



Original Research

# Cognitive Correlates of Instrumental Activities of Daily Living Performance in Parkinson Disease Without Dementia



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## KEYWORDS

Activities of daily living, Cognition; Parkinson disease; Rehabilitation

**Abstract Objective:** To investigate cognitive correlates of instrumental activities of daily living (IADL) performance among people with Parkinson disease (PD) without dementia.

**Design:** Cross-sectional.

**Setting:** Academic medical center.

**Participants:** Volunteer sample (N=161) comprising participants with PD without dementia (n=102) and healthy comparison (HC) participants (n=59).

**Interventions:** Not applicable.

**Main Outcome Measures:** Performance-based assessment of cognitively-demanding IADL (meal preparation, bill paying, shopping, medication management, small home repair), neuropsychological tests (attentional control/flexibility, planning, working memory, memory, crystallized intelligence), and measures of motor function and other characteristics (eg, depressive symptoms).

**Results:** There were no group differences in neuropsychological test performance ( $P > .06$ ). The PD group performed more poorly than the HC group on a number of cognitive IADL tasks ( $P < .04$ ). After accounting for the effects of motor impairment and other disease-related characteristics, neuropsychological test performance accounted for a small but unique portion of the variance in performance of all cognitive IADL combined, meal preparation, shopping, and medication management in the PD group ( $R^2 = 4\% - 13\%$ ;  $P \leq .01$ ).

**Conclusions:** The PD group had cognitive IADL performance limitations despite being unimpaired on neuropsychological tests. Within PD, neuropsychological test performance accounted for a

**List of abbreviations:** CANTAB, Cambridge Neuropsychological Test Automated Battery; HC, healthy comparison; IADL, instrumental activities of daily living; IED, Intra-Extra Dimensional Set Shift test; MMSE, Mini Mental Status Examination; PAL, Paired Associates Learning; PASS, Performance Assessment of Self-care Skills; PD, Parkinson disease; SOC, Stockings of Cambridge; SWM, spatial working memory; UPDRS, Unified Parkinson's Disease Rating Scale; WTAR, Wechsler Test of Adult Reading.

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small but significant portion of the variance in cognitive IADL performance over and above the effects of motor and other impairments. These results support the added value of using performance-based IADL assessments in functional evaluations of individuals with early and mild PD without dementia.

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Parkinson disease (PD) is the second most common neurodegenerative disease, affecting 7-10 million people worldwide.<sup>1</sup> Even with optimal medical management, PD is associated with disability and reduced health-related quality of life.<sup>2-5</sup> Cognitive dysfunction is believed to be an important contributor to early activity limitations and participation restrictions in PD.<sup>6,7</sup> Mild cognitive deficits can be detected in the earliest stages of PD<sup>8,9</sup> and are associated with reported limitations in instrumental activities of daily living (IADL)<sup>7,10</sup>; reduced quality of life<sup>11</sup>; and reduced participation in instrumental, leisure, and social activities.<sup>6</sup> Because of its negative effect on function and quality of life, mild cognitive impairment in PD is considered a prime target for intervention development.<sup>12-17</sup>

There are currently no biomarkers for mild cognitive deficits in PD, so sensitive behavioral measures of cognition will be essential as outcome measures for future cognitive intervention trials. Although there are numerous cognitive tests to detect mild cognitive deficits in PD, direct measures of the functional effect of these deficits are lacking.<sup>12,18</sup> Such functional measures are necessary to provide evidence of the clinical relevance of cognitive test results and treatment effects.<sup>19</sup>

The ability to carry out IADL is a key functional outcome of cognition.<sup>18</sup> IADL assessment in PD has primarily consisted of self- or informant-report measures, which are limited by subjectivity, dependence on insight, association with depressive symptoms, reporting bias, and imprecision.<sup>12,20,21</sup> Importantly, self-reported IADL function may be particularly susceptible to underestimation of problems by people with PD.<sup>22</sup> Informant-report measures are additionally subject to bias from denial, caregiver burden, and amount of time spent with the person,<sup>23-26</sup> and it can be difficult for caregivers to distinguish between motor and cognitive contributions to IADL function.<sup>27</sup> Incorporating measures that involve standardized observation and scoring of IADL performance by a trained professional may address the limitations of self- or informant-report measures and provide a more accurate and complete understanding of the functional consequences of mild cognitive deficits in this population.

Performance-based IADL assessment is emerging in PD. Studies have demonstrated objective IADL performance limitations in people with PD without dementia.<sup>28-32</sup> However, the evidence is inconsistent regarding the underlying cognitive deficits that contribute to these limitations. Whereas some studies have found associations between IADL performance and global cognitive impairment<sup>27,28</sup> or deficits in specific cognitive domains such as cognitive flexibility, attention, memory, and executive functioning,<sup>29,32-36</sup> others have found no relationships.<sup>30,31</sup> A better understanding of

the cognitive mechanisms of IADL performance limitations in PD may improve detection of and intervention for early functional decline in this population.

The purpose of this study was to investigate the cognitive correlates of IADL performance among people with PD. We used the Performance Assessment of Self-care Skills (PASS)<sup>37,38</sup> to assess cognitively-demanding IADL performance in participants with PD without dementia and healthy comparison (HC) participants without PD. We previously found that the PASS cognitive IADL tasks discriminate between people with PD without dementia and adults without PD and that PASS cognitive IADL performance in PD is associated with global cognitive impairment and, to a lesser extent, motor impairment.<sup>28</sup> The current study extends our prior work in a larger sample and with a battery of neuropsychological tests to assess the relationships of specific cognitive domains and motor function with cognitive IADL performance.

## Methods

This study was approved by the university's internal review board, and all participants provided written informed consent upon enrollment.

## Participants

Participants were community-dwelling people with PD and adults without PD (HC). Participants with PD were recruited from the university's movement disorders center, and HC participants were recruited from the university's research participant registry and word of mouth. Participants with PD met diagnostic criteria for idiopathic typical PD<sup>39</sup> and were classified as Hoehn and Yahr stage I-III.<sup>40</sup> Exclusion criteria for the participants with PD included suspected dementia or global cognitive impairment (per clinical record, physician, and/or caregiver report or a score <25 on the Mini-Mental Status Examination [MMSE]<sup>41</sup>), a standardized score <85 on the Wechsler Test of Adult Reading (WTAR),<sup>42</sup> other neurologic conditions, brain surgery, history of or current psychotic disorder, significant current psychiatric symptoms, or any condition that would interfere with testing (eg, non-English speaking). Exclusion criteria for the HC participants included the above in addition to the suspected presence of PD, biological family history of PD, and being a spouse or caregiver of someone with PD or another participant in the study.

## Procedure

Testing was conducted in a university research unit. Participants with PD were tested while on their regular medications to represent their real-world functional status. During the testing session demographic information was collected via interview, the MMSE was administered to measure global cognitive function, the Beck Depression Inventory II<sup>43</sup> was administered to assess depressive symptoms, and then IADL and neuropsychological testing occurred (described in Assessments; order counterbalanced across participants). Clinical characteristics of the participants with PD were obtained from clinical records (eg, Hoehn and Yahr stage, Unified Parkinson Disease Rating Scale [UPDRS] Motor score<sup>44</sup> from within 3 months of study participation, disease duration, medications).

## Assessments

### Cognitive IADL performance

The PASS<sup>37,38</sup> assessed cognitively-demanding IADL performance. The PASS is a standardized, observer-based, criterion-referenced measure. Detailed information regarding training, administration, piloting, refinement, and reliability of the PASS for this study were reported by Foster.<sup>28</sup> Ten cognitive IADL were administered: (1) oven use, (2) stovetop use, (3) sharp utensil use, (4) clean up, (5) bill paying by check, (6) checkbook balancing, (7) mailing bills, (8) shopping, (9) medication management, and (10) small home repairs (ie, flashlight repair).

Examiners provided scripted instructions for each activity and then observed and rated performance according to pre-specified criterion-referenced critical subtasks. If the participant could not proceed independently with an activity or made a mistake, the examiner began a process of graduated cueing to facilitate activity completion, following a 9-level cueing hierarchy that increases in power of assistance: (1) verbal supportive, (2) verbal nondirective, (3) verbal directive, (4) gesture, (5) task object or environmental rearrangement, (6) demonstration, (7) physical guidance, (8) physical support, and (9) total assist. Examiners refrained from cueing unless absolutely necessary (including not cueing for delays or slowness owing to bradyphrenia or bradykinesia), started with the lowest level of cueing possible, and provided 2-3 cues per level before moving to the next level. The level and number of cues needed for activity completion were used to determine the weighted cue score for that activity. This score is a sum of the number of cues given in each level multiplied by the cue level. To reduce the number of comparisons for this study and because the following individual activities are administered and performed together, the bill paying by check, checkbook balancing, and mailing activity scores were summed to yield a Bill Paying score, and the oven use, stovetop use, use of sharp utensils and clean up scores were summed to yield a Meal Preparation score. Additionally, all activity scores were summed to yield an All IADL score.

### Neuropsychological testing

Selected tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB)<sup>a</sup> assessed executive and

memory function. The CANTAB is a computerized neuropsychological test battery and is well-validated and widely-used in PD. The Stockings of Cambridge (SOC) test assessed spatial planning and working memory, the Intra-Extra Dimensional Set Shift (IED) test assessed rule acquisition/reversal and attentional control, the Spatial Working Memory (SWM) test assessed spatial working memory and strategy use, and the Paired Associates Learning (PAL) test assessed visual episodic memory and new learning. The primary nonmotor-dependent outcome measures from each test were used in this study. In addition, the CANTAB Motor Screening test was used as a measure of motor speed, and the WTAR was used as an estimate of premorbid crystallized intelligence.

## Statistical analysis

Data were stored and managed using REDCap<sup>b</sup> electronic data capture tools hosted at the university<sup>45</sup> and analyzed using IBM SPSS Statistics 25.<sup>c</sup> Descriptive statistics were calculated for all variables and data were visually inspected for normality. Independent samples *t* tests (or chi-square for categorical data) compared the PD and HC groups on participant characteristics, cognitive IADL performance, and neuropsychological performance. Pearson *r* correlations assessed the bivariate relationships between cognitive IADL performance and participant characteristics and neuropsychological performance within groups. Then, multiple linear regression analyses examined independent predictors of cognitive IADL performance within the PD group. Separate models were run for each cognitive IADL that had significant bivariate correlations with participant characteristics and/or neuropsychological performance. Participant characteristics were entered in the first step, and then the neuropsychological test scores were entered in the second step. All statistical tests were 2-tailed, and *P* < .05 was considered significant.

## Results

### Participant characteristics

Demographic and clinical characteristics of the sample (102 PD, 59 HC) are shown in table 1. Groups were equivalent in age, sex, education, ethnicity, race, living status, and MMSE (*P* ≥ .13). The PD group had higher Beck Depression Inventory II scores (*t*(159) = -3.6; *P* < .001), indicating more frequent or severe depressive symptoms on average. However, there were no group differences in the distribution of depressive symptom severity according to clinical cutoffs ( $\chi^2=6.1$ ; *P* = .11). In the PD and HC groups, respectively, 72 and 51 participants had minimal symptomology, 14 and 3 had mild symptomology, 13 and 3 had moderate symptomology, and 3 and 2 had severe symptomology.

### Group comparisons of cognitive IADL and neuropsychological test performance

The PD group had poorer scores than the HC group for All IADL, Meal Preparation, and Shopping, but there were no

**Table 1** Sample characteristics

| Variable                         | HC Group | PD Group    |
|----------------------------------|----------|-------------|
| No. of participants (N=161)      | 59       | 102         |
| Age, y                           | 61.7±6.0 | 62.4±5.2    |
| Male/female, n/n                 | 29/30    | 56/46       |
| Education, y                     | 15.9±2.4 | 15.4±2.4    |
| Ethnicity, n                     |          |             |
| Hispanic or Latino               | 0        | 4           |
| Not Hispanic or Latino           | 57       | 97          |
| Declined to state                | 2        | 1           |
| Race, n                          |          |             |
| American Indian or Alaska Native | 1        | 2           |
| Asian                            | 2        | 1           |
| Black or African American        | 4        | 1           |
| White                            | 50       | 96          |
| Declined to state                | 2        | 2           |
| Living status, n                 |          |             |
| Living with someone              | 50       | 93          |
| Living alone                     | 9        | 9           |
| MMSE                             | 29.2±1.0 | 29.0±1.2    |
| BDI-II*                          | 6.4±8.2  | 11.1±7.8    |
| Duration of diagnosis, y         | NA       | 4.9±4.2     |
| LEDD, mg                         | NA       | 955.5±694.3 |
| UPDRS Motor (on medication)      | NA       | 17.7±8.2    |
| Hoehn and Yahr Stage, n          | NA       | NA          |
| 1                                |          | 5           |
| 2                                |          | 83          |
| 2.5                              |          | 12          |
| 3                                |          | 2           |

NOTE. Values are mean ± SD or number of participants where indicated.

Abbreviations: BDI-II, Beck Depression Inventory, 2nd edition; LEDD, levodopa equivalent daily dose.

\* HC different from PD,  $P < .05$ .

group differences in neuropsychological test performance (table 2). In addition, the PD group took longer to complete the PASS than the HC group (mean ± SD, PD: 78.3±16.8 min, HC: 65.2±12.0 min;  $t(159) = -5.40$ ,  $P < .001$ ).

### Within-groups bivariate relationships between cognitive IADL performance, participant characteristics, and neuropsychological test performance

Correlations between cognitive IADL and neuropsychological test performance in the PD group are shown in table 3. In the PD group, All IADL correlated with IED, PAL, SWM, and SOC; Meal Preparation correlated with IED; Shopping correlated with PAL, SWM, and SOC; and Medication Management correlated with WTAR, PAL, and SWM. For all relationships, poorer cognitive IADL performance was related to poorer neuropsychological performance.

For correlations between cognitive IADL performance and participant characteristics in the PD group, All IADL correlated with duration of diagnosis, levodopa equivalent daily dose, and UPDRS Motor ( $r \geq 0.20$ ,  $P \leq .05$ ), and Medication Management correlated with duration of diagnosis ( $r = 0.20$ ,  $P = .04$ ). For these relationships, poorer cognitive IADL performance was related to longer disease duration, higher levels of medication, and/or more severe motor impairment.

There were no correlations between cognitive IADL performance and neuropsychological test performance or participant characteristics in the HC group ( $r \leq 0.20$ ,  $P \geq .14$ ). Nor were there any correlations between time taken to complete the PASS and neuropsychological test performance or participant characteristics in either group ( $r \leq 0.19$ ,  $P \geq .07$ ).

**Table 2** Comparison of group cognitive IADL and neuropsychological test performance

| Variable                             | HC Group       | PD Group       | $t(159)$ | $P$ Value |
|--------------------------------------|----------------|----------------|----------|-----------|
| No. of participants (N=161)          | 59             | 102            |          |           |
| PASS activity                        |                |                |          |           |
| All IADL                             | 14.47±13.04    | 20.99±19.00    | -2.57    | .01*      |
| Meal preparation                     | 4.41±6.12      | 6.96±9.14      | -2.09    | .04*      |
| Bill paying                          | 6.93±7.17      | 6.89±8.91      | 0.03     | .98       |
| Shopping                             | 0.31±0.91      | 1.95±3.64      | -4.33    | <.001*    |
| Medication management                | 1.98±4.47      | 3.43±5.77      | -1.77    | .07       |
| Flashlight repair                    | 1.03±3.11      | 1.75±4.36      | -1.12    | .27       |
| CANTAB test                          |                |                |          |           |
| MOT mean latency, ms                 | 1189.64±351.10 | 1234.72±366.85 | -0.76    | .45       |
| IED total errors                     | 32.83±36.10    | 41.29±47.00    | -1.19    | .24       |
| PAL total errors                     | 26.95±20.44    | 29.68±25.78    | -0.69    | .49       |
| SWM total errors                     | 33.32±21.27    | 36.57±19.64    | -0.98    | .33       |
| SOC problems solved in minimum moves | 8.45±1.70      | 7.85±2.01      | 1.90     | .06       |
| WTAR scaled score                    | 110.4±10.9     | 110.0±10.7     | 0.23     | .82       |

NOTE. Values are mean ± SD.

Abbreviation: MOT, motor screening test.

\* PD worse than HC,  $P < .05$ .

**Table 3** Correlations (Pearson *r*) between cognitive IADL performance and neuropsychological test performance within the PD group

| Variable                             | All IADL | Meal Preparation | Money Management | Shopping | Medication Management | Flashlight Repair |
|--------------------------------------|----------|------------------|------------------|----------|-----------------------|-------------------|
| MOT mean latency                     | 0.11     | 0.08             | 0.09             | 0.09     | 0.09                  | -0.07             |
| IED total errors                     | 0.25*    | 0.20†            | 0.12             | 0.15     | 0.19                  | -0.03             |
| PAL total errors                     | 0.29*    | 0.19             | 0.11             | 0.29*    | 0.21†                 | 0.03              |
| SWM total errors                     | 0.25*    | 0.12             | 0.11             | 0.21†    | 0.23†                 | 0.14              |
| SOC problems solved in minimum moves | -0.25*   | -0.12            | -0.15            | -0.21†   | -0.11                 | -0.19             |
| WTAR scaled score                    | -0.15    | -0.06            | -0.05            | -0.15    | -0.26*                | 0.09              |

NOTE: n=102.

Abbreviation: MOT, motor screening test.

\*  $P \leq .01$ .†  $P < .05$ .

### Independent associations between cognitive IADL performance and participant characteristics and/or neuropsychological test performance within the PD group

Coefficients for each regression model are shown in table 4. For All IADL, duration of diagnosis, levodopa equivalent daily dose, and UPDRS Motor accounted for an initial 7% of the variance ( $F^{3,95}=2.19$ ;  $P=.09$ ), and the neuropsychological variables (IED, PAL, SWM, SOC) together accounted for an additional 13% of the variance ( $F^{4,91}=3.61$ ;  $P=.009$ ), resulting in a significant model ( $R^2=0.19$ ;  $F^{7,91}=3.12$ ;  $P=.006$ ). For Meal Preparation, IED accounted for 4% of the variance resulting

in a significant model ( $F^{1,97}=4.07$ ;  $P=.03$ ). For Shopping, PAL, SWM, and SOC together accounted for 11% of the variance resulting in a significant model ( $F^{3,95}=3.96$ ;  $P=.01$ ). For Medication Management, duration of diagnosis accounted for an initial 2% of the variance ( $F^{1,97}=1.87$ ;  $P=.18$ ), and WTAR, PAL, and SWM together accounted for an additional 12% of the variance ( $F^{3,94}=4.22$ ;  $P=.008$ ), resulting in a significant model ( $R^2=0.14$ ;  $F^{4,94}=3.68$ ;  $P=.008$ ).

When participants with MMSE scores below 27 (n=16) were removed from analyses, the significant correlations remained. Furthermore, regression diagnostics (eg, Cooks D, leverage, studentized residuals) revealed no problematic influential observations.

**Table 4** Multiple linear regression models examining independent predictors of cognitive IADL performance within the PD group (n = 102)

| Variables                                 | B     | SE B  | $\beta$ | <i>t</i> | <i>P</i> Value |
|---|-------|-------|---------|----------|----------------|
| Dependent variable: All IADL              |       |       |         |          |                |
| Duration of diagnosis                     | 0.24  | 0.53  | 0.05    | 0.45     | .65            |
| LEDD                                      | <0.01 | <0.01 | 0.10    | 0.93     | .36            |
| UPDRS Motor                               | 0.42  | 0.22  | 0.18    | 1.85     | .07            |
| IED                                       | 0.06  | 0.04  | 0.16    | 1.59     | .11            |
| PAL                                       | 0.13  | 0.07  | 0.18    | 1.70     | .09            |
| SWM                                       | 0.07  | 0.11  | 0.07    | 0.62     | .53            |
| SOC                                       | -0.95 | 1.04  | -0.11   | -0.92    | .36            |
| Dependent variable: Meal Preparation      |       |       |         |          |                |
| IED                                       | 0.04  | 0.02  | 0.21    | 2.68     | .008*          |
| Dependent variable: Shopping              |       |       |         |          |                |
| PAL                                       | 0.04  | 0.02  | 0.25    | 2.38     | .02*           |
| SWM                                       | 0.03  | 0.02  | 0.13    | 1.19     | .24            |
| SOC                                       | -0.10 | 0.21  | -0.06   | -0.48    | .63            |
| Dependent variable: Medication Management |       |       |         |          |                |
| Duration of diagnosis                     | 0.23  | 0.16  | 0.15    | 1.45     | .15            |
| WTAR                                      | -0.11 | 0.05  | -0.20   | -2.03    | .05*           |
| PAL                                       | 0.03  | 0.02  | 0.15    | 1.54     | .13            |
| SWM                                       | 0.04  | 0.03  | 0.15    | 1.48     | .14            |

NOTE. n=102.

Abbreviation: LEDD, levodopa equivalent daily dose.

\*  $P < .05$ .

## Discussion

We examined cognitive predictors of cognitive IADL performance in a large sample of people with PD without dementia and adults without PD. Despite being cognitively high functioning and having relatively early and mild disease progression, the PD group had impaired cognitive IADL performance. Within PD, neuropsychological test performance accounted for a small but significant portion of the variance in cognitive IADL performance, over and above the effects of motor function or other disease-related characteristics, and there were some selective relationships between specific cognitive domains and specific cognitive IADL tasks. These results provide insight into the functional relevance of cognitive changes in PD and the potential benefit of incorporating performance-based IADL assessment into functional evaluations of people with PD.

Although there were no group differences in neuropsychological test performance, the PD group had slower cognitive IADL performance and required more assistance to complete cognitive IADL (specifically, meal preparation and shopping) than their peers without PD. Reduced activity performance in the absence of neuropsychological test impairment has been observed in PD using a novel and complex work simulation activity.<sup>46</sup> The current study found performance limitations in more familiar and simpler tasks, which further supports the sensitivity of performance-based IADL assessment to early functional decline in PD. The longer time taken by participants with PD to complete the PASS is also consistent with studies that have used performance-based measures.<sup>29,36,46</sup> Of clinical relevance, this finding dovetails with qualitative work revealing that a major factor influencing daily function among people with PD is the increased time taken to perform daily activities.<sup>47</sup> Interestingly, although participants with PD perceived both physical and mental slowness in daily activities,<sup>47</sup> neither motor nor cognitive function were related to cognitive IADL performance time in this study. Regardless of the source of slowed cognitive IADL performance, our findings demonstrate the added value of using performance-based IADL assessment early in the disease, because subtle inefficiencies in the completion of complex IADL may portend more overt impairment on neuropsychological tests and potentially lead to earlier detection of cognitive functional decline.

Neuropsychological test performance was associated with cognitive IADL performance after accounting for the effects of motor impairment or other markers of disease severity (ie, levodopa equivalent daily dose, disease duration). Motor impairment was not correlated with any of the individual cognitive IADL and was not a significant independent predictor of overall cognitive IADL performance. Most existing studies have had similar results with respect to the contribution of motor function, finding no relationships with individual activities<sup>30,31,46</sup> or weak to moderate relationships with overall IADL performance that either do not reach significance in adjusted models or after which cognition is still an independent predictor.<sup>27,29,34</sup> Additionally, although depression is known to influence self-reports of daily function in PD,<sup>6,20,21</sup> it was not associated with cognitive IADL performance in this study or in 2 prior studies that used performance-based measures.<sup>29,30</sup>

Taken together, these findings suggest that the PASS and other performance-based IADL assessments are sensitive and valid indicators of functional abilities related to cognitive more so than motor impairments in PD. They also highlight another potential advantage of performance-based measures in that they may be less subject to bias by mood or other psychological factors than self-report measures. However, it is worth noting that the existing literature is not entirely consistent with regard to these issues. There is a wide range in the magnitude of correlations between motor function and IADL performance across different assessments, severity of PD, or severity cognitive impairment within PD, and some studies have found associations between depression and IADL performance in PD.<sup>31,34</sup> Furthermore, many other factors may contribute to cognitive IADL performance, ranging from personal factors like apathy and sex to contextual factors like the physical environment and social support. Future investigations should aim to disentangle the relative contributions of cognitive, motor, psychological, and other factors to IADL performance among people with PD.

There were few relationships between specific cognitive domains and cognitive IADL performance. Whereas the combination of executive and memory variables predicted overall cognitive IADL performance, none of the individual neuropsychological tests were significant predictors. In terms of individual cognitive IADL, only meal preparation, shopping, and medication management were related to neuropsychological test performance, and only attentional control, memory, and crystallized intelligence were weak independent predictors of these IADL, respectively. The reasons for these specific relationships are unclear. Although it is likely that in real life, different IADL differentially demand underlying cognitive processes, the correlations found in this study may be more indicative of overlap in the demands of the tests themselves than generalizable relationships between specific cognitive processes and activities per se. This notion is reflected in the existing literature on financial management and medication management performance in PD. Reports vary from no relationships between these activities and neuropsychological tests<sup>30,31</sup> to strong correlations with a range of cognitive abilities,<sup>29,33</sup> depending on the assessments used. Our findings are not altogether surprising, because IADL performance requires the integration of cognitive skills, and it may be difficult to detect contributions of single cognitive processes, especially when performance is combined across activities. It may be most appropriate to consider performance-based cognitive IADL assessments as indicators of the ability to perform cognitively-demanding daily activities in general or of the synergistic or additive effects of cognitive processes, rather than as measures of the ability to perform specific activities or of specific cognitive processes.

## Study limitations

This study has several limitations that can be addressed in future research. The generalizability of our results to the broader population with PD is limited because our sample was relatively young, primarily White, and had high education, high cognitive function, and relatively early and mild

disease progression. These features may have also limited our variance and ability to detect associations. Our cognitive assessment battery was limited by the use of the MMSE as a screen for dementia and the CANTAB as the sole neuropsychological test, which primarily uses visuospatial tasks. Future studies would benefit from a more sensitive cognitive screen (eg, the Montreal Cognitive Assessment), formal clinical diagnostic interview, and comprehensive neuropsychological battery. This would permit more certain diagnosis of dementia, the subgrouping of participants with PD without dementia into those with or without PD-related mild cognitive impairment,<sup>48</sup> and examination of the associations of verbal cognitive skills and/or more traditional neuropsychological test scores with PASS performance in PD. Additionally, inclusion of a more commonly used self- or informant-report IADL measure for comparison may provide further information on the clinical relevance of performance-based IADL assessment results. Finally, more specific, sensitive, or relevant measures of motor function (eg, dexterity, upper extremity use, CANTAB Reaction Time, UPDRS Motor rating closer to the time of IADL testing) may prove to be more strongly associated with IADL performance than general motor dysfunction severity or motor speed.

## Conclusions

In summary, we found reliable objective cognitive IADL performance problems among nondemented people with early PD that were specifically attributable to cognitive dysfunction. Accurate identification of early functional changes in people with PD is crucial for the timely initiation of interventions to prevent or attenuate further decline in function and quality of life. Our results provide support for the use of the PASS cognitive IADL tasks in functional evaluations to serve this purpose and supplement existing cognitive assessment methods in PD. Although it is critical to have functional outcome measures that are sensitive and specific to cognition, it is also important to recognize that “functional cognition,” or cognition in the context of daily activity performance, involves the integration of cognitive skills with other body functions and the environment.<sup>49</sup> It is clear from the inconsistencies in the existing literature that more research is needed to better understand the effects of the various PD-related impairments and other factors on cognitive IADL performance and to characterize the demands and purposes of the different performance-based IADL assessments. This information will aid in the selection of the most appropriate assessment for a given intervention depending on factors such as the intervention approach, targeted outcome, population, and setting. It will also lead to better understanding of daily function in PD, which will facilitate the development of more comprehensive and targeted interventions.

## Suppliers

- a. CANTAB cognitive assessment software; Cambridge Cognition.
- b. REDCap; Vanderbilt University.
- c. SPSS, version 25; IBM Corp.

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