Correlates of neuropsychiatric and motor tests with language assessment in patients with Lewy body dementia

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Abstract

Background: Lewy body dementia (LBD) impairs performance in daily activities and affects motor, language and visuospatial tasks. Objective: We aimed to correlate neuropsychiatric and motor assessments with language and visual organization tests in LBD. Methods: Twenty-two patients with dementia with Lewy bodies and ten patients with Parkinson’s disease dementia participated on a cross-sectional study that assessed cognition, functionality, caregiver burden, verbal fluency, the primer-level dictation section of the Boston Diagnostic Aphasia Examination (PLD-BDAE), the Hooper Visual Organization Test, the Neuropsychiatric Inventory and the Movement Disorder Society – Unified Parkinson’s Disease Rating Scale. Results: Language and visuospatial test results followed motor impairment and general cognitive performance. Whereas visual organization did not predict performance in the PLD-BDAE, visuospatial abilities and verbal fluency were concurrently associated, suggesting that linguistic impairment in LBD may be attributed to neuropsychological components of cognition and language. Only visual organization was associated with behaviour, suggesting that neuropsychiatric symptoms associate with differential impairment of visual organization in comparison with language in LBD. Schooling did not affect visual organization or language test performance, while the length of dementia was negatively associated with visual organization and verbal fluency. Discussion: Though visual organization tests follow behaviour and motor performance in LBD, there is differential impairment regarding language skills.

Keywords: Lewy body dementia, language, spatial processing, neuropsychiatry, neuropsychological tests.

Introduction

Deficits in visuospatial abilities, memory, executive functions and language are the most evident neuropsychological symptoms in patients with Lewy body dementia (LBD) syndromes, corresponding to frontal-striatal dopaminergic dysmodulation associated with diffuse cholinergic cortical dysfunction. Essentially, the spectrum of these syndromes consists of dementia with Lewy bodies and Parkinson’s disease dementia, comprising the second leading cause of degenerative dementia in older people after Alzheimer’s dementia (AD). Nevertheless, sensitivity of clinical diagnosis of LBD is not always good, particularly in severe dementia, although specificity tends to be high. The main etiological hypothesis for LBD entails the histopathological presence of Lewy bodies in the brainstem, subcortical nuclei, limbic cortex (cingulate cortex and amygdala), and in the neocortex. In Parkinson’s disease dementia, Lewy body formation and neuron loss usually start in brainstem nuclei and in the substantia nigra, whereas in dementia with Lewy bodies they occur in paralimbic and neocortical structures from disease onset. In addition, amyloid pathology helps predict the onset of dementia in parkinsonian syndromes. Nevertheless, cholinergic denervation is the main source of linguistic impairments in patients with LBD, particularly when involving cortical or subcortical language networks.

Approximately 80% of all patients with Parkinson’s disease develop dementia, more frequently when they are male and have more severe motor signs at examination. The burden of motor and neuropsychiatric manifestations of LBD considerably affects functional independence and social activities, impacting quality of life. Visuospatial skills and behavioural symptoms are helpful for differential diagnosis between LBD and AD, whereas cerebrovascular risk might be more important for pathogenesis of AD, but cholinesterase inhibitors are usually valuable for treatment of neuropsychiatric symptoms of both AD and LBD.

Despite the fact that some associations are well established for dementia syndromes, such as functional decline following cognitive decline in severe dementia, impairment of language has not been deeply studied in LBD. We hypothesized that language domains could be primarily affected in LBD, whereas motor signs, behavioural symptoms, linguistic and cognitive features would be concurrently impaired; therefore, we aimed to analyse associations of neuropsychiatric and motor assessments with language and visual organization test results in patients with LBD.

Methods

Participants

In this cross-sectional study, consecutive outpatients with LBD in different levels of clinical evolution were recruited from the Department of Neurology and Neurosurgery at Hospital São Paulo, Federal University of São Paulo (Unifesp). All patients with LBD who were followed at the outpatient clinic were assessed from January 2014 to April 2015. Diagnosis of Parkinson’s disease followed traditional
Clinical assessment

After diagnostic confirmation, patients and caregivers were assessed for: patient age, gender, schooling, estimated age at dementia onset, sleep satisfaction and estimated daily length of sleep, use of any medications, and scores on the Neuropsychiatric Inventory, the Mini-Mental State Examination, the Clinical Dementia Rating sum-of-boxes, a 15-item clock drawing test (free drawing), the Schwab & England scale, Lawton's Scale for Instrumental Activities of Daily Living, the Brazilian Version of the Zarit Caregiver Burden Interview, forward digit span and reverse digit span, the Movement Disorder Society – Unified Parkinson's Disease Rating Scale, and the Hoehn & Yahr stages in the off state.

In a second evaluation, patients with LBD were also assessed with the Hooper Visual Organization Test (HVOT), verbal fluency (VF), and the primer-level dictation section of the Boston Diagnostic Aphasia Examination (PLD-BDAE), including primer words, regular phonics, and common irregular words. All cognitive assessments were conducted on weekdays at morning time, by two examiners (FCM and FFO).

The Schwab & England scale was employed for overall performance in activities of daily living. A trichotomous version (1 = unable; 2 = able with help; 3 = able without help) of Lawton's Scale for Instrumental Activities of Daily Living was employed, with scores for using the telephone, getting to places beyond walking distance, grocery shopping, meal preparation, housekeeping, doing handyman work, doing laundry, taking own medications, and handling finances; caregivers provided all information, with a total score of 9 to 27.

For the HVOT, each participant was presented with 30 figures of fragmented objects in ascending order of difficulty. In the VF tasks, the patient should generate the largest possible number of words in one minute for each category, including words beginning with F, A and S (F-A-S), as well as all animals, fruits and grocery items that might be known. In the PLD-BDAE, the patient writes regular and irregular words to dictation.

Statistical analyses

Fisher's exact test and the Mann-Whitney test were used for comparisons of neurological features between dementia syndromes. Simple linear regressions were employed for comparisons between test results. A multiple linear regression model was employed for associations between each visual organization or language test (HVOT, VF, and the PLD-BDAE) and the following independent variables: schooling and length of the dementia syndrome; p-values were corrected with the Bonferroni test. The threshold of significance was set at p < 0.05.

Ethical aspects

This study is part of the research project 064990/2013 approved by the Ethics Committee of Hospital São Paulo, Unifesp, in October 2013. All invited patients and their legal representatives agreed to participate on the research and signed the Informed Consent Form before the evaluation.

Results

Overall, 39 participants were recruited; between the first and the second assessments, three patients passed away (7.7%), and four patients did not complete the second evaluation (10.3%), resulting in a final sample of 32 patients – 19 women (59.4%) and 13 men (40.6%). Twenty-one patients were diagnosed with probable dementia with Lewy bodies, one patient was diagnosed with possible dementia with Lewy bodies, nine patients were diagnosed with probable Parkinson's disease dementia, and one patient was diagnosed with possible Parkinson's disease dementia. Nineteen patients with dementia with Lewy bodies (86.4%) had visual hallucinations, versus six patients with Parkinson's disease dementia (60.0%), p = 0.165. Sixteen patients with dementia with Lewy bodies (72.7%) had parkinsonism, versus ten patients with Parkinson's disease dementia (100.0%), p = 0.142. Moreover, fifteen patients with dementia with Lewy bodies had fluctuations (68.2%). Demographic data and test results for all patients with LBD are summarized in Table 1.

There was no statistically significant difference between patients with dementia with Lewy bodies and patients with Parkinson's disease.

Table 1. Demographic data and test results

| Variables, n = 32 | Mean or n (%) | SD | Range |
|------------------|--------------|----|-------|
| Age at examination (years-old) | 75.84 | 9.1 | 54-89 |
| Age at dementia onset (years-old) | 71.14 | 9.8 | 50-87 |
| Length of the dementia syndrome (years) | 4.81 | 3.4 | 1-12 |
| Schooling (years) | 3.59 | 3.4 | 0-12 |
| Sleep Satisfaction | 23 (71.9%) | - | |
| Hours of Sleep | 8.25 | 2.3 | 4-13 |
| Daily amount of different medications | 5.03 | 2.5 | 0-13 |
| Daily amount of pills/injections | 7.42 | 5.4 | 0-25.5 |
| Clinical Dementia Rating sum-of-boxes (0.0-18.0 points) | 10.83 | 4.1 | 4.0-18.0 |
| Neuropsychiatric Inventory (0-144 points) | 41.25 | 19.5 | 7-84 |
| Mini-Mental State Examination (0-30 points) | 17.72 | 5.7 | 7-27 |
| Clock Drawing Test (0-15 points) | 5.16 | 4.1 | 0-15 |
| Schwab & England scale (0%-100%) | 56.56% | 25.6% | 10%-90% |
| Lawton's Scale for Instrumental Activities of Daily Living (9-27 points) | 13.41 | 4.4 | 9-22 |
| Brazilian Version of the Zarit Caregiver Burden Interview (0-56 points) | 20.00 | 8.4 | 3-35 |
| Forward Digit Span | 4.72 | 1.3 | 3-8 |
| Reverse Digit Span | 2.25 | 0.7 | 1-3 |
| MDS-UPDRS – Part I | 19.53 | 5.5 | 6-30 |
| MDS-UPDRS – Part II | 17.97 | 11.9 | 0-42 |
| MDS-UPDRS – Part III | 33.38 | 26.5 | 1-99 |
| MDS-UPDRS – Part IV | 3.47 | 5.0 | 0-17 |
| Hoehn & Yahr stage – OFF state (0-5) | 2.88 | 1.6 | 0-5 |
| Hooper Visual Organization Test | 6.97 | 3.4 | 0-15 |
| Verbal Fluency (F-A-S) | 6.44 | 5.7 | 0-24 |
| Verbal Fluency (animals) | 6.78 | 4.1 | 0-18 |
| Verbal Fluency (fruits) | 5.59 | 2.4 | 0-10 |
| Verbal Fluency (grocery items) | 6.31 | 3.7 | 0-15 |
| PLD-BDAE | 5.06 | 5.6 | 0-18 |

SD: standard deviation; MDS-UPDRS: Movement Disorder Society – Unified Parkinson's Disease Rating Scale; PLD-BDAE: primer-level dictation section of the Boston Diagnostic Aphasia Examination.
dementia regarding age (p = 0.291), gender (p = 0.999), schooling (p = 0.597), age at dementia onset (0.626), estimated length of sleep (p = 0.143), use of different medications (p = 0.067), or scores on the Neuropsychiatric Inventory (p = 0.655), the Mini-Mental State Examination (p = 0.382), the Clinical Dementia Rating sum-of-boxes (p = 0.291), the clock drawing test (p = 0.092), the Brazilian Version of the Zarit Caregiver Burden Interview (p = 0.871), forward digit span (p = 0.291), reverse digit span (p = 0.371), the HVOT (p = 0.855) or VF (p = 0.999), but patients with dementia with Lewy bodies were more satisfied with their sleep (p = 0.013).

Table 2 summarizes the results from simple linear regressions between visual organization and language test results for all patients with LBD. Visual organization was associated with category VF, whereas all language tests were correlated with each other, except for the association between VF (animals) and the PLD-BDAE.

Tables 3 and 4 list results from simple linear regressions regarding visual organization and language tests for predictions of associations with other neuropsychiatric features. Visual organization was associated with basic (but not instrumental) functionality, general cognitive tests, motor examination and the Neuropsychiatric Inventory total scores. All categories of VF were associated with general cognitive tests, and inversely associated with global dementia rating; however, only VF for F-A-S and for fruits was associated with the clock drawing test, only VF for F-A-S and for grocery items was associated with non-motor experiences of daily living, and only VF for fruits was associated with motor experiences of daily living and motor examination. All categories of VF were associated with forward digit span, except for fruits, the only category associated with reverse digit span. Sleep satisfaction was negatively associated with all categories of VF, except for fruits. The PLD-BDAE was associated with basic (but not instrumental) functionality, general cognitive tests, motor experiences of daily living and motor examination. Length of sleep, instrumental functionality, and caregiver distress regarding behavioural symptoms had no significant associations with visual organization or language tests.

Table 5 lists results from multiple linear regressions involving language and visual organization tests. Schooling did not affect performance in any test, while the length of the dementia syndrome was negatively associated with performance in the HVOT and VF (animals).

### Table 2. Results from simple linear regressions for predictions between visual organization and language test results

| Variable 1          | Variable 2          | Squared multiple R | t     | F-ratio | p-value |
|---------------------|---------------------|--------------------|-------|---------|---------|
| HVOT                | VF (F-A-S)          | 0.118              | 2.003 | 4.013   | 0.051   |
| HVOT                | VF (Fruits)         | 0.043              | 1.790 | 3.203   | 0.004   |
| HVOT                | VF (grocery items)  | 0.246              | 3.125 | 9.788   | <0.001  |
| HVOT                | PLD-BDAE            | 0.096              | 1.790 | 3.203   | 0.004   |
| VF (F-A-S)          | VF (animals)        | 0.453              | 4.983 | 24.826  | <0.001  |
| VF (F-A-S)          | VF (fruits)         | 0.171              | 2.485 | 6.177   | <0.001  |
| VF (F-A-S)          | VF (grocery items)  | 0.445              | 4.909 | 24.096  | <0.001  |
| VF (F-A-S)          | PLD-BDAE            | 0.213              | 2.851 | 8.126   | <0.001  |
| VF (animals)        | VF (fruits)         | 0.288              | 3.313 | 10.975  | <0.001  |
| VF (animals)        | VF (grocery items)  | 0.586              | 6.516 | 42.465  | <0.001  |
| VF (animals)        | PLD-BDAE            | 0.045              | 1.185 | 1.404   | 0.244   |
| VF (fruits)         | VF (grocery items)  | 0.470              | 5.161 | 26.640  | <0.001  |
| VF (fruits)         | PLD-BDAE            | 0.134              | 2.156 | 4.647   | 0.037   |
| VF (grocery items)  | PLD-BDAE            | 0.151              | 2.306 | 5.391   | 0.027   |

HVOT: Hooper Visual Organization Test; VF: verbal fluency; PLD-BDAE: primer-level dictation section of the Boston Diagnostic Aphasia Examination.

### Table 3. Results from simple linear regressions for predictions between test results (with reference to visual organization and language functions)

| Variable 1          | Variable 2          | Squared multiple R | t     | F-ratio | p-value |
|---------------------|---------------------|--------------------|-------|---------|---------|
| HVOT                | Clinical Dementia Rating sum-of-boxes | 0.272              | -3.352 | 11.234  | 0.002   |
| HVOT                | 15-item Clock Drawing Test | 0.217              | 2.880  | 8.293   | 0.007   |
| HVOT                | Forward Digit Span  | 0.046              | 1.208  | 1.459   | 0.235   |
| HVOT                | Reverse Digit Span  | 0.025              | 0.870  | 0.758   | 0.605   |
| HVOT                | Lawton’s Scale for Instrumental Activities of Daily Living | 0.079              | 1.604  | 2.573   | 0.116   |
| HVOT                | Schwab & England scale | 0.212              | 2.833  | 8.058   | 0.008   |
| HVOT                | Mini-Mental State Examination | 0.239              | 3.071  | 9.433   | 0.005   |
| HVOT                | MDS-UPDRS – Part I  | 0.015              | -0.679 | 0.461   | 0.609   |
| HVOT                | MDS-UPDRS – Part II | 0.002              | -1.475 | 3.046   | 0.088   |
| HVOT                | MDS-UPDRS – Part III | 0.136              | -2.169 | 4.707   | 0.036   |
| HVOT                | Hoehn & Yahr stage – OFF | 0.139              | -2.198 | 4.833   | 0.034   |
| VF (F-A-S)          | Clinical Dementia Rating sum-of-boxes | 0.239              | -3.072 | 9.437   | 0.005   |
| VF (F-A-S)          | 15-item Clock Drawing Test | 0.164              | 2.429  | 5.900   | 0.020   |
| VF (F-A-S)          | Forward Digit Span  | 0.314              | 3.703  | 13.715  | 0.001   |
| VF (F-A-S)          | Reverse Digit Span  | <0.001             | 0.116  | 0.013   | 0.904   |
| VF (F-A-S)          | Lawton’s Scale for Instrumental Activities of Daily Living | 0.057              | 1.351  | 1.826   | 0.184   |
| VF (F-A-S)          | Schwab & England scale | 0.043              | 1.156  | 1.336   | 0.256   |
| VF (F-A-S)          | Mini-Mental State Examination | 0.313              | 3.889  | 15.128  | <0.001  |
Discussion

In this study, associations among neuropsychiatric features of patients with LBD could be more accurately evaluated by specific tests. Knowledge of less studied clinical features, such as language disorders in LBD, can be useful to promote deinstitutionalized care and caregiver education.

Visual organization and PLD-BDAE test results were not significantly correlated, suggesting that the HVOT does not predict performance in the PLD-BDAE; in other words, this finding confirms that impairment of language may be a primary feature of LBD, and not necessarily secondary to cognitive deficits. Nonetheless, VF and visuospatial abilities were concurrently associated in LBD. Visual organization is related to the frontal-subcortical circuitry that is not necessarily secondary to cognitive deficits.
affected early in the course of LBD\textsuperscript{36}. Moreover, poor VF is associated with incident dementia in Parkinson’s disease, and could be due to impaired self-generated search\textsuperscript{37}. Nevertheless, other studies have found that naming tests can be the best predictor of performance in the HVOT\textsuperscript{38}. Patients with dementia with Lewy bodies have disproportionate deficits in visuospatial skills, attention and letter fluency\textsuperscript{36}. Visuospatial processing, attention and executive functions in Parkinson’s disease dementia have also been described to be similar to dementia with Lewy bodies\textsuperscript{37}.

Impaired connectivity with the frontal cortex leads to severely impaired grammatical expression in patients with LBD: failing to complete sentences, omitting the verb phrase, perseveration, and impaired self-generated search\textsuperscript{37}.}

Table 4. Results from simple linear regressions for predictions between visual organization and language tests, features of sleep and neuropsychiatric inventory test results

| Variable 1 | Variable 2 | Squared multiple R | t | F-ratio | p-value |
|------------|------------|--------------------|---|---------|---------|
| HVOT       | 12-item Neuropsychiatric Inventory total scores | 0.152 | 2.323 | 5.396 | 0.026 |
| HVOT       | 12-item Neuropsychiatric Inventory – caregiver distress total scores | 0.084 | 1.663 | 2.765 | 0.103 |
| HVOT       | Sleep satisfaction | 0.017 | -0.712 | 0.507 | 0.511 |
| HVOT       | Hours of sleep | 0.051 | -1.270 | 1.613 | 0.211 |
| VF (F-A-S) | 12-item Neuropsychiatric Inventory total scores | 0.097 | -1.791 | 3.208 | 0.080 |
| VF (F-A-S) | 12-item Neuropsychiatric Inventory – caregiver distress total scores | 0.011 | -0.589 | 0.347 | 0.567 |
| VF (F-A-S) | Sleep satisfaction | 0.170 | -2.479 | 6.146 | 0.018 |
| VF (F-A-S) | Hours of sleep | 0.019 | -0.769 | 0.592 | 0.546 |
| VF (ANIMALS) | 12-item Neuropsychiatric Inventory total scores | 0.008 | -0.505 | 0.295 | 0.623 |
| VF (ANIMALS) | 12-item Neuropsychiatric Inventory – caregiver distress total scores | <0.001 | -0.097 | 0.009 | 0.920 |
| VF (ANIMALS) | Sleep satisfaction | 0.140 | -2.213 | 4.899 | 0.033 |
| VF (ANIMALS) | Hours of sleep | 0.051 | -1.273 | 1.621 | 0.210 |
| VF (FRUITS) | 12-item Neuropsychiatric Inventory total scores | 0.005 | 0.383 | 0.147 | 0.706 |
| VF (FRUITS) | 12-item Neuropsychiatric Inventory – caregiver distress total scores | 0.005 | 0.383 | 0.146 | 0.706 |
| VF (FRUITS) | Sleep satisfaction | 0.100 | -1.825 | 3.330 | 0.075 |
| VF (FRUITS) | Hours of sleep | 0.060 | -1.381 | 1.907 | 0.174 |
| VF (GROCERY ITEMS) | 12-item Neuropsychiatric Inventory total scores | <0.001 | -0.080 | 0.006 | 0.934 |
| VF (GROCERY ITEMS) | 12-item Neuropsychiatric Inventory – caregiver distress total scores | 0.025 | 0.873 | 0.763 | 0.607 |
| VF (GROCERY ITEMS) | Sleep satisfaction | 0.166 | -2.441 | 5.957 | 0.020 |
| VF (GROCERY ITEMS) | Hours of sleep | 0.025 | -0.873 | 0.762 | 0.606 |
| PLD-BDAE | 12-item Neuropsychiatric Inventory total scores | 0.002 | -0.269 | 0.073 | 0.785 |
| PLD-BDAE | 12-item Neuropsychiatric Inventory – caregiver distress total scores | 0.011 | -0.567 | 0.322 | 0.581 |
| PLD-BDAE | Sleep satisfaction | <0.001 | 0.039 | 0.001 | 0.968 |
| PLD-BDAE | Hours of sleep | 0.010 | 0.540 | 0.291 | 0.600 |

**Table 5. Multiple linear regressions for visual organization and language test results**

| Variable (units) | Coefficient** | Coefficient** for schooling | Coefficient** for the length of dementia | Adjusted squared multiple R | t | F-ratio | p-value** for the regression |
|------------------|---------------|-----------------------------|------------------------------------------|-----------------------------|---|---------|-----------------------------|
| HVOT             | 8.259 (p < 0.001) | 0.210 (p = 0.242) | -0.425 (p = 0.025) | 0.113 | 7.591 | 2.980 | 0.067 |
| VF (F-A-S)       | 6.783 (p < 0.001) | 0.3 (p = 0.341) | -0.296 (p = 0.358) | 0.000 | 3.534 | 0.716 | 0.497 |
| VF (ANIMALS)     | 8.508 (p < 0.001) | 0.146 (p = 0.504) | -0.468 (p = 0.042) | 0.075 | 6.363 | 2.259 | 0.123 |
| VF (FRUITS)      | 6.615 (p < 0.001) | -0.096 (p = 0.463) | -0.141 (p = 0.292) | 0.009 | 8.312 | 1.143 | 0.333 |
| VF (GROCERY ITEMS) | 7.295 (p < 0.001) | 0.083 (p = 0.643) | -0.273 (p = 0.191) | 0.000 | 5.891 | 0.903 | 0.416 |
| PLD-BDAE         | 3.889 (p = 0.048) | 0.443 (p = 0.155) | -0.087 (p = 0.781) | 0.004 | 2.067 | 1.069 | 0.356 |

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*Multiple linear regressions for each of the listed dependent variables in relation to the following factors (2 degrees of freedom): schooling (years) and estimated length of the dementia syndrome (years).

**All p-values have been corrected with the Bonferroni test.

SD: standard deviation; HVOT: Hooper Visual Organization Test; VF: verbal fluency; PLD-BDAE: primer-level dictation section of the Boston Diagnostic Aphasia Examination.
requiring additional time to plan sentences. We observed similar errors in the narrative discourse of our patients, but it should be noted that cortical involvement may occur earlier in dementia with Lewy bodies compared to Parkinson's disease dementia.

Cognitive and functional tests are usually correlated with one another in all stages of AD. In our study with patients with LBD, we found that the higher the Clinical Dementia Rating sum-of-boxes scores, the lower were language and visuospatial test results. Likewise, language and visuospatial test results followed Mini-Mental State Examination scores. This could be helpful for differential diagnoses, since visuospatial abilities are more impaired in LBD than in other dementia syndromes. In comparison with AD, patients with LBD have better contextual verbal delayed recall and recognition, and less short-term memory deficits, but worse letter fluency deficits and qualitative measures of executive functioning, and worsening visuoconstruction following overall cognitive decline.

The Hoehn and Yahr stages grade severity of parkinsonism, while the clock drawing test is a measure of visuospatial dysfunction also useful for screening cognitive impairment. When performances in the HVOT and in the PLD-BDAE were worse, patients also had more severe parkinsonism and lower scores in the clock drawing test. It has been shown that patients with LBD who lose more motor function also have the greatest visuospatial impairment.

Only VF had a negative association with sleep satisfaction, but not with length of sleep, suggesting that sleep satisfaction may be inversely correlated with the stage of LBD. Sleep disturbances occur in three quarters of autopsy-confirmed cases of dementia with Lewy bodies, but may not necessarily correlate with sleep satisfaction; in addition to attentional, executive functioning, and visuospatial impairments, the presence of impaired verbal learning helps identify prodromal dementia with Lewy bodies in patients with sleep disorders. Moreover, it has been shown that the severity of psychotic symptoms in patients with Parkinson's disease is directly associated with the severity of cognitive impairment and sleep disturbances.

In our analyses, only the HVOT was associated with total scores of the Neuropsychiatric Inventory. Behavioural symptoms may affect sustained attention and, therefore, cognitive functioning. Despite the increased frequency of visual hallucinations in LBD when compared to other dementia syndromes, they also lead to worse prognosis. Still regarding neuropsychiatric symptoms, caregiver distress had no significant associations with visual organization or language tests, possibly representing low sensitivity to score variations in these tests.

All categories of VF were associated with forward digit span, except for fruits, the only category associated with reverse digit span. These findings suggest that attention and executive functions are important for most forms of category VF, but working memory might not decline concurrently.

Visual organization and language performance were not affected by education. This could be due to the cross-sectional nature of our study, but also to the fact that mechanisms of neurodegeneration supersede protective factors in these patients.

The length of the dementia syndrome was negatively associated with visual organization and VF for animals, an important finding to be correlated with the rapid cognitive decline usually found in patients with LBD. On the other hand, instrumental functionality had no significant associations with visual organization or language tests, possibly due to the fact that instrumental functional decline occurs earlier, while visuospatial and language decline happen throughout the course of LBD.

The most important limitations of our study comprise its small sample size, its cross-sectional nature, and the fact that all patients were recruited from a single centre, thus limiting generalizability. Also, the size of our sample did not allow stratification into patient groups according to diagnoses (dementia with Lewy bodies or Parkinson's disease dementia), but pathophysiology is similar for these two diseases, and our results were mostly unaffected by this choice. Furthermore, the wide age range of the patients (spanning 45 years) could have affected our results due to the fact that young and older adults use different strategies to accommodate to impairments in executive function, but, considering that all patients were over 50 years-old and had at least one year of dementia diagnosis, we believe this to be unlikely.

We conclude that language and visual organization tend to follow motor skills and general cognitive performance in patients with LBD. Whereas visual organization did not predict performance in the PLD-BDAE, visuospatial abilities and VF were concurrently associated, suggesting that features of linguistic impairment in LBD may be attributed to components of cognition and language. Moreover, only visual organization was associated with behavioural performance, suggesting that neuropsychiatric symptoms are differentially associated with visual organization in comparison with linguistic features in LBD. Future studies should address neuropsychiatric correlations in prospective assessments.

Conflicts of interest

The authors report no conflicts of interest related to this paper.

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