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Predictors of HVOT Performance in Parkinson's Disease

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Abstract

Evidence suggests that the Hooper Visual Organization Test (HVOT) has naming and executive components that vary in size depending on neurological diagnosis. The current study used a sample of individuals with Parkinson's disease (PD) to demonstrate for the first time that an executive measure can be the best predictor of HVOT performance. Forty-eight non-demented and non-depressed individuals with idiopathic PD completed the HVOT and other measures of visuoception, executive function, and visual confrontation naming. Despite average performance on all neuropsychological measures, an executive measure, Trails B-A, was clearly the best predictor of HVOT performance in a standard regression. The pattern of neurocognitive predictors is unlike that reported in healthy individuals and other patient samples, suggesting that the presence of a neuropathological process can alter neurocognitive correlates even when performance is intact, and supporting the contention that executive function is paramount in the cognitive profile associated with PD.

The Hooper Visual Organization Test (HVOT; Hooper, 1983) requires examinees to state the name of objects in drawings that are cut into scattered pieces. The HVOT has traditionally been conceptualized as a measure of visuoception (Lezak et al., 2004), and this has been supported in the literature (Merten, 2005; Paolo et al., 1996; Ricker & Axelrod, 1995); however, empirical evidence suggests that the HVOT also includes elements of visual confrontation naming (Greve et al., 2000; Paolo et al., 1996; Ricker & Axelrod, 1995) and executive function. Jefferson et al. (2006) reported that 4% of HVOT variance was predicted by confrontation naming and 12% was predicted by letter fluency, included as a measure of executive function, in a group of healthy individuals, but 43% was predicted by naming with letter fluency not predicting significant variance in a group of individuals with mild cognitive impairment (Jefferson et al., 2006). In a study of individuals with vascular

dementia naming did not contribute to the prediction of HVOT performance (Paul et al., 2001). Therefore, it appears that the size of the naming and executive components can vary depending on neurological diagnosis, and presumably, the nature and location of neuropathology.

Although there is evidence that naming can be the best predictor of HVOT performance (i.e., in MCI), it has not been demonstrated that an executive measure can be the best predictor of HVOT performance. This was the purpose of the current study. A sample of individuals with Parkinson's disease (PD) was used because PD has been associated with visuo perceptual deficits (Bowen et al., 1972; Cronin-Golomb & Braun, 1997; Globus et al., 1985; Green et al., 2002; Hovestadt et al., 1987; Levin et al., 1991; Relja & Klepac, 2006; Vingerhoets et al., 2003) that have been related to executive dysfunction (Bondi et al., 1993; R. G. Brown & Marsden, 1986; Crucian et al., 2003; Mahurin et al., 1993; Ogden et al., 1990). Although HVOT performance has been studied in PD (Boller et al., 1984; Globus et al., 1985; Levin et al., 1991; Relja & Klepac, 2006), its neurocognitive correlates have not been evaluated in this population. We hypothesized that an executive measure would make the strongest contribution to the prediction of HVOT performance compared to another measure of visuo perception and a measure of confrontation naming.

Method

Participants

Forty-eight (15 female) individuals with idiopathic PD who were potential candidates for functional neurosurgery underwent neuropsychological assessment. Patients were diagnosed by a board-certified neurologist (V.L.W.) and excluded from the study if they met Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV; American Psychiatric Association, 1994) criteria for dementia or depression (based on a neuropsychologist's impression of test and interview data); underwent previous neurosurgical intervention; or had a history of other illness that impacts cognition. See Table 1 for demographic information.

Procedure

As part of their evaluation, PD patients were administered a neuropsychological test battery including a measure of visuo perception, the Block Design subtest from the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III; Wechsler, 1997), a measure involving executive function, the Trail Making Test (Reitan, 1958), a measure of visual confrontation naming, the Boston Naming Test (BNT; Kaplan et al., 1983), and the HVOT. Tests were administered by a licensed clinical psychologist specializing in neuropsychological assessment or a postdoctoral neuropsychology fellow supervised by the psychologist and trained in standardized test administration. All patients were taking antiparkinsonian medication at the time of testing and were tested while in the "on" state. In addition, participants were evaluated on the United Parkinson's Disease Rating Scale (UPDRS; Fahn, Elton, & the Members of the UPDRS Development Committee, 1987). The UPDRS measures PD symptom severity and was completed by a board-certified neurologist (V.L.W.). The motor scale (part III) consists of 14 items (e.g., speech, tremor at rest, gait) that are rated on a five-point Likert scale based on observation of the participant. Scores can range from 0 to 56 with higher scores indicating greater impairment. This study was approved by the appropriate institutional review boards (IRB) and procedures were in compliance with relevant laws.

Data Analysis

Cognitive variables included in analyses were total raw score from Block Design, time to complete Part B minus time to complete Part A from the Trail Making Test (Trails B-A), and total spontaneous correct responses plus correct responses following a semantic cue from the 60-item BNT. Research suggests that Trails B-A is a more pure measure of executive function than Trails B because it reduces the motor and visuospatial elements of performance (Drane, Yuspeh, Huthwaite, and Klingler, 2002; Sanchez-Cubillo et al., 2009). Trails B-A was chosen instead of Trails B/A, another measure thought to isolate executive function, because unlike Trails B/A, Trails B-A correlates with Digit Span Backwards, Stroop Color-Word, and performance on a card sorting task (Sanchez-Cubillo et al., 2009). In order to provide an indication of level of performance, variables were converted to T-scores [$10((\text{raw} - \text{mean})/\text{SD}) + 50$] based on the WAIS-III normative sample for Block Design (Wechsler, 1997); Drane et al., 2002) for Trails B-A; Heaton, Avitable, Grant, and Matthews (1999) for BNT; and the HVOT normative sample. The Drane et al. (2002) sample included 285 adults without a history of psychiatric or neurologic disorder ranging from 18 to 90 years of age and 6 to 20 years of education stratified into eight age groups by decade. The Heaton et al. (1999) sample consisted of 531 adults without a history of illness likely to affect central nervous system function and with an average (*SD*) of 48.12 (9.12) years of age and 13.85 (2.35) years of education. Each measure was transformed so that higher T-scores indicated better performance.

The data analytic strategy involved a regression approach. Initially, correlation coefficients were computed to determine the linear relationship between demographic variables (age, gender, and years of education), neuropsychological predictor variables (raw scores from Block Design, Trails B-A, and BNT), and the criterion (HVOT raw score). Raw scores rather than standardized scores were entered in these analyses to allow for a clear indication of the relationship between demographic variables and test performance and to maximize variability. Pearson correlation coefficients were computed for all variables except those involving gender, for which Spearman's rho was computed. All variables that significantly correlated with the HVOT were then entered into a standard (simultaneous) multiple regression analysis. A standard regression was used rather than a stepwise regression [which was used by Jefferson et al. (2006) and Greve et al. (2000)] to allow for a clear comparison of the contribution of *all* variables to the prediction of the criterion. This is an important issue because predictors that significantly correlate with the criterion can be left out of stepwise regression models. In order to address assumptions of the statistic, variable tolerances were reviewed for values less than .10, standardized residuals were evaluated for values greater than 3.3 or less than -3.3, a scatterplot of the standardized residuals was reviewed, and a normal probability plot was evaluated (Pallant, 2005). The total predictive ability of the independent variables was determined via R^2 and the associated *F* value. The standardized beta value of each predictor was evaluated to determine the unique contribution of each variable to the prediction of HVOT performance and to determine which variable was the best predictor. Alpha was set to .05.

Results

Raw and T-scores for the neuropsychological variables are listed in Table 1. Surprisingly, compared to the respective normative samples, performance on the neuropsychological measures was in the average range and near the mean. Correlation coefficients are listed in Table 2. Age, Block Design and Trails B-A were significantly correlated with the HVOT. The correlation between the BNT and HVOT was marginally significant and because the effect size approached medium (Cohen, 1988) the BNT was included in the regression. Tolerances, standardized residuals, and the normal probability plot indicated that the assumptions of multiple regression were met. Regression results are listed in Table 3. The

overall value of R was .59 [$F(4,43) = 5.64, p = .001$], indicating that a statistically significant 34% of the variance in HVOT was predicted. The beta value for Trails B-A (−.31) clearly exceeded those of age (−.19), Block Design (.15), and BNT (.14) which were similar in magnitude. The contribution that Trails B-A made to the prediction of HVOT performance *independent of the other predictors* was marginally significant ($p = .069$).

Discussion

The purpose of the current study was to test the hypothesis that an executive measure would be the best predictor of HVOT performance in PD, supporting the contention that the size of the naming and executive components of the HVOT can vary depending on neurological diagnosis. Beta weights indicate that a measure of executive function, Trails B-A, was indeed the best predictor of HVOT performance in our sample of individuals with PD, better than demographic variables, confrontation naming, and even better than another measure of visuo-perceptual function. This is consistent with the large bivariate correlation between Trails B-A and the HVOT, indicating that by itself Trails B-A predicted a significant 28% of the variance in HVOT performance compared to the 34% predicted by all four variables in the regression. The marginal significance of the *unique* contribution of Trails B-A suggests that the other predictors in the regression model account for some of the same variance in HVOT performance and this is supported by the correlations between Trails B-A and the other predictors, especially Block Design.

The novel pattern of predictors of HVOT performance observed in this sample of individuals with PD is intriguing in light of the sample's intact performance on all of the neuropsychological measures. This was surprising given that visuo-perceptual deficits (Bowen et al., 1972; Cronin-Golomb & Braun, 1997; Green et al., 2002; Hovestadt et al., 1987; Vingerhoets et al., 2003) and executive deficits (Brown et al., 1997; Dalrymple-Alford et al., 1994; Owen et al., 1992; Owen et al., 1998; Richards et al., 1993; Tamaru, 1997; Taylor et al., 1990) are well known in PD. In terms of the HVOT specifically, results in PD samples are mixed with two studies reporting impaired performance (Globus et al., 1985; Relja & Klepac, 2006), one reporting impairment only in individuals with disease duration greater than five years (Levin et al., 1991), and one reporting intact performance (Boller et al., 1984). One possible explanation for the intact performance of our sample on the HVOT is the exclusion of patients with dementia and depression. In any case, one might expect that the naming, executive, and visuo-perceptual components of the HVOT would be similar in magnitude to those seen in healthy controls when a patient sample's performance is within normal limits; however, these data suggest that this is not the case, and the presence of a neuropathological process can alter the neurocognitive correlates even when performance is intact.

The ability of Trails B-A to predict a large proportion of the variance in the HVOT is consistent with the hypothesis that the performance of individuals with PD on this visuospatial task is related to frontal-subcortical circuitry (Zgaljardic et al., 2003), as has been suggested for their performance on other measures of visuo-perception (Bondi et al., 1993; R. G. Brown & Marsden, 1986; Crucian et al., 2003; Mahurin et al., 1993; Ogden et al., 1990) and their performance on measures of memory (Bondi et al., 1993; Higginson et al., 2003; Higginson et al., 2005; Taylor et al., 1986). This hypothesis requires further scrutiny given evidence of pathology in the mesial temporal lobe early in the course of PD, prior to neocortical involvement (Braak & Braak, 2000; Braak et al., 2003). Based on the general location of this early pathology one might expect a greater role for naming in the HVOT than in healthy individuals (Seidenberg et al. (2005); however, the BNT did not predict such a large proportion of the variance in HVOT performance, suggesting that this pathology does not significantly impact HVOT performance in PD.

A number of limitations to this study should be noted. First, the sample was relatively small in size, predominantly male, and well educated, limiting generalizability of the results. Second, the inclusion of a control group would have been preferable to the use of norms for the transformation of raw to standardized scores because a control group would allow for direct verification of similarity between the groups on extraneous variables that could impact test performance. Third, as is apparent from the discussion above, this research is complicated by the multifactorial nature of the tests included. Indeed, it is difficult to ascertain with certainty the elements of cognition that are assessed, and inferences based on correlation are debatable. Fourth, although the measure of executive function included, Trails B-A, has established construct validity (see above), the results may have differed had other measures of executive function been included.

In conclusion, a measure of executive function, Trails B-A, was the best predictor of HVOT performance in this sample of individuals with PD, even though a second measure of visuospatial perception was included as a predictor and the sample's performance was within normal limits on all neuropsychological measures. This pattern of neurocognitive predictors is unlike that reported in healthy individuals and other patient populations and supports the contention that the sizes of the naming and executive elements of the HVOT vary depending on neurological diagnosis. The notion that executive function plays a significant role in the cognitive profile of PD was also supported. Future research should address the neurocognitive predictors of HVOT performance in other PD samples and different patient populations using different measures of executive function. Clinicians are encouraged to keep in mind the multifactorial nature of the HVOT and interpret individual patient performance on this task in light of neurological diagnosis. When an individual with PD performs poorly on the HVOT clinicians should consider the potential impact of executive function as well as visual confrontation naming and visuospatial perception on HVOT performance.

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Table 1

Demographic and Test Data: Mean (SD)

	Raw	T-Score
Age (years)	62.1 (8.8)	
Education (years)	15.2 (3.0)	
Disease Duration (years since diagnosis)	9.8 (6.1)	
UPDRS-Motor Score (Off) ^a	23.4 (9.2)	
UPDRS-Motor Score (On) ^b	10.4 (6.3)	
Hooper Visual Organization Test	25.0 (2.5)	49.2 (5.5)
Block Design	32.0 (10.4)	49.9 (8.3)
Trail Making Test, Part B - Part A	67.4 (54.0)	51.6 (13.0)
Boston Naming Test	55.4 (5.9)	51.4 (12.6)

Note. UPDRS = United Parkinson's Disease Rating Scale

Table 2

Intercorrelation Matrix

	Education	Gender ^a	Block Design	Trails B-A	BNT	HVOT
Age	.02	-.05	-.37**	.50***	-.11	-.41**
Education		-.37**	.31*	-.09	.16	-.07
Gender ^a			-.24	.11	-.07	.00
Block Design				-.59**	.18	.43**
Trails B-A					-.25	-.53***
BNT						.27 ^b

Note. Trails B-A = Trail Making Test, Part B - Part A; BNT = Boston Naming Test; HVOT = Hooper Visual Organization Test.

^a Spearman's rho.

^b $p = .064$.

*

$p < .05$.

**

$p < .01$.

 $p < .001$.

Table 3

Summary of Standard Multiple Regression

Variable	<i>B</i>	<i>SE B</i>	β
Age	−0.05	0.04	−0.19
Block Design	0.04	0.04	0.15
Trail Making Test, Part B - Part A	−0.02	0.01	−0.31 ^a
Boston Naming Test	0.06	0.06	0.14

Note. $R^2 = .34$ ($p = .001$).

^a $p = .069$.