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Detection of mild cognitive deficits in Parkinson's disease patients with the WAIS–R NI

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Abstract

The relative insensitivity of traditional IQ tests to mild cognitive deficits has led investigators to develop a version of the widely used Wechsler intelligence scales that allows quantitative analysis of underlying qualitative responses. This instrument, the Wechsler Adult Intelligence Scale–Revised as a Neuropsychological Instrument (WAIS–R NI) was administered to 16 Parkinson's disease (PD) patients and 30 normal controls (NC). The 2 groups did not differ significantly in mean age or education, or on their mean Mattis Dementia Rating Scale score. Relative to NC participants, PD patients showed decreased visual attention span, longer response latencies, slower visuomotor processing, and more stimulus-bound errors. Many of the WAIS–R NI measures were able to detect cognitive impairment in a greater percentage of patients than the traditional WAIS–R measures, making it easier to identify deficits that could affect quality of life early in the course of the disease. (*JINS*, 2001, *7*, 535–543.)

Keywords: Parkinson's disease, Cognition, Assessment

INTRODUCTION

A number of studies have shown that patients with Parkinson's disease (PD) suffer mild cognitive decline that is evident when they are assessed with sensitive measures of specific cognitive abilities. The most prominent deficits occur in the so-called frontal lobe or executive functions (Bondi et al., 1993; Cooper et al., 1991; Gotham et al., 1988; Jacobs et al., 1995) and include impaired retrieval (Auriacombe et al., 1993; Massman et al., 1990; McFadden et al., 1996; Mohr et al., 1990; Randolph et al., 1993; Tröster & Fields, 1995), processing difficulties when confronted with a situation that requires a highly effortful response (Taylor & Saint-Cyr, 1995; Weingartner et al., 1984), deficits in working memory (Dalrymple-Alford et al., 1994), abnormally rapid disengagement of attention (i.e., difficulty maintaining attention to relevant visual stimuli; Filoteo et al., 1994; Maddox et al., 1996), and an instability of cognitive set (Flowers & Robertson, 1985). Deficits in visuospatial abilities have also been demonstrated in nondemented patients with PD (Bondi et al., 1993; Levin et al., 1991; Mohr et al., 1990; Stern et al., 1993), and may be due, in part, to executive dysfunction (Bondi et al., 1993; Levin et al., 1991; Mohr et al., 1990) or to deficits in visual attention (Filoteo et al., 1994). Decreased speed of information processing, or cognitive slowing, is another prominent manifestation of PD that may contribute to the overall cognitive decline in nondemented individuals (Pate & Margolin, 1994).

Despite evidence of mild cognitive dysfunction in patients with PD, deficits are not always apparent on tests of generalized intellectual functioning. Studies using well-known standardized intelligence quotients (IQ) such as the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955), or the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981), for example, have revealed very few differences between nondemented patients with PD and nor-

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mal controls (NC) (Bondi et al., 1993; Cooper et al., 1991; Gotham et al., 1988; Lees & Smith, 1983; Matison et al., 1982; McFadden et al., 1996; Sullivan et al., 1989). Those studies that have reported WAIS–R deficits in nondemented PD patients have found them almost exclusively on Performance subtests (Bondi et al., 1993; Brown & Marsden, 1988; Cooper et al., 1991; Mohr et al., 1990; Ross et al., 1996), although one study reported that nondemented patients with PD and NC subjects differed on several WAIS Verbal subtests (Ross et al., 1996). This relative insensitivity of the WAIS and WAIS–R to mild cognitive impairment in patients with PD may stem from the tests' emphasis on global achievement at the expense of detailed information regarding specific cognitive functions that might be affected in these patients.

Recently, a version of the WAIS–R that may prove to be particularly sensitive to the mild cognitive decline that occurs in patients with PD was developed as a neuropsychological instrument that allows identification and quantification of qualitative processes underlying a patient's responses. This relatively new instrument, the WAIS–R as a Neuropsychological Instrument (WAIS–R NI; Kaplan et al., 1991), allows traditional WAIS–R scores to be acquired while providing new scores that reflect qualitative aspects of performance. Among the procedural changes from the WAIS–R that are included in the WAIS–R NI are the acquisition of both time-limited and untimed scores on the Performance subtests and the Arithmetic subtest to enable the examiner to determine whether the examinee is unable to reach a solution or is simply slow in responding; administration of items beyond the usual discontinue rules to permit a larger sampling of test items within a given subtest; and the addition of a multiple-choice format for four WAIS–R subtests (Information, Vocabulary, Comprehension, Similarities) to minimize the confounding effects of problems with activation, impaired retrieval, poor motivation, or language deficits on subtest performance. In keeping with the orientation of the process approach to neuropsychological assessment (Kaplan, 1988), the WAIS–R NI instructions also require the examiner to record responses that allow quantitative analysis of qualitative variables such as types of errors and problem solving strategies. In addition, the WAIS–R NI incorporates normative data on intrasubtest scatter scores to alert the examiner to significant variability in the examinee's level of arousal, attention, or motivation.

In light of the detailed assessment of cognitive processes provided by the WAIS–R NI, the present study was designed to examine the extent to which this new instrument could detect mild cognitive deficits in PD patients who did not differ on a measure of global cognitive functioning (Mattis Dementia Rating Scale; DRS, Mattis, 1988) from NC participants. Based on previous studies of the specific cognitive deficits that are associated with PD, we expected minimal to no differences between these PD patients and NC participants on untimed tests of verbal processing such as Information, Vocabulary, Comprehension, and Similarities, but mildly impaired performance by PD patients on tests assessing various aspects of attention (e.g., Digit Span, Spatial Span, Arithmetic), visuomotor abilities (e.g., Digit Symbol, Symbol Copy), and psychomotor speed (e.g., Digit Symbol, Symbol Copy). In addition, we expected the PD patients to show at least mildly impaired performance on tests of problem solving and visuospatial skills (e.g., Picture Arrangement, Sentence Arrangement, Object Assembly, Block Design), and to have longer response latencies, larger scatter scores, and a greater discrepancy between timed and untimed scores than NC participants. Finally, we anticipated that these PD patients would show greater than normal improvement on multiple-choice recognition testing relative to free recall (e.g., Vocabulary, Comprehension, Similarities), given the evidence suggesting that PD patients have a deficit in retrieval.

METHODS

Research Participants

Forty-six adults participated in the study: 16 PD patients (5 female and 11 male) and 30 NC participants (21 female and 9 male). Table 1 shows the mean age, years of education, Mattis DRS (Mattis, 1988) score, and Beck Depression In-

Table 1. Mean demographic characteristics, mental status scores, and depression inventory scores for Parkinson's disease (PD) and normal control (NC) participants

	NC (N = 30)			PD (N = 16)		
Characteristic	*M*	*SD*	Range	*M*	*SD*	Range
Age	63.0	10.3	39–79	64.2	7.8	54–75
Education	15.6	2.4	12–19	15.4	2.3	12–19
Mattis DRS Total	141.4	1.9	137–144	140.5	2.7	135–144
BDI	4.6	4.4	0–16	5.7	4.4	0–16
Illness Duration	—	—	—	11.7	6.8	3.1–24.9

Note. Maximum score on Mattis Dementia Rating Scale (DRS) = 144. Maximum score on Beck Depression Inventory (BDI) = 63.

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ventory (BDI; Beck, 1978) score for the two groups, as well as duration of illness for the patient group. The groups did not differ significantly in age, education, or DRS score. Based on Mattis DRS normative data published by Monsch et al. (1995), none of the PD patients in the study would be considered demented. Group means on the BDI were within normal limits with respect to level of depression, and the range of BDI scores was the same for both groups.

All PD patients were recruited from a movement disorder clinic at the University of California, San Diego and volunteered for research. Administration of the WAIS–R NI was not part of the clinical work-up. A senior staff neurologist (C.W.S.) made a diagnosis of idiopathic PD on the basis of the presence of at least two of the three classic Parkinsonian symptoms of tremor, rigidity, and bradykinesia. The motor symptoms of all patients were judged by the neurologist to be of mild to moderate severity and were bilateral in all but 1 case. Six of the PD patients received a Hoehn and Yahr (1967) rating of 2, one received a rating of 1, and the remaining 9 participants were not formally rated with this scale. A review of their records, however, indicated that their motor symptoms were equivalent to a Hoehn and Yahr rating of 1 or 2. Patients with a history of severe head injury, alcoholism, or serious and prolonged psychiatric illness were excluded. At the time of testing, all but 1 PD patient were taking medication (e.g., Sinemet) for their Parkinsonian symptoms. Only 1 patient was taking a psychotropic medication (i.e., Wellbutrin) at the time of testing; his score on the BDI was 9, which suggested little or no depression. None of the patients had medical problems, including problems with vision and hearing, that were judged sufficient to interfere with performance on neuropsychological testing.

The NC participants were either spouses of patients or individuals who volunteered after learning of the study through newspaper advertisements. Individuals with past or current alcoholism, serious and prolonged psychiatric illness, stroke, or other neurologic disorder were excluded from the study. None of the NC participants had medical problems, including problems with vision and hearing, that were judged sufficient to interfere with performance on neuropsychological testing.

Test Materials

The WAIS–R NI is a modification and expansion of the standardized procedures of the WAIS–R. The test employs the standard WAIS–R test materials and instructions with the following modifications: (1) scores are computed for both the discontinue rule and for items beyond the discontinue rules; (2) both time-limited and untimed scores are computed for the Picture Completion, Picture Arrangement, Arithmetic, and Object Assembly subtests; (3) multiple-choice versions of all the items on the Information, Vocabulary, and Similarities subtests, and the proverb items on the Comprehension subtest, are presented at the end of each of these subtests; (4) a new forward and backward visual span subtest is presented as a spatial analogue to the Digit Span subtest; (5) the examinee is asked to tell a story for his or her arrangement of pictures on each trial of the Picture Arrangement subtest; (6) a Sentence Arrangement task is presented as a verbal analogue to the Picture Arrangement subtest; (7) on the Block Design subtest, 12 blocks are available on every trial, the examinee must indicate whether or not their construction is correct, and each failed design is attempted again using a picture of the design with each block demarcated with solid lines; (8) failed items on the Arithmetic subtest are repeated with the question visually presented to the examinee, then with paper and pencil available to the examinee, and finally with computations written out; (9) the Digit Symbol subtest is continued until the third row is completed, followed by an incidental memory test for the digit-symbol pairs and for symbols by themselves; and (10) a new Symbol Copy task is presented in which the examinee copies a series of symbols from the Digit Symbol task into empty boxes directly below each symbol (in order to assess the motor component of this task). The number of symbols correctly copied in 90 s is recorded.

Because most of the modifications in the WAIS–R NI do not change or interfere with the basic WAIS–R administration procedures, traditional WAIS–R scaled scores were computed for 10 of the 11 subtests, and age-corrected scaled scores were generated using the WAIS–R standardization sample. The subtests were scored in the traditional way by noting the status of each response at the usual time limit and by scoring each subtest according to the discontinue rules. The modifications in the administration of the Block Design subtest preclude the computation of a scaled score for this task. Based on the scaled scores, a VIQ, a prorated (excluding Block Design) PIQ, and an FSIQ were calculated.

In addition to the standard WAIS–R measures, the following subtest scores were derived from the WAIS–R NI: Information Multiple-Choice, Vocabulary Multiple-Choice, Comprehension Multiple-Choice, Similarities Multiple-Choice, Sentence Arrangement, Spatial Span Forward, Spatial Span Backward, and Symbol Copy. A number of qualitative indices of performance were generated including scores following the use of paper and pencil or computational presentation of the items on the Arithmetic subtest; stimulus-bound errors on the multiple-choice versions of the Vocabulary, Comprehension and Similarities subtests; sequence scores on the Picture Arrangement and Sentence Arrangement subtests; a gist score for key elements and main points from the examinee's stories on the Picture Arrangement subtest; untimed scores on the Arithmetic, Picture Completion, Object Assembly, Picture Arrangement, Block Design, and Sentence Arrangement subtests; response latencies from the end of the instructions to the examinee's first response on the Picture Arrangement, Sentence Arrangement, and Object Assembly subtests; a score indicating the type of strategy a subject used to construct puzzles on the Object Assembly subtest; raw scores for the Forward and Backward components of the Digit Span subtest; difference scores for free-recall *versus* multiple-choice administration of the Information,

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Table 2. Mean WAIS–R scores for Parkinson's disease (PD) and normal control (NC) participants

	NC		PD	
WAIS–R scores	*M*	*SD*	*M*	*SD*
IQ Scores				
VIQ	118.2	9.9	114.8	11.1
PIQ	118.1	9.9	108.5*	12.1
FSIQ	120.4	10.9	113.6	11.9
Age-corrected subtest scores				
Verbal				
Information	13.7	2.0	13.1	1.9
Digit Span	12.8	2.9	12.4	3.4
Vocabulary	14.0	1.6	13.0	1.7
Arithmetic	13.0	2.2	11.9	3.4
Comprehension	11.8	1.9	11.0	2.0
Similarities	12.9	1.6	13.2	1.4
Performance				
Picture Completion	12.4	2.3	12.4	2.9
Picture Arrangement	13.2	1.8	11.4	2.9
Object Assembly	12.6	2.5	10.7	1.9
Digit Symbol	13.5	2.1	9.9*	2.1

*$p \leq .01$

Vocabulary, Comprehension and Similarities subtests; recall of the symbols and symbol-digit pairs on the Digit Symbol subtest, and intrasubtest scatter scores that reflect nonconsecutive correct answers on the Information, Vocabulary, Arithmetic, Comprehension, Similarities, Picture Completion, Picture Arrangement, Block Design and Sentence Arrangement subtests.

Procedure

All participants were tested individually in a quiet, well-lit room. The WAIS–R NI, the DRS, and the BDI were administered to all participants. The WAIS–R NI and DRS were administered in standardized fashion as described in the respective test manuals (Kaplan et al., 1991; Mattis, 1988). The administration of the WAIS–R NI required an average of 4 hr with the PD patients and 2 hr with the NC participants. The entire test session required an additional 1 hr. Frequent rest breaks were provided throughout the test session to reduce the effects of fatigue.

Group comparisons for each measure were made with pairwise *t* tests (all probability values based on two-tailed tests). In instances of heterogeneous variance, we report *t* values (as well as degrees of freedom and probability values) based on separate variance estimates. In several cases comparisons were also made with nonparametric (Mann-Whitney) procedures because of unequal group variances; since the results of these comparisons were identical to those with *t* tests, only the latter are reported. Due to the large number of variables examined, differences between groups were considered significant if $p \leq .01$.

RESULTS

Traditional WAIS–R IQ and Subtest Scores

Table 2 displays the means and standard deviations for the PD and NC subjects on each standardized WAIS–R IQ and age-corrected scaled score.

The PD group did not differ significantly from the NC group on Full Scale IQ (FSIQ), VIQ, or any of the six Verbal subtests. They did, however, score lower than the NC group on overall PIQ [$t(44) = 2.9$, $p < .01$] and on the Digit Symbol subtest [$t(44) = 5.5$, $p < .001$]. There was a trend for the PD patients to score lower than the controls on two additional Performance subtests, Picture Arrangement [$t(21.2) = 2.3$, $p < .04$] and Object Assembly [$t(44) = 2.5$, $p < .02$].

WAIS–R NI Subtest Scores

Table 3 shows the means and standard deviations of the raw scores obtained by the PD patients and NC subjects on each

Table 3. Mean raw scores on additional WAIS–R NI subtests of Parkinson's disease (PD) and normal control (NC) participants

	NC		PD	
WAIS–R NI subtest	*M*	*SD*	*M*	*SD*
Information Multiple-Choice	27.2	1.4	26.6	1.9
Vocabulary Multiple-Choice	65.3	2.7	63.8	3.8
Comprehension Multiple-Choice (Proverbs only)	5.5	0.73	5.6	0.72
Similarities Multiple-Choice	26.5	1.7	26.9	1.1
Sentence Arrangement	19.9	2.2	17.1	5.9
Spatial Span Forward	8.2	1.5	7.2	2.3
Spatial Span Backward	7.9	1.5	6.9	2.6
Symbol Copy	92.4	1.6	76.3*	18.4
Block Design (nonstandardized administration)	29.0	7.8	25.2	9.8

*$p \leq .01$

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of the additional WAIS–R NI subtests. The PD group scored significantly lower than the NC group when asked simply to copy the symbols from the Digit Symbol subtest as quickly as possible [Symbol Copy; $t(15.1) = 3.5$, $p < .004$]. The groups did not differ significantly on any of the other additional WAIS–R NI subtests.

Qualitative Measures

The means and standard deviations of the raw scores for qualitative measures obtained from the WAIS–R NI for the PD and NC participants are shown in Tables 4 to 6. The qualitative measures can be roughly divided into those that assess problem solving skills, initiation and attention, and retrieval and retention. Each type of measure is presented in turn.

Problem-solving

The PD and NC groups did not differ significantly in the number of stimulus-bound responses they made on the multiple-choice versions of the Vocabulary (e.g., "sanitary" for *sanctuary*), Comprehension (e.g., "Shallow brook water makes echoes noisier" for *Shallow brooks are noisy*), and Similarities (e.g., "They both have wings" in response to *fly–tree*) subtests. The PD patients, however, made more *capture errors* (Reason, 1979) on the Sentence Arrangement subtest than controls [$t(15.6) = 3.5$, $p < .004$], as shown in Table 4. That is, they tended to link two highly related words, even though this precludes the possibility of a meaningful sentence (e.g., "The hair brush long clogged" as opposed to *Long hair clogged the brush*).

The PD patients did not differ from the NC group on Picture Arrangement or Sentence Arrangement sequence indices that take into account partially correct sequences. However, when asked to recount each story on the Picture Arrangement subtest after arranging the pictures according to standard instructions, the PD group scored lower than the NC group on both the number of main points identified [$t(21.5) = -3.0$, $p < .01$] and the number of key elements produced [$t(18.7) = -3.6$; $p < .003$].

The type of strategy used by the respondent to construct the puzzles on the Object Assembly subtest (Kaplan et al., 1991; Wechsler, 1944) was recorded by the examiner for

Table 4. Mean WAIS–R NI qualitative measures of problem solving in Parkinson's disease (PD) and normal control (NC) participants

	NC		PD	
Measure	*M*	*SD*	*M*	*SD*
Stimulus-bound errors				
Vocabulary	0.07	0.25	0.25	0.45
Sentence Arrangement capture errors	0.10	0.31	1.5*	1.6
Sequence indices (%)				
Picture Arrangement	70.4	15.1	56.9	25.8
Sentence Arrangement	90.7	10.6	80.9	26.0
Problem-solving strategies				
Sentence Arrangement				
Main Point	7.2	1.3	5.5*	2.1
Key Elements	41.6	4.2	33.2*	8.8
Object Assembly				
Edge alignment	1.1	0.25	0.87	0.34
Trial and error	0.23	0.43	0.69	0.79

*$p \leq .01$

Table 5. Mean WAIS–R NI qualitative measures of initiation and attention in Parkinson's disease (PD) and normal control (NC) participants

	NC		PD	
Measure	*M*	*SD*	*M*	*SD*
Response Latency				
Picture Arrangement	8.0	4.9	17.9*	13.7
Sentence Arrangement	4.7	3.0	13.5*	12.5
Object Assembly	2.9	1.1	5.5*	2.2
Digit Span				
Forward	9.7	1.9	9.5	2.9
Backward	8.4	2.3	7.7	2.4
Greatest no. of digits correctly sequenced				
Forward	7.6	1.1	7.1	1.5
Backward	5.8	1.3	5.2	1.3
Spatial Span				
Greatest no. of cubes correctly sequenced				
Forward	6.1	1.0	5.1*	1.4
Backward	5.7	1.1	4.9	1.6

*$p \leq .01$

Table 6. Mean WAIS–R NI qualitative measures of retrieval and retention for Parkinson's disease (PD) and normal control (NC) participants

	NC		PD	
Measure	*M*	*SD*	*M*	*SD*
Difference between raw and multiple-choice scores				
Information	2.7	1.8	2.8	1.8
Vocabulary	4.4	3.1	5.2	2.8
Comprehension (Proverbs only)	1.4	1.3	2.6*	1.7
Similarities	4.7	2.0	5.1	2.5
Digit Symbol A				
Number correct	5.9	2.4	4.7	3.0
Number incorrect	1.2	1.3	2.6	2.8
Digit Symbol Free Recall				
Number correct	7.5	1.2	7.5	1.1
Number incorrect	.63	.72	1.0	.89

*$p \leq .01$

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each item. According to Kaplan et al. (1991), the participant who uses primarily internal-detail matching tends to match up surface lines printed on the puzzle pieces, and to ignore contour and alignment of the puzzle-piece edges. The participant who uses primarily edge alignment is generally able to perceive the global shape or contours of the puzzle, but may have difficulty processing the internal details. Finally, the participant who uses a trial-and-error strategy haphazardly puts pieces together. The PD group did not differ from controls in the type of strategy used on the traditional WAIS–R Object Assembly items, but on the new WAIS–R NI items (*car*, *circle*, *cow*), there was a trend for the PD patients to be more likely than controls to use a trial-and-error strategy [$t(19.8) = 2.1$, $p < .05$], and less likely to use internal-detail [$t(21.0) = -2.3$, $p < .04$] and edge-alignment [$t(44) = -2.2$, $p < .04$] strategies.

Initiation and attention

Table 5 contains the means and standard deviations (raw scores) for the qualitative measures of initiation and attention. The PD group had significantly longer latencies than the NC group to make their first response following the completion of instructions on all three subtests on which this score was obtained [Picture Arrangement: $t(17.1) = 2.8$, $p = .01$; Sentence Arrangement: $t(15.9) = 2.7$, $p = .01$; Object Assembly: $t(18.8) = 4.4$, $p < .001$].

Patients with PD did not differ from the NC group on raw scores in either the forward or backward condition of the Digit Span subtest, nor on span length (i.e., the greatest number of digits correctly sequenced). However, when the greatest number of cubes sequenced was computed for the Spatial Span task, the PD patients obtained significantly lower scores than controls in the forward [$t(44) = -2.9$, $p < .01$] condition, and there was a trend for the PD patients to obtain lower scores in the backward [$t(44) = -2.1$; $p < .04$] condition.

The PD patients and controls did not differ significantly on overtime scores (i.e., points obtained on a subtest after the standard time limit was reached) on any timed subtest, on intrasubtest scatter scores used to assess the degree to which the respondent deviated from an expected pattern of performance determined by item difficulty within a particular subtest, or on various forms of the Arithmetic subtest (i.e., visual presentation of the word problems, use of pencil and paper, or computational form).

Retrieval and retention

Raw scores obtained in the free-recall condition of four subtests (Information, Vocabulary, Comprehension, Similarities) were subtracted from scores in the multiple-choice condition of these subtests to assess the degree to which participants benefited from a recognition format (see Table 6). The PD patients showed significantly greater benefit than controls only on the Comprehension subtest [$t(44) = -2.5$, $p = .01$].

The standard administration of the Digit Symbol subtest was followed by the Digit Symbol A condition, in which the participant was presented with one row of numbers without the number–symbol template and asked to fill in any of the corresponding symbols he/she could remember. These responses were then covered, and the participant was asked to produce as many symbols as possible without matching them to their corresponding numbers (free-recall condition). The PD group did not differ significantly from the control group on the number of correct or incorrect responses in the Digit Symbol A or free recall conditions (Table 6) and scored well within 1 standard deviation of the mean when compared to another group of healthy older adults for whom norms were available (Milberg et al., 1996). Identifying the types of errors of commission in the free recall condition, however, was more useful in differentiating between the groups. Of a total of 19 errors made by 16 of the 30 NC participants in this condition, 15 (79%) were incorrect rotations (⊏, ⊓) of symbols made up of three sides of a square (three-sided "square"), two (10.5%) were rotations of other symbols, and two (10.5%) were perseverations. Of a total of 16 errors made by 10 of the 16 PD patients, three (19%) were incorrect rotations (⊏, ⊓) of the three-sided "square," seven (44%) were rotations of other symbols, four (25%) were perseverations, and two (12%) were other types of errors. A 2×4 Pearson chi-square analysis comparing NC and PD participants on type of error (rotation of three-sided "square," other rotation, perseveration, other error) was significant ($\chi^2 = 13.3$, $df = 3$, $p < .01$).

DISCUSSION

The PD patients did not differ from controls on any of the traditional WAIS–R Verbal subtests, the Verbal IQ, or the prorated Full Scale IQ. They did, however, score significantly lower than controls on the prorated Performance IQ, and more specifically on the Digit Symbol subtest. There were no significant differences between groups on scores on the nonstandard administration of the Block Design subtest. The results obtained with the standard administration of the WAIS–R are generally consistent with previous investigations that have shown mild deficits on Performance subtests of the Wechsler intelligence scales in PD patients. Standard administration, however, does not allow examination of many of the cognitive processes found to be impaired in previous studies using more sensitive tests.

When details of participants' responses were analyzed using data from the WAIS–R NI, the PD patients scored significantly lower than the NC subjects on the Symbol Copy subtest, suggesting deficits in simple visuomotor speed. Another measure of visual processing, visual (spatial) span length, revealed mildly impaired performance in the PD group compared to controls, suggesting problems with basic attention for visual detail. Similarly, the PD group made more capture errors than the NC group when asked to construct sentences, and showed problems identifying the over-

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all themes and key elements when asked to construct stories. They also showed longer response latencies when asked to construct sentences, stories, and objects using visual cues. These deficits could be related, at least in part, to problems maintaining visual attention or set, as proposed in previous studies (Filoteo et al., 1994, Maddox et al., 1996).

Several investigators have attempted to identify a single unifying neurobehavioral theory to account for the cognitive deficits seen in PD patients. Based on Norman and Shallice's cognitive model of attention (Shallice, 1988), Brown and Marsden (1990) described a decrease in the processing resources within a supervisory attention system and linked these changes to dysfunction in frontal systems. In contrast, Downes et al. (1993) proposed a deficit in inhibitory attentional processes associated with basal ganglia compromise resulting in impaired suppression of extraneous information. Although not designed to directly compare these theories, the results of this study are more consistent with the latter theory that proposes a deficit in inhibitory attentional processes. For example, compared to controls, the PD patients' difficulty separating highly associated words (i.e., capture errors) on the sentence arrangement task, problems selecting the proper theme of a story possibly due to an inability to ignore irrelevant components, and a tendency to produce long latencies on tasks that require response selection, could be due to problems inhibiting competing responses. That is not to say that a decrease in processing resources does not impact PD patients' performance, however, given the wide variety of functions that were affected.

The large number of variables included in the WAIS–R NI provides multiple measures within specific cognitive domains, and, in some cases, this may lead to conflicting results concerning spared or impaired abilities within a domain. For example, sequencing, identifying a story theme, producing strategies for constructing puzzles, and inhibiting stimulus-bound errors have all been considered executive functions, and a number of studies have emphasized the presence of executive dysfunction in patients in the early stages of PD (Bondi et al., 1993; Cooper et al., 1991; Dalrymple-Alford et al., 1994; Gotham et al., 1988; Jacobs et al., 1995; Lees & Smith, 1983; Taylor & Saint-Cyr, 1995). In our study, a number of tasks commonly considered measures of executive functions yielded significant differences between the groups, while others (e.g., Similarities subtest, Comprehension proverb interpretation, sequence indices) did not.

In addition, tasks considered largely measures of attention also produced somewhat inconsistent findings. Whereas PD patients scored significantly lower on the number of cubes correctly sequenced forward (Spatial Span) and consistently showed greater response latencies, they did not differ from the NC group on other measures of attention, including Digit Span scores and intrasubtest scatter scores. Similarly, the PD group benefited from the multiple choice format on proverb interpretation, but not on the Information, Similarities, and Vocabulary subtests. Finally, while the PD group was significantly slower than the NC group on the Symbol Copy subtest, the two groups did not differ on a number of overtime scores expected to show differences in speed of processing or motor speed.

The conflicting results obtained with various measures of executive function and attention may be due, in part, to differences in the sensitivity of the tasks. While it is possible to make stimulus-bound responses on both the Sentence Arrangement and the Comprehension subtests, for example, the former may be more difficult, making it more likely the subject cannot inhibit certain responses and will be "pulled" to errors. In some cases, the temporal order and mode of presentation may have influenced performance. For example, it was expected that the PD patients would have more difficulty than controls on measures of attention such as the Digit Span and Spatial Span subtests. The fact that there were differences on Spatial span length and not on Digit span length could have been related to the notion that PD patients are more vulnerable on tasks requiring visuospatial processing than on verbal tasks compared to normal controls (Bondi et al., 1993; Levin et al., 1991; Mohr et al., 1990; Stern et al., 1993). The Spatial Span was also presented much later in the testing session than the Digit Span subtest, and it is possible the performance of the PD patients was more influenced by fatigue than that of controls.

The WAIS–R NI measures of incidental memory derived from the Digit Symbol subtest showed no differences between PD and controls with respect to the number of correct and incorrect responses. This is not consistent with previous findings in which PD patients were found to have problems with information retrieval and retention. It may be that the WAIS–R NI recall tasks are less difficult than those able to differentiate PD patients from controls in previous studies. Interestingly, however, the types of errors committed, and on these tasks, and the increased variability in the types of errors produced, did differentiate between the two groups. For example, PD patients produced more perseverative errors than controls. These errors and the increased variability seen in the types of errors exhibited by PD patients compared to the controls are consistent with the notion that PD patients suffer a deficit in the ability to inhibit competing responses (Downes et al., 1993).

The findings of this study support the assertion that the WAIS–R NI allows assessment of a number of cognitive functions not possible with the WAIS–R. In the present study, impairment was defined as 2 or more standard deviations below the mean based on the NC sample. Less than 10% of the patients were considered impaired on the traditional Information, Digit Span, Similarities and Comprehension subtests, 13% on the Object Assembly subtest, 19% on the Vocabulary subtest, and 44% on the Digit Symbol subtest. In contrast, qualitative measures based on these subtests identified impairment in 19% of patients administered the Information and Digit Span subtests, 13% given the Similarities subtest, 25% administered the Comprehension and Vocabulary subtests, and over 60% administered

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the Object Assembly and Digit Symbol subtests. Many of the WAIS–R NI qualitative measures, therefore, provide an advantage in detecting clinically significant differences between the performances of patients with minimal WAIS–R scale score deficits (e.g., mild head injury) and intact individuals, and in diagnosing patients in the very early stages of a neurodegenerative disorder.

A major limitation of the WAIS–R NI is the amount of time and effort required to administer and score the test when the entire instrument is used. For clinical purposes, it is important to identify those subtests that, by adding the tasks developed by Kaplan and colleagues, will increase sensitivity. The current study suggests that including the WAIS–R NI versions of the Symbol Copy, Sentence Arrangement, Picture Arrangement, Digit Symbol (with free recall task), Digit Span, and Spatial Span subtests could help to identify problems in early stages of PD by measuring simple motor speed, speed of processing, response latency, verbal and visual attention, stimulus boundedness, and visual retention. In addition, identifying specific measures that can differentiate between disease groups with different neuropathological substrates (e.g., PD and AD) could lead to a more efficient evaluation, accurate diagnosis, and precise identification of cognitive strengths and weaknesses useful for treatment planning and care.

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REFERENCES

Auriacombe, S., Grossman, M., Carvell, S., Gollomp, S., Stern, M.B., & Hurtig, H.I. (1993). Verbal fluency deficits in Parkinson's disease. *Neuropsychology*, *7*, 182–192.

Beck, A.T. (1978). *Beck Depression Inventory*. San Antonio, TX: Psychological Assessment Resources.

Bondi, M.W., Kaszniak, A.W., Bayles, K.A., & Vance, K.T. (1993). Contributions of frontal system dysfunction to memory and perceptual abilities in Parkinson's disease. *Neuropsychology*, *7*, 89–102.

Brown, R.G. & Marsden, C.D. (1988). Internal versus external cues and the control of attention in Parkinson's disease. *Brain*, *111*, 323–345.

Brown, R.G. & Marsden, C.D. (1990). Cognitive function in Parkinson's disease: From description to theory. *Trends in Neurosciences*, *13*, 21–29.

Cooper, J.A., Sagar, H.J., Jordan, N., Harvey, N.S., & Sullivan, E.V. (1991). Cognitive impairment in early, untreated Parkinson's disease and its relationship to motor disability. *Brain*, *114*, 2095–2122.

Dalrymple-Alford, J.C., Kalders, A.S., Jones, R.D., & Watson, R.W. (1994). A central executive deficit in patients with Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry*, *57*, 360–367.

Downes, J.J., Sharp, H.M., Costall, B.M., Sagar, H.J., & Howe, J. (1993). Alternating fluency in Parkinson's disease. An evaluation of the attentional control theory of cognitive impairment. *Brain*, *116*, 887–902.

Filoteo, J.V., Delis, D.C., Demadura, T.L., Salmon, D.P., Roman, M.J., & Shults, C.W. (1994). Abnormally rapid disengagement of covert attention to global and local stimulus levels may underlie the visuoperceptual impairment in Parkinson's patients. *Neuropsychology*, *8*, 210–217.

Flowers, K.A. & Robertson, C. (1985). The effect of Parkinson's disease on the ability to maintain a mental set. *Journal of Neurology, Neurosurgery, and Psychiatry*, *48*, 517–529.

Gotham, A.M., Brown, R.G., & Marsden, C.D. (1988). 'Frontal' cognitive function in patients with Parkinson's disease 'on' and 'off' levodopa. *Brain*, *111*, 299–321.

Hoehn, M.M. & Yahr, M.D. (1967). Parkinsonism: onset, progression and mortality. *Neurology*, *17*, 427–442.

Jacobs, D.M., Marder, K., Côté, L.J., Sano, M., Stern, Y., & Mayeux, R. (1995). Neuropsychological characteristics of preclinical dementia in Parkinson's disease. *Neurology*, *45*, 1691–1696.

Kaplan, E. (1988). A process approach to neuropsychological assessment. In T. Boll & B.K. Bryant (Eds.), *Clinical neuropsychology and brain function: Research, measurement, and practice* (pp. 143–155). Washington D.C.: American Psychological Association.

Kaplan, E., Fein, D., Morris, R., & Delis, D.C. (1991). *WAIS–R as a Neuropsychological Instrument*. San Antonio, TX: The Psychological Corporation.

Lees, A.J. & Smith, E. (1983). Cognitive deficits in the early stages of Parkinson's disease. *Brain*, *106*, 257–270.

Levin, B.E., Llabre, M.M., Reisman, S., Weiner, W.J., Sanchez-Ramos, J., Singer, C., & Brown, M.C. (1991). Visuospatial impairment in Parkinson's disease. *Neurology*, *41*, 365–369.

Maddox, W.T., Filoteo, J.V., Delis, D.C., & Salmon, D.P. (1996). Visual selective attention deficits in patients with Parkinson's disease: A quantitative model-based approach. *Neuropsychology*, *10*, 197–218.

Massman, P.J., Delis, D.C., Butters, N., Levin, B.E., & Salmon, D.P. (1990). Are all subcortical dementias alike? Verbal learning and memory in Parkinson's and Huntington's disease patients. *Journal of Clinical and Experimental Neuropsychology*, *5*, 736–751.

Matison, R., Mayeux, R., Rosen, J., & Fahn, S. (1982). "Tip-of-the-tongue" phenomenon in Parkinson's disease. *Neurology*, *32*, 567–570.

Mattis, S. (1988). *DRS: Dementia Rating Scale professional manual*. New York: Psychological Assessment Resources.

McFadden, L., Mohr, E., Sampson, M., Mendis, T., & Grimes, D. (1996). A profile analysis of demented and nondemented Parkinson's disease patients. In L. Battistin, G. Scarlato, T. Caraceni, & S. Ruggieri (Eds.), *Advances in neurology* (Vol. 69, pp. 339–341). Philadelphia: Lippincott-Raven Publishers.

Milberg, W.P., Hebben, N., & Kaplan, E. (1996). The Boston approach to neuropsychological assessment. In I. Grant & K. M. Adams (Eds.), *Neuropsychological assessment of neuropsychiatric disorders* (2nd ed., pp. 58–80). New York: Oxford University Press.

Mohr, E., Juncos, J., Cox, C., Litvan, I., Fedio, P., & Chase, T.N. (1990). Selective deficits in cognition and memory in high-functioning Parkinsonian patients. *Journal of Neurology, Neurosurgery, and Psychiatry*, *53*, 603–606.

Monsch, A.U., Bondi, M.W., Salmon, D.P., Butters, N., Thal, L.J., Hansen, L.A., Wiederholt, W.C., Cahn, D.A., & Klauber, M.R. (1995). 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. *Archives of Neurology*, *52*, 899–904.

Pate, D.S. & Margolin, D.I. (1994). Cognitive slowing in Parkinson's and Alzheimer's patients: Distinguishing bradyphrenia from dementia. *Neurology*, *44*, 669–674.

Randolph, C., Braun, A.R., Goldberg, T.E., & Chase, T.N. (1993). Semantic fluency in Alzheimer's, Parkinson's, and Huntington's disease: Dissociation of storage and retrieval failures. *Neuropsychology*, *7*, 82–88.

Reason, J.T. (1979). Action not as planned. In G. Underwood & R. Stevens (Eds.), *Aspects of consciousness* (pp. 67–89). London: Academic Press.

Ross, H.F., Hughes, T.A., Boyd, J.L., Biggins, A., Madeley, P., Mindham, R.H.S., & Spokes, E.G.S. (1996). The evolution and profile of dementia in Parkinson's disease. In L. Battistin, G. Scarlato, T. Caraceni, & S. Ruggieri (Eds.), *Advances in neurology* (Vol. 69, pp. 343–347). Philadelphia: Lippincott-Raven Publishers.

Shallice, T. (1988). *From neuropsychology to mental structure*. New York: Cambridge University Press.

Stern, Y., Richards, M., Sano, M., & Mayeux, R. (1993). Comparison of cognitive changes in patients with Alzheimer's and Parkinson's disease. *Archives of Neurology*, *50*, 1040–1045.

Sullivan, E.V., Sagar, H.J., Gabrieli, J.D.E., Corkin, S., & Growdon, J.H. (1989). Different cognitive profiles on standard behavioral tests in Parkinson's disease and Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology*, *11*, 799–820.

Taylor, A.E. & Saint-Cyr, J.A. (1995). The neuropsychology of Parkinson's disease. *Brain and Cognition*, *28*, 281–296.

Tröster, A.I. & Fields, J.A. (1995). Frontal cognitive function and memory in Parkinson's disease: Toward a distinction between prospective and declarative memory impairments. *Behavioural Neurology*, *8*, 59–74.

Wechsler, D. (1944). *The measurement of adult intelligence* (3rd ed.). Baltimore: Williams & Wilkins.

Wechsler, D. (1955). *The Wechsler Adult Intelligence Scale*. New York: The Psychological Corporation.

Wechsler, D. (1981). *Manual for the Wechsler Adult Intelligence Scale–Revised*. New York: The Psychological Corporation.

Weingartner, H., Burns, S., Diebel, R., & LeWitt, P.A. (1984). Cognitive impairments in Parkinson's disease: Distinguishing between effort-demanding and automatic cognitive processes. *Psychiatry Research*, *11*, 223–235.