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Screening for DSM-IV-TR Cognitive Disorder NOS in Parkinson's disease using the Mattis Dementia Rating Scale

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Abstract

Objective—This study explores the utility of the Mattis Dementia Rating Scale (MDRS) as a screening tool for the Diagnostic and Statistical Manual for Mental Disorders 4th edition (DSM-IV-TR) diagnosis Cognitive Disorder Not Otherwise Specified in Parkinson's disease(PD).

Methods—125 individuals with PD were diagnosed using DSM-IV-TR criteria for Cognitive Disorder NOS and dementia. Receiver operating characteristics tested the discriminant validity of the MDRS, with the clinician's diagnosis serving as the gold standard.

Results—The MDRS ROC curve to discriminate subjects with Cognitive Disorder NOS from non-demented subjects had an AUC of 0.59 (std. err.= 0.08, 95% CI: 0.43–0.74).

Conclusions—The MDRS is not effective for identifying PD patients with Cognitive Disorder NOS without dementia.

Keywords

Parkinson's disease; non-motor symptoms; cognitive impairment; cognitive screening; dementia rating scale

Introduction

Cognitive impairment, representing selective rather than global cognitive deficits as seen in dementia, is reported to occur in 20%–55% of non-demented Parkinson's disease (PD) patients.(Caviness, 2007, Foltynie, 2004, Janvin, 2003, Muslimovic, 2005, Williams-Gray, 2007) Cognitive impairment in non-demented PD patients is clinically important as it has been associated with a decline in quality of life, greater disability, and increased risk for dementia.(Caviness, 2007, Muslimovic, 2005, Williams-Gray, 2007, Marras, 2008, Sabbagh, 2007, Weintraub, 2004) The ability to detect and distinguish individuals with

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cognitive impairment from patients with no clinically significant cognitive impairment and demented patients will become increasingly important as clinical trials for cognitive impairment in PD are developed.

Comprehensive neuropsychological test batteries can reliably identify cognitive impairments in non-demented PD patients, (Aarsland, 2003, Aarsland, 2003, Azuma, 2003, Dubois, 1997) however they are time consuming and often difficult to administer. In clinical practice, the Diagnostic and Statistical Manual for Mental Disorders 4th edition text revision (DSM-IV-TR) diagnosis, Cognitive Disorder Not Otherwise Specified (Cognitive Disorder NOS), provides criteria for the identification of cognitive impairment including a subjective determination on how impairment impacts function however, it is also time intensive and rarely used in non-psychiatric practices. Standardized instruments used to screen for dementia, like the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA), while shorter and easier to administer, often fail to detect the selective cognitive impairments in PD patients or lack specificity. (Chou, 2010, Hoops, 2009, Nazem, 2009, Riedel, 2008, Zadikoff, 2008) The MMSE, despite its wide use, has not been validated in PD and does not measure executive dysfunction. Although the MoCA has been recommended as an adequately sensitive (0.83) screening instrument for mild cognitive impairment in clinical trials of PD where cognition is not the focus, its specificity is low (0.53) at a cutoff of 26/27. (Chou, 2010, Hoops, 2009)

The Mattis Dementia Rating Scale (MDRS) is a standardized test of global cognitive function that has been shown to be a sensitive measure of frontal-subcortical deficits. (Mattis, 1988, Monsch, 1995) The MDRS has been validated in PD (Aarsland, 2003, Brown, 1999) and cut-off scores from a recent study (Llebaria, 2008) suggest that it can be used to distinguish PD with dementia (PD-D) from non-demented PD. However, no previous study has proposed MDRS cut-off scores to distinguish PD patients with no deficits (PD-ND) defined in this study as no DSM-IV-TR cognitive disorder NOS or dementia from PD patients with only limited cognitive impairment defined as meeting criteria for Cognitive Disorder NOS (PD-CD). Therefore to clarify the utility of the MDRS as an objective measure for distinguishing PD-CD from PD-ND and PD-D in clinical trials we conducted a study to examine the sensitivity and specificity of the MDRS for detecting Cognitive Disorder NOS in subjects with PD.

Methods

Participants with idiopathic PD (Hughes, 1992) were enrolled in a longitudinal research protocol with prospective brain donation to study cognitive, motor, psychiatric, and clinical-pathological features of PD. The cohort was recruited from tertiary care and community practices and included older individuals with advanced disease along with those younger and less affected who could be followed for a longer duration. The initial cohort was consecutively recruited; however participants that went on to autopsy, died, or who were lost to follow up were replaced over the course of the 11-year study in order to keep active enrollment at approximately 100 participants at any given time. Participants or their power of attorney gave written informed consent to participate. The Johns Hopkins University Institutional Review Board approved the protocol. Only baseline data was used for this analysis. A complete MDRS was the only inclusion criteria for this analysis.

Psychiatric and cognitive symptoms were assessed by a geriatric psychiatrist and research nurse using a combination of a semi-structured clinical interview [Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Non-Patient edition (SCID)] (First, 2002), informant interviews, and medical records review. Using this information and the mental status exam, the psychiatrist assigned final psychiatric diagnoses using DSM-IV-

TR criteria for dementia and Cognitive Disorder NOS. DSM-IV-TR criteria for dementia requires impairment in memory and at least one additional cognitive domain, impairment that results in a significant decline from a previous functioning, gradual onset and progressive course, and is not due to any other process. Cognitive Disorder NOS as defined in the Mild Neurocognitive Disorder appendix of the DSM-IV-TR is cognitive dysfunction presumed to be due to the direct effect of a general medical condition (e.g. PD) that does not meet criteria for dementia or delirium, affects at least two cognitive domains, and has a mild impact on functioning (e.g. can be compensated for with additional effort).

Additional measures used in this analysis included the MMSE (Folstein, 1975) as an adjunctive measure of global cognitive status and the Unified Parkinson's Disease Rating Scale (UPDRS) motor subscale (Fahn, 1987) and Hoehn and Yahr (HY) stage (Hoehn, 1967) as measures of motor deficits and disease stage, respectively. Levodopa equivalent daily dose was calculated using conversion factors detailed in Romito et al. (Romito, 2002)

Analyses were conducted using STATA statistical software (Version 9.0). Analysis of variance was used to assess group differences in continuous variables, the chi squared statistic for gender, and Fischer's exact tests for HY stage. Receiver operating characteristic (ROC) curves tested the discriminant validity of the MDRS, with the clinician's diagnosis of cognitive impairment serving as the gold standard. The ROCCOMP command using a χ^2 statistic and logistic regressions were used to test the influence of demographic and clinical features on the area under the curve (AUC). Indices were evaluated at cut-offs defined as the maximum sum of sensitivity and specificity.

Results

The demographic and clinical characteristics of the 125 subjects who completed the MDRS at baseline were: [mean (SD); age 65.8 (10.4) years, education 16.5 (3.1) years, 62.4% men, PD duration 9.3 (6.6) years (n=123), UPDRS part III 27.3 (15.4), HY 2.4 (0.8), daily l-dopa equivalents 618.1 (430.3), and MDRS total score 133.6 (10.8)]. Cognitive Disorder NOS was diagnosed in 21 subjects (16.8%, 95% CI: 10.2–23.4) and dementia was diagnosed in 27 subjects (21.6%, 95% CI: 14.3–28.9).

Table 1 compares the demographic and clinical characteristics between PD-ND, PD-CD, and PD-D. The PD-D group had significantly lower MDRS scores compared to the PD-ND and PD-CD groups, while there were no significant differences on MDRS total score or its sub-scores between PD-CD and PD-ND groups. Figure 1 shows histograms displaying the range of total MDRS scores for each group. PD-ND and PD-CD have similar distributions while the histogram of PD-D subjects is shifted to the left toward lower total MDRS scores.

Based on the distribution of MDRS scores across the three cognitive groups, the PD-ND and PD-CD cognitive groups were collapsed into one group for the main ROC analysis. The ROC curve for the MDRS total score to discriminate PD-D subjects from PD-ND and PD-CD subjects was characterized by an AUC of 0.93 (std. err=0.02, 95% CI: 0.89–0.97). (Figure 2) A MDRS score of 132 yielded a sensitivity of 88.9%, a specificity of 86.7%, and a positive and negative predictive values of 64.9% and 96.6%, respectively. (Appendix 1) Excluding PD-CD patients from the analysis yielded a similar ROC curve characterized by an AUC of 0.94 (std. err.=0.02, 95% CI: 0.90–0.98). However, the discriminant properties of the MDRS diminished when attempting to distinguish PD-CD patients from PD-ND patients AUC 0.59 (std. err.= 0.08, 95% CI: 0.43–0.74). Under this curve, a MDRS score of 137 yielded a sensitivity of 61.9%, a specificity of 70.1%, and a positive and negative predictive value of 36.1% and 87.1%, respectively. MDRS subtests (data not shown) did not perform better than the total MDRS score in any of the above comparisons.

There were no statistically significant AUC differences when the curves were stratified by age, sex, education, MMSE score, PD duration, UPDRS part III score, HY stage, or daily l-dopa equivalents.

Discussion

The main finding of this study is that the MDRS total score cannot differentiate PD subjects with Cognitive Disorder NOS from PD subjects without clinically detectable cognitive impairment. However, similar to Llebaria et al. (Llebaria, 2008) we found that the MDRS is a useful screening test for dementia in PD. Furthermore, we demonstrated that the MDRS total score can discriminate between demented and non-demented PD subjects even when the non-demented group contains subjects with Cognitive Disorder NOS, e.g. PD-CD. Scale performance was not affected by any demographic or clinical variable measured in this study.

The ROC analysis showed that the discriminant validity of the MDRS for detecting dementia in PD was good with an AUC of 0.93. Our results were similar to a recent study by Llebaria et al. (Llebaria, 2008) who found that the MDRS performed well as a screening test for dementia in PD with an AUC of 0.91. In addition, they divided dementia into categories based on Clinical Dementia Rating Scale (CDRS) scores of 1 for mild, 2 for moderate, and 3 for severe and found significant differences on the MDRS between all levels of dementia severity and when each group was compared to non-demented PD subjects. For a diagnosis of dementia they required a score of 1 on the CDRS and that the DSM-IV-TR criteria for dementia was established for each case implying that cognition was affected globally and therefore mild cases would not be analogous to patients with only selective cognitive impairments. Thus their study provided no data regarding how cases with selective cognitive impairment could potentially affect the discriminative ability of the MDRS. Our analysis shows that the MDRS remains sensitive for dementia even when the comparison group of non-demented subjects contains individuals with PD-CD.

A recent review of brief tests of cognitive function in PD by the Parkinson Study Group (PSG) Cognitive/Psychiatric Work Group did not consider the MDRS as a screening instrument for selective cognitive impairments in PD because it took too long (>15 minutes) to administer.(Chou, 2010) The review concluded that of five screening measures considered to be sufficiently brief, the MoCA was the most useful as a screen for mild cognitive impairment and dementia in PD for trials in which the main outcome is not cognitive performance. However, while the MoCA is adequately sensitive, the review points out the many shortcomings of this instrument. Namely it is not specific (0.53) for cognitive impairment in PD, using a cutoff of 26/27, has poor positive predictive value (46%) and lacks normative data for age and education levels. Thus, while brief, the MoCA is not optimal.

The most significant limitation of this study is the lack of a standardized clinical definition for cognitive impairment that does not yet reach the threshold for dementia in PD, a clinical entity akin to 'mild cognitive impairment'.(Caviness, 2007, Chou, 2010, Hoops, 2009, Dubois, 2007, Sollinger, 2010) Although we used the DSM-IV-TR criteria for the diagnosis of Cognitive Disorder NOS and included corroborative information from caregivers when available, the subjective nature of clinical diagnosis has inherent problems with reliability. Therefore, due to the absence of a standard definition and the subjective nature of clinical diagnosis, what we captured using criteria for Cognitive Disorder NOS and what other studies report as 'mild cognitive impairment' using a variety of methods is likely to represent an overlapping but heterogeneous set of conditions.

Cognitive Disorder NOS was diagnosed in 16.8% (n=21) of our sample. This represents a conservative estimate of cognitive impairment in PD compared to prevalence estimates that range from 20%–55% in previous studies.(Caviness, 2007, Foltynie, 2004, Janvin, 2003, Muslimovic, 2005, Williams-Gray, 2007) These studies used a variety of methods to identify cognitive impairment, such as 1.5 standard deviation deficit in at least one cognitive domain without dementia(Caviness, 2007), 2 standard deviations below control group in one or more cognitive domains in the absence of dementia(Janvin, 2003), and by more complicated means using a variety of neuropsychological tests (Foltynie, 2004, Muslimovic, 2005, Williams-Gray, 2007) therefore it is difficult to make direct comparisons between studies. In addition, the DSM-IV-TR criteria for Cognitive Disorder NOS require evidence of ‘mild impact on functioning’, whereas the non-clinical methods for identifying cognitive impairment above do not require evidence of functional impairment; a difference which may contribute to a more conservative estimate in our sample.

Recruitment from tertiary care centers and the high level of education in our sample is a potential source of bias. The education level in our sample was [mean (SD)] 16.5 (3.1) compared to 8.9 (5.0) in the Llebaria et al. study which also used the MDRS to screen for dementia in PD.(Llebaria, 2008) A lower level of education correlates with poorer performance on neuropsychological tests. As a result, our cutoff score for dementia 132, was higher than Llebaria et al. at 123, but still in line with the 129 identified for patients with Alzheimer’s type dementia with a more comparable level of education.(Monsch, 1995) The high level of education in our study may also be a source of bias as the MDRS has been shown to have reduced discriminative ability in the higher range of intelligence.(Lucas, 1998) Similarly, the lack of differences in the MDRS subtest scores in our study when comparing PD-ND to PD-CD may have been the result of a ceiling effect due to the high educational level of our sample and the low difficulty level of certain subtests. Exclusion of 28 subjects who were not administered the MDRS as part of an abbreviated home assessment may also introduce a bias into the study. However, the prevalence of dementia was similar in patients included in this analysis and excluded from the analysis; suggesting any residual bias may be limited. Finally, it must also be noted that dopaminergic drugs may affect cognitive functioning and may influence the results since total l-dopa could not be standardized between groups.

The existing literature and the results of this study emphasize that there is still a need 1) to develop a standardized clinical definition for cognitive deficits that are not yet at the level of dementia in PD and 2) to develop or identify a brief screening tool that can reliably identify patients with these cognitive deficits. Early identification is clinically important because patients with cognitive deficits have been shown to be at higher risk for dementia, more disabled, and to have a worse quality of life.(Caviness, 2007, Muslimovic, 2005, Williams-Gray, 2007, Marras, 2008, Sabbagh, 2007, Weintraub, 2004)

In conclusion, the MDRS can distinguish demented from non-demented patients; however, it is not a good screening tool for identifying PD subjects with Cognitive Disorder NOS without dementia. With new clinical trials to treat ‘mild cognitive impairment’ in PD underway there remains the need for a formal definition of cognitive impairment in PD and a brief screening instrument that is both sensitive and specific to identify these individuals.

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References

1. Caviness JN, Driver-Dunckley E, Connor DJ, et al. Defining mild cognitive impairment in Parkinson's disease. *Mov Disord.* 2007; 22:1272–1277. [PubMed: 17415797]
2. Foltynie T, Brayne CE, Robbins TW, et al. The cognitive ability of an incident cohort of Parkinson's patients in the UK. the CamPaIGN study. *Brain.* 2004; 127:550–560. [PubMed: 14691062]
3. Janvin C, Aarsland D, Larsen JP, et al. Neuropsychological profile of patients with Parkinson's disease without dementia. *Dement Geriatr Cogn Disord.* 2003; 15:126–131. [PubMed: 12584427]
4. Muslimovic D, Post B, Speelman JD, et al. Cognitive profile of patients with newly diagnosed Parkinson disease. *Neurology.* 2005; 65:1239–1245. [PubMed: 16247051]
5. Williams-Gray CH, Foltynie T, Brayne CE, et al. Evolution of cognitive dysfunction in an incident Parkinson's disease cohort. *Brain.* 2007; 130:1787–1798. [PubMed: 17535834]
6. Marras C, McDermott MP, Rochon PA, et al. Predictors of deterioration in health-related quality of life in Parkinson's disease: Results from the DATATOP trial. *Mov Disord.* 2008; 23:653–9. quiz 776. [PubMed: 18076084]
7. Sabbagh MN, Lahti T, Connor DJ, et al. Functional ability correlates with cognitive impairment in Parkinson's disease and Alzheimer's disease. *Dement Geriatr Cogn Disord.* 2007; 24:327–334. [PubMed: 17851237]
8. Weintraub D, Moberg PJ, Duda JE, et al. Effect of psychiatric and other nonmotor symptoms on disability in Parkinson's disease. *J Am Geriatr Soc.* 2004; 52:784–788. [PubMed: 15086662]
9. Aarsland D, Andersen K, Larsen JP, et al. Prevalence and characteristics of dementia in Parkinson disease: An 8-year prospective study. *Arch Neurol.* 2003; 60:387–392. [PubMed: 12633150]
10. Aarsland D, Litvan I, Salmon D, et al. Performance on the dementia rating scale in Parkinson's disease with dementia and dementia with lewy bodies: Comparison with progressive supranuclear palsy and Alzheimer's disease. *J Neurol Neurosurg Psychiatry.* 2003; 74:1215–1220. [PubMed: 12933921]
11. Azuma T, Cruz RF, Bayles KA, et al. A longitudinal study of neuropsychological change in individuals with Parkinson's disease. *Int J Geriatr Psychiatry.* 2003; 18:1115–1120. [PubMed: 14677144]
12. Dubois B, Pillon B. Cognitive deficits in Parkinson's disease. *J Neurol.* 1997; 244:2–8. [PubMed: 9007738]
13. Chou KL, Amick MM, Brandt J, et al. A recommended scale for cognitive screening in clinical trials of Parkinson's disease. *Mov Disord.* 2010; 25:2501–2507. [PubMed: 20878991]
14. Hoops S, Nazem S, Siderowf AD, et al. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology.* 2009; 73:1738–1745. [PubMed: 19933974]
15. Nazem S, Siderowf AD, Duda JE, et al. Montreal cognitive assessment performance in patients with Parkinson's disease with "normal" global cognition according to mini-mental state examination score. *J Am Geriatr Soc.* 2009; 57:304–308. [PubMed: 19170786]

16. Riedel O, Klotsche J, Spottke A, et al. Cognitive impairment in 873 patients with idiopathic Parkinson's disease. results from the German study on epidemiology of Parkinson's disease with dementia (GEPAD). *J Neurol*. 2008; 255:255–264. [PubMed: 18204803]
17. Zadikoff C, Fox SH, Tang-Wai DF, et al. A comparison of the mini mental state exam to the Montreal cognitive assessment in identifying cognitive deficits in Parkinson's disease. *Mov Disord*. 2008; 23:297–299. [PubMed: 18044697]
18. Mattis, S. Dementia rating scale: professional manual. Florida: Odessa; 1988.
19. Monsch AU, Bondi MW, Salmon DP, et al. Clinical validity of the Mattis dementia rating scale in detecting dementia of the Alzheimer type. A double cross-validation and application to a community-dwelling sample. *Arch Neurol*. 1995; 52:899–904. [PubMed: 7661728]
20. Brown GG, Rahill AA, Gorell JM, et al. Validity of the dementia rating scale in assessing cognitive function in Parkinson's disease. *J Geriatr Psychiatry Neurol*. 1999; 12:180–188. [PubMed: 10616865]
21. Llebaria G, Pagonabarraga J, Kulisevsky J, et al. Cut-off score of the Mattis dementia rating scale for screening dementia in Parkinson's disease. *Mov Disord*. 2008; 23:1546–1550. [PubMed: 18546326]
22. Hughes AJ, Daniel SE, Kilford L, et al. Accuracy of clinical diagnosis of idiopathic Parkinson's disease: A clinico-pathological study of 100 cases. *J Neurol Neurosurg Psychiatry*. 1992; 55:181–184. [PubMed: 1564476]
23. First, MB.; Spitzer, RL.; Gibbon, M., et al. Structured clinical interview for DSM-IV-TR axis I disorders, research version, non-patient edition (SCID-I/NP). New York: Biometrics Research, New York State Psychiatric Institute; Nov. 2002
24. Folstein MF, Folstein SE, McHugh PR. "Mini-Mental State": a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975; 12:189–198. [PubMed: 1202204]
25. Fahn, S.; Elton, RL. members of the UPDRS Development Committee. Unified Parkinson's Disease Rating Scale. In: Fahn, S.; Marsden, CD.; Goldstein, M., editors. Recent developments in Parkinson's disease II. New York: Macmillan; 1987. p. 153-163.
26. Hoehn MM, Yahr MD. Parkinsonism: Onset, progression, and mortality 1967. *Neurology*. 2001; 57:S11–26. [PubMed: 11775596]
27. Romito LM, Scerrati M, Contarino MF, et al. Long-term follow up of subthalamic nucleus stimulation in Parkinson's disease. *Neurology*. 2002; 58:1546–50. [PubMed: 12034798]
28. Dubois B. Is PD-MCI a useful concept? *Mov Disord*. 2007; 22:1215–1216. [PubMed: 17557344]
29. Sollinger AB, Goldstein FC, Lah JJ, et al. Mild cognitive impairment in Parkinson's disease: Subtypes and motor characteristics. *Parkinsonism Relat Disord*. 2010; 16:177–180. [PubMed: 19939721]
30. Lucas JA, Ivnik RJ, Smith GE, et al. Normative Data for the Mattis Dementia Rating Scale. *J Clin Experimental Neuropsychology*. 1998; 20:536–547.

Figure 1.

Histograms of the distribution of total Mattis Dementia Rating Scale scores across three groups: PD-ND, PD No Cognitive disorder or dementia; PD-CD, PD Cognitive Disorder NOS; PD-D, PD with dementia. ROC curve: PD-D versus PD-CD and PD-ND

Figure 2.

Receiver Operating Characteristics (ROC) curve showing the discriminant properties of the total Mattis Dementia Rating Scale score between subjects with Parkinson's and dementia (PD-D) and a combined group of subjects with Parkinson's with Cognitive Disorder NOS (PD-CD) and no cognitive deficits (PD-ND).

Table 1

Demographic and clinical characteristics of PD-ND, PD-CD, and PD-D patients

	PD-ND (n = 77)	PD-CD (n = 21)	PD-D (n = 27)	Group Test Statistic	Post-hoc Comparisons (for p < .05)
Age (y)	63.2 ± 10.0	64.5 ± 9.3	74.2 ± 7.7	F(2,122) = 13.8	PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
Education (y)	16.5 ± 3.1	16.8 ± 3.1	16.3 ± 3.3	F(2, 122) = 0.14	P = 0.88
Gender (%)	49 M/28 F	11 M/10 F	18 M/9 F	$\chi^2_{(2)} = 1.2$	P = 0.56
PD duration (y)	9.0 ± 7.3 (n = 75)	7.3 ± 3.7	11.5 ± 6.1	F(2, 120) = 2.6	P = 0.08
UPDRS-III	23.7 ± 13.6	26.4 ± 14.9	38.3 ± 15.9	F(2, 122) = 10.4	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.85 <0.001 0.031
Hoehn and Yahr Stage					
I	11 (14%)	0 (0%)	1 (4%)		P = 0.10
II	51 (66 %)	16 (76%)	15 (55%)		
III	12 (16%)	3 (14%)	5 (19%)		
IV	2 (3%)	2 (10%)	2 (7%)		
V	1 (1%)	0 (0%)	4 (15%)		
Cumulative LDOPA Total (mg)	547.6 ± 433.9	639.2 ± 435.6	802.6 ± 369.3	F(2, 120) = 3.7	P = 0.03
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.78 0.02 0.44
MMSE Total Score	28.3 ± 1.8	27.1 ± 2.6	24.3 ± 3.0	F(2, 122) = 30.9	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.16 <0.001 0.004
MDRS Total Score	137.8 ± 5.9	135.7 ± 6.6	119.7 ± 12.9	F(2, 122) = 52.2	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.47 <0.001 <0.001
MDRS--Attention	36.0 ± 1.1	36.1 ± 0.9	35.1 ± 1.7	F(2, 122) = 5.5	P = 0.005
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.95 0.06 0.04
MDRS--Initiation	35.6 ± 2.9	35.1 ± 3.6	28.8 ± 5.6	F(2, 122) = 34.8	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.90 <0.001 <0.001
MDRS--Construction	5.8 ± 0.5	5.8 ± 0.6	4.8 ± 1.5	F(2, 122) = 14.2	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.98 0.01 0.02
MDRS--Conceptualization	36.8 ± 2.1	35.9 ± 2.6	32.6 ± 5.1	F(2, 122) = 19.0	P < 0.001
					PD-ND vs. PD-CD PD-ND vs. PD-D PD-CD vs. PD-D
					0.36 0.001 0.02

	PD-ND (n = 77)	PD-CD (n = 21)	PD-D (n = 27)	Group Test Statistic	Post-hoc Comparisons (for p < .05)
MDRS--Memory	23.6 ± 1.6	22.9 ± 2.0	18.4 ± 3.5	F(2, 122) = 55.7 P < 0.001	PD-ND vs. PD-CD 0.38 PD-ND vs. PD-D < 0.001 PD-CD vs. PD-D < 0.001

Values expressed as mean ± SD. Group test statistic derived using ANOVA.

PD-ND, PD No Cognitive disorder or dementia; PD-CD, PD Cognitive Disorder NOS; PD-D, PD with dementia; UPDRS, Unified Parkinson's Disease Rating Scale; MDRS, Mattis Dementia Rating Scale.

Appendix 1a
Sensitivity, specificity, positive and negative predictive values of Dementia only at different scores for the Dementia Rating Scale Total Scores

(Dementia only vs. no Dementia, no Cognitive Disorder NOS)

Score	140	139	138	137	136	135	134	133	132	131	130
Sensitivity	100	100	100	100	100	96.3	92.6	92.6	88.9	85.2	74.1
Specificity	36.4	55.8	62.3	70.1	74.0	76.6	80.5	84.4	89.6	90.9	90.9
PPV	35.5	44.3	48.2	54.0	57.4	59.1	62.5	67.6	75.0	76.7	74.1
NPV	100	100	100	100	100	98.3	96.9	97.0	95.8	94.6	90.9

Score	129	128	127	126	125	124	123	122	121	120
Sensitivity	66.7	66.7	63.0	59.3	51.9	51.9	51.9	51.9	48.1	44.4
Specificity	90.9	90.9	93.5	93.5	94.8	96.1	97.4	97.4	97.4	97.4
PPV	72.0	72.0	77.3	76.2	77.8	82.4	87.5	87.5	86.7	85.7
NPV	88.6	88.6	87.8	86.7	84.9	85.1	85.2	85.2	84.3	83.3

Appendix 1b
Sensitivity, specificity, positive and negative predictive values of Dementia at different scores for the Dementia Rating Scale Total Scores
(Dementia vs. Cognitive Disorder NOS + no Dementia, no Cognitive Disorder NOS)

Score	140	139	138	137	136	135	134	133	132	131	130
Sensitivity	100	100	100	100	100	96.3	92.6	92.6	88.9	85.2	74.1
Specificity	36.7	52.0	57.1	63.3	68.4	72.4	77.6	81.6	86.7	87.8	88.8
PPV	30.3	36.5	39.1	42.9	46.6	49.1	53.2	58.1	64.9	65.7	64.5
NPV	100	100	100	100	100	98.6	97.4	97.6	96.6	95.6	92.6

Score	129	128	127	126	125	124	123	122	121	120
Sensitivity	66.7	66.7	63.0	59.3	51.9	51.9	51.9	51.9	48.1	44.4
Specificity	88.8	89.8	92.9	92.9	93.9	94.9	96.9	96.9	96.9	96.9
PPV	62.1	64.3	70.8	69.6	70.0	73.7	82.4	82.4	81.3	80.0
NPV	90.6	90.7	90.1	89.2	87.6	87.7	88.0	88.0	87.2	86.4

Appendix 1c

Sensitivity, specificity, positive and negative predictive values of any cognitive disorder at different scores for the Dementia Rating Scale Total Scores

(Dementia + Cognitive Disorder NOS vs. no Dementia, no Cognitive Disorder NOS)

Score	140	139	138	137	136	135	134	133	132	131	130
Sensitivity	83.3	83.3	83.3	83.3	79.2	72.9	66.7	64.6	60.4	58.3	50.0
Specificity	36.4	55.8	62.3	70.1	74.0	76.6	80.5	84.4	89.6	90.9	90.9
PPV	44.9	54.1	58.0	63.5	65.5	66.0	68.1	72.1	78.4	80.0	77.4
NPV	77.8	84.3	85.7	87.1	85.1	81.9	79.5	79.3	78.4	77.8	74.5

Score	129	128	127	126	125	124	123	122	121	120
Sensitivity	45.8	43.8	39.6	37.5	33.3	33.3	31.3	31.3	29.2	27.1
Specificity	90.9	90.9	93.5	93.5	94.8	96.1	97.4	97.4	97.4	97.4
PPV	75.9	75.0	79.2	78.3	80.0	84.2	88.2	88.2	87.5	86.7
NPV	72.9	72.2	71.3	70.6	69.5	69.8	69.4	69.4	68.8	68.2

Appendix 2d
Sensitivity, specificity, positive and negative predictive values of Cognitive Disorder NOS at different scores for the Dementia Rating Scale
Total Scores

(Cognitive Disorder NOS only vs. no Dementia, no Cognitive Disorder NOS)												
Score	140	139	138	137	136	135	134	133	132	131	130	
Sensitivity	61.9	61.9	61.9	61.9	52.4	42.9	33.3	28.6	23.8	23.8	19.0	
Specificity	36.4	55.8	62.3	70.1	74.0	76.6	80.5	84.4	89.6	90.9	90.9	
PPV	21.0	27.7	31.0	36.1	35.5	33.3	31.8	33.3	38.5	41.7	36.4	
NPV	77.8	84.3	85.7	87.1	85.1	83.1	81.6	81.3	81.2	81.4	80.5	
Score	129	128	127	126	125	124	123	122	121	120		
Sensitivity	19.0	14.3	9.5	9.5	9.5	9.5	4.8	4.8	4.8	4.8	4.8	
Specificity	90.9	90.9	93.5	93.5	94.8	96.1	97.4	97.4	97.4	97.4	97.4	
PPV	36.4	30.0	28.6	28.6	33.3	40.0	33.3	33.3	33.3	33.3	33.3	
NPV	80.5	79.5	79.1	79.1	79.3	79.6	78.9	78.9	78.9	78.9	78.9	