Original Article

Validity of the Mini-Mental State Examination, the Clock Drawing Test, and the Vienna Visuo-Constructional Test 3.0-Screening for Diagnosing Parkinson's Disease

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Abstract: Parkinson's disease (PD) leads to cognitive impairment. Widely used methods to assess cognition are the Clock Drawing Test (CDT) and the Mini-Mental State Examination (MMSE). Another option is the Vienna Visuo-Constructional Test 3.0 Screening (VVT-3.0). We studied the neuropsychological and demographic data of 45 healthy controls (HC) and 64 individuals diagnosed with PD (total N = 109) and compared the validity of each test by using receiver-operator characteristic (ROC) curves and logistic regression analyses. The ROC analyses of PD yielded areas under the curve (AUC) of 0.68 using VVT-3.0, 0.74 using MMSE, and 0.72 using CDT as predictors, respectively. The VVT-3.0 shows comparable validity to the more established measurement tools and MMSE und CDT and is easy to administer in a clinical setting.

Keywords: Parkinson's disease, cognitive screening, Vienna Visuo-Constructional Test 3.0 Screening (VVT-3.0), Mini-Mental State Examination (MMSE), Clock Drawing Test (CDT)

Vergleich der Aussagekraft von Mini-Mental State Examination, Clock Drawing Test, und Vienna Visuo-Constructional Test 3.0-Screening bei der Parkinson-Krankheit

Zusammenfassung: Die Parkinson-Krankheit führt zu einer kognitiven Beeinträchtigung. Weit verbreitete Methoden zur Erfassung der Kognition sind der Uhrentest und die Mini-Mental State Examination, eine weitere Option ist das Vienna Visuo-Constructional Test 3.0 Screening. Neuropsychologische und demographische Daten von 45 gesunden Kontrollpersonen und 64 Parkinsonpatienten (N = 109) wurden untersucht. Die Validität jedes Tests wurde anhand von Receiver Operator Characteristic (ROC)-Kurven und logistischen Regressionsanalysen verglichen. ROC-Analysen ergaben eine AUC von 0.68 für den VVT-3.0 von 0.74 für den MMSE und 0.72 für den CDT als Prädiktor. Der VVT-3.0 zeigt eine vergleichbare Validität wie die etablierten Messinstrumente MMSE und CDT und ist im klinischen Setting einfach anzuwenden.

Schlüsselworte: Parkinson-Krankheit, kognitives Screening, Vienna Visuo-Constructional Test 3.0 Screening (VVT-3.0), Mini-Mental State Examination (MMSE), Uhrzeichentest (CDT)

Introduction

Parkinson's disease (PD) is the second most prevalent neurodegenerative disease (Tysnes & Storstein, 2017). It is a progressive disorder that leads to specific movement disturbances, i.e., rigidity, bradykinesia, rest tremors, and postural instability (Dickson, 2018). Even though the clinical diagnosis according to the criteria by Gibb and Lees (1988) relies chiefly on the presence of motor symptoms, PD is also associated with various nonmotor features (Schapira et al., 2017). These nonmotor features come to the foreground as the neurodegeneration progresses, significantly affecting patients' quality of life with PD (Chaudhuri et al., 2006; Schapira et al., 2017). Progressive cognitive impairment is considered one of PD's most important nonmotor manifestations (Obeso et al., 2017). Research shows that many cognitive domains can be affected by PD (Hoogland et al., 2017), which manifests in a range of cognitive dysfunctions, ranging from mild cognitive impairment (PD-MCI) (Litvan et al., 2012) to dementia (PDD) (Emre et al., 2007).

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Neuropsychological tests can efficiently gauge cognitive deficits. Widely used methods are the Mini-Mental State Examination (MMSE) (Folstein et al., 1975; Watson et al., 2013) and the Clock Drawing Test (CDT) (Sunderland et al., 1989). Another, newer option is the Vienna Visuo-Constructional Test 3.0 Screening (VVT-3.0) (Lehrner, 2021), which measures visuoconstructional ability (Lehrner et al., 2015). This is one of the most important cognitive domains affected by PD (Dubois et al., 2007; Levin et al., 1991). The Movement Disorder Society (MDS) published diagnostic criteria for dementia in PD (PDD) (Emre et al., 2007) and criteria for mild cognitive impairment associated with PD (PD-MCI) (Litvan et al., 2012), recommending the assessment of visuospatial/visuoconstructive functioning as one of five cognitive domains (Dubois et al., 2007). This study investigates the validity of the VVT-3.0 and compares it to that of the MMSE and CDT in patients with PD.

Methods

We collected the data at the outpatient clinic of the Department of Neurology of the Medical University of Vienna and examined them retrospectively. The patients had originally been admitted to the clinic for a neurological examination. We completed the research in accordance with the Helsinki Declaration. The Ethics Committee of the Medical University of Vienna (EK 294/2008) approved this study.

Participants

We diagnosed the patients clinically at the Department of Neurology with PD using the UK Parkinson's Disease Society Brain Bank Clinical Diagnostic Criteria (Gibb & Lees, 1988), while the healthy controls (HC) had to be neurologically healthy (no epilepsy, stroke, or traumatic brain injuries). The HC received a standardized clinical interview and cognitive screening. We did not use routine blood tests, neurological examination, imaging, or informant evaluation methods. HC were not supposed to have any active neurological or psychiatric diseases or be taking psychotropic medication. If a comorbidity was present, it could not be one that caused cognitive impairment. We recruited the healthy controls via public announcements and flyers.

In total, 127 persons participated in this study, 63 HC and 64 patients with PD, ranging in age from 30 to 86 years. A decisive criterion for inclusion in the study was completing all three tests: VVT-3.0, CDT, and MMSE. Since not every participant performed all three of them, 18 of the 127 participants were excluded from the analysis, resulting in 45 HC and 64 patients with PD.

We pseudonymized the data by replacing the names of the patients with numbers to prohibit the emergence of sensitive personal data. Subjects took part in the study voluntarily, were informed about the aim and content of the project, and gave written consent. They were not exposed to any strains or risks and were allowed to quit at any time without explanation or disadvantages.

Measures

We evaluated all patients using standard neuropsychological tests and neurological examinations. The Beck Depression Inventory (BDI-II) measured the severity of depressive symptoms (Beck et al., 1996), and the Wortschatz-Test (WST) assessed patients' premorbid IQs (Schmidt & Metzler, 1992). Besides these tests and the Neuropsychological Test Battery Vienna (NTBV), the participants completed the VVT-3.0, MMSE, and CDT.

Vienna Visuo-Constructional Test 3.0 (VVT-3.0) Screening

The Vienna Visuo-Constructional Test 3.0 Screening presents three figures, which the subjects copy as accurately as possible: a clock with 12 digits depicting 10 minutes past 11 o'clock, two overlapping pentagons, and a three-dimensional cube. The clock is widely used in neuropsychological tests (cf. the Clock Drawing Test, Sunderland et al., 1989). The score for this screening is based on the figure's correctly drawn contour, correctly placed digits and hands, and shorter hour hand (three points in total for the clock). The two overlapping pentagons resemble a part of the Mini-Mental State Examination (Folstein et al., 1975). To achieve the total amount of three points for the pentagons, the subject must draw two five-sided figures in an overlapping manner and then draw a four-sided overlapping area. The cube is also present in the Alzheimer's Disease Assessment Scale – Cognitive Subscale (ADAS-COG) (Mohs et al., 1997). This figure should be drawn in a three-dimensional shape, with accurately copied inner lines, a correctly faced front panel, and parallel lines (4 points in total for the cube). The test scores of the VVT-3.0 range from 0 to 10 points (Lehrner, 2021).

Mini-Mental State Examination (MMSE)

The MMSE is a widely used dementia screening tool (Folstein et al., 1975; Watson et al., 2013) that is divided into two parts: the first evaluates orientation, attention, and memory, and the second assesses object recognition, the

ability to follow commands, verbal fluency, and visuoconstructive function. The scores range from 0 to 30 (Folstein et al., 1975).

Clock Drawing Test (CDT)

The CDT is a common neurological drawing test used as a screening instrument for cognitive functions, especially of the elderly. One can administer this test in two ways: the command and the copy condition. The former modality, in which the subject is verbally requested to draw a clock depicting 10 past 11 o'clock, evaluates the language, memory, and executive functions of the person (De Pandis et al., 2010). In the latter, the subject must copy a drawing of a clock, which requires more visuospatial processes than language or memory functions (De Pandis et al., 2010).

The CDT has many different scoring methods (Mendes-Santos et al., 2015; Mendez et al., 1992; Shulman et al., 1993; Sunderland et al., 1989). For this study, the scoring system used was that of Sunderland et al. (1989); its scores range from 1 to 10, with scores 1–5 rated as "Drawing of clock face with circle and numbers is not intact" and scores 6–10 as "Drawing of clock face with circle and numbers is generally intact."

Parameters and Research Questions

The primary parameters were VVT-3.0, MMSE, and CDT scores. We evaluated the following measures of validity: sensitivity, specificity, area under the curve, positive predictive value (PPV), negative predictive value (NGV), positive likelihood ratio (LR+), negative likelihood ratio (LR-) of VVT-3.0, MMSE, and CDT. The primary question was whether the validity of VVT-3.0 is superior regarding the validity to the MMSE and CDT in identifying PD. As a secondary question, we assessed whether there is a correlation between VVT-3.0, MMSE, and CDT as well as demographic variables and NTBV scores.

Statistical Analysis

To assess the predictive validity of VVT-3.0, MMSE, and CDT, we utilized receiver operating characteristics (ROC) to define the sensitivity and specificity of each test. We determined the optimum cut-off according to the Youden Index.

We carried out a correlation analysis between the metric variables VVT-3.0, MMSE, and CDT, sociodemographic data (age, school years), and NTBV scores for the total group of participants, the PD group, and the healthy control group, respectively.

We used binary logistic regression to assess whether VVT-3.0, MMSE, CDT, age, school years, sex, and BDI-II score can discriminate HC from PD. After performing univariate logistic regression analyses, we further analyzed the data with two multivariate regression analyses – one blockwise and one stepwise backward.

We conducted the descriptive and inferential statistics using IBM SPSS Statistics 26.0.

Results

We included 109 participants in the analysis: 64 patients with PD and 45 HC. Table 1 shows the descriptive results of sex, age, school years, VVT-3.0, MMSE, CDT, BDI-II, and WST for both the total and each diagnostic group. Furthermore, Table 1 contains a descriptive analysis of the variables' disease duration, the onset of the disease, and Unified Parkinsons Disease Rating Scale (UPDRS) motor examination score of the PD group. Table S1 presents the NTBV variables for the total and each diagnostic group. We analyzed the differences between the diagnostic groups regarding these variables via *t*-test or Mann-Whitney *U*-test. We tested the distribution of sex via a chi-square test.

ROC Analyses

We performed ROC analyses with PD patients as positive conditions for all three measures (VVT-3.0, MMSE, CDT). We report the areas under the curve (AUC) with a 95 % confidence interval (CI), the optimum cut-off based on the Youden Index, sensitivity and specificity, positive predictive value (PPV), negative predictive value (NGV), positive likelihood ratio (LR+), and negative likelihood Ratio (LR-). See Table 2 for the results and Figure 1 for the illustration of the ROC curves.

Correlation Analysis

We performed correlation analysis between the metric variables VVT-3.0, MMSE, and CDT, sociodemographic data (age, school years), and NTBV variables. Table S2 describes the results for the total group and each diagnostic group, PD and HC.

Binary Logistic Regression Analyses

Table 3 depicts the results of several univariate logistic regressions for the dependent variable "group membership"

Table 1. Demographic and clinical characteristics (mean ± *SD*/median (IQR)) of total, Parkinson's disease group, and healthy control group

Variables	Total	PD	HC
N	109	64	45
M/F***	58/51	39/25	19/26
Age (*n* = 109)**	61.0 ± 11.0	64.0 ±11.0	56.0 ± 10.0
School years (*n* = 108)**	11.0 (8.0)	10.0 (4.75)	14.0 (8.0)
VVT-3.0 (*n* = 109)**	9.0 (1.0)	9.0 (1.0)	10.0 (1.0)
MMSE (*n* = 109)**	28.0 (2.0)	27.0 (3.0)	29.0 (2.0)
CDT (*n* = 109)**	10.0 (2.0)	9.0 (3.0)	10.0 (0.0)
BDI-II (*n* = 97)**	5.0 (8.5)	8.5 (7.0)	3.0 (6.0)
WST-IQ (*n* = 96)*	108.5 ± 13.2	105.2 ± 14.8	112.4 ± 9.8
Duration of disease in months (*n* = 31)		120.0 (110.0)	
UPDRS III Motor examination score (*n* = 28)		20.4 ± 10.9	
Age at onset of disease (*n* = 31)		54.0 ± 10.0	

Note. PD: Parkinson's disease group; HC: healthy control group; M/F: Male/Female; MMSE: Mini-Mental-State Examination; CDT: Clock Drawing Test; VVT-3.0: Vienna Visuo-Constructional Test; BDI-II: Beck Depression Inventory; WST: Wortschatztest; UPDRS: Unified Parkinson's Disease Rating Scale, ***$p < .001$, **$p < .01$, *$p < .05$.

Table 2. Results of ROC analyses (*N* = 109)

Predictor	Area under the curve (AUC)	95% confidence interval	Youden Index Optimal cut-off	Sensitivity/ specificity	PPV	NPV	LR+	LR-
VVT-3.0	0.693	[0.593; 0.793]	9.5	0.67/0.69	0.75	0.60	2.16	0.48
MMSE	0.736	[0.644; 0.828]	27.5	0.53/0.89	0.87	0.57	4.78	0.53
CDT	0.722	[0.623; 0.821]	9.5	0.67/0.79	0.81	0.63	3.04	0.42

Note. VVT-3.0: Vienna Visuo-Constructional Test; MMSE: Mini-Mental State Examination; CDT: Clock Drawing Test; PPV: Positive Predictive value, NGV: Negative Predictive Value; LR+: Positive Likelihood Ratio; LR-: Negative Likelihood Ratio.

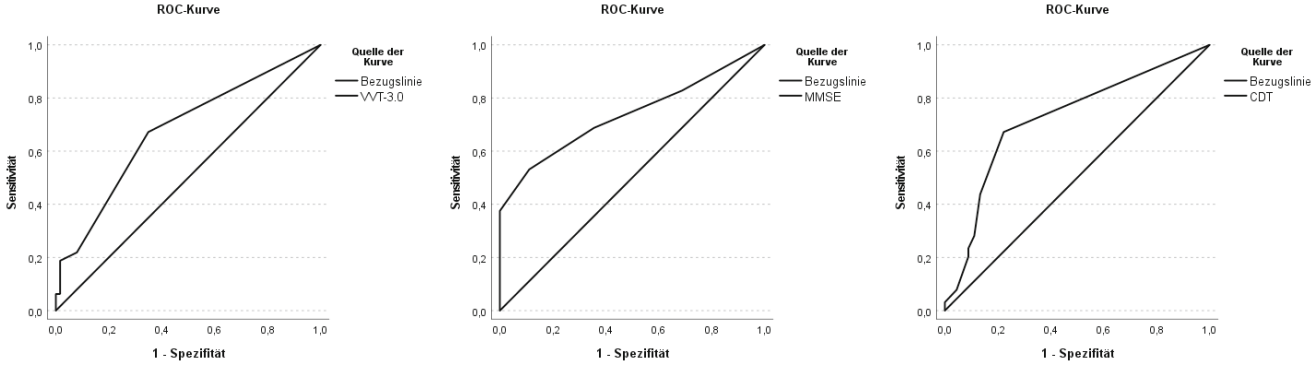

Figure 1. ROC curves for the VVT-3.0 Vienna Visuo-Constructional Test (Figure 1A), the MMSE Mini-Mental State Examination (Figure 1B), and the CDT Clock Drawing Test (Figure 1C).

(healthy controls vs. Parkinson patients) with the variables VVT-3.0, MMSE, CDT, age, school years, sex, and BDI-II score. For the VVT-3.0, the model predicted 65% of healthy controls correctly and 67% of PD patients correctly; Nagelkerkes R^2 was 0.15. For the MMSE, the model predicted 64% of healthy controls correctly and 68% of PD patients correctly; Nagelkerkes R^2 was 0.27. For the CDT, the model correctly predicted 77% of healthy controls and 67% of PD patients; Nagelkerkes R^2 was 0.14. For school years, the model correctly predicted 60% of healthy controls and 78% of PD patients; Nagelkerkes R^2 was 0.20. For sex, the model predicted 63% of healthy controls and 60% of PD patients correctly; Nagelkerkes R^2 was 0.08. For the BDI-II, the model correctly predicted 75% of healthy controls and 65% of PD patients; Nagelkerkes R^2 was 0.17.

Furthermore, a blockwise logistic regression analysis was conducted, with the variables and VVT-3.0, MMSE, and CDT, where the factors MMSE (p = .002), CDT (p = .049), and VVT-3.0 (p = .043) contributed significantly to predicting diagnostic group membership. The model correctly predicted 69% of healthy controls and 72% of PD patients; Nagelkerkes R^2 was 0.37. Table 4 shows the results.

Additionally, we performed a blockwise logistic regression with the variables VVT-3.0, MMSE, CDT, age, school years, sex, and BDI score. MMSE (p = .038), school years (p = .030), BDI-II (p = .009), and sex (p = .002) contributed significantly to predicting diagnostic group membership. VVT-3.0. CDT and age were nonsignificant predictors for this model. The model correctly predicted 75% of healthy controls and 81% of PD patients; Nagelkerkes R^2 was 0.50. Table 5, section A , lists the results.

Subsequently, we conducted a stepwise backward logistic regression analysis with the variables VVT-3.0 MMSE, CDT, age, school years, sex, and BDI score. MMSE (p = .024), CDT (p = .027), school years (p = .008), sex (p = .002), and BDI-II (p = .007) contributed significantly to predicting diagnostic group membership. VVT-3.0 and age were nonsignificant predictors for this model. The model correctly predicted 65.9% of healthy controls and 80.8% of PD patients; Nagelkerkes R^2 was 0.48. Table 5, section B, lists the results.

Table 3. Results of several univariate logistic regression analyses for the dependent variable "group membership" (healthy controls vs. Parkinson patients) N = 109 (BDI-II: N = 97).

	B	*SE*	*p*	Exp(*B*)	Wald
VVT-3.0	0.64	0.22	0.004	1.89	8.50
MMSE	0.60	0.16	0.001	1.83	14.94
CDT	0.39	0.13	0.003	1.48	8.63
Age	−0.07	0.17	0.001	0.94	14.98
School years	0.19	0.05	0.001	1.21	17.24
Sex	−0.02	0.18	0.929	0.98	0.01
BDI-II	−0.14	0.04	0.001	0.87	10.29

Note. VVT-3.0: Vienna Visuo-Constructional Test; *MMSE:* Mini-Mental State Examination; *CDT*: Clock Drawing Test; BDI-II: Beck Depression Inventory.

Discussion

Visuoconstructional functioning is an important factor that can reflect the cognitive ability of patients with cognitive impairment; hence, the VVT-3.0 was developed (Lehrner et al., 2015). This study investigated the validity of the VVT-3.0 and compared it to the MMSE and CDT in patients with PD.

There was a significant difference between the PD and HC groups regarding visuoconstructive functioning. Thus, although previous studies showed the decline in visuospatial skills in PD to be inconsistent (Crucian & Okun, 2003), this study clearly demonstrated a dysfunction in visuoconstructive functioning in PD.

In the next step, we evaluated the correlation between VVT-3.0, MMSE, CDT, the demographic variables age and school years, and the NTBV scores, as depicted in Table S2. The results show a statistically significant correlation (r_s > 0.3) between the three neuropsychological tests for the total group. Nonetheless, when split into the diagnostic groups, VVT-3.0 and MMSE correlated with each other in the PD group, and VVT-3.0 and CDT had no correlation. In the HC group, there was only a weak correlation between VVT-3.0 and CDT and no correlation between VVT-3.0 and MMSE. Furthermore, in the total group, VVT-3.0, MMSE, and CDT had a significant negative correlation with the variable age. In the PD group, only MMSE and CDT showed a correlation with age, and in the HC group, there was no correlation between age and the three tests. Regarding the factor of school years (indicating years of schooling), we measured a significant correlation between VVT-3.0 and school years and between MMSE and school years in the PD group. In contrast,

Table 4. Results of a blockwise logistic regression analysis for the dependent variable "group membership," N = 96

	B	*SE*	*p*	Exp(*B*)	Wald
VVT-3.0	0.66	0.33	0.043	1.93	4.08
MMSE	0.50	0.16	0.002	1.65	9.44
CDT	0.27	0.14	0.049	1.31	3.89

Note. VVT-3.0: Vienna Visuo-Constructional Test; MMSE: Mini-Mental State Examination; CDT: Clock Drawing Test.

Table 5. Results of a blockwise multiple logistic regression for the dependent variable "group membership" (analysis A) and results of a stepwise backward multiple logistic regression for the dependent variable "group membership" (analysis B), $N = 96$

Analysis A	*B*	*SE*	*p*	Exp(*B*)	Wald
VVT-3.0	0.26	0.37	0.492	0.77	0.47
MMSE	0.41	0.20	0.038	0.66	4.30
CDT	0.31	0.17	0.066	0.73	3.38
Age	0.38	0.03	0.158	1.03	1.99
School years	0.15	0.07	0.030	0.86	4.71
Sex	1.97	0.64	0.002	0.14	9.42
BDI-II	0.13	0.05	0.009	1.14	6.75
Analysis B	*B*	*SE*	*p*	Exp*(B)*	Wald
MMSE	0.44	0.20	0.024	0.66	5.07
CDT	0.36	0.16	0.027	0.74	4.92
School years	0.17	0.06	0.008	0.86	6.97
Sex	2.00	0.63	0.002	1.14	10.08
BDI-II	0.13	0.05	0.007	0.14	7.33

Note. VVT-3.0: Vienna Visuo-Constructional Test; MMSE: Mini-Mental State Examination; CDT: Clock Drawing Test; BDI-II: Beck Depression Inventory.

there was a significant correlation only between VVT-3.0 and school years in the HC group. We further found significant correlations between VVT-3.0 and the other assessed cognitive domains of the neuropsychological test battery for the total group, but when split into the diagnostic groups, we could demonstrate only weak to no correlation between VVT-3.0 and each variable of the neuropsychological test battery, indicating that VVT-3.0 assesses an autonomous cognitive domain. We obtained similar results for the MMSE and CDT, suggesting that these three tests assess similar cognitive processes. In summary, in the total group, there was a statistically significant correlation between the three neuropsychological tests ($r_s > 0.3$), school years ($r_s > 0.3$), and age (MMSE and CDT $r_s > -0.3$; VVT-3.0 $r_s = -0.289$). In line with the findings of a study published in 2015 (Lehrner et al., 2015), we found a low to moderate correlation between the three tests and the other cognitive domains of the neuropsychological test battery.

Some of our results may be explained by the very limited variance of the test values, especially in HC (see Table 1, especially for CDT and VVT-3.0), which makes any inferential statistical analyses difficult or limits their validity. The variance in test results might be higher in patients with a higher degree of cognitive decline. Furthermore, the finding of no association between several variables (e.g., age) and the VVT-3.0 might also result from the low variance of test results.

Furthermore, the low association between VVT-3.0, CDT, and MMSE might primarily be caused by the content and measurement principles of the measures. While the MMSE is somewhat broader in terms of content, the CDT is supposed to measure executive functions, and the VVT-3.0 measures visuoconstructional functions.

ROC analyses led to a comparable AUC for VVT-3.0, MMSE, and CDT, respectively. However, although the sensitivity of the VVT is comparable to that of the CDT (and better than that of the MMSE), the specificity of the VVT is not, which is significantly lower than that of the other two short tests. Interestingly, the MMSE showed a low specificity and a high sensitivity in detecting PD patients and controls compared to VVT 3.0 and CDT, indicating that differing diagnostic values might be operating.

The VVT-3.0 is a sensitive neuropsychological screening tool with a sensitivity and specificity similar to the MMSE and CDT. This result is satisfactory since both the MMSE and CDT are recommended for cognitive evaluation in PD patients. Furthermore, the VVT-3.0 is very time-saving and easy to apply. Also, compared to the MMSE, the VVT-3.0 is not language-dependent (Borson et al., 1999), making it a valuable screening tool especially in testing patients with a language barrier.

Moreover, the univariate binary logistic regression models with the three neuropsychological tests as predictors were all significant and could classify the patients into diagnostic groups with similar correct prediction rates.

A blockwise regression analysis with the variables VVT-3.0, MMSE, and CDT showed the lowest model fit. A blockwise regression analysis with the inclusion of age, school years, sex, and BDI-II score led to increased correct group assignments and increased explained variance for the criterion (Nagelkerke's *R*).

VVT-3.0 and age were no longer significant predictors for this model. The variable sex, however, did have a significant estimate, which aligns with previous studies on visuospatial function and gender (Amick et al., 2006).

In a stepwise backward logistic regression with the variables VVT-3.0, MMSE, CDT, age, school years, BDI-II, and sex, the factors MMSE, school years, sex, and BDI-II significantly predicted diagnostic group membership. This model did not include VVT-3.0, CDT, and age, indicating that most variance can be explained through the remaining variables.

Some limitations of the study should be noted. The results may not be representative of the whole population, as the participants of this study were not drawn randomly from the general population. Upcoming studies should include epidemiologically defined HC. It may also be beneficial if the study were repeated with a bigger sample size to

improve the accuracy of the stepwise regression analysis. Additionally, it may be of great interest to define PD group subgroups based on the patients' cognitive performance, such as PD with normal cognition, PD-MCI, and PDD, and to determine their visuoconstructive abilities via the VVT-3.0. Furthermore, the influence of motor symptoms on the results of these neuropsychological tests is unknown, since motor symptoms could interfere with the ability to draw (Emre et al., 2007).

In summary, this study compared the validity of the VVT-3.0, MMSE, and CDT in PD patients. We found the VVT-3.0 to have similar AUC compared to the CDT and MMSE, albeit with somewhat different sensitivity and specificity. Furthermore, we found that the VVT-3.0 is simple to apply in a clinical context. An advantage of the VVT-3.0, making it a valuable screening tool, is the short administration and evaluation time, the former taking approximately 2–3 minutes and the latter 1 minute. Thus, the VVT-3.0 can easily be incorporated into practice, even by nonspecialists since it requires minimal training in cognitive evaluation. Additionally, the VVT-3.0, like the CDT and unlike the MMSE (Borson et al., 1999), is not language-dependent, since the VVT-3.0 mainly comprises copying tasks. This is of utmost importance for a multilingual and multiethnic community.

The VVT-3.0 is a suitable and practicable screening tool that can be easily administered in a clinical setting as a first step in detecting patients with cognitive impairment from Parkinson's disease. After screening patients with the VVT-3.0, one can utilize more detailed, labor-intensive, and time-consuming tests such as the MMSE, inter alia, for further in-depth cognitive assessment.

Future research should examine the VVT-3.0's test-retest reliability, its capability to diagnose PD-MCI and PDD, and its ability in disease monitoring. The VVT-3.0 is a newly established measurement tool that can be easily and successfully utilized to assess visuoconstructive dysfunction in patients with cognitive deficits, such as those with PD.

Electronic supplementary material

The electronic supplementary material (ESM) is available with the online version of the article at https://doi.org/10.1024/1016-264X/a000385

ESM 1. Neuropsychological characteristics (median (IQR) of Total group, Parkinson's disease group, and healthy control (HC) group (Table).

ESM 2. Spearman's rank correlation coefficient r_s and significance p (2-tailed) for total group, Parkinson's disease and healthy control group (Table).

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Conflict of Interest
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