Deficits on Visuospacial Tests Involving Forward Planning in High-Functioning Parkinsonians

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Summary: Twenty nondemented, nondepressed subjects with idiopathic Parkinson’s disease were assessed on a test involving complex visuospatial abilities and two tests involving visuospatial as well as executive planning and sequencing abilities. They did not differ from a control group on the test involving only visuospatial abilities, but were significantly impaired on the two tests that also involved planning and sequencing. This suggests that the deficits demonstrated by parkinsonians on some complex visuospatial tasks may, to a large extent, be a consequence of frontal lobe executive impairments, and not primarily a consequence of a visuospatial deficit. Key Words: Parkinson’s disease—Visuospatial abilities—Planning and sequencing abilities. NNBN 3:125–139, 1990

It is becoming increasingly evident that the majority of people with idiopathic Parkinson’s disease (PD) demonstrate cognitive deficits on some tasks (Loranger et al., 1972; Mayeux and Stern, 1983). Several studies have provided data suggesting that these subjects have a preponderance of visuospatial deficits compared to language deficits. This skewed pattern certainly holds true for subjects with dementia (Bentin et al., 1981; Chui et al., 1986; Pirozzolo et al., 1982). However, the evidence for visuospatial deficits in nondemented parkinsonian subjects is conflicting. In some studies, visuospatial deficits have been found (Loranger et al., 1972; Martin et al., 1973; Mortimer et al., 1982; Pirozzolo et al., 1982; Proctor

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et al., 1964), but other studies have found no evidence of visuospatial deficits (Della Sala et al., 1986; Taylor et al. 1986).

Taylor et al. (1986) conducted a careful study of 40 nondemented subjects with PD in which they used a range of neuropsychological tests to assess psychomotor skills, memory, visuospatial skills, and executive functions. Their hypothesis was that if the function of the frontal cortex is disturbed in PD as a consequence of its disconnection from the basal ganglia, only cognitive impairments associated with frontal lobe dysfunction should be found in nondemented parkinsonian subjects. Impairments in executive functions, such as forward planning and shifting cognitive set, would therefore be expected, and this has been supported by a number of studies (Bowen et al., 1972, 1975, 1976; Cools et al., 1984; Lees and Smith, 1983; Mayeux et al., 1981). However, visuospatial functions should not be impaired, as they are usually associated with posterior cortical lesions.

The results of Taylor et al.’s study largely supported their hypothesis in that the subjects with PD demonstrated deficits only on the psychomotor tasks (expected as a consequence of the physical symptoms of PD) and tasks that Taylor et al. argued were dependent on the integrity of the frontal lobes. These were the Wisconsin Card Sorting Test (WCST), free recall on the Rey Auditory Verbal Learning Test (RAVLT), and the Delayed Recognition Test in which the subject views a pattern of black circles and on each successive presentation must identify an additional circle inserted into the pattern. This memory task puts demands on recency as opposed to novelty decisions, and there is some evidence that it is a frontal lobe function (Milner and Petrides, 1984). The WCST certainly requires the ability to initiate concepts and change set, both of which are “executive” functions, and according to Taylor et al., the free recall stage of the RAVLT requires the formation of subjectively generated heuristics. Thus, all the tasks on which the parkinsonians were impaired required the ability to initiate guidelines or strategies that would enable success. According to Taylor et al., complex tasks involving executive abilities, but which have explicit rules, should not pose a problem for subjects with frontal lobe dysfunction.

Taken together, these studies suggest two possible hypotheses. The first is that nondemented parkinsonian subjects have visuospatial deficits and deficits of executive functions, and where patients perform normally on visuospatial tasks (Della Sala et al., 1986; Taylor et al., 1986), it is because the tasks are too simple and therefore not sensitive enough to expose the subjects’ visuospatial deficits. The second hypothesis is that subjects with PD have deficits of executive functions only, and these, or motor deficits, underlie the impairments on the visuospatial tasks they fail on.

In this study, we assessed a group of 20 nondemented, nondepressed subjects with PD on three tests chosen to assess planning and sequential aspects of performance, as well as visuospatial functions, and contrasted their performances with those of healthy control subjects. As most of the PD subjects were taking dopaminergic or anticholinergic medications, the possible drug effects on cognition

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were assessed by comparing neuropsychological test results of groups of subjects whose medications differed.

The first test was the Spatial Relations test taken from the Differential Aptitude Tests (Bennett et al., 1972). This test assesses visuospatial perception and imagery, but does not depend on verbal or fine motor skills for its performance.

The second test given to the subjects was the Rey-Osterreith Complex Figure (Osterreith, 1944; Rey, 1941). This does involve motor skills, but has proven to be a sensitive indicator of visuospatial impairments over a range of neurological disorders (Ogden, 1986; Walsh, 1987). In particular, it appears to be sensitive to frontal lobe pathology (Walsh, 1987), in that it demands the ability to organize and integrate components into a visuospatial whole. To our knowledge, there are no accounts in the literature of its use in the assessment of subjects with PD. It has a number of possible advantages when used with this group. It involves copying a complex pattern and is therefore likely to be more sensitive to subtle visuospatial impairments than tests involving simpler visual stimuli.

The scoring criteria (for accuracy) are very explicit, producing high inter- and intrarater reliabilities. Whereas normal adults usually copy the figure in a holistic manner, beginning with the base rectangle and then adding the bisecting lines, diagonals, and other parts of the pattern in a logical sequence, young children tend to copy it in a piecemeal fashion, and, for example, often do not draw the base rectangle in sequential movements (Waber and Holmes, 1985). Possibly, the piecemeal approach taken by young children is a consequence of their inability to initiate an overall plan and to sequence their responses in a logical manner. Therefore, analysis of the approach taken by adult subjects when copying the figure provides an additional measure of normal visuospatial functioning, independent of accuracy, that is possibly related to forward planning and sequencing of responses. Finally, the recall trial allows the assessment of delayed recall of visual material that is difficult to verbalize.

The third test given to the subjects was the Picture Arrangement (PA) subtest of the Wechsler Adult Intelligence Scale—Revised (WAIS-R) (Wechsler, 1981). A previous study carried out in this laboratory (Sullivan et al., 1985) found that a group of patients with PD, some of whom were mildly demented, were impaired on the PA subtest relative to a control group. In this study of nondepressed parkinsonian subjects, we used the PA subtest again in order to ascertain whether the impairment on PA found by Sullivan et al. was associated with some degree of general intellectual decline or was a measure of a more specific cognitive deficit in otherwise intellectually intact and nondepressed subjects with PD. Given that this test requires the ability to initiate concepts (how the pictures fit together to make a story) and follow through with a plan of action involving temporal sequencing, subjects with frontal lobe dysfunction as a consequence of PD might be predicted to demonstrate impairments on this test.
METHODS

Subjects

Subjects from Massachusetts General Hospital with a firm diagnosis of idiopathic PD established by conventional criteria (Adams and Victor, 1985; Gordon and Scheife, 1982) and no evidence of other neurological disorders were asked to participate in the study. All willing subjects were then given a further full neurological examination by neurologists with extensive knowledge and experience in the diagnosis and treatment of PD, Alzheimer’s disease, and other dementing diseases. The clinical characteristics for each subject were recorded. Subjects whose diagnosis of idiopathic PD was confirmed with a high degree of confidence, and who did not demonstrate evidence of other neurological or psychiatric disorders, were then screened for dementia and depression, and subjects with evidence of either of these were excluded from the study.

Exclusion criteria included signs of general intellectual decline or depressed mood on clinical interview or in the view of family members or caregivers, or if recorded in the subject’s medical file. In addition, a quantitative measure of dementia was employed, this being the memory and orientation section of the Blessed Dementia Scale (BDS) (Blessed et al., 1968). This structured mental status examination is commonly used to assess the presence and severity of dementia in patients with Alzheimer’s disease. The maximum score on this section of the BDS is 37, and entry to the study required a score of 2 or less, well within the normal range.

After these exclusions, the final experimental PD group included 13 men and 7 women (mean age 65.4 years, range 47–82 years; mean formal education 15.5 years, range 12–20 years). The clinical characteristics for each subject, including stage of disease (Hoehn and Yahr, 1967) and current antiparkinsonian medications, are given in Table 1. Tremor, bradykinesia, and rigidity were each evaluated on a scale of 0–4, where 0 indicates no disability and 4 indicates the most severe level of disability, as specified by Duvoison (1971). Table 2 gives the gender ratio, mean age, mean age at onset of PD, and mean disease duration for subjects in each of the Hoehn and Yahr stages. Subjects in stages II and III were grouped together because tremor and rigidity may be equally severe in these groups. Stage III has the added characteristic of impaired postural rigidity.

In support of the efficacy of the criteria used to exclude subjects with dementia, only 2 of the 20 subjects (a physician and a typist) had retired from their jobs because of their PD, and in both cases, it was because of their motor symptoms. The PD group included a large number of subjects in occupations requiring a university education. Included were two lawyers (both practicing), two physicians (one practicing), an engineer and a physicist (both practicing), and two teachers (one still teaching). Of the subjects who were past retiring age, all but one subject with Stage IV PD (a physician) led full and active lives, including a wheelchair-bound woman (a teacher) who continued to participate actively in
TABLE 1. Clinical features of PD in 20 patients assessed neuropsychologically

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Gender</th>
<th>Age in years</th>
<th>Hoehn and Yahr stage</th>
<th>Cardinal Motor Symptoms*</th>
<th>Medications*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tremor</td>
<td>Dopaminergic</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
<td>61</td>
<td>I (R)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>82</td>
<td>I (R)</td>
<td>0</td>
<td>0 (1)</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>71</td>
<td>I (R)</td>
<td>2</td>
<td>0 (1)</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>47</td>
<td>I (R)</td>
<td>0 (1)</td>
<td>0 (1)</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>58</td>
<td>I (L)</td>
<td>1</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>53</td>
<td>I (R)</td>
<td>0 (1)</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>71</td>
<td>I (R)</td>
<td>1</td>
<td>0 (1)</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>67</td>
<td>I (R)</td>
<td>1</td>
<td>0 (1)</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>67</td>
<td>II</td>
<td>0</td>
<td>2 (2)</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>76</td>
<td>II</td>
<td>1</td>
<td>1 (1)</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>63</td>
<td>II</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>60</td>
<td>II</td>
<td>3</td>
<td>1 (2)</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>71</td>
<td>II</td>
<td>0</td>
<td>0 (1)</td>
</tr>
<tr>
<td>14</td>
<td>M</td>
<td>62</td>
<td>II</td>
<td>0 (1)</td>
<td>0 (1)</td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>55</td>
<td>II</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>F</td>
<td>65</td>
<td>II</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>59</td>
<td>III</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>70</td>
<td>III</td>
<td>2</td>
<td>1 (2)</td>
</tr>
<tr>
<td>19</td>
<td>F</td>
<td>80</td>
<td>IV</td>
<td>2</td>
<td>1 (2)</td>
</tr>
<tr>
<td>20</td>
<td>M</td>
<td>69</td>
<td>IV</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

R, right-sided symptoms; L, left-sided symptoms.

*Cardinal motor symptoms: on scale of 0–4, where 0 = absent, 4 = most severe. Numbers in parentheses give an estimate of the motor symptom severity without treatment.

*Medications: +, prescribed; 0, not prescribed.

community affairs and was an active bridge player. All but one subject under 65 years, the typist, were in full-time employment and experienced no difficulties with the intellectual or physical demands of their jobs. The oldest subject was still practicing law on a part-time basis at the age of 82.

TABLE 2. Characteristics of patients with PD, grouped according to Hoehn and Yahr stages

<table>
<thead>
<tr>
<th>Hoehn and Yahr stage</th>
<th>n</th>
<th>Gender ratio M:F</th>
<th>Mean age in years (range)</th>
<th>Mean age at PD onset in years (range)</th>
<th>Mean disease duration in years (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (7R + 1L)</td>
<td>8</td>
<td>4:4</td>
<td>63.8 (47–82)</td>
<td>61.4 (43–80)</td>
<td>2.3 (0.5–5)</td>
</tr>
<tr>
<td>II or III</td>
<td>10</td>
<td>8:2</td>
<td>64.8 (55–76)</td>
<td>57.1 (40–73)</td>
<td>7.7 (2.5–19)</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>1:1</td>
<td>74.5 (69–80)</td>
<td>62.0 (61–63)</td>
<td>12.5 (6–19)</td>
</tr>
</tbody>
</table>

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The control group included 6 men and 8 women (mean age 60.0 years, range 41–79 years; mean formal education 14.6 years, range 12–19 years), who were recruited from the same Massachusetts General Hospital population, as were the patients with PD. All control subjects had a normal neurological and psychiatric examination, scored 2 or less on the BDS, and had no evidence of general intellectual decline or depression on clinical interview or in their recent medical history. t Tests showed that the control group did not differ significantly from the PD group in age or in years of formal education. Subjects in this group who had had a university education included one retired physicist and three school teachers, one of whom was still teaching.

Neuropsychological Assessment

The experimental and control groups were given the following tests in one session.

Spatial Relations

This test consisted of 10 items taken from the Differential Aptitude Tests (Bennett et al., 1972). The subject was shown a drawing of a two-dimensional shape and was asked to decide which of four pictures of three-dimensional shapes represented the target shape if it were folded along specified lines. This test therefore required the ability to mentally construct three-dimensional images. Two scores were obtained—the number correct and the total time to complete the test.

Complex Figure

All subjects were given the Rey-Osterreith Complex Figure to copy and were given a delayed recall trial without warning 45 min later. During the copy trial, the tester handed subjects a pen of a new color to use each time they paused while drawing. This procedure allowed an analysis of the approach (holistic or piecemeal) used by the subjects when copying the figure. The recall test was done in pencil. The drawings were scored according to the accuracy criteria specified by Taylor (1969), giving a maximum score of 36 for each drawing. Subjects with PD were not penalized for errors or distortions that may have been the consequence of their motor symptoms. For example, points were not deducted for unsteady lines, or lines that slightly overshot or undershot the correct termination points. Three scores were given for the copy administration; the score out of 36 for accuracy, the time taken to copy the figure, and whether or not the base rectangle was drawn as a single entity.

The recall administration was also scored for accuracy out of 36. A percent recall score was calculated using the formula $100 \times \frac{1-(\text{copy-delay}/\text{copy})}{\text{copy}}$ (Jones-Gotman, 1986). The percent recall score provided a purer measure of memory than the raw delayed recall score, as it was based on the subject's copy rather than
the original figure. Thus, the percent recall score did not penalize subjects for initial perceptual and visuospatial errors, nor for constant manipulospatial impairments, as these deficits were presumably represented equally in the copy and recall drawings.

**Picture Arrangement**

In this subtest of the WAIS-R, the subject's task was to arrange a series of cartoon pictures in a logical order so as to tell a story. All 10 items of the subtest were given to all subjects, and no time limits were imposed. Subjects were encouraged to verbalize their thoughts as they ordered the cards, and on completion of each item, they were asked to tell the story. The time taken to order the cards was measured for each item. Three scores were calculated: the raw score out of 20 for the items completed correctly within the WAIS-R standardized time limits, the scaled score derived from the raw timed score, and the raw score out of 20 for the items completed correctly regardless of time limit.

**RESULTS**

Analyses of Variance (ANOVAs) tested the significance of mean differences between groups formed by dividing the subjects according to diagnosis (PD, control), age (<66 or young, >66 or old), dopaminergic (Sinemet, bromocriptine) and anticholinergic drugs (for PD subjects only, yes or no for each type of drug), and, for PD subjects, the Hoehn and Yahr stage. Sample size restrictions prevented the simultaneous analysis of all these classifications. Consequently, three sets of analyses were performed: two-way ANOVAs that crossed diagnosis and age, two-way ANOVAs that crossed dopaminergic and anticholinergic medications, and two-way ANOVAs that crossed the Hoehn and Yahr stage and age. It can be assumed that none of the interactions was significant unless specified. As the subdivision of the PD group results in small sample sizes (2 Stage IV PD subjects, and 2 PD subjects on no medication), insignificant results relating to the effects of stage of PD or medication should be viewed with caution.

**Spatial Relations**

The PD and control groups differed significantly only on the time taken to complete the test ($F_{(1,30)} = 4.66; p < 0.05$). There were no significant effects for score or for time taken to complete the test due to age, medication, or Hoehn and Yahr stage. Table 3 gives the mean scores and range of scores and the mean times and range of times to complete the test for the two groups.

**Complex Figure Test**

The PD group was significantly inferior to the control group on the copy of the Rey-Osterreith figure ($F_{(1,30)} = 15.12; p < 0.001$), on the 45-min delayed recall.
TABLE 3. Mean scores and times for the spatial relations test for the PD group (N = 20) and the control group (N = 14)

<table>
<thead>
<tr>
<th>Group</th>
<th>Score (maximum of 10)</th>
<th>Time to complete (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Mean 6.71</td>
<td>242.36</td>
</tr>
<tr>
<td></td>
<td>SD 2.05</td>
<td>104.67</td>
</tr>
<tr>
<td></td>
<td>Range 3–10</td>
<td>101–474</td>
</tr>
<tr>
<td>PD</td>
<td>Mean 6.50</td>
<td>339.30*</td>
</tr>
<tr>
<td></td>
<td>SD 2.01</td>
<td>132.08</td>
</tr>
<tr>
<td></td>
<td>Range 3–10</td>
<td>123–545</td>
</tr>
</tbody>
</table>

PD group mean differs from control mean; *p < 0.05.

\(F_{(1,30)} = 22.02; p < 0.001\), and on the percent memory scores \(F_{(1,30)} = 10.74; p < 0.01\). There was also a main effect of age on the time taken to copy the figure \(p < 0.05\), with the older subjects being slower than the younger subjects in both groups. On delayed recall, the older subjects had significantly lower scores than the younger subjects \(p < 0.05\), and this pattern was also true for the percent memory score \(p < 0.05\). Although none of the age multiplied by group interactions approached significance, demonstrating no marked effect of age on the significant difference between the PD and control groups on any of the scoring criteria, it is possible that the poorer performance of the PD subjects could be partially influenced by the fact that they were, on average, 5 years older than the control group subjects. Figure 1 shows the Rey-Osterreith figure together with the copy and recall drawings of four subjects with PD. These examples were selected from many equally poor drawings because they emphasized the extreme dissociation between the subjects' superior overall intellectual abilities and their impairment on this visuospatial task.

On examination of the color sequences in the copied drawings, it was clear that many of the subjects with PD had copied the drawing in a piecemeal fashion. Using the least ambiguous measure of structure, that is, whether or not the basic rectangle was copied as a single entity, 12 of the 20 subjects with PD did not draw the rectangle in one step or in a series of successive steps. In contrast, only one of the 14 control subjects failed to draw the rectangle as a single entity. Upon being shown their completed copies after the recall administration, some of the subjects with PD who copied the figure in a piecemeal fashion said that they had not perceived the rectangle at all when they were copying the drawing, but when it was pointed out to them they could see it clearly.

When the PD subjects were divided according to the Hoehn and Yahr stages, no significant differences were found between the subgroups for any of the scores, and there were no significant medication effects. Table 4 gives the PD and control groups' mean scores and significance levels for the Rey-Osterreith figure.
FIG. 1. The Rey-Osterreith Complex Figure. The top figure is the model copied by the subjects. The eight drawings below are the copy administrations (labeled A) and the 45-min delayed recall administrations (labeled B) for four subjects with PD (designated 1, 2, 3, 4, respectively). Subject 1 is a 58-year-old practicing physician with a 6-month history of Stage I PD; subject 2 is a 71-year-old woman with a 9-year history of Stage II PD; subject 3 is a 67-year-old man with an 18-month history of Stage I PD; and subject 4 is a 71-year-old woman with a 2-year history of Stage I PD. Subject 1 is on a combination of dopaminergic and anticholinergic drugs; subjects 2 and 3 are on Sinemet; and Subject 4 was not medicated.

Picture Arrangement

The PD group’s scores were significantly lower than those of the control group for all measures (timed score: $F_{(1,30)} = 12.08$, $p < 0.001$; untimed score: $F_{(1,30)} = 11.68$, $p < 0.001$; scaled score: $F_{(1,30)} = 6.36$, $p < 0.01$) (Table 5). The main effect for age was also significant for all three scores; that is, younger subjects

<table>
<thead>
<tr>
<th>TABLE 4. Mean scores for the Rey-Osterreith Complex Figure for the PD group (N = 20) and the control group (N = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>SD</td>
</tr>
<tr>
<td>PD</td>
</tr>
<tr>
<td>SD</td>
</tr>
</tbody>
</table>

PD group mean differs from control group mean; $^a p < 0.01$, $^b p < 0.001$.
TABLE 5. Mean scores for the picture arrangement subtest of the WAIS-R for the PD group (N = 20) and the control group (N = 14)

<table>
<thead>
<tr>
<th>Group</th>
<th>Timed score (maximum of 20)</th>
<th>Untimed score (maximum of 20)</th>
<th>Scaled score (maximum of 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>13.00</td>
<td>13.79</td>
<td>9.50</td>
</tr>
<tr>
<td>SD</td>
<td>3.16</td>
<td>2.69</td>
<td>2.65</td>
</tr>
<tr>
<td>PD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.80&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SD</td>
<td>4.68</td>
<td>4.55</td>
<td>3.04</td>
</tr>
</tbody>
</table>

PD group mean differs from control group mean; <sup>a</sup>p = 0.01; <sup>b</sup>p = 0.001.

achieved significantly higher scores than older subjects (timed score p < 0.01; untimed score p < 0.05; scaled score p < 0.05), but the group multiplied by age interactions did not approach significance. However, as for the complex figure, it remains a possibility that age may have a small influence on the poorer scores of the PD group, given their slightly older mean age.

When the PD group was subdivided into medication groups and test scores compared, there were significant main effects for dopaminergic and anticholinergic medications for all three Picture Arrangement scores (p < 0.05 for all). The two medications did not interact. The mean PA scores were lowest for the two subjects on no medication, were higher for the three subjects on anticholinergics only, were higher still for the nine subjects on dopaminergic drugs only, and were highest of all for the six subjects on a combination of dopaminergic and anticholinergic medications. These results must be interpreted with caution, however, because of the nonrandom prescription of medications to subjects: The fact that subjects were medicated according to their clinical presentation and personal and career needs, and that only two subjects were drug-free, limit the implications of this result regarding the cognitive effects of neurochemical manipulations.

An ANOVA comparing the ages of subjects with PD grouped by medications resulted in an interaction between the two types of medication that nearly reached significance ($F_{1,14} = 3.65$, p < 0.07). Among the PD subjects (many of whom worked full-time in intellectually demanding occupations), those receiving a combination of dopaminergic and anticholinergic drugs had a mean age of 57.8 years, whereas those receiving only Sinemet, only anticholinergic drugs, or no medications had mean ages of 68.2, 71.3, and 66.0 years, respectively. Medicating younger (and employed) subjects with both drugs may result in optimal control of their physical symptoms, thereby enabling them to continue working in their professions without being disabled or embarrassed by their motor symptoms. However, the subjects receiving both kinds of medication might have been best at PA even without medication, as they were younger and therefore less

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subject to the effects of normal aging on cognition. This group included three Stage I, one Stage II, and two Stage III PD subjects, and their mean years of formal education (14.7) was 0.4 years below the mean for the entire PD group. Thus, their less impaired scores on PA were attributable neither to milder PD nor to more education. It would seem, however, that dopaminergic and anticholinergic drugs do not have a marked deleterious effect on the cognitive abilities assessed by PA, at least in the short term.

DISCUSSION

In this study, a group of nondemented, nondepressed subjects with PD, many of whom were actively involved in intellectually demanding occupations, demonstrated significant impairments on two of the three tests they were assessed on.

On the Spatial Relations Test, a test on which very few neurologically intact subjects obtain perfect scores, the subjects with PD were as able as the control subjects to arrive at correct solutions. This test involves both visuospatial perception and the ability to form and manipulate mental visual images. It thus requires quite sophisticated visuospatial abilities, but does not require forward planning. The parkinsonian subjects were significantly slower than the controls to complete the test, and this could be the result of a difficulty to initiate concepts (the image of the folded shape) or a manifestation of bradyphrenia (slowed thinking). There is some evidence for bradyphrenia in older subjects with PD from experiments using a mental scanning paradigm (Wilson et al., 1980), although others have not found this (Rafal et al., 1984).

The parkinsonian subjects were significantly impaired relative to the control subjects on the copy, recall, and pure memory scores of the Complex Figure. In addition, the majority of the subjects with PD copied the figure in a piecemeal manner, reminiscent of young children. Many of the parkinsonians who copied the figure piecemeal drew most of the details in one quadrant and then went onto a second quadrant. As a result of this approach, even the diagonals and bisecting horizontal and vertical lines were drawn in a piecemeal manner. One possible explanation for this approach is that when parkinsonians look at a complex visual pattern, they have difficulty in perceiving it as a whole because of a difficulty with rapid visual scanning caused by abnormal saccadic eye movements (White et al., 1983). Another explanation is that parkinsonians are impaired on copying the Complex Figure because of an inability to plan cognitive strategies involving the sequencing of movements and the correct placing of parts within a whole. The tendency for some parkinsonians to demonstrate writing or drawing that becomes increasingly smaller (hypometria) was not apparent in any of the drawings, and therefore, this is unlikely to be a factor in their poor performance on this test.

The impaired percent recall scores of the subjects with PD on the Complex Figure do not necessarily point to a visuospatial memory deficit. Given that many of the PD subjects copied the figure piecemeal, presumably they processed and
stored the figure in the same form. Consequently, they later had to recall a much more complex stimulus than if they had stored the figure as, for example, "a rectangle with diagonals" or "a spaceship on its side." The idea that a piecemeal concept was more difficult to recall than a more holistic one is supported by the finding that the mean percent recall of the 12 PD subjects who copied the figure piecemeal was 24.5 (SD 16.1), whereas the mean percent recall of the 8 PD subjects who copied the basic rectangle in one color was 40.6 (SD 7.3).

The poor performance on the Complex Figure by the eight subjects with Stage 1 PD, seven of whom had right-sided symptoms suggesting left striatal pathology, supports the hypothesis that the deficit is one of planning and organization related to frontal lobe dysfunction, apparently left or right, and not primarily of visuospatial perception and construction, given that these latter deficits are more clearly associated with right hemispheric dysfunction.

On Picture Arrangement, the PD subjects demonstrated accurate perception of the details of each picture by correctly describing the pictures as they performed the test. No subject had difficulty with the motor actions necessary to place the pictures in the desired sequence, and no subject demonstrated a tendency to leave pictures in the positions they were placed in by the tester. The subjects were neither constrained nor stressed by a time limit, but they were impaired relative to the control group on the untimed and timed scores. Their poor scores were not a result of their giving up sooner, nor did they lack motivation, as in general, subjects with PD took much longer than control subjects to complete each item, whether or not they were correct.

Many subjects with PD who had placed the pictures in an illogical sequence commented that a particular detail did not make sense in the context of their overall story. However, they rarely changed the position of the picture as a result, but simply commented that it did not make sense to them, or verbally tried to incorporate the out-of-place detail into the story at that point. This fits with the behavior of subjects with frontal lobe lesions and PD when doing the WCST. These subjects frequently fail to initiate plans of action despite being able to verbalize the correct solution (Milner, 1963; Taylor et al., 1986). In marked contrast to the subjects with PD, most control subjects acted on their observations of out-of-place details by changing the positions of the pictures. Another qualitative observation that paralleled the behavior of subjects with frontal lobe lesions when doing the WCST was that the subjects with PD were initially slower to move the picture cards, possibly indicating a slowness to form an initial story concept. Heaton (1981) found that subjects with frontal lobe lesions took more trials than controls to complete a first category on the WCST, suggesting an inability to initiate a concept, and Taylor et al. (1986) also noted this with their PD group.

One explanation for the difficulty the subjects with PD had with this test is that they were unable to switch from the first story line they thought of to a new one that better fitted the details in the pictures. Such a hypothesis finds support in a number of studies that have found that subjects with PD have difficulty switching

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set on a range of tasks (Bowen et al., 1972, 1975, 1976; Cools et al., 1984; Lees and Smith, 1983; Mayeux et al., 1981).

The lack of correlation between the disease stage and impairment on the Complex Figure and Picture Arrangement tests is surprising, but may be a result of the fact that there were only two subjects in Hoehn and Yahr Stage IV, compared with nine in Stages II and III combined and eight in Stage I.

The finding that the subjects with PD performed accurately on the test involving visuospatial and imagery abilities, but demonstrated significant impairments on two tests requiring executive abilities as well as visuospatial abilities, provides some support for the hypothesis that nondemented, nondepressed subjects with PD do not have impairments of visuospatial functions per se, but rather have deficits in switching set and initiating and carrying out cognitive and motor plans. Therefore, performance is impaired on visuospatial tests that also require these executive functions. Executive frontal lobe deficits can be seen as a logical consequence of PD and could occur either as a result of degenerating subcortical dopaminergic neurons in the ventral tegmentum that project directly to the frontal cortex, or as a result of atrophy in related neurons of the substantia nigra pars compacta, whose influence on the frontal cortex is expressed indirectly through striatal–pallidal–thalamic projections (Alexander et al., 1986).

The deficits shown by nondemented parkinsonians on PA and the Complex Figure may have some clinical application. It is of some concern to realize that physicians, lawyers, engineers, and teachers remain active in their professions, aware that they have PD but unaware that they have cognitive impairments that may interfere with their ability to initiate and carry out novel plans, and perhaps result in an inability to make logical decisions. PA and the Complex Figure test may be particularly sensitive to the specific cognitive deficits of PD and could therefore serve as useful instruments in screening this population for early signs of cognitive impairment.

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