Cognition in Parkinson’s Disease

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Aim. Studies of accentuated drop in cognitive functioning of Parkinson’s disease patients mostly use global intelligence measures that have a masking effect on differential drop in specific cognitive abilities. The goal of this study was to investigate the possible differential drop in different types of cognitive tasks. Applied tests tapped fluid and crystallized intelligence, memory, and metacognition.

Method. A sample of 116 participants participated in the study. Half of the participants were diagnosed with Parkinson’s disease (average duration of disease 6.5 years) and control group participants equaled them in age, sex, and education level. All participants were tested using Raven’s Colored Progressive Matrices (CPM), Crichton Vocabulary Scale (CVS), memory subtests from Wechsler Adult Intelligence Scale (WAIS DS-F, WAIS DS-B), and Mini-mental Status Examination (MMSE). Participants, and in the case of clinical group their caregivers as well, were asked questions concerning their metamemory and metacognition.

Results. Parkinson’s disease patients scored lower than control group on all instruments used but the difference was significant only on CPM (F[1,114]=19.14, p=0.001) and MMSE (F[1,110]=4.04, p=0.047).

Conclusion. Patients with Parkinson’s disease have greater cognitive damage in fluid intelligence than in crystallized intelligence. They seem to have relatively accurate metamemory and metacognition.

Key words: cognition; intelligence; memory; Parkinson disease

In his descriptions of the disease, James Parkinson did not include the intellectual changes caused by the consequences of Parkinson’s disease, but later research indicated the connection between Parkinson’s disease and a certain degree of cognitive deficit similar to the one caused by ‘normal’ ageing processes. Cognitive deficits connected to ageing processes are memory impairments, substantial Intelligence quotient (IQ) drop, and slowing of metacognitive processes (1).

Regarding the deficits in memory processes, the capacity for memorizing does not change significantly. Ever growing importance is attributed to the changes in data processing. It seems that attention processes, closely linked to the functioning of working memory (WM), are impaired the most, while the long-term semantic memory is the least affected by ageing (2). Metacognition refers to one’s knowledge about his or her knowledge and intelligence. It involves self-evaluation of one’s cognitive processes, regulation and use of efficient strategies in dealing with cognitive and everyday problems. The research on metacognition shows that the elderly are aware of their slower processing. As a result, they develop various strategies to maintain their total cognitive efficiency (2). Different research approaches try to link metacognition to intelligence but so far no unified theory of this connection has been established.

Cattell (3,4), and Horn and Cattell (5) define two basic types of intelligence: fluid and crystallized intelligence. Fluid intelligence is intertwined in different types of mental activities, whereas crystallized intelligence is a final product of one’s experience at a certain developmental time-point. Fluid intelligence, as a neurological potential of general ability to form relations, invests itself in the crystallized ability to learn, i.e. in a certain experience. Fluid intelligence includes primary factors of intelligence such as reasoning, problem solving, and visual perception. It is assessed and measured by culture free tests, tests of intelligence speed characterized by limited testing time. Crystallized intelligence is best defined by verbal competence, language development, understanding of written text, and general information knowledge and is mainly measured by tests of intelligence power, characterized by unlimited testing time. However, crystallized intelligence is not just mere knowledge but it is also an ability to acquire and use this
knowledge efficiently (6). The basic difference between these two main types of intelligence is in the kind of information processing it uses. Fluid intelligence employs parallel, while crystallized intelligence employs serial type of information processing. Studies tapping fluid and crystallized intelligence are usually done on healthy subjects, so little is known about these two types of intelligences in clinical samples, including patients with Parkinson’s disease.

According to Horn (7-9) a decline in fluid intelligence begins after the age of 25, not just in the speed tests, but also in tests of intelligence power. Between the age of 25-40, the drop is about five IQ units (average IQ is 100±15), and afterwards for another 5 points every ten years. Crystallized intelligence, in the function of age, has almost a reverse growth pattern. This means that in the global intelligence measures, such as IQ tests, no drop will show until the very late age, but we have to keep in mind that this measure is made out of two components differently affected by age. The correlation between fluid intelligence and crystallized intelligence varies as a function of age, and in adults it is about 0.40, as a result of general intelligence factor.

For more complex cognitive functions, above all on measures of fluid intelligence, the drop in the function of age is more related to physical health than to chronological age. The drop is clearly visible in patients with coronary diseases, cerebral insufficiencies, diabetes, and Parkinson’s disease (9). Also, the effects of general health on intelligence are not high. The opposite tendency can be observed for the motor and perceptive processes, i.e., the effect of the chronological age on these processes is greater the more complex the task, and the greater the difference between young and old. Naturally, the impairment of sensory-motor processes due to the disease can have a more negative effect on more complex cognitive functions.

Little is known about the accentuated drop in specific cognitive functions of Parkinson’s disease patients. The studies mostly use global intelligence measures that have a masking effect for the differential drop of certain cognitive abilities (7). The main goal of the present study was to examine whether Parkinson’s disease causes some cognitive deficits that cannot be attributed solely to the normal ageing processes. We investigated the differential drop in some basic procedures of information processing used in different kinds of cognitive tasks. We also investigated the mental speed of processing and metacognition of these patients.

Participants and Methods

Participants

A sample of 116 patients, 70 men and 46 women, participated in this research. Participants were middle- and old-aged (42-83 years), of different educational levels. Education varied from no formal education to postgraduate education. Half of them were diagnosed with idiopathic Parkinson’s disease in Hoehn and Yahr clinical stage 1-3 (the clinical group) (10). Parkinson’s disease patients were tested from November, 2001 to May, 2002. These patients were selected in accordance with UK brain bank criteria for diagnosis of Parkinson’s disease (10). Some of these patients came for the first time and some had been undergoing medical treatment for 30 years. The average duration of Parkinson’s disease was 6.48 years (SD = 5.68). Participants in the control group were recruited from the homes for the elderly and selected using the equivalent pairs technique. They were of the same sex, age (M_parkinson = 66.09; M_control = 66.85), and education (Table 1) as participants from the clinical group. None of the control group participants was diagnosed with any disease that could influence their cognitive functioning (brain damage, brain tumor, disturbance of perception or behavior and similar). Some of the patients came accompanied by their caregivers and in this case their caregivers also participated in the study, as it will be explained in the Procedure section. All together, caregivers of 24 patients participated in the study. All caregivers were members of patients’ immediate family.

Table 1. Educational level of patients with Parkinson’s disease and their controls

<table>
<thead>
<tr>
<th>Level of education achieved</th>
<th>Patients with Parkinson’s disease</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary school</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>High school</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>University degree</td>
<td>15</td>
<td>17</td>
</tr>
</tbody>
</table>

*Chi-square=1.84, df=2, p = 0.339.

Measuring Instruments

Colored Progressive Matrices (CPM) is a nonverbal test (11). It consists of 36 items divided in 3 series (A, Ab and B). Every item is a drawing with a part missing to it. The task is to answer, according to a certain principle, which part, out of 6 possible, is the missing part. In all of the series, the items are ordered from easy to more difficult ones. In older participants it is used to assess the level of impairment of cognitive functions (11).

Crichton Vocabulary Scale – CVS (1988) was developed by Raven et al (12). It consists of 80 words that form 2 parallel series. The words in each series are set in order of difficulty, according to the frequency with which children under 11 years of age can explain their meaning. An oral definition is required for every word, i.e., the meaning of the word should be given in one’s own words. It examines verbal abilities in children and adults with impairment of cognition. The CVS results usually correspond well with the CPM results (12).

CPM is considered a good measure of fluid intelligence, and CVS of crystallized intelligence. We evaluated psychometrical characteristics of these instruments on a clinical group of patients of this research, and found that construct validity and reliability of these tests was satisfactory (13).

Two subtests of the Wechsler Adult Intelligence Scale/memory subtests were used. In the digit span forward subtest (DS-F), the subject is required to repeat, in the same order as they were presented, the sequences of 3 to 9 digits. In the digit span backward subtest (DS-B), a participant is required to repeat the presented sequence backwards. The length of these sequences varies from 2-8 digits. The total score equals the maximum number of digits repeated correctly. DS-F assesses short-term memory. DS-B assesses working memory because information should be not only be kept and transformed at the same time. These tests also tap the efficiency of attention.

Mini-Mental Status Examination (MMSE) is one of the most frequently used instruments for a rough triage of impaired cognitive abilities of a patient, tracking of the disease progress, and the evaluation of the mental state (14). The test refers to the patient’s orientation, attention, immediate and postponed remembering, use of language, ability to follow simple verbal and written instructions, and copying geometric figures. The criteria for diagnosing dementia is a number of mistakes higher than the number of mistakes done by healthy participants. The number of mistakes varies depending on education and age of the participants but scores above 24 are considered to be dementia-related regardless of the educational or age group of the participant (15).

To test metamemory and metacognition, the subjects were asked the following questions regarding their metamemory (the first two questions) and metacognition (the third question):
than the control group (Table 2). The average ratios of
gence, the clinical group scored significantly lower
in the research was necessary so that the intellectual functions of
patients with Parkinson's disease could be compared to the func-
tions of healthy people.

The demographic data was gathered. The tests were distrib-
uted in the following order: CPM, CVS, DS-F, DS-B, and MMSE,
followed by the questions on metamemory and metacognition.
The time on any of the tests was not limited and the experimenter
noted the time needed to solve CPM and CVS. At the end, partici-
pants were asked about their metamemory and metacognition.

After examining the clinical group, we asked the patients’
caregivers the same three questions concerning the patients’ abil-
ities:
1. Does the patient memorize new information with more diffi-
culty than before?
2. Can she or he memorize personal names and names of objects?
3. Do you have the impression that now you comprehend
more slowly than before?

If participants answered yes to any of the asked questions,
one point was added, and if she or he answered with a no, no
points were added. Therefore, higher scores show greater prob-
lems in everyday cognitive processes of the participants.

Testing
All participants were tested individually. The administration
of the entire test battery lasted about an hour. Patients were tested
during their regular medical check-up and control participants
were tested during a visit to their retirement homes. Prior to test-
ing, the following motivational instruction was given: “You are
participating in a research on thinking and comprehension of pa-
tients with Parkinson’s disease. The information obtained from
this research will be used for scientific purpose only, but will also
be of practical use for people working with patients with Parkin-
sion’s disease.” The control group was told that their participation
in the research was necessary so that the intellectual functions of
patients with Parkinson’s disease could be compared to the func-
tions of healthy people.

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3. Do you have the impression that now you comprehend
more slowly than before?

All participants were asked for their consent to participate
in the research; they could withdraw anytime and without any
consequences. The study was approved by the Ethical Commit-
tee of the Psychology Department of the Faculty of Philosophy in
Zagreb.

Statistical Analysis
Kolmogorov–Smirnov test found that the results of the two
groups in all tests showed normal distribution. Parametri-
cal tests were used to determine the differences in continuous
variables. Pearson’s coefficients of correlation were also calcula-
ted. Levene’s test for the equality of variance in the clinical and
control group showed that none of the single differences was sta-
tistically significant, and for this reason an analysis of the variance
for testing the differences in arithmetic mean of the criterion vari-
able was used.

Results
Level of Success in Cognition
In CPM, the test operationalizing the fluid intelli-
genic, the clinical group scored significantly lower
than the control group (Table 2). The average ratios of
solved tasks in the three subscales were p(A) = 0.74,
p(Ab) = 0.62, and p(B) = 0.47 for the clinical group
and p(A) = 0.83, p(Ab) = 0.80, and p(B) = 0.59 for the
control group. The sequence of average ratios in sub-
scales is the same for both groups, meaning that all
participants found the items in the subscale A to be
the easiest and those of the subscale B to be the most
difficult to solve. The variation of results in the clinical
group was much greater than in the control group (al-
most 50%). The variability coefficient was V = 30.41% in
the clinical, compared with V = 20.93% in the con-
trol group.

The difference between the two groups in CVS
was not statistically significant. Both groups achieved
similar scores in CVS (Table 2). The correct answer
ratio was p(A) = 0.56 and p(B) = 0.55 in the clinical and
p(A) = 0.60 and p(B) = 0.55 in the control group. It
seemed that participants of both groups found this test
to be of about average difficulty.

In Wechsler’s memory subtests, the difference
between the clinical and control group was also not
statistically significant. In the first subtest, DS-F, par-
ticipants of both groups could repeat a little less than
six numbers on average, and in DS-B they could re-
peat a little more than three numbers on average. The
results in the backwards reproduction of numbers var-
died more in the clinical (0 to 6) than in the control
group (2 to 6). In his publication “A Standardized Me-
ory Scale for Clinical Use”, Wechsler (16) cited sim-
ilar norms for the elderly: M = 5.98 for the digit span
forward and M = 4.30 for the digit span backward.

MMSE, the test used to diagnose dementia in its
early stages, showed a significant difference between
the two groups. Because the average scores in both
groups were above 24, it was assumed that some par-
ticipants in both groups had a tendency for a mild de-
mentia. This finding was more pronounced in the
clinical group. Since many of the participants in both
groups were fairly old, such results were, to some
extent, expected.

Parkinson’s disease affects cognition. The poten-
tial moderating variable of cognition is the duration of
the disease. We separated the effect of age and the ef-
fact of the disease duration because they can obvi-
ously correlate. Table 3 shows Pearson’s correlation
coefficients between cognitive tests, age and disease
duration, and Table 4 shows the relation of the dura-
tion and the score on cognitive tests when the effect of
the age was partialised, i.e., correlations between cog-
nitive tests and disease duration was computed with
the effect of age being taken out of the correlation.
Since no relation between the age and duration of the
disease was found in our sample, partialization did

<table>
<thead>
<tr>
<th>Test</th>
<th>Scores (mean ± SD) in subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with Parkinson’s disease</td>
</tr>
<tr>
<td>Raven’s Colored Progressive Matrices</td>
<td>21.8 ± 6.63</td>
</tr>
<tr>
<td>Crichton Vocabulary Test</td>
<td>45.6 ± 12.26</td>
</tr>
<tr>
<td>Digit Span-forward Wechsler Memory Subtest</td>
<td>3.8 ± 1.14</td>
</tr>
<tr>
<td>Digit Span-backward Wechsler Memory Subtest</td>
<td>3.3 ± 1.13</td>
</tr>
<tr>
<td>Mini Mental Status Examination</td>
<td>26.1 ± 2.76</td>
</tr>
</tbody>
</table>

F* – F-ratio,
† – level of significance.

Table 2. The scores of clinical and control group participants on all tests.
not affect the relation among the observed variables. Although there was a trend for the duration of disease to bring cognitive deterioration with it, the correlations of duration of disease and scores on cognitive tests did not reach the 5% level of significance. Differences in the number of subjects for each correlations coefficients come from the missing data in a given variable, ie some participants did not fully complete the test or they skipped an item.

**Speed of Processing**

Solving of CPM and CVS was not timed, but the differences in the solving time between the two groups were observed. A statistically significant difference in the average solving time was found for CVS \(p=0.014\). The average time needed to solve the CVS was 15.5±7.5 and 12.8 ±3.0 minutes for patients with Parkinson’s disease and control group, respectively. Although there was no significant difference between two groups in the results of the test, on the average participants in control group solved the test faster. The clinical group also varied more in the solving time than did control group. The variability coefficient for the clinical group was \(V=48.48\%\) and \(V=23.29\%\) for the control group.

**Metacognitive Processes**

One of our aims was to examine the quality of metacognitive processes in both groups. The comparison of the two groups showed that clinical participants felt they now memorized new information with more difficulty than they did before (Table 5). It was also more difficult for them to memorize the names of people and objects and they had the impression to comprehend things more slowly than before. However, the only significant difference between the clinical and control group was in slower comprehension. Patients with Parkinson’s disease believed they comprehended things more slowly than control subjects \((t=6.57, p=0.012)\).

The differences in self-perception of patients and caregivers’ perception of patients’ memory and overall understanding indicated the accuracy of patients’ metacognition (Table 6). Answers of the immediate family members to all of the three questions showed that caregivers find the memory problems of patients to be smaller than the patients themselves thought. Following this pattern, caregivers were of the impres-

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**Table 3.** Pearson correlation coefficients between duration of illness, age, and results in various measures of cognitive abilities in patients with Parkinson’s disease

<table>
<thead>
<tr>
<th>Test of cognitive abilities</th>
<th>Person correlation coefficients for duration of illness</th>
<th>Person correlation coefficients for age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>r</td>
</tr>
<tr>
<td>Mini Mental Status Examination</td>
<td>54</td>
<td>-0.085</td>
</tr>
<tr>
<td>Raven’s Colored Progressive Matrices</td>
<td>58</td>
<td>-0.132</td>
</tr>
<tr>
<td>Crichton Vocabulary Test</td>
<td>58</td>
<td>-0.097</td>
</tr>
<tr>
<td>Digit Span-forward Wechsler Memory Subtest</td>
<td>58</td>
<td>-0.149</td>
</tr>
<tr>
<td>Digit Span-backward Wechsler Memory Subtest</td>
<td>58</td>
<td>-0.134</td>
</tr>
</tbody>
</table>

*r – Pearson correlation coefficient.  
*p – level of significance.

**Table 4.** Pearson correlation coefficients between duration of illness and results in various cognitive abilities partialized for the effect of age of the Parkinson’s disease patients

<table>
<thead>
<tr>
<th>Test of cognitive abilities</th>
<th>Duration of illness</th>
<th>No. of patients</th>
<th>r*</th>
<th>p†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini Mental Status Examination</td>
<td>50</td>
<td>-0.06</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>Raven’s Colored Progressive Matrices</td>
<td>50</td>
<td>-0.17</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Crichton Vocabulary Test</td>
<td>50</td>
<td>-0.16</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Digit Span-forward Wechsler Memory Subtest</td>
<td>50</td>
<td>-0.23</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Digit Span-backward Wechsler Memory Subtest</td>
<td>50</td>
<td>-0.21</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

*r – Pearson correlation coefficient.  
*p – level of significance.

**Table 5.** Scores (mean±standard deviation) of control and clinical group on questions concerning metacognition and statistical significance of differences

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it now more difficult for you to memorize new information than it was before?</td>
<td>patients with Parkinson’s disease</td>
</tr>
<tr>
<td>Can you memorize the names of people and objects?</td>
<td>patients with Parkinson’s disease</td>
</tr>
<tr>
<td>Do you have a feeling that you comprehend things more slowly than you used to?</td>
<td>patients with Parkinson’s disease</td>
</tr>
</tbody>
</table>

Ф – F-ratio.  
п – level of significance.

**Table 6.** Scores (mean±standard deviation) on self-reports and caregiver’s assessments (n = 24) of cognitive functioning of Parkinson’s disease patients

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
</tr>
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<tbody>
<tr>
<td>Is it now more difficult for you to memorize new information than it was before?</td>
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</tr>
<tr>
<td>Can you memorize the names of people and objects?</td>
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</tr>
<tr>
<td>Do you have a feeling that you comprehend things more slowly than you used to?</td>
<td>patients with Parkinson’s disease</td>
</tr>
</tbody>
</table>

Self-reports of Parkinson disease patients.

t – t-test.  
df – degrees of freedom.  
p – level of significance.  
Assessment of a family member.
sion that the patients’ comprehension was less impaired than the patients themselves felt. The difference in self-reports and assessments of others was significant only in answering the question: “Do you now memorize new information with more difficulty/Do you memorize new information harder than before?” This question indicates relative accuracy of the metacognition of patients. Although some differences in cognitive abilities between to groups were found, we did not find dramatic cognitive impairments in our clinical group participants. We were dealing with the patients whose physical disturbances were most pronounced and we found their metacognitive abilities to be more accurate that those of their caregivers. Their caregivers did not notice significant changes in patients’ cognitive functioning.

Discussion

In comparison with the control group, Parkinson’s disease patients showed no significant drop in the verbal aspects of intelligence (ie, serial processing or crystallized intelligence). A drop was evident in nonverbal abilities (ie, in parallel processing or fluid intelligence). The usual underachievement in neurological tests found in Parkinson’s disease patients is mostly related to the degeneration of the right hemisphere functions (visual and spatial tasks) and/or functions of the frontal lobe (abstraction, planning, evaluating) (3). The early acquired skills stay intact, while the newly learned are more severely affected.

Our findings are similar to findings of other studies conducted in this area (4). The significant difference was found in the test measuring fluid intelligence as opposed to that measuring crystallized intelligence. This suggests that Parkinson’s disease effects parallel more than serial processing. Parallel processing is more disturbed in “normal” age functioning as well. In Parkinsonism, this disturbance seems to be more pronounced. CPM evaluates the mental development in terms of a degree at which an individual has the ability to reason successfully by using analogies. The studies show that this degree of intellectual maturing is one of first to deteriorate as a result of organic dysfunction (9). Therefore, this study points to the possibility of a organic dysfunction connected with reasoning ability in Parkinson’s disease patients.

The factors lying in the core of the discrepancy between the results in Raven’s Colored Progressive Matrices and Crichton Vocabulary Test are interest and attention, educational possibilities, and physical health (11). In Parkinsonism, the scores in CPM are lower than the scores on CVS. This suggests that we are probably dealing with an attention disturbance functioning of working memory, which can be caused by neglected organic brain damage. Such damage affects the ability to focus on what the person is doing than the ability to remember well the acquired information. Following on this, our clinical participants scored significantly lower when they had to maintain attention (Raven’s Colored Progressive Matrices), than when they had to recall information acquired long ago (Crichton Vocabulary Test).

On measures of memory, we expected no difference in STM (operationalized by Digit span-forward Wechsler Memory Subtest). Differences in the measure of working memory were expected due to the requirement and found of parallel processing in functioning of WM (operationalized by Digit span-backward Wechsler Memory Subtest). One of the possible reasons for not obtaining the difference between the clinical and control group in the DS-B is that it is primarily a test for diagnosing mental retardation and the results of the clinical group do not fall into the category of subnormality.

The data concerning the prevalence of dementia in patients with Parkinson’s disease are contradictory. Olanow et al (10) summarize the body of research results in this area: about 20% of patients with Parkinson’s disease show significant mental deterioration, and only a small number has a pure idiopathic Parkinson’s disease. Raven et al (11) found that patients with dementia achieved lower CPM results than the group of healthy participants. The results of our research confirm such findings, ie the clinical group scores lower in both MMSE and CPM tests.

The longer time it took the clinical group to complete CVS was expected since it is a verbal test. Slow and silent speech is one of the characteristics of patients with Parkinson’s disease (8), which surely affects their time for solving verbal tests. As the duration of the disease progresses, the speech of patients with Parkinson’s disease becomes monotone, silent, poorly articulated and gradually soundless. These speech difficulties enhance the impression of slowed down course of thought of these patients. Although it did not affect the results in this verbal test, the conclusion remains that the patients with Parkinson’s disease have also slowed down in serial processing.

A brief investigation of metamemory and metacognition showed that patients with Parkinson’s disease had relatively accurate metamemory and metacognition. These patients were aware of the slowing of their cognitive processes. Participants who responded as not having more difficulty in memorizing now than they did before, informed us in the informal conversation that the problem was not in the worse memory for the new information. They simply lacked interest for memorizing new information or those they found irrelevant. This is accordance with the reports that the elderly spontaneously reduce demands for memorizing by not trying to memorize events and information that are irrelevant for them (1).

Since the clinical group in this study consisted of patients with idiopathic Parkinson’s disease, our findings are limited to these patients. Future research is needed to test these findings on other subgroups of Parkinson’s disease patients. Our results show that patients with Parkinson’s disease show some specific cognitive deficits but these deficits should not be generalized to their overall cognitive performance. This study revealed that Parkinson’s disease patients are a good and accurate source of information concerning their own condition. Information provided by these patients should be used by practitioners when planning the treatment and therapy for a specific patient.
References


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