RESEARCH ARTICLE

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Does the Geriatric Depression Scale measure depression in Parkinson's disease?

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Background

The Geriatric Depression Scale (GDS) is recommended for screening depression in individuals with Parkinson's disease (PD). Empirical evidence, however, is limited regarding its validity and factor structure in PD. Thus, the current study sought to evaluate the convergent and divergent validity of the GDS, as well as the structure and validity of the derived factors.

Method: Nondemented individuals with PD (n = 158) completed the GDS-30, and items were subjected to a principle component analysis. Geriatric Depression Scale total and factor scores were correlated with depression items from the Movement Disorder Society Unified Parkinson's disease Rating Scale (MDS-UPDRSd) and Hamilton Rating Scale for Depression (HAMDd), as well as with the Apathy Scale (AS), State-Trait Anxiety Inventory (STAI), Modified Fatigue Impact Scale (MFIS), Parkinson's disease Sleep Scale, and a Subjective Cognitive Function composite score.

Results: The GDS total score was strongly correlated with divergent neuropsychiatric measures (AS, $r = 0.57$; STAI, $r = 0.66$; MFIS, $r = 0.60$), while only moderately correlated with convergent measures (MDS-UPDRSd, $r = 0.36$; HAMDd, $r = 0.32$; $Ps < 0.05$). Linear regression analyses revealed standardized measures of anxiety, apathy, and fatigue independently predicted the GDS total score, while depression items (MDS-UPDRSd and HAMDd) failed to reach significance. Three independent factors were identified: Anxiety, Apathy, and Fatigue. These factors were significantly predicted by their respective convergent measures.

Conclusions: Taken together, our findings suggest that the GDS and its subscales appear to primarily measure anxiety, apathy, and fatigue in PD, or alternatively, these symptom dimensions may be predominant in PD-depression. Future research with clinically diagnosed samples is needed to confirm these initial findings.

KEYWORDS

anxiety, apathy, depression, factors, fatigue, Parkinson's disease, validity

1 | INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disease characterized by motor abnormalities and nonmotor symptoms, including depression, anxiety, apathy, and fatigue.[1,2] Depression is one of the most common nonmotor symptoms, with reported prevalence rates between 40% and 50%.[3] The assessment of depression in PD remains a challenge due to the overlap between disease and depressive-

related symptoms.[4] As depression can negatively impact cognition, everyday functioning, and health-related quality of life,[2] the accurate assessment of depression in PD is essential.

Clinician-, informant-, and self-rating scales are often used to identify depressive symptomology in PD. One of the most common self-report rating scales for depression in PD is the Geriatric Depression Scale (GDS).[5] Several systematic reviews have recommended the GDS (both 30- and 15-item versions) for depression screening purposes in PD predominantly due to its minimal focus on motor and somatic symptoms as well as its sound psychometric properties, including strong internal consistency of its items, moderate convergent validity, and high discriminant validity.[4,6] Prior work has assessed the convergent validity of the GDS by correlating the GDS total score with positive diagnoses of depression in PD using either (1) structured clinical interviews for DSM disorders and DSM-IV criteria[7-9] or (2) validated depression rating scales (ie, Beck Depression Inventory; BDI[10]; Hamilton Rating Scale for Depression-17[11,12]) that include both affective (ie, depressed mood) and somatic (eg, fatigue, sleep disturbance) symptomology. These approaches have been questioned due to the high degree of overlap between depression and PD symptomology.[6,13] This is particularly true in regard to somatic symptoms, which comprise secondary ("noncore") symptoms of depression as well as symptoms associated with PD that may be unrelated to depression. Thus, assessing the convergent validity of the GDS with the core features of depression (ie, depressed mood independent of somatic symptoms) may shed light on the manifestation of depression in PD.

Discriminant validity, or the ability of the GDS to discriminate between minor and major depressive symptoms,[8] or between depressed and nondepressed groups,[7] has been adequately evaluated. However, divergent validity, defined by weak or nonsignificant correlations with other neuropsychiatric or somatic measures, has yet to be properly assessed. Divergent validation is essential for any measure, but especially for a measure of depression in PD, given that there is a significant overlap between depression and disease-related symptoms (eg, fatigue and sleep disturbance).

In addition, despite several psychometric validation studies of the GDS,[4,6] none to date have evaluated the factor structure of the GDS in PD. In a geriatric non-PD population, a factor analytic study identified six GDS factors, which represented (1) dysphoric mood, (2) withdrawal-apathy-vigor, (3) worry, (4) cognitive impairment, (5) hopelessness, and (6) agitation.[14] In a sample of individuals with Alzheimer's disease, a four-factor structure was identified: (1) dysphoria, (2) meaninglessness, (3) apathy, and (4) cognitive impairment.[15] Factor titles were qualitatively determined by item content, but the quantitative validation of these subscales with convergent measures has yet to be evaluated. Moreover, validation analysis has yet to be done in a PD population. The importance of examining and validating the factor structure of the GDS in PD is twofold. First, it will determine whether the GDS represents a unidimensional or multidimensional construct composed of independent symptom features. Second, validating factors with convergent measures will determine utility of subscales for use in clinical practice and research. This is especially important given that "depression" in PD may not present with the characteristic

Key points

- In a PD sample, the Geriatric Depression Scale (GDS) total score was strongly correlated with measures of anxiety, apathy, and fatigue, while standardized depression items failed to uniquely predict GDS scores.

- Three GDS subscales—Anxiety, Apathy, and Fatigue— were identified, which were validated against corresponding standardized measures of anxiety, apathy, and fatigue, respectively.

- The GDS and its subscales appear to capture multiple mood/somatic symptoms, primarily anxiety, apathy, and fatigue; findings question the validity of the GDS as a pure measure of affective depression in PD or alternatively, PD-depression may be characterized by these nonanhedonic symptom dimensions.

constellation of symptoms that are seen in the general or non-PD populations.[13,16-18]

The primary purpose of this study was to test the psychometric properties of the GDS by examining convergent validity with items of affective or anhedonic depression (ie, depressed mood in isolation from somatic features) as well as divergent validity with common overlapping cognitive, psychological, and somatic (eg, anxiety, apathy, sleep, and fatigue) symptoms. In addition, an important secondary aim of this study was to examine the underlying factor structure of the GDS and validity of derived factors for potential utility in nondemented individuals with PD.

2 | METHOD

2.1 | Participants

One-hundred fifty-eight individuals diagnosed with PD participated in this study. Parkinson's disease diagnosis was determined using the UK Brain Bank Criteria by a board-certified neurologist specializing in movement disorders.[19] Participants were recruited from the Movement Disorders Clinic at the University of California, San Diego, and the Veterans Affairs San Diego Healthcare System. This study was approved by the Department of Veterans Affairs Institutional Review Board (IRB), and all participants provided written, informed consent. Participants who met criteria for dementia using the Diagnostic and Statistical Manual of Mental Disorders-IV-TR criteria[20] defined in Emre et al,[21] or a cutoff score[22] of ≤123 on the Mattis Dementia Rating Scale[23] were excluded. Participants were tested while on their normal dosages of medications. Levodopa equivalents were calculated using the method of Tomlinson and colleagues.[24] Disease stage and motor function were assessed using the Modified Hoehn and Yahr Stage[25] and Finger Tapping Test,[26] respectively. See Table 1 for demographics, disease characteristics, and scores on neuropsychiatric measures of participants.

TABLE 1 Demographics, disease characteristics, and neuropsychological test performances of participants (n = 158)

	Mean (SD)	Range
Age (years)	67.6 (8.24)	40-90
Gender (males/females)	108/50	
Education (years)	16.6 (2.36)	12-20
Handedness (right/left)	140/18	
Mattis Dementia Rating Scale	138 (3.94)	124-144
Cognitive diagnosis (nondemented/MCI)	112/46	
Disease duration (months)	65.8 (61.5)	1-420
Finger Tapping Test—dominant hand (T score)	39.8 (13.2)	8-69
Finger Tapping Test—nondominant hand (T score)	40.1 (13.2)	10-72
Modified Hoehn and Yahr Stage (%)		
Stage 0	1.3	
Stage 1	24.7	
Stage 1.5	1.3	
Stage 2	50.6	
Stage 2.5	7.8	
Stage 3	11.0	
Stage 3.5	0.8	
Stage 4	1.9	
Stage 5	0.6	
Levodopa equivalent dosage (mg/day)	736 (747)	0-4925
Geriatric Depression Scale	6.30 (5.21)	0-26
HAMDd	0.43 (0.85)	0-3
MDS-UPDRSd	0.33 (0.64)	0-3
Apathy Scale	11.6 (5.36)	1-28
State Trait Anxiety Inventory-State Scale	34.9 (10.0)	20-68
Modified Fatigue Impact Scale	33.1 (17.3)	0-71
Parkinson's disease Sleep Scale	102 (21.3)	39.8-140
Subjective Cognitive unction	1.22 (.877)	0-3

Abbreviations: HAMDd, Hamilton Depression Rating Scale depression item; MDS-UPDRSd, Movement Disorder Society-Unified Parkinson's disease Rating Scale depression item. Participants were determined to have Mild Cognitive Impairment (MCI) using criteria described in previous work.[27]

2.2 | Materials and procedure

2.2.1 | Geriatric Depression Scale

The GDS is a 30-item "yes/no" self-report measure of depressive symptoms.[5] The individual is asked to report whether they have experienced these symptoms over the past week. The GDS has a maximum score of 30, with higher scores representing more severe symptoms.

2.2.2 | Depression items

The Hamilton Depression Rating Scale (HAMD)[11] is a 17-item clinician-administered-to-patient measure shown to be valid and reliable in PD samples.[4,6] Of the 17 items, only six have been found to be valid for assessing depression (rank ordered): (1) depressed mood, (2) lack of interests, (3) tiredness, (4) anxious mood, (5) guilt feeling, and (6) psychomotor retardation.[28] Depressed mood is the only core symptom of depression, and in line with common practice,[29] this item, termed HAMDd here within, was used in subsequent analyses. The HAMDd ("Have you been feeling down or depressed this past week?") is rated on a 5-point Likert scale (0 = "Normal" to 4 = "Severe"), with higher scores representing greater depressed mood severity.

The Movement Disorder Society Unified Parkinson's Disease Rating Scale (MDS-UPDRS)[30] Part I is a clinician-administered-to-patient measure of nonmotor aspects of experiences of daily living. Item three assesses depressed mood (MDS-UPDRSd; "Over the past week have you felt low, sad, hopeless or unable to enjoy things?") experienced over the past week. Items are rated on a 5-point Likert scale (0 = "Normal" to 4 = "Severe"), with higher scores indicating more severe depressive symptoms. The MDS-UPDRSd has shown moderate concurrent validity with the GDS and HAMD-17, and preliminary evidence for validity in PD.[31]

2.2.3 | Measures of other neuropsychiatric symptoms

The Apathy Scale (AS)[32] is a validated self-report measure that includes 14 items rated on a 4-point Likert scale (0="Not At All" to 3 = "A Lot") that was developed to assess apathy in PD patients over the past 4 weeks. Total scores range from 0 to 42, with higher scores representing greater apathy symptoms.

The State-Trait Anxiety Inventory-State Scale (STAI-S)[33] includes 20 self-rated items on a 4-point Likert scale (1 = "Almost Never" to 4 = "Almost Always"). The STAI-S was designed to assess how anxious one feels "right now, at this moment." Total scores range from 20 to 80, with higher scores denoting greater anxiety symptomatology.

The STAI-S has shown evidence for convergent and discriminant validity in PD samples.[34]

The Modified Fatigue Impact Scale (MFIS)[35] includes 21 self-rated items on a 5-point Likert scale (0 = "Never" to 4 = "Almost Always") assessing the impact of fatigue on functioning over the past 4 weeks. Total scores range from 0 to 84, with higher scores indicating greater impact of fatigue. The MFIS has shown evidence for validity in PD.[36]

The Parkinson's disease Sleep Scale (PDSS)[37] is a validated 15-item self-report rating scale on a visual analogue scale (0 = "Always" to 10 = "Never") that assesses sleep symptoms experienced by individuals with PD over a 1-week period. Total scores range from 0 to 150, with *lower* scores representing greater sleep disturbance symptoms.

A clinician-administered-to-patient measure of Subjective Cognitive Function was generated from the following three "yes/no" questions: "Have you noticed any of the following changes over the last three years in doing the following: 1) remembering things, 2) finding the names of familiar people or things, or 3) getting around in familiar places." Total scores range from 0 to 3, with higher scores indicating greater subjective cognitive complaints.

2.3 | Statistical analyses

To examine convergent and divergent validity, Pearson bivariate correlations were performed on the GDS total score with the HAMDd, MDS-UPDRSd, AS, STAI-S, MFIS, PDSS, Subjective Cognitive Function, and demographic characteristics of the sample. To evaluate the underlying factor structure of the GDS, the individual scores were subjected to a principal component analysis with a varimax rotation. Chi-square goodness-of-fit test was performed on the proposed model. Cronbach's alpha was used to examine the internal consistency of all 30 items and the items within the factors identified in the principal component analysis. Cronbach's alpha reliability coefficients (α) that were greater than 0.7 were interpreted as acceptable, and coefficients less than 0.7 were interpreted as questionable.[38] To determine the best predictor(s) of GDS total and factor scores, stepwise linear regression analyses were conducted with GDS total and factor scores serving as criterions and variables that were significant in correlational analyses were entered as predictors. To further investigate the effect of significant predictors, structure coefficients* (r_s) and squared structure coefficients (r^2_s) were examined in combination with standardized beta weights[†] (β) calculated from the stepwise linear regression analyses.[39] Significant correlation coefficients that were greater than 0.5 were interpreted as strong, coefficients of 0.3 to 0.5 were interpreted as moderate, and coefficients less than 0.3 were interpreted as weak.[40] Based on recommended[6] total score cutoffs (HAMD cutoff = 9/10 or GDS total = 9/10), all analyses were repeated in a depressed subset of the sample. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 21 (SPSS IBM, New York, USA).

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*A structure coefficient is a correlation between a predictor variable and the predicted criterion, unaffected by multicollinearity.

†A standardized beta weight is the slope of a linear relationship between a predictor variable and the predicted criterion, often used for interpreting predictor contribution of an explained effect.

3 | RESULTS

3.1 | Convergent and divergent validity of GDS total score

To evaluate convergent and divergent validity of the GDS total score, Pearson bivariate correlations were performed on the GDS total score with AS, MDS-UPDRSd, HAMDd, STAI-S, MFIS, PDSS, Subjective Cognitive Function, and demographic characteristics (see Table 2). The bivariate associations between the GDS total score with the HAMDd and MDS-UPDRSd were significant indicating moderate convergent validity. The GDS was weakly correlated with Subjective Cognitive Function, suggesting potential good divergence. However, the GDS was moderately to strongly correlated with all other neuropsychiatric measures (ie, AS, STAI-S, MFIS, and PDSS), suggesting poor divergent validity of the GDS among other mood/somatic/distress measures. The correlation between the GDS total score and age was weak but significant, while the relationship between GDS total score and gender, years of education, disease duration or stage, and levodopa equivalent dosage was not significant, indicating adequate divergence from nonpsychological demographic characteristics.

Pearson bivariate correlations were performed in a depressed subset (n = 28) defined by a standard HAMD cutoff score of 9/10[6]. In this subsample, only the MFIS (r = 0.534), STAI-S (r = 0.506), and AS (r = 0.473) were significantly and strongly correlated with the GDS total score (Ps < 0.05). In addition, HAMDd (r = 0.063, P = 0.750) and UPDRSd (r = −0.026, P = 0.895) were not significantly correlated with the GDS total score. Similarly, using a standard GDS cutoff score of 9/10[6] (n = 42), the STAI-S (r = 0.586), the MFIS (r = 0.382), and AS (r = 0.331) were significantly strongly to moderately correlated with the GDS total score in the depressed subsample

TABLE 2 Pearson bivariate correlations of Geriatric Depression Scale (GDS) total score with demographic characteristics, and neuropsychiatric functioning measures

	GDS Total Score
Age (years)	−0.233*
Gender	0.015
Education (years)	0.030
Disease duration (months)	−0.049
Finger Tapping Test—dominant hand	−0.113
Modified Hoehn and Yahr stage	0.070
Levodopa equivalent dosage (mg/day)	0.096
HAMDd	0.324**
MDS-UPDRSd	0.363**
Apathy Scale	0.565**
State Trait Anxiety Inventory-State Scale	0.660**
Modified Fatigue Impact Scale	0.596**
Parkinson's disease Sleep Scale	−0.325**
Subjective Cognitive Function	0.228*

Abbreviations: HAMDd, Hamilton Depression Rating Scale depression item; MDS-UPDRSd, Movement Disorder Society-Unified Parkinson's disease Rating Scale depression item.

*P < 0.05.

**P < 0.01.

($Ps < 0.05$), but the HAMDd ($r = 0.137$, $P = 0.387$) and UPDRSd ($r = 0.207$, $P = 0.188$) were not.

To determine the best predictor of the total GDS score, significant variables (HAMDd, MDS-UPDRSd, AS, STAI-S, MFIS, PDSS, Subjective Cognitive Function, and age) were entered into a stepwise linear regression analysis. The final model included STAI-S, AS, MFIS, MDS-UPDRSd, and Subjective Cognitive Function and explained 59% of the variance in the GDS total score, $R^2 = 0.591$, $F(5,140) = 43$, $P < 0.001$ (see Table 3). The STAI-S had the largest effect on the GDS total, followed by AS and MFIS, while MDS-UPDRSd and Subjective Cognitive Function had the smallest effect. Multicollinearity statistics were within the acceptable limits (variance inflation factor (VIF) < 2.0; Tolerance > 0.50). In line with the regression analysis, squared structure coefficients demonstrated that the STAI-S contributed most of the variance in the explained effect, followed by the MFIS and AS, respectively.

Stepwise linear regressions were performed in the aforementioned depressed subsets.[6] Using the HAMD cutoff, the STAI-S, ($\beta = 0.397$, $r_s = 0.817$, $r_s^2 = 0.667$), and MFIS, ($\beta = 0.385$, $r_s = 0.811$, $r_s^2 = 0.658$), explained 36% of the variance of the GDS total score ($R^2 = 0.361$, $F(2, 23) = 8.05$, $P = 0.002$). Similarly, using the GDS cutoff, the STAI-S, ($\beta = 0.499$, $r_s = 0.886$, $r_s^2 = 0.785$), and MFIS ($\beta = 0.310$, $r_s = 0.648$, $r_s^2 = 0.420$) explained 39.5% of the variance in the GDS total score ($R^2 = 0.395$, $F(2, 39) = 13.8$, $P < 0.001$). The HAMDd ($Ps = 0.432-0.875$) and UPDRSd ($Ps = 0.558-0.974$) did not add significantly to either model and were excluded as a result.

3.2 | Factor structure of GDS

All 30 items of the GDS had strong internal consistency ($\alpha = 0.875$). When the items were subjected to a principle component analysis, eight factors had eigenvalues greater than 1.0; however, Cattell's scree plot did not suggest a definitive solution model. Therefore, an eigenvalue Monte Carlo simulation analysis was performed, which revealed a significant three-factor model accounting for 36.6% of the variance ($\chi^2 = 1491.05$, $P < 0.001$). All items loaded onto a factor, apart from item 25 ("often feel like crying"), which was not included in the subsequent analyses (α excluding item 25 = 0.878).

The three factors were interpreted as representing the following constructs: Apathy, Anxiety, and Fatigue (see Table 4[‡]). Ten items loaded onto the Apathy factor, 10 items loaded onto the Anxiety factor, and 9 items loaded onto the Fatigue factor. The GDS items that comprised each factor had strong internal consistency (Apathy $\alpha = 0.804$; Anxiety $\alpha = 0.793$; Fatigue $\alpha = 0.706$). Subsequent descriptive analyses were performed to determine the percentage of participants endorsing at least one item on each factor. Fatigue was the highest factor endorsed (86.1%, M = 3.08, SD = 2.17, Range = 0-9), followed by Apathy (64.6%, M = 1.85, SD = 2.23, Range = 0-10). The Anxiety factor was endorsed the least, but approximately 50% of the sample endorsed this factor (M = 1.30, SD = 1.89, Range = 0-10).

[‡]Item labels were derived by item content and subsequent analyses below.

TABLE 3 Geriatric Depression Scale (GDS) total score: stepwise linear regression results

Predictors	β	r_s	r_s^2	R_s^2
State Trait Anxiety Inventory-State Scale	0.334	0.833**	0.694	0.410
Apathy Scale	0.252	0.741**	0.549	0.324
Modified Fatigue Impact Scale	0.247	0.782**	0.612	0.362
MDS-UPDRSd	0.146	0.524**	0.275	0.163
Subjective Cognitive Function	0.132	0.286**	0.082	0.048

Abbreviations: R_s^2, predictor $r_s^2 \times$ factor R^2; MDS-UPDRSd, Movement Disorder Society-Unified Parkinson's disease Rating Scale depression item.
**$P < 0.01$.

TABLE 4 Principle component factor analysis with varimax rotation

Item	Description	Apathy	Anxiety	Fatigue
2	Dropped activities	**0.522**	0.312	0.155
4	Often get bored	**0.587**	0.362	0.132
7	In good spirits	**0.506**	−0.308	0.121
9	Happy most of the time	**0.673**	0.159	0.139
12	Prefer to stay at home	**0.481**	−0.017	0.098
15	Wonderful to be alive now	**0.570**	0.062	0.224
16	Downhearted and blue	**0.541**	0.353	0.071
17	Feel pretty worthless	**0.522**	0.471	0.009
19	Find life very exciting	**0.567**	−0.053	0.359
28	Prefer to avoid social contact	**0.596**	0.086	0.072
1	Satisfied with life	0.428	**0.446**	0.260
3	Your life is empty	0.477	**0.481**	0.012
5	Hopeful about the future	0.238	**0.588**	−0.149
6	Bothered by thoughts	−0.006	**0.488**	0.403
8	Afraid something bad will happen	0.121	**0.488**	0.313
10	Often feel helpless	0.265	**0.582**	0.242
13	Worry about the future	0.191	**0.420**	0.287
18	Worry about the past	0.002	**0.631**	0.123
22	Situation is hopeless	0.018	**0.593**	−0.051
24	Upset over little things	−0.001	**0.477**	0.346
11	Restless and fidgety	−0.076	0.317	**0.545**
14	Problems with memory	0.005	0.096	**0.508**
20	Hard to get started on projects	0.274	0.059	**0.526**
21	Feel full of energy	0.216	0.111	**0.436**
23	Most people are better off than you	−0.040	0.377	**0.401**
26	Have trouble concentrating	0.195	0.114	**0.585**
27	Enjoy getting up in the morning	0.171	0.024	**0.413**
29	Easy to make decisions	0.282	−0.067	**0.448**
30	Mind as clear as it used to be	0.187	−0.045	**0.612**
25	Often feel like crying	0.026	0.070	0.202

Item description does not reflect the Geriatric Depression Scale (GDS) item text in its entirety. Bold-faced type indicates highest factor loading for each item.

3.3 | Convergent and divergent validity of GDS factors

3.3.1 | Apathy factor

To evaluate convergent and divergent validity, Pearson bivariate correlations were performed on the Apathy factor with AS, MDS-

UPDRSd, HAMDd, STAI-S, MFIS, PDSS, Subjective Cognitive Function, and demographic characteristics (see Table 5). The correlation between the Apathy factor and AS was significant, with a correlation strength at the upper end of the moderate range. Correlations between the Apathy factor and depression items (MDRS-UPDRSd and HAMd) were significant, but weak. The Apathy factor was significantly correlated with additional measures of neuropsychiatric functioning, with correlations ranging from moderate (STAI-S and MFIS) to weak (PDSS and Subjective Cognitive Function). The Apathy factor was unrelated to demographic characteristics, except for a weak correlation with age.

The final stepwise linear regression model included AS, STAI-S, and MDS-UPDRSd and explained 33.4% of the variance in the Apathy factor score, $R^2 = 0.334$, $F(3,142) = 25.2$, $P < 0.001$ (see Table 6). The AS had the largest effect on the Apathy factor score, followed by the STAI-S and the MDS-UPDRS. Multicollinearity statistics were within the acceptable limits (VIF < 1.5; Tolerance > 0.70). In line with the regression analysis, squared structure coefficients demonstrated that the AS contributed most of the variance in the explained effect.

3.3.2 | Anxiety factor

To evaluate convergent and divergent validity, Pearson bivariate correlations were performed on the Anxiety factor with STAI-S, MDS-UPDRSd, HAMDd, AS, MFIS, PDSS, Subjective Cognitive Function, and demographic characteristics (see Table 5). The correlation between the Anxiety factor and STAI-S was significant and strong. The Anxiety factor was significantly correlated with depression items; however, the relationship was weak. Correlations between the Anxiety factor and additional measures of neuropsychiatric functioning were weak

TABLE 5 Pearson bivariate correlations of geriatric depression scale (GDS) factor scores with demographic characteristics, and neuropsychiatric functioning measures

	Apathy	Anxiety	Fatigue
Age (years)	−0.180*	−0.178*	−0.208*
Gender	−0.027	−0.050	0.094
Education (years)	−0.031	0.056	0.059
Disease duration (months)	−0.015	−0.119	−0.003
Finger tapping test – Dominant hand	−0.130	−0.080	−0.080
Modified Hoehn and Yahr stage	0.067	−0.016	0.099
Levodopa equivalent dosage (mg/day)	0.045	0.090	0.093
HAMDd	0.217*	0.232*	0.332**
MDS-UPDRSd	0.273*	0.270*	0.333**
Apathy Scale	0.476**	0.320**	0.585**
State–trait anxiety inventory-state scale	0.498**	0.609**	0.530**
Modified fatigue impact scale	0.432**	0.374**	0.654**
Parkinson's disease sleep scale	−0.182*	−0.263*	−0.371**
Subjective cognitive function	0.167*	0.199*	0.192*

Abbreviations: HAMDd, Hamilton Depression Rating Scale depression item; MDS-UPDRSd, Movement Disorder Society-Unified Parkinson's disease Rating Scale depression item.

*$P < 0.05$,

**$P < 0.01$.

TABLE 6 Geriatric Depression Scale (GDS) factor scores: Stepwise linear regression results

	β	r_s	r^2_s	R^2_s
Apathy Factor				
Apathy Scale	0.355	0.851**	0.724	0.242
State-Trait Anxiety Inventory-State Scale	0.243	0.797**	0.635	0.212
MDS-UPDRSd	0.154	0.553**	0.306	0.102
Anxiety Factor				
State-Trait Anxiety Inventory-State Scale	0.608	0.972**	0.945	0.377
Subjective Cognitive Function	0.151	0.317**	0.100	0.040
Fatigue Factor				
Modified Fatigue Impact Scale	0.424	0.889**	0.790	0.423
Apathy Scale	0.308	0.799**	0.638	0.342
State-Trait Anxiety Inventory-State Scale	0.159	0.705**	0.497	0.266

Abbreviations: R^2_s, predictor r^2_s × factor R^2; MDS-UPDRSd, Movement Disorder Society-Unified Parkinson's disease Rating Scale depression item.

**$P < 0.01$.

(PDSS and Subjective Cognitive Function) to moderate (AS and MFIS), but significant. The Anxiety factor was unrelated to any demographic characteristics, apart from a weak relationship with age.

The final stepwise linear regression model included STAI-S and Subjective Cognitive Function and explained 39.9% of the variance in the Anxiety factor score, $R^2 = 0.399$, $F(2,143) = 49.1$, $P < 0.001$ (see Table 6). The STAI-S had the largest effect on the Anxiety factor score, followed by Subjective Cognitive Function. Multicollinearity statistics were within the acceptable limits (VIF < 1.0; Tolerance >0.90). In line with the regression analysis, the squared structure coefficients demonstrated that STAI-S contributed most of the variance in the explained effect.

3.3.3 | Fatigue factor

To evaluate convergent and divergent validity, Pearson bivariate correlations were performed on the Fatigue factor with MFIS, Subjective Cognitive Function, MDS-UPDRSd, HAMDd, AS, STAI-S, PDSS, and demographic characteristics (see Table 5). The correlation between the Fatigue factor and MFIS was significant and strong, whereas the significant correlation with Subjective Cognitive Function was weak. Correlations between the Fatigue factor and depression items (MDS-UPDRSd and HAMDd) were significant, but weak. The significant correlations between the Fatigue factor and additional measures of neuropsychiatric functioning were moderate (PDSS) to strong (AS and STAI-S). The Fatigue factor did not correlate with any demographic characteristic, except for a weak but significant correlation with age.

The final stepwise linear regression model included MFIS, AS, and STAI-S and explained 53.6% of the variance in the Fatigue factor score, $R^2 = 0.536$, $F(3,142) = 56.8$, $P < 0.001$ (see Table 6). The MFIS had the largest effect on the Fatigue factor score, followed by the AS and STAI-S. Multicollinearity statistics were within the acceptable limits (VIF < 1.5; Tolerance > 0.60). In line with the regression analysis, the squared structure coefficients demonstrated that the MFIS contributed the most variance in the explained effect.

4 | DISCUSSION

Our findings revealed that the GDS total score was moderately convergent with items of affective depression (ie, depressed mood) and poorly divergent from other neuropsychiatric measures (eg, anxiety, apathy, and fatigue) in a nondemented and overall nondepressed PD sample. Analyses indicated that the GDS total score was largely accounted for by anxiety, apathy, and fatigue, as well as a smaller portion of variance accounted for by subjective cognitive functioning and depression (MDS-UPDRSd). Depression appeared to offer little predictive power and accounted for one of the smallest percentages of explained variance. These findings may highlight that the GDS is particularly sensitive to other mood/somatic symptoms and/or secondary "noncore" symptoms of depression are prominent in PD.

Consistent with existing literature,[4,6] the individual items of the GDS-30 demonstrated strong internal consistency. The principal component analysis revealed three derived factors from 29 valid items representing constructs consistent with apathy, anxiety, and fatigue. Analyses confirmed that independent measures of anxiety, apathy, and fatigue best predicted the hypothesized symptom factors. While additional symptoms of apathy, anxiety, and subjective cognitive impairment were predictive of the factors, the additional variance explained by these symptoms was small. Taken together, these factors largely measure their respective intended constructs and represent valid GDS subscales.

This study was the first to provide preliminary evidence for multiple dimensions within the underlying factor structure of the GDS in PD. Furthermore, the quantity and quality of these dimensions differ from previous work in non-PD samples.[14,15] For example, four- and six-factor models with the inclusion of one or more affective factors have been previously identified. In the current study, none of the identified dimensions in our sample appeared to measure affective depression, anhedonia, or dysphoria. Taken together, these results suggest that the GDS appears to be more sensitive to ancillary or related symptoms of depression including anxiety, apathy, and fatigue. Surprisingly, our findings were not consistent with work from two prior studies that examined the reliability and validity of the GDS in PD.[7,8] Indeed, prior work demonstrated the clinical utility of the GDS including acceptable internal consistency and discriminant validity (eg, between minor and major depressive symptoms[8] or depressed and nondepressed groups[7]) in PD patients with clinically diagnosed depression. While patients in our study were not diagnosed clinically, our study had a unique advantage of isolating symptom clusters and conducting convergent and divergent analyses, a limitation of past studies and possible limitation of clinical diagnoses that can include several symptoms in addition to affective depression.

These findings raise a critical question regarding the profile of "depression" in PD. Although a definitive profile remains unclear in PD,[13] previous research has demonstrated that PD-depression differs from non-PD populations and presents with greater somatic and cognitive symptoms in relation to decreased incidence of suicide and dysphoric symptoms, such as guilt and anhedonia.[16-18] Somewhat consistent with this characterization, our findings revealed that (what are typically characterized as) "secondary or ancillary symptoms" of depression—fatigue, apathy, and anxiety—were paramount in symptom presentation compared with depressed mood as measured by the GDS. Since the prevalence of depressive symptoms is high, yet the incidence of major depressive disorder is low in comparison to minor and subsyndromal depression in PD,[31] either PD-depression is not characteristically affective or anhedonic or the GDS does not primarily measure affective depression in PD. As the GDS, as well as other "depression measures," is often used to characterize depression in PD, these findings have important clinical and practical implications including identifying effective treatments for PD-depression. Our findings could be used to not only identify symptom profiles that are resistant to traditional depression treatments but also pinpoint alternative targets for intervention. Furthermore, it may be beneficial to use adjunctive measures of anhedonic depression, such as the HAMDd or MDS-UPDRSd, or clinical interviews, to fully assess affective depression in this population.

There are limitations of this study to acknowledge. First, our participants were early in disease stage, nondemented, primarily White, and highly educated, which may limit the generalizability of these findings to other PD samples. Thus, to expand generalizability, future studies including individuals with PD with more severe cognitive impairment and greater ethnic and educational diversity is warranted. Another potential limitation is that, on average, our sample did not have clinical levels of depression. Nonetheless, secondary analyses within a depressed subset were similar to that of the entire sample. Although additional research is needed, these preliminary results suggest that the magnitude of depressive symptoms endorsed on the GDS was not a significant factor in the results. In addition, the GDS and other measures of neuropsychiatric symptoms were self-reported (with minimal clinician administration). Although evidence exists for the interchangeable use of clinician-administered and self-report measures,[41-43] future research should address this limitation by using both methods to determine whether the administration process affects results. Lastly, to our knowledge, this study was the first to examine the factor structure of the GDS in PD, thus, warranting future research to confirm the validity and reliability of these factors. Such an approach may further elucidate the clinical and research merit of the GDS in PD.

In summary, the findings of this study demonstrate that the GDS total score is not an independent index or a primary measure of affective depression in PD. Instead, the GDS total score appears to encompass several depression-related symptoms including anxiety, apathy, and fatigue. These symptoms may indicate a nonaffective atypical profile of "depression" in PD. Concordant with these findings, results revealed a PD-specific factor structure with three subscales that significantly correlated with validated measures of anxiety, apathy, and fatigue. Taken together, this study suggests that clinicians and researchers should be aware that multiple mood and somatic symptoms may contribute to positive responses on the GDS in PD. Our findings further underscore the importance of validating neuropsychiatric measures in patient-specific populations, such as PD.

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