# The Dementia Cognitive Fluctuation Scale, a New Psychometric Test for Clinicians to Identify Cognitive Fluctuations in People with Dementia

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**Objectives:** *Cognitive fluctuation (CF) is a common feature of dementia and a core diagnostic symptom for dementia with Lewy bodies (DLB). CF remains difficult to accurately and reliably detect clinically. This study aimed to develop a psychometric test that could be used by clinicians to facilitate the identification of CF and improve the recognition and diagnosis of DLB and Parkinson disease, and to improve differential diagnosis of other dementias.* **Methods:** *We compiled a 17-item psychometric test for identifying CF and applied this measure in a cross-sectional design. Participants were recruited from the North East of England, and assessments were made in individuals' homes. We recruited people with four subtypes of dementia and a healthy comparison group, and all subjects were administered this pilot scale together with other standard ratings. The psychometric properties of the scale were examined with exploratory factor analysis. We also examined the ability of individual items to identify CF to discriminate between dementia subtypes. The sensitivity and specificity of discriminating items were explored along with validity and reliability analyses.* **Results:** *Participants comprised 32 comparison subjects, 30 people with Alzheimer disease, 30 with vascular dementia, 29 with DLB, and 32 with dementia associated with Parkinson disease. Four items significantly discriminated between dementia groups and showed good levels of sensitivity (range: 78.6%–80.3%) and specificity (range: 73.9%–79.3%). The scale had very good levels of test–retest (Cronbach's alpha: 0.82) and interrater (0.81) reliabilities. The four items loaded onto three different factors. These items were: 1) marked differences in functioning during the daytime; 2) daytime somnolence; 3) daytime drowsiness; and 4) altered levels of consciousness during the day.* **Conclusions:** *We identified four items that provide valid, sensitive, and specific questions for reliably identifying CF and distinguishing the Lewy body dementias*

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*from other major causes of dementia (Alzheimer disease and vascular dementia).*
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Cognitive fluctuations (CF) are spontaneous alterations in cognition, attention, and arousal. They are common features in all types of dementia, occurring in about 20% of people with Alzheimer disease (AD);[1–3] in 35%–50% of people with vascular dementia (VaD);[4,5] and are more frequent in people with dementia with Lewy bodies (DLB) and dementia associated with Parkinson disease (PDD), being reported in around 90% of each.[6–8] As a result, CF are a core diagnostic feature of DLB.[7] Both DLB and PDD are generally considered to be part of the same spectrum with similar neuropsychiatric phenomena (e.g., CF, hallucinations, rapid eye movement sleep behavior disorder), and the same underlying pathologic features of alpha-synucleinopathy are present in both of these forms of dementia.[9,10] We therefore use the term *Lewy body dementia* (LBD) when referring to both of these dementias, with PDD and DLB being considered as a single entity. Although different diagnostic criteria are recognized for all major subtypes of dementia, there is ongoing debate about the degree of overlap between LBD, especially DLB, and AD, as well as between AD and VaD. This confusion is in part due to the identification of multiple pathologies in people with dementia at autopsy[11] but also because of the difficulty clinically in distinguishing subtypes. People with DLB are often misdiagnosed as having AD,[12,13] and one of the factors contributing to this misdiagnosis is the inaccurate recognition of CF. The identification and assessment of CF still present a major clinical challenge[7,14,15] despite several attempts to identify, quantify, and assess the phenomenon.[6,16–21] Failure to accurately recognize CF contributes to the poor differential diagnosis of DLB because it is one of the three core diagnostic features, of which two need to be present for a confident diagnosis of DLB (probable DLB), and this in turn leads to poorer differential diagnosis in dementia overall. Furthermore, poor recognition of CF represents an important clinical issue because the inaccurate diagnosis of people with DLB leads to inappropriate management, including the prescription of antipsychotic medications; approximately 40% of patients with DLB who are prescribed antipsychotic medications will exhibit increased sensitivity to these agents, often with serious or even fatal consequences.[15,16]

The goal of the current study was to develop a short instrument by identifying questions that could be used by all physicians assessing subjects with possible dementia, or known dementia, to facilitate the identification of CF and thus improve the recognition and diagnosis of DLB and PDD, and concomitantly to improve the differential diagnosis of the other dementias. Given the overlap of PDD and DLB, and because CF in particular are the same psychopathologically in PDD and DLB,[21] the DLB and PDD groups were then merged for the primary analyses and compared with the non-LBD groups (AD and VaD) combined. For other analyses, dementia groups were considered separately.

## METHODS

The Dementia Cognitive Fluctuation Scale (DCFS) was designed based on three preexisting measures: the Mayo Composite Fluctuations Scale (MCFS),[6] the Clinician Assessment of Fluctuation,[17] and the One Day Fluctuation Assessment Scale (ODFAS).[17] The grant applicants for this study who are experienced in LBD research (AJT, UM, and IM) met and discussed the items from these measures together with Dr. Lee to identify which items to include in the pilot version for this study. MCFS items that sensitively distinguished between groups were selected and included in the DCFS (e.g., drowsiness, sleepiness, staring into space). Items from the Clinician Assessment of Fluctuation and ODFAS that were considered to represent CF (e.g., alertness, confusion, daytime somnolence) were also included in the DCFS; items considered unrelated to CF (e.g., falls) were excluded. The final version of the pilot DCFS to be investigated in the current study comprised 17 questions under 4 domains that might identify CF in people with dementia: confusion, sleep, alertness, and communication.[6,17] Appendix 1 (available online)

presents the DCFS as used in the current study. Based on earlier work,[6] our power calculation suggested that group sizes of approximately 30 would have sufficient power to detect significant differences between groups using these questions.

### Study Participants

The healthy older comparison participants were recruited through local advertisements, were cognitively intact, and did not have any psychiatric illness. This status was confirmed at the interview by the researcher (DL), a psychologist experienced in dementia, and by a Mini–Mental State Examination (MMSE) score >27. Patients were recruited through referrals from Old Age Psychiatry and Neurology National Health Service (NHS) programs in the North East of England and had had a dementia subtype diagnosis made in NHS services (AD, DLB, PDD, and VaD). The case notes were reviewed by two of the three Old Age Psychiatrists on the research team (AJT, AGN, and LG) to confirm that the diagnosis met appropriate internationally recognized diagnostic criteria before entry into the study: probable AD,[22] probable DLB,[7] possible or probable VaD,[5] and probable PDD.[23] Patients with possible or probable VaD were recruited to capture a sample more representative of clinical practice in nonspecialist settings. Where there was disagreement over diagnosis, the three Old Age Psychiatrists reviewed the case notes to reach a consensus agreement on diagnosis. We chose to include possible and probable categories for VaD to ensure we captured a representative cohort of older patients with dementia. Participants were group-matched for age and gender, and participants with dementia were group-matched for cognitive status by using the MMSE.[24]

Ethical approval for this study was obtained from the NHS Research Ethics Committee. All participants and their identified primary caregivers were approached for written informed consent. Where patients lacked capacity, the patients' primary caregivers provided written advice as consultees on behalf of the person with dementia, consistent with the provisions of the Mental Capacity Act (2005) and in accordance with ethical approval for this study.

### Study Assessments

All participants were examined by Dr. Lee (who was blinded to patients' diagnoses until the end of all data collection) by using: 1) the Unified Parkinson's Disease Rating Scale II and III;[25] 2) the Cambridge Examination for Mental Disorders in the Elderly;[26] 3) the Neuropsychiatric Inventory;[27] and 4) the pilot 17-item DCFS. The pilot DCFS was administered by Dr. Lee to caregivers for subjects with dementia and self-rated for the comparison group. A subgroup of participants was recontacted within 2 weeks of the initial testing to repeat the DCFS to examine test–retest reliability of the measure. A further subgroup was recontacted within 2 weeks of initial testing by another researcher (LG) to repeat the DCFS to examine the interrater reliability of the measure. Both of these groups comprised subjects with dementia from each of the diagnostic groups and subjects from the healthy comparison group. The test–retest group (n = 22) comprised 2 comparison participants, 10 AD patients, 4 VaD patients, 3 DLB patients, and 3 PDD patients. The interrater reliability group (n = 25) comprised 3 comparison participants, 5 AD patients, 4 VaD patients, 4 DLB patients, and 9 PDD patients.

### Analysis of Data

Between-group differences on all measures were conducted by using one-way analyses of variance (ANOVAs) with post hoc Bonferroni corrections applied to significant differences between groups (comparison group versus AD versus VaD versus DLB versus PDD). Homogeneity of variance was examined by using Levene's tests. As explained earlier, for the primary analyses, data were combined and grouped for those participants with LBD (DLB and PDD) and those with other dementias (AD and VaD), and between-group differences were again conducted by using one-way ANOVAs. Levene's tests were again used to examine the homogeneity of variance between groups. The psychometric properties of the DCFS were determined by using exploratory factor analysis, using varimax rotations and selecting items that loaded onto factors within the analysis at eigenvalues >1; items were considered to load significantly onto a factor if their component score was >0.5.[28] The sensitivity and specificity of the significantly discriminative DCFS items (as identified by using ANOVAs [described earlier]) were explored by using receiving operating characteristic (ROC) curves. Between-subject one-way ANOVA was used

**TABLE 1. Demographic and Clinical Data According to Diagnostic Group from DCFS Study Participants**

| | Comparison (n = 32) | AD (n = 30) | VaD (n = 30) | DLB (n = 29) | PDD (n = 32) |
|---|---|---|---|---|---|
| Patient age | 79.3 (6.9) | 77.9 (6.4) | 81.4 (6.9) | 80.3 (6.7) | 75.9 (5.7)[a] |
| No. (%) male | 15 (46.9) | 14 (46.7) | 15 (50.0) | 17 (58.6) | 27 (84.6)[b] |
| Years of education | 11.2 (2.8) | 9.8 (2.0) | 9.4 (0.9)[c] | 9.6 (1.3) | 11.0 (3.0) |
| Caregiver age[d] | No Carer | 64.0 (11.6) | 68.0 (13.1) | 63.4 (13.8) | 67.2 (9.3) |
| UPDRS2[e] | 1.3 (2.0) | 5.2 (5.0) | 8.1 (5.6) | 14.7 (8.3) | 21.5 (7.8) |
| UPDRS3[f] | 5.5 (7.4) | 16.1 (13.3) | 24.6 (14.3) | 38.2 (17.2) | 44.2 (14.3) |
| CAMCOG total[g] | 95.0 (7.5) | 61.8 (13.8) | 58.8 (17.0) | 58.1 (20.4) | 68.9 (14.9) |
| MMSE[h] | 28.4 (1.5) | 17.9 (5.0) | 17.6 (6.3) | 15.8 (6.1)[i] | 19.7 (5.5) |
| NPI total | 3.1 (4.5)[j] | 16.8 (18.4)[k] | 22.6 (16.3) | 27.4 (21.3) | 31.6 (18.1) |

*Notes:* Values are mean (standard deviation) unless otherwise noted. Assessment consisted of one-way analyses of variance ($df = 4, 148$) with post hoc Bonferroni tests to examine significant differences between groups, except patient gender, which was examined by using a $\chi^2$ test. All F tests were significant except where indicated in the following footnotes. AD: Alzheimer disease; CAMCOG: Cambridge Cognition Examination; DLB: dementia with Lewy bodies; MMSE: Mini–Mental State Examination; NPI: Neuropsychiatric Inventory; PDD: dementia associated with Parkinson disease; UPDRS: Unified Parkinson's Disease Rating Scale; VaD: vascular dementia.

[a]PDD significantly younger than VaD ($p = 0.01$); no other significant differences in age between groups.
[b]Significantly more male PDD patients than female ($\chi^2 = 13.1$; $p = 0.011$; $df = 4, 153$).
[c]VaD significantly fewer years of education than comparison ($p = 0.014$ ) and PDD ($p = 0.044$).
[d]No significant differences between groups.
[e]All groups significantly different at $p < 0.001$ except comparison versus AD ($p = 0.125$) and AD vs VaD ($p = 0.700$).
[f]All groups significantly different from each other at $p < 0.05$ other, except AD versus VaD ($p = 0.168$) and DLB versus PDD ($p = 0.868$).
[g]All groups significantly different from comparison ($p < 0.05$).
[h]All groups significantly different from comparison ($p < 0.01$).
[i]DLB significantly different from PDD ($p = 0.041$).
[j]Comparison significantly different from all other groups ($p < 0.016$).
[k]AD significantly different from PDD ($p = 0.006$).

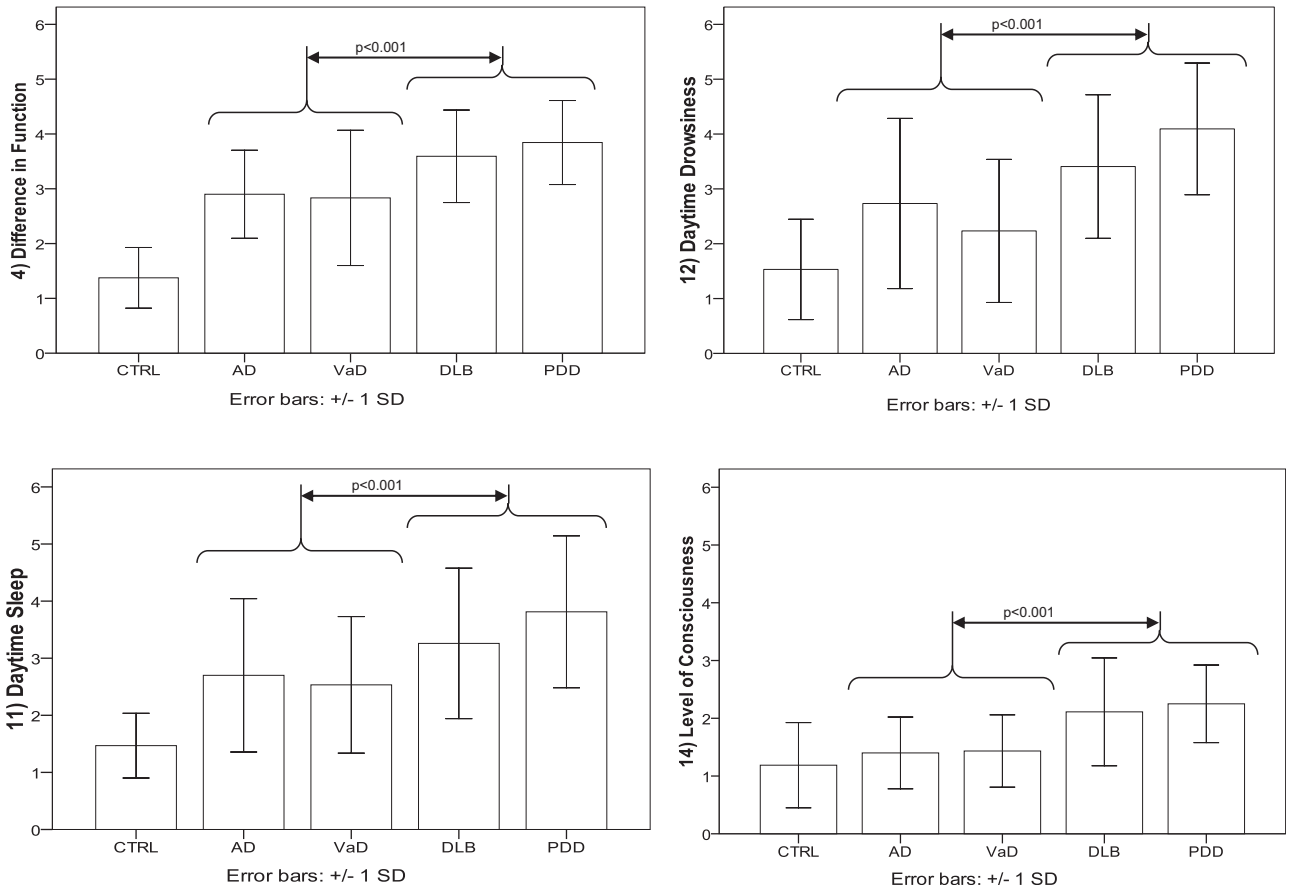
to explore differences in medication consumption between groups. Tests for interrater and test–retest reliabilities of the discriminating DCFS items were conducted by using Pearson's correlations.

## RESULTS

The final study cohort comprised 153 subjects: 30 AD, 29 DLB, 30 VaD, 32 PDD, and 32 healthy older comparison participants. Test–retest data on the DCFS were collected from 22 caregivers, and interrater reliability data were collected from 25 caregivers (both within 2 weeks of initial testing). Demographic and clinical data from all participants who participated in the study are presented in Table 1.

Combining AD and VaD groups (other dementia) and comparing that data with data from the LBD groups (DLB and PDD combined), we found no significant differences in age: LBD group mean (standard deviation) age was 78.0 (6.5) years versus 79.7 (6.8) years in the other dementia group. We also found no significant differences in cognitive function as measured by using the Cambridge Examination for Mental Disorders in the Elderly total score (LBD mean score: 60.3 [15.4]; other dementia mean score: 64.0 [18.3]) and the MMSE (LBD mean score: 17.8 [6.0]; other dementia mean score: 17.7 [5.6]) by using ANOVA (all $p > 0.3$). Comparison of gender balance between these groups was nonsignificant for the other dementia group (29 men, 31 women), but there was a significantly larger number of male subjects in the LBD group (44 men, 17 women; Pearson's $\chi^2 = 7.16$; $p = 0.07$; $df = 3, 153$) due to the large prevalence (27 of 32 [86.4%]) of males in the PDD group. Because age, gender, and education levels were similar across groups (with the exception of more males in the PDD group), these variables were not corrected for in the analyses to maintain statistical power. Table 1 provides demographic and clinical data for each diagnostic group. Study subjects were taking the usual range of nonpsychotropic medications for people their age. All dementia groups included subjects taking acetylcholinesterase inhibitors, with those with VaD taking significantly fewer than other dementia groups ($F_{[3, 106]} = 13.62$; $p < 0.001$). Dopaminergic medication was only being used by LBD subjects, and examining the impact of these drugs on DCFS items indicated no drug-related

**FIGURE 1. Histograms of significantly discriminative Dementia Cognitive Fluctuation Scale items. p values indicate significant differences between Alzheimer disease (AD) and vascular dementia (VaD) groups combined versus those with dementia with Lewy bodies (DLB) and dementia associated with Parkinson disease (PDD) combined. Tests were one-way analysis of variance ($df = 4, 148$). Values are given as mean (standard deviation).**




effects: ANOVA of DCFS items grouped by those consuming dopaminergic medication compared with those not taking these agents revealed no significant differences in DCFS items scores (all $F < 3.00$; all $p > 0.09$; $df = 1, 152$).

The DCFS comprised 17 questions, but only 5 were significantly discriminative across all 4 dementia groups and comparison participants. These questions were derived from our primary analysis of the LBD group versus other dementia groups. The 17 questions on the full DCFS are shown in Appendix 2 (available online), where items with an asterisk are those that significantly discriminated between dementia groups. These discriminative items are presented in the proposed researcher and clinician versions of the DCFS in Appendices 2 and 3 (available online; without item 10, which relates to the presence of rapid eye movement sleep behavior disorder and, as such, is not related to CF per se). This item was included because REM sleep behaviour disorder is another recognized core symptom in the diagnostic criteria for LBD that has been shown to discriminate LBD from other dementias.[7] For brevity, the remainder of this article will only explore these four discriminative items* (4, 11, 12, and 14) while omitting item 10.

Figure 1 presents histograms of these four discriminative items across the five groups examined in this study, but significance data relate to differences between LBD (DLB and PDD) and other (AD and VaD) combined group data. The internal consistency of the DCFS was explored by using exploratory factor analytic techniques. The rotated

**TABLE 2. ROC Defined AUC, Specificity, and Sensitivity Data of DCFS Items at Distinguishing Between LBD (DLB and PDD) and Other (AD and VaD) Dementia Groups**

| | ROC AUC | Sensitivity (%) | Specificity (%) | 95% CI |
|---|---|---|---|---|
| Item 4: difference in function | 0.818 | 70.5 | 82.6 | 0.751–0.885 |
| Item 11: daytime sleep | 0.761 | 74.5 | 67.4 | 0.682–0.839 |
| Item 12: daytime drowsiness | 0.784 | 80.3 | 67.4 | 0.710–0.858 |
| Item 14: consciousness | 0.787 | 80.3 | 73.9 | 0.711–0.863 |
| Items 4, 11, 12, and 14 combined | 0.864 | 78.7 | 75.0 | 0.806–0.921 |
| Items 4, 11, and 12 combined | 0.856 | 80.3 | 73.9 | 0.798–0.915 |
| Items 4, 11, and 14 combined | 0.860 | 78.6 | 76.9 | 0.801–0.919 |
| Items 4, 12, and 14 combined | 0.865 | 80.3 | 75.0 | 0.808–0.902 |
| Items 11, 12, and 14 combined | 0.827 | 78.7 | 79.3 | 0.760–0.893 |

*Notes:* Combined ROC analyses were conducted to explore the three most discriminative questions. Each item was scored on a 1- to 5-point scale. Optimal cutoff scores for the individual sensitivities and specificities were: items 4, 11, and 12: a cutoff score of 3; and item 14, a cutoff score of 2. AD: Alzheimer disease; AUC: area under the curve; CI: confidence interval; DLB: dementia with Lewy bodies; LBD: Lewy body dementia; PDD: dementia associated with Parkinson disease; VaD: vascular dementia.

**TABLE 3. Test–Retest and Interrater Reliability from the Four Best Discriminating DCFS Items**

| DCFS Item | Test–Retest Reliability (Cronbach's α) | Interrater Reliability (Cronbach's α) |
|---|---|---|
| Item 4: difference in function | 0.510[a] | 0.520 |
| Item 11: daytime sleep | 0.841 | 0.952 |
| Item 12: drowsiness | 0.810 | 0.683 |
| Item 14: consciousness | 0.691 | 0.739 |
| Pooled (items 4, 11, 12, and 14) | 0.713 | 0.724 |

*Notes:* All $p < 0.001$, except.

[a]$p < 0.05$. Test–retest reliability using Pearson's correlations was based on reports from 22 caregivers retested within 2 weeks of initial testing. Interrater reliability using Pearson's correlations was based on reports from 25 caregivers retested within 2 weeks of initial testing. DCFS: Dementia Cognitive Fluctuation Scale.

component matrix of the full DCFS items are presented in Appendix 2 (available online) and yielded five components, which collectively explained 65.1% of the variance within the model. The relative contribution of these five components to the factor structure of the DCFS was as follows: component 1 (consciousness), explaining 20.2% of the variance within the model; component 2 (sleep routine), explaining 12.7% of the variance within the model; component 3 (sleep disturbance factors), explaining 12.0% of the variance within the model; component 4 (confusion), explaining 11.3% of the variance within the model; and component 5 (function), explaining 8.9% of the variance within the model. The remaining 34.9% of the variance within the model was explained by components with eigenvalues <1 and therefore were not considered as significant contributors to the model.

The four significantly discriminative DCFS items loaded onto three of these five separate factors. Item 4 (difference in function) was the only item to load onto component 5; item 11 (daytime sleep) and item 12 (daytime drowsiness) loaded onto component 3 "sleep disturbance factors"; and item 14 (consciousness) loaded onto component 1. No other items discriminated significantly between groups.

The sensitivity and specificity of these four DCFS items at discriminating between dementia groups were explored by using ROC curves. These sensitivity and specificity data are presented in Table 2. The optimal cutoff scores for each item are included as a footnote in Table 2.

Selecting participants with an MMSE score >18 (n = 86) and repeating these ROC analyses on the 4 discriminative DCFS items revealed a mean sensitivity value of 76.0% and a mean specificity value of 78.9% at distinguishing between LBD and other dementia groups. However, repeating these ROC analyses on those with MMSE scores ≤18 (n = 65) reduced the mean sensitivity value to 67.7% and the mean specificity value to 67.3%. This result suggests that these four discriminative DCFS items were more accurate at distinguishing LBD from other dementias in milder rather than in more advanced cognitive impairment.

Test–retest and interrater reliability data from the DCFS are presented in Table 3. Between-subject ANOVA with Bonferroni corrections of the four DCFS items across the dementia and comparison subgroups are presented in Table 4.

**TABLE 4. Between-Subject ANOVA for Discriminative DCFS Items Cross all Four Dementia Groups and Comparison Participants**

| | N | Mean | SD | p Versus Control | p Versus AD | p Versus VaD | p Versus DLB |
|---|---|---|---|---|---|---|---|
| Item 4: difference in function[a] | | | | | | | |
| Control | 32 | 1.38 | 0.55 | - | – | – | – |
| AD | 30 | 2.90 | 0.80 | **<0.001** | – | – | – |
| VaD | 30 | 2.83 | 1.23 | **<0.001** | 1.000 | – | – |
| DLB | 29 | 3.59 | 0.91 | **<0.001** | 0.031 | **0.012** | – |
| PDD | 32 | 3.84 | 0.78 | **<0.001** | **<0.001** | **<0.001** | 1.000 |
| Item 11: daytime sleep[a] | | | | | | | |
| Control | 32 | 1.47 | 0.57 | – | – | – | – |
| AD | 30 | 2.70 | 1.34 | **0.001** | – | – | – |
| VaD | 30 | 2.53 | 1.20 | **0.005** | 1.000 | – | – |
| DLB | 29 | 3.21 | 1.29 | **<0.001** | 1.000 | 0.297 | – |
| PDD | 32 | 3.81 | 1.33 | **<0.001** | **0.003** | **<0.001** | 0.468 |
| Item 12: daytime drowsiness[a] | | | | | | | |
| Control | 32 | 1.53 | 0.92 | – | – | – | – |
| AD | 30 | 2.73 | 1.55 | **0.003** | – | – | – |
| VaD | 30 | 2.23 | 1.30 | 0.322 | 1.000 | – | – |
| DLB | 29 | 3.28 | 1.36 | **<0.001** | 1.000 | 0.021 | – |
| PDD | 32 | 4.09 | 1.20 | **<0.001** | **<0.001** | **<0.001** | 0.136 |
| Item 14: level of consciousness | | | | | | | |
| Control | 32 | 1.19 | 0.74 | – | – | – | – |
| AD | 30 | 1.40 | 0.62 | 1.000 | – | – | – |
| VaD | 30 | 1.43 | 0.63 | 1.000 | 1.000 | – | – |
| DLB | 29 | 2.04 | 0.94 | **<0.001** | **0.010** | 0.018 | – |
| PDD | 32 | 2.25 | 0.67 | **<0.001** | **<0.001** | **<0.001** | 1.000 |

*Notes:* F tests for analyses of variance (ANOVA): Item 4, $F_{[4,\ 148]} = 38.01$; $p < 0.001$. Item 11, $F_{[4,\ 148]} = 17.33$; $p < 0.001$. Item 12, $F_{[4,\ 148]} = 18.57$; $p < 0.001$. Item 14, $F_{[4,\ 148]} = 12.23$; $p < 0.001$. Bold figures indicate significance at $p < 0.0125$ after applying Bonferroni corrections. $p = 1.000$ data appear in the table because these p values represent the Bonferroni-corrected post hoc analyses. AD: Alzheimer disease; DCFS: Dementia Cognitive Fluctuation Scale; DLB: dementia with Lewy bodies; PDD: dementia associated with Parkinson disease; VaD: vascular dementia.

[a]Indicates that Levene's tests for homogeneity of variances were significant at $p < 0.001$.

## DISCUSSION

### Main Findings

Four items from the DCFS discriminated between groups of people with LBD and non-LBD dementia. The DCFS described a robust factor structure, with five factors explaining 65.1% of the variance in the model, and with no items significantly loading onto more than one factor. These findings (Appendix 2; available online) indicate that cognitive fluctuation operates within 3 domains: 1) problems with consciousness (1 item on the DCFS); 2) daytime sleepiness (2 items on the DCFS); and 3) daytime functioning (1 item on the DCFS). As shown in Table 2, each of these items had good sensitivity and specificity for discriminating between these dementia groupings, and when combined, they achieved even better discrimination. Each of these items also showed good test–retest and interrater reliabilities. The questions for each item are brief and could be incorporated into clinical practice. A suggested clinician version of the DCFS using the four discriminative items is presented in Appendix 3 (available online). It is important to note that this is an adaptation of the DCFS questions investigated in the current study, and the questions in this form have not yet been studied. However, we think it is important to try and help clinicians identify CF, and we therefore suggest this scale (which needs studying in its own right) and acknowledge further work is needed on CF using these and related items from the MCFS that have previously been shown to help identify CF and diagnose LBD.

A fourth component of CF identified by the DCFS was the "confusion" component, which explained 11.3% of the variance within the factor analysis model. The items within this component failed to discriminate between groups, but there is a possibility that confusion requires further exploration because it is an important aspect of CF in these groups.

Two of these DCFS items replicated the findings of Ferman et al.,[6] who also reported high levels of discrimination between DLB and AD patients for MCFS questions relating to daytime drowsiness and daytime sleep. However, they did not have a VaD group, and our study extends these findings by additionally demonstrating that these items discriminate LBD groups from VaD subjects. In their study, they also found weaker, but still significant, levels of discrimination for questions relating to disorganized thoughts and staring into space, but these items failed to discriminate significantly between groups in our study. Several items from the ODFAS,[17] which related to CF, were included in the DCFS to examine their utility. We found that a moderate to large difference in function and a question on consciousness ("how would you rate the level of consciousness of the patient on a usual day") did discriminate significantly between groups, whereas questions about confusion and communication did not. Similarly to the MCFS, the question on daytime drowsiness (also included in the ODFAS) was a sensitive discriminator for CF across our study groups of people with dementia.

These findings corroborate those of previous authors.[6,17] Difference in functioning was found to be a significant predictor of CF if it was considered as moderate to severe but not if it was considered to be absent or mild. Daytime sleep was found to be a significant predictor of CF if the patient slept for >1 hour of the day (after waking in the morning and before going to bed at night), unlike the Ferman et al.[6] finding of ≥2 hours. Drowsiness during the daytime was found to be a significant predictor of CF if it occurred for >1 hour of the day, whereas Walker et al.[17] used a scale of 25%, 25%–75%, or >75% of the day but did not report sensitivity or specificity data for any of these thresholds. The consciousness item was found here to be a significant predictor of CF if the patient was considered moderately difficult or difficult to arouse during the day, as opposed to being easy to arouse or mostly alert, whereas Walker et al. used a scale of alert, lethargic (drowsy but easy to arouse), or stuporous (difficult to arouse) but again did not report sensitivity or specificity data for any of these thresholds.

### Potential Value for Differential Diagnosis

Test–retest and interrater reliability data for these questions indicated that they had very good levels of reliability when applied by the same (DL) or another (LG) researcher. Various combinations of the four items were examined to explore which questions on the DCFS had the most predictive validity, but these findings were equivocal (Table 2). Therefore, we recommend using all four items with a positive answer to three or more of these items on the DCFS identifying CF with good levels of sensitivity (range: 78.6%–80.3%) and specificity (range: 73.9%–79.3%). Furthermore, the DCFS showed improved levels of sensitivity and specificity in those with mild/moderate dementia compared with those with more advanced dementia (based on an MMSE threshold of 18). This cutoff is clinically important because decisions regarding diagnosis and subtype are usually made, and important to make accurately, early in dementia, and the four-item DCFS therefore seems to have benefits for the early differential diagnosis of dementia. However, with sensitivities and specificities in the 74%–80% range, false-positive and false-negative identifications will occur, and we do not propose that the DCFS should be used on its own for DLB diagnosis. We recommend it as a helpful tool for identifying CF that should be used in combination with other measures and clinical assessment for diagnosis.

### Strengths and Limitations

This study recruited a representative sample of older people with dementia and thus has provided evidence that the four DCFS items can be used for improving DLB diagnosis in typical dementia clinic settings. Further research could usefully explore the diagnostic utility of the DCFS in other forms of dementia, such as fronto-temporal dementia. As noted earlier, however, a limitation of our suggested clinician version is that the questions have not been directly tested when phrased in this way. Our power calculation suggested group sizes of approximately 30 would allow sufficient power to detect significant differences between groups, and our findings confirmed this hypothesis, with DCFS items achieving highly significant between-group differences. Our study also benefited from the main clinical rater (DL) being blinded to diagnostic groupings until the end of data collection, which minimized the potential for bias during assessments. However, in some cases with LBD, the presence of Parkinsonism at interview was apparent. Another potential

limitation is that we used the diagnostic criteria of McKeith et al.[7] (including suggestive features of DLB [e.g., RBD]) to make a diagnosis of DLB for those recruited into the DLB group of this study, which include CF as one of the core features. However, the majority (27 of 29) of DLB participants were diagnosed with DLB without considering CF (because they had at least two other core and suggestive features of the disease); although it may be argued there is potential bias due to the circularity of including CF in the diagnosis, we repeated the main analyses (between-group ANOVAs and ROC analyses) with the two participants (who required CF for DLB diagnosis) removed and found no changes to any of the outcomes presented here. Any concern that including CF in the DLB diagnosis affected our findings is also mitigated by the high levels of discrimination the four items showed between PDD and non-LBD dementias. An important limitation in our findings is that although the four items seem to provide good discrimination between LBD and other dementias, they were not as good at discriminating DLB from AD and VaD, with only item 14 (level of consciousness) being significantly different after Bonferroni correction. Another potential concern is that participants were all assessed while taking their regular medications. Although we did not identify any likely impact of medication, it is impossible to entirely exclude potential pharmacologic effects on the cognitive performance of participants, especially considering the significantly different levels of consumption of acetylcholinesterase inhibitors and dopaminergic agents across the groups recruited into this study. However, the lack of any significant differences in CF outcomes between those participants on medications compared with those not consuming medications (notably, acetylcholinesterase inhibitors and dopaminergic agents) indicated that the utility of these CF questions was not adversely affected by drugs.

## CONCLUSIONS

Other scales for the accurate diagnosis of CF in dementia have been described, and we built on these in developing this new scale to examine CF in subjects with dementia. We replicated some previous findings as well as collected data from a wider range of dementia subgroups. Detailed analyses of sensitivity, specificity, reliability, and external validity of this new measure are encouraging, with the DCFS accurately distinguishing between groups of individuals with LBD and those with AD or VaD and comparison participants.

The accurate differential diagnosis of dementia remains a challenge, and the lack of reliable measures to identify CF presents difficulties for the accurate discrimination of LBD from other forms of dementia. Because CF is recognized as a core feature of LBD, it is hoped that the proposed measure, the clinician four-item DCFS (DCFS-C), will facilitate the early and accurate differential diagnosis of people with dementia and that the scaled research version (DCFS-R) will facilitate future research into the phenomenon of CF in people with dementia.

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*Dr. Lee designed the study, collected and analyzed the data, and wrote the manuscript. Drs. McKeith and Mosimann designed the study and commented on draft manuscripts. Dr. Ghosh-Nodiyal provided diagnostic opinions on patients recruited into the study. Dr. Grayson provided diagnostic opinions on patients recruited into the study, assisted with recruitment, and conducted retesting of a subgroup of participants. Dr. Wilson recruited participants into the study and assisted with data collection and analysis. Dr. Thomas designed the study, provided diagnostic opinions of patients recruited into the study, contributed to the analysis of data, and co-wrote the manuscript.*

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