinations of other items. No items were excluded from the analysis, hence the final correlation matrix was based on Spearman's correlation. Minimum Likelihood Estimation (MLE) was used to estimate model parameters and goodness-of-fit of all the CFA models was examined with RMSEA $\leq$0.06, SRMR $\leq$0.08, CFI $\geq$0.95 (Brown, 2015; Hu & Bentler, 1999). Additionally, the chi-square/df ratio $\leq$3 rule was also used (Kline 2005).

The association between (age, years of education, SES) and HVOT Total Score was determined by Spearman's correlation coefficient because some of the variables were not normally distributed. The association between gender and the HVOT Total Score was determined by Wilcoxon's Rank Sum test.

The effect of age, gender, years of education and SES on the HVOT Total Score were determined by simultaneous multiple regression. Squared terms in age and years of education were added as suggested by the plots of these variables vs. the HVOT Total Score. The assumptions of regression analysis were tested for all models. Homoscedasticity was evaluated by inspection of diagnostic plots of residuals vs. predicted values. The existence of multicollinearity was assessed by the VIFs (<10 considered as

Table 3. Confirmatory factor analysis (CFA) using a single-factor model.

Model fit	Model 1	Model 2
Chi-square	630.7	538.4
Chi-square DF	405	324
Pr > chi-Square	<0.0001	<0.0001
Standardized RMR (SRMR)	0.051	0.051
RMSEA estimate	0.040	0.044
Bentler comparative fit index	0.859	0.865
Chi-Square/df	1.56	1.66

Note: Model two excludes item 2, 3, and 12.

no multicollinearity). Potential influential cases were identified by calculating Cook's distance. The normality of the residuals was investigated by assessing the distribution of the standardized residuals.

Regression-based norming was performed as follows (Van Der Elst et al., 2007): Predicted scores were calculated for each participant using the multiple regression model. Residuals were calculated (residuals = observed score–predicted score) and standardized according to the standard deviation of the residuals in the study sample. Then the percentile of standardized residuals was calculated using the empirical cumulative distribution function. Stratified groups with a sample size of five or less were excluded from the report, all of them belonging to the category of 0–3 years of education.

Results

The McDonald's omega (0.86) analysis of internal consistency reliability for the total score of the HVOT (30 item) was good. The CFA model showed an acceptable fit (Table 3) except for the CFI, providing general support for the unidimensional structure of the HVOT. Factor loadings ranged from 0.06 to 0.66. The loadings for items 1, 3, and 12 were not significant (Table 4). However, a second model excluding these times did not improve the model fit (Table 3).

Table 5 presents the frequency of full score, half of score and zero score for each of the HVOT items and the level of difficulty of each item (P), calculated based on the proportion of correct answers (Wauters et al., 2012). The difficulty values reveal that items 3 (Table), 2 (Saw), 5 (Ball), 4 (Airplane) and 18 (Candle) are the easiest, whereas 28 (Key), 30 (Broom), 25 (Block), 29 (Ring), and 27 (Shoe) are the most difficult.

Spearman correlation analyses (Table 6), revealed a significant negative correlation between age and the total HVOT Total Score, suggesting a poorer performance in older participants. The significant positive correlation observed between years of schooling and HVOT total implies that more years of education are linked to a higher score on the HVOT. The Wilcoxon's Rank test (Table 7) reveal that the median (IQR) Hooper test total was significantly higher for males compared to females. The SES and HVOT Total Score did not have a significant correlation.

The simultaneous multiple regression conducted with the HVOT Total Score and the demographic variables shows that the term in age^2 and SES were not significant, hence, they were removed from the model. The statistics summary for the final model are given in Table 8. Thus, only age,

Table 4. Standardized factor loading for each HVOT item for model 1 and model 2 of the confirmatory factor analysis.

HVOT item	Statistics	Model 1	Model 2
1	Estimate	0.1077	*
	Std error	0.0564	
	t-Value	1.9086	
	p-Value	0.0563	
2	Estimate	0.1731	0.1743
	Std error	0.0554	0.0554
	t-Value	3.1231	3.1456
	p-Value	0.00179	0.001658
3	Estimate	0.065	*
	Std error	0.0568	
	t-Value	1.1451	
	p-Value	0.2521	
4	Estimate	0.3552	0.3565
	Std error	0.0504	0.0503
	t-Value	7.0539	7.0845
	p-Value	<.0001	<.0001
5	Estimate	0.4249	0.4242
	Std error	0.0475	0.0476
	t-Value	8.9447	8.9211
	p-Value	<.0001	<.0001
6	Estimate	0.3249	0.3267
	Std error	0.0514	0.0514
	t-Value	6.3156	6.3559
	p-Value	<.0001	<.0001
7	Estimate	0.1732	0.1749
	Std Error	0.0554	0.0554
	t-Value	3.1249	3.1563
	p-Value	0.001779	0.001598
8	Estimate	0.4592	0.4572
	Std error	0.0459	0.046
	t-Value	9.9999	9.9349
	p-Value	<.0001	<.0001
9	Estimate	0.3944	0.3947
	Std error	0.0488	0.0488
	t-Value	8.0801	8.0839
	p-Value	<.0001	<.0001
10	Estimate	0.4031	0.4057
	Std error	0.0485	0.0484
	t-Value	8.3203	8.3894
	p-Value	<.0001	<.0001
11	Estimate	0.3484	0.348
	Std error	0.0506	0.0506
	t-Value	6.8822	6.8725
	p-Value	<.0001	<.0001
12	Estimate	0.0998	*
	Std error	0.0565	
	t-Value	1.7674	
	p-Value	0.0772	
13	Estimate	0.5258	0.5248
	Std error	0.0425	0.0426
	t-Value	12.3748	12.3322
	p-Value	<.0001	<.0001
14	Estimate	0.3845	0.384
	Std error	0.0492	0.0493
	t-Value	7.811	7.7961
	p-Value	<.0001	<.0001
15	Estimate	0.3403	0.3409
	Std error	0.0509	0.0509
	t-Value	6.6851	6.6964
	p-Value	<.0001	<.0001
16	Estimate	0.4042	0.404
	Std error	0.0484	0.0484
	t-Value	8.3491	8.3409
	p-Value	<.0001	<.0001
17	Estimate	0.5754	0.5767
	Std error	0.0396	0.0396
	t-Value	14.5141	14.5665
	p-Value	<.0001	<.0001
18	Estimate	0.2121	0.2117
	Std error	0.0546	0.0547
	t-Value	3.8815	3.8723
	p-Value	0.000104	0.000108

(*continued*)

Table 4. Continued.

HVOT item	Statistics	Model 1	Model 2
19	Estimate	0.5001	0.5006
	Std error	0.0439	0.0438
	t-Value	11.4011	11.4174
	p-Value	<.0001	<.0001
20	Estimate	0.6082	0.6089
	Std error	0.0376	0.0376
	t-value	16.1583	16.1905
	p-value	<.0001	<.0001
21	Estimate	0.426	0.425
	Std error	0.0475	0.0475
	t-Value	8.9764	8.944
	p-Value	<.0001	<.0001
22	Estimate	0.5942	0.5938
	Std error	0.0385	0.0386
	t-Value	15.4316	15.401
	p-Value	<.0001	<.0001
23	Estimate	0.4912	0.49
	Std error	0.0443	0.0444
	t-Value	11.082	11.0366
	p-Value	<.0001	<.0001
24	Estimate	0.6589	0.6597
	Std Error	0.0343	0.0343
	t-Value	19.1857	19.2308
	p-Value	<.0001	<.0001
25	Estimate	0.4798	0.4798
	Std error	0.0449	0.0449
	t-Value	10.6848	10.6819
	p-Value	<.0001	<.0001
26	Estimate	0.6582	0.6573
	Std Error	0.0344	0.0345
	t-Value	19.1355	19.0682
	p-Value	<.0001	<.0001
27	Estimate	0.2211	0.2211
	Std error	0.0544	0.0544
	t-Value	4.061	4.0608
	p-Value	<.0001	<.0001
28	Estimate	0.4476	0.4462
	Std error	0.0465	0.0465
	t-Value	9.6339	9.585
	p-Value	<.0001	<.0001
29	Estimate	0.3144	0.3153
	Std error	0.0518	0.0518
	t-Value	6.069	6.0879
	p-Value	<.0001	<.0001
30	Estimate	0.4333	0.4329
	Std error	0.0471	0.0472
	t-Value	9.1949	9.1797
	p-Value	<.0001	<.0001

Note: *Items with non-significant loadings were excluded for Model 2.

years of education, and gender were taken into consideration for the stratification of the regression-based norms (Table 9).

Discussion

The main objective of the present study was to develop stratified HVOT norms for the Venezuelan population. For this, we investigated the effects of sociodemographic variables on the HVOT total score. Lastly, we explored the internal consistency and item appropriateness of this test for our specific population.

Our findings indicate that the HVOT has good internal consistency, which supports previous studies (Giannakou & Kosmidis, 2006; Lopez et al., 2003; Merten & Beal, 1999). The CFA results indicate an acceptable fit which suggests that the HVOT is unidimensional as previously reported (Johnstone & Wilhelm, 1997). However, our results cannot be considered as providing unequivocal support for construct validity for the HVOT because the use of factor analyses for this purpose has been challenged (Delis, Jacobson, Bondi, Hamilton, & Salmon, 2003). Most neuropsychological measures, including the HVOT, are considered to be "multifactorial" (p. 405, Jefferson et al., 2006) and cognitive functions in the healthy brain are more likely to share variance, providing results that mask the underlying constructs of the test under investigation (Delis et al., 2003). For example, our original test battery did not include naming measures (e.g. Boston Naming Test) to explore a potential confounding association between naming abilities and performance on the HVOT, which has been previously noted (Greve et al., 2000). Moreover, our study did not provide evidence of predictive or concurrent validity, which is necessary for the evaluation of the clinical utility of this test in Venezuela.

Despite having acceptable internal consistency, the quality of several items in the HVOT have been criticized (for a detailed analysis see Merten & Beal, 1999 and Merten, 2002). Although we were not able to investigate the discriminant power of the HVOT due to the lack of clinical groups in our study, we identified issues with the adequacy (including order of administration) of some of the items. The items' difficulty values indicate the need for the development and validation of a short version of the HVOT and the reorganization of the order of administration as previously suggested by other studies (DeVries, 2005; Giannakou & Kosmidis, 2006; Merten, 2002; Merten & Beal, 1999). Specifically, and in contrast to other reports (DeVries, 2005), none of the items in our sample received 100% of correct responses. Item three (table) was the easiest one with only 1.14% of the participants giving incorrect responses. This item has been found to be the easiest in other studies (DeVries, 2005). Other examples include items 12 (basket) and 18 (candle), which were among the ten easiest items, while 14 (cane) was one of the ten most difficult ones. Hence, the administration order should follow empirical data that is context-specific. Presenting the items by order of difficulty opens the possibility of considering the application of a discontinuation rule, which has previously yielded good discriminatory power (Wetzel & Murphy, 1991) and reduces administration time and levels of fatigue for the patient. Nevertheless, Venezuelan clinicians using the HVOT according to Hooper's (1983) guidelines should administer all items until a revised version of the HVOT is adapted and validated for our population.

Our findings indicate that, in line with previous critiques (DeVries, 2005; Merten, 2002), items 16 and 19 are not appropriate for the Venezuelan context and their scoring should be flexible until future studies explore their exclusion. In several items, some errors had a high frequency (>5%), namely, item 14 (pencil = 19.66%), 22 (pipe = 10.83), 24 (dog = 7.41%), 25 (house = 27.07%, box = 5.13%, and dice = 5.13%), 27 (iron = 29.91% and toilet = 12.54%), 28 (knives and other similar tools = 29.34%), 29 (padlock = 27.64%), 30 (lamp = 8.26% and bottle = 5.13%). Pencil and pipe were reported by Hooper (1983) as

Table 5. Frequencies of full credit, half credit, and no credit for each of the HVOT items and item response analysis.

	1 Credit		0.5 Credit		0 Credit		Frequent errors			
Item	*n*	%	*n*	%	*n*	%	Answer	*n*	%	*p*-Value (item difficulty)
1 Fish	329	93.73			22	6.27				.937
2 Saw	338	96.30			13	3.70				.963
3 Table	347	98.86			4	1.14				.989
4 Airplane	331	94.30			20	5.70				.943
5 Ball	332	94.59			19	5.41				.946
6 Hammer	321	91.45			30	8.55				.915
7 Dog	319	90.88	3	0.85	29	8.26				.917
8 Truck	205	58.40	80	22.79	66	18.80				.812
9 Cup	300	85.47	30	8.55	21	5.98				.940
10 Hand	304	86.61	24	6.84	23	6.55				.934
11 Apple	326	92.88	3	0.85	22	6.27				.937
12 Basket	290	82.62			61	17.38				.826
13 Scissors	323	92.02			28	7.98				.920
14 Cane	193	54.99			158	45.01	Pencil	69	19.66	.550
15 Sailboat	252	71.79			99	28.21				.718
16 Kettle	290	82.62	22	6.27	39	11.11				.889
17 Chair	287	81.77			64	18.23				.818
18 Candle	331	94.30			20	5.70				.943
19 Teapot	267	76.07			84	23.93				.761
20 Cat	280	79.77	4	1.14	67	19.09				.809
21 Flower	270	76.92			81	23.08				.769
22 Mouse	265	75.50	1	0.28	85	24.22	Pipe	38	10.83	.758
23 Book	283	80.63			68	19.37				.806
24 Rabbit	251	71.51	12	3.42	88	25.07	Dog	26	7.41	.749
24 Block	127	36.18			224	63.82	House	95	27.07	.362
							Box	18	5.13	
							Dice	18	5.13	
26 Lighthouse	194	55.27	56	15.95	101	28.77				.712
27 Shoe	96	27.35			255	72.65	Iron	105	29.91	.274
							Toilet	44	12.54	
28 Key	167	47.58			184	52.42	Knive[a]	103	29.34	.476
29 Ring	104	29.63			247	70.37	Padlock	97	27.64	.296
30 Broom	148	42.17			203	57.83	Lamp	29	8.26	.422
							Bottle	18	5.13	

$n = 351$.
[a]Includes knife, utility knives and pocket knives.

Table 6. Spearman correlations between HVOT total score and sociodemographic variables (age, years of education, and socio-economic status).

	Age	Years of education	SES
HVOT total score			
rho	−0.4466	0.37765	−0.00686
p-Value	<.0001	<.0001	.8981

Spearman correlation coefficients Prob >\|r\| under H0: Rho = 0.
$n = 351$.

Table 7. Wilcoxon's Rank Sum test for the association between the HVOT Total Score and gender.

Gender	*n*	Median	IQR	Minimum	Maximum	*p*
Female	194	23	19.5–25.5	5	30	.0005
Male	157	24.5	22–27	4	30	

Table 8. Simultaneous multiple regression summary of the model (HVOT total score).

	Parameter estimate	Standard error	*t* Value	Pr>|t|
Intercept	21.79	1.02	21.47	<0.0001
Age	−0.11	0.01	−8.98	<0.0001
Years of education 1	0.99	0.15	6.61	<0.0001
Years of education 2	−0.03	0.01	−4.36	<0.0001
Male	1.08	0.40	2.70	0.0074

DF = 1.
$n = 351$.

common isolate responses for items 14 and 22, respectively. A high percentage of errors in a control sample reduces the clinical value of these items when used in clinical groups (DeVries, 2005), therefore, the presence of these specific errors in clinical samples in Venezuela should not be pathologized.

A closer look at the raw data assisted in the identification of two types of errors, namely, isolate and bizarre responses (Hooper, 1983; Lezak et al., 2012). The first category includes answers that only refer to one part of the picture. For example, in item 22, 10.83% of our participants gave "pipe" as an answer, this high prevalence has not been reported for other control samples (DeVries, 2005). The second type consists of bizarre responses that do not relate to the stimuli in any way and have been linked to psychotic thinking (Hooper, 1983; Lezak et al., 2012); in our sample, these answers don't have the typical psychotic-like quality (e.g. representing abstract feelings or ideas), instead they reflect a severe visuospatial deficit (examples of these errors can be found in Supplementary Table 1). The presence (although low) and variety of these errors in the great majority of items was unexpected, because these answers are reported as frequent among psychiatric and neurological patients and not in control samples (DeVries, 2005; Hooper, 1983). Studies on the diagnostic value of these errors for our population are needed. Neologisms and perseverations were not present in our data.

Our results show that age and years of education are the main variables that have an impact on the total score of the HVOT. These findings are generally consistent with previous

Table 9. Venezuelan norms for the HVOT stratified by age, years of education, and gender.

Age	Years of education	Gender	n	5th Pctl	10th Pctl	20th Pctl	30th Pctl	40th Pctl	50th Pctl	60th Pctl	70th Pctl	80th Pctl	90th Pctl	95th Pctl	99th Pctl
20–35	4–11	Female	35	16	17	21	23	24	25	26	26	27	28	30	31
		Male	33	22	23	23	25	26	26	27	28	29	30	30	30
	≥12	Female	15	20	21	22	23	25	25	27	27	28	28	29	29
		Male	21	24	24	25	25	26	27	27	27	28	29	29	30
36–50	4–11	Female	35	15	18	20	20	21	22	24	25	25	26	29	29
		Male	32	18	19	21	22	23	24	24	25	26	28	28	30
	≥12	Female	22	20	21	22	24	24	25	26	27	27	29	29	30
		Male	12	19	21	21	23	24	25	26	27	27	29	30	30
51–65	0–3	Female	10	6	8	10	12	17	20	21	22	22	23	24	24
	4–11	Female	33	14	16	17	18	20	22	22	24	24	26	27	28
		Male	26	13	14	18	21	24	24	24	25	25	28	28	28
	≥12	Female	12	17	21	21	22	23	25	26	26	26	27	28	28
		Male	9	21	21	23	23	25	26	26	27	27	27	27	27
66–85	0–3	Female	5	11	11	12	13	13	14	16	18	19	19	19	19
	4–11	Female	18	9	11	15	17	17	18	19	21	21	24	27	27
		Male	10	14	14	17	19	20	21	22	22	24	25	25	25
	≥12	Female	6	13	13	23	23	25	25	25	25	25	27	27	27
		Male	5	16	16	17	18	20	22	23	24	25	25	25	25

normative data reported for Venezuela (Campagna, 2015) and observed in other reported normative data for the HVOT (Giannakou & Kosmidis, 2006; Hooper, 1983), whereas other studies present norms stratified only by age (DeVries, 2005; Miller et al., 2015). Although the original HVOT norms are stratified by age, they incorporate the significant influence of education by providing adjustments for age and education (Hooper, 1983). Our results indicate that younger people performed better than older ones, people with more years of education had a better performance than those with less, and man performed better than woman. In our study, participants with less year of education presented a steeper decline on the HVOT scores. Although this interaction suggests that education acts as a protective factor against the decline on 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). It is known that education attainment has an impact on the development of specific abilities, on the access to higher socioeconomic levels (Ardila et al., 2000), and on health-related behaviors (Zahodne et al., 2015).

We found that gender also had a significant correlation with the total score, with males performing better than females, for this reason, it was taken into consideration in the norms stratification. A gender bias in the visuospatial functions benefiting men has been suggested (Hatta et al., 2015; Parsons et al., 2004), but other norming studies on the HVOT have not supported this finding (DeVries, 2005; Tosello, 2005). Moreover, future studies in Venezuela should explore the potential contribution of gender toward the total score of the HVOT while controlling for age and years of education.

In this study, we present the HVOT regression-based norms for the Venezuelan population stratified by age and years of education. To our knowledge, no other norms for the HVOT are available in this country. Our normative data are comparable to those that use stratifications that take into account both age and education level. Specifically, our norms are similar to the Greek (Giannakou & Kosmidis, 2006) and the Main-Syracuse (USA) (Elias et al., 2011) normative study, both of which presented norms stratified years of education and differ from ours in less than 2 points. In contrast, larger discrepancies (up to six points) were noted between our norms and those that do not control for years of education, such as those published by Jefferson et al. (2006) and Miller et al. (2015).

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. few years of education).

In conclusion, our study highlights the need for a detailed psychometric study of the discriminatory power of the HVOT items in the Venezuelan population. Psychometric analyses using Item Response Theory (IRT) are recommended. Our findings imply that a shortened version of the test may be more appropriate for our population, such as the one developed by Merten (2002). In the meantime, Venezuelan practitioners should 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 used of foreign norms.

Acknowledgments

The authors are grateful to the members of the *Hospital Universitario de Caracas* that were part of this project, especially to the psychologists Sandra Crespo, Alyst Castro, and Melissa Rosales. We are grateful to Dr Petra Gaylard for her assistance with the statistical analyses.

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