Performance of Patients with Early Parkinson Disease on an Executive and Social Cognition Battery

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Objective: To demonstrate the usefulness of incorporating the Executive and Social Cognition Battery (ESCB) to detect executive and social cognition deficits, which are otherwise not captured by more "classical" executive tests in early Parkinson disease (PD).

Background: PD is a neurodegenerative disorder that includes executive and social cognition deficits. While cognitive assessment in PD still relies on classical executive tasks to detect frontal deficits, these traditional tests often fail to uncover subtle, yet relevant, frontal impairment.

Methods: We evaluated 39 PD patients and 47 controls with a battery of classical executive tests and the ESCB. The ESCB includes a series of tasks that more closely resemble real-life activities and have been previously shown to be useful in detecting executive deficits in other neuropsychiatric disorders with frontal involvement.

Results: We observed that both batteries used in a complementary way yielded better results, as 15 of the 39 patients presented deficits only on some of the ESCB tests, but not on the classical battery, while 5 patients presented deficits only on some tests of the classical battery, but not on the ESCB. Fourteen patients presented deficits on some tests of either battery, and 5 patients did not present deficits on any of the tests.

Conclusions: We found that, used along with traditional neuropsychological tasks, the ESCB may be useful in providing a more comprehensive evaluation of frontal dysfunction among patients with PD, thus contributing to the early diagnosis of cognitive disorders in this patient population.

Key Words: Parkinson disease, executive function, social cognition, frontal assessment, Executive and Social Cognition Battery (ESCB)

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ESCB = Executive and Social Cognition Battery. **IGT** = Iowa Gambling Task. **MET-HV** = Multiple Errands Test Hospital Version. **PD** = Parkinson disease. **TMT** = Trail Making Test. **WCST** = Wisconsin Card Sorting Test.

Although Parkinson disease (PD) is primarily characterized by its motor symptoms, it is now widely accepted that nonmotor changes are frequently present, even during the early stages of the disease (Chaudhuri et al, 2006; Lima et al, 2012; Roca et al, 2012). In particular, cognitive dysfunction has been extensively described, with executive dysfunction being the most frequently reported cognitive symptom among patients with PD (Foltynie et al, 2004; Hindle et al, 2014; Kudlicka et al, 2011; Lewis et al, 2005; Williams-Gray et al, 2007). These executive deficits have been attributed mainly to the frontal dysfunction caused by disruption of frontal-subcortical circuits in PD, a pathological process that has also been associated with other cognitive and social functions, such as attention and regulation (Boord et al, 2017; Foo et al, 2017; Kudlicka et al, 2013; Stam et al, 1993).

Executive functioning refers to a set of cognitive processes that are necessary to select and successfully monitor goal-directed behaviors. Executive functions encompass different processes, such as working memory, cognitive flexibility, reasoning, planning, and set shifting, and rely heavily on the integrity of the prefrontal cortex (Burgess and Alderman, 2004). A plethora of tests have been designed to assess these many different executive processes and are widely used in clinical practice, including the well-known Wisconsin Card Sorting Test (WCST) (Nelson, 1976), phonological fluency tests (Benton et al, 1994; Butman et al, 2000), and the Trail Making Test (TMT) (Partington and Leiter, 1949). Deficits in such classical executive tests have been described in early PD (Dirnberger and Jahanshahi, 2013; Kudlicka et al, 2011).

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Similarly, other functions associated with higher-level cognitive skills, such as multitasking, decision making, and social cognition, have been related to frontal functions (Godefroy et al, 2010) and have also been found to be impaired even in the early stages of PD. Specifically, deficits in the ability to infer other people's intentions (Bodden et al, 2010a, 2010b; Kemp et al, 2012), the ability to maintain higher-order internal goals while other subgoals are being performed (Brown et al, 2010; Hackney and Earhart, 2010; LaPointe et al, 2010), and the capacity to make favorable choices by taking into account the long-term negative outcomes and ignoring immediate gains (Gleichgerrcht et al, 2010a; Herz et al, 2016; Mimura et al, 2006; Xi et al, 2015) have all been described in early PD.

Even though it is now well recognized that performance on classical executive tests can be spared in the presence of frontal dysfunction (Burgess et al, 2006; Cohen et al, 2012; de Frias et al, 2009; Roca et al, 2013; Torralva et al, 2009), the clinical assessment of frontal cognitive function in PD still relies almost exclusively on the use of classical executive tests.

In order to provide a more comprehensive evaluation capable of detecting the variety of cognitive deficits shown by patients with frontal dysfunction, our group previously designed the Executive and Social Cognition Battery (ESCB), which demonstrated superior ability to detect subtle frontal deficits otherwise not captured by classical executive tests (Torralva et al, 2009). The ESCB was originally designed to assess patients suffering from behavioral variant frontotemporal dementia, as they often have decreased everyday function in real life, especially early in the disease, yet they frequently perform normally on standard frontal batteries. For this reason, the ESCB was designed to include tests that address multitasking (the Multiple Errands Test Hospital Version [MET-HV] and Hotel Task), theory of mind (Faux Pas and Mind in the Eyes tests), and decision making (Iowa Gambling Task [IGT]). In fact, because it is a common observation that patients may experience everyday dysexecution not always detected by classical frontal tests, the ESCB has demonstrated good value in the assessment of other neurologic disorders with frontal involvement, such as multiple sclerosis (Roca et al, 2014) and frontal lobe lesions (Roca et al, 2010).

Our objective in this study was to demonstrate the usefulness of incorporating more "ecological" tests of executive and social functioning in PD neuropsychological assessment. In particular, and based on our experience with other clinical populations (Caletti et al, 2013; Gleichgerrcht et al, 2010b; Torralva et al, 2009), we hypothesized that the ESCB would be able to detect performance deficits otherwise not captured by more "classical" executive tests in early PD. To accomplish such an objective, we included only patients in the early stages of PD with the objective of exploring whether social and executive deficits in this condition are found even at the beginning of the disease.

METHODS

Participants

Thirty-nine patients who met UK Parkinson's Disease Society Brain Bank criteria (Hughes et al, 1992), Hoehn and Yahr stage I or II (ie, early-stage PD), were recruited from the INECO Data Base in Buenos Aires, Argentina, and the Movement Disorders Clinic at the Institute of Neuroscience at Favaloro Foundation University Hospital in Buenos Aires, Argentina. Mean (standard deviation) age for the patient population was 62.97 (10.04) years. Information on disease history and drug therapy was obtained by neurologists specializing in studying PD. Patients with different neurologic diagnoses or presenting radiologic structural brain abnormalities compatible with diagnoses other than PD were excluded from this study. We also excluded patients who scored under 24 on the Mini-Mental State Examination (Folstein et al, 1975) to ensure a good level of overall cognitive performance outside the sphere of executive functions.

Of the patients selected, 17 were under pharmacologic treatment with either levodopa or a dopamine agonist, with a mean levodopa-equivalent daily dose of 269.04 (263.27) mg. Among those patients, assessment was conducted during the "on" state of the medication. Twenty-two of the patients were not taking any medication for their motor symptoms. Performance between medicated and nonmedicated patients was compared a priori in order to ensure that results were not influenced by medication intake. The differences between the two groups were not significant (our data are shown in Supplemental Digital Content 1, http://links.lww.com/CBN/A70 and 2, http://links.lww.com/CBN/A71). In addition, a comparison of the classical and ESCB tests between patients with Hoehn and Yahr stage I or II showed no significant differences (see data in Supplemental Digital Content 3, http://links.lww.com/CBN/A72 and 4, http://links.lww.com/CBN/A73).

Permission for the study was initially obtained from the local research ethics committee, and all participants provided written informed consent prior to their inclusion. The participants' consent was obtained according to the Declaration of Helsinki.

Healthy control volunteers (n = 47) were recruited through word of mouth and were matched to patients taking into account the mean and range of age and years of education. Controls were recruited from the same geographic area as patients. Participants were included in the control group if they reported no history of neurologic or psychiatric disorders, including traumatic brain injury or substance abuse.

Of all the participants, 32 patients and 22 controls had been evaluated for a previous study (Roca et al, 2012). These participants had been evaluated by all of the tests cited in the present work, but the results of only five tests were used in the 2012 study (WCST, Verbal Fluency, Hotel Task, Faux Pas, and Mind in the Eyes). Seven additional patients and 25 controls were assessed for the present work. Table 1 shows demographic and clinical data for all participants.

Cognitive Assessment

General Neuropsychological Battery

Cognitive status was measured using the Mini-Mental State Examination (Folstein et al, 1975). Patients were also assessed with the Addenbrooke's Cognitive Examination Revised (Mioshi et al, 2006), a well-validated scale that has been shown to be useful for the assessment of patients with

TABLE 1. Demographics and Neurocognitive Test Data for Patients with Parkinson Disease and Controls

	Patients	Controls	*P*	Glass's Delta
Demographics				
Age (years)	63.30 (10.12)	59.58 (11.03)	0.10	0.33
Education (years)	13.39 (4.85)	14.91 (2.97)	0.07	0.51
Cognitive Status				
ACE-R	90.43 (7.37)	96.05 (3.94)	**< 0.01**	1.42
MMSE	28.69 (1.48)	29.35 (0.95)	**0.02**	0.69
Attention				
Digit span forward	6.11 (0.97)	7.12 (1.08)	**< 0.01**	0.93
TMT-A (seconds)	51.62 (34.26)	34.66 (12.54)	**< 0.01**	1.35
Frontal Assessment Battery				
Similarities	2.42 (0.83)	2.79 (0.49)	0.14	0.75
Fluency	2.68 (0.47)	2.96 (0.18)	**0.02**	1.55
Motor series	2.63 (0.95)	2.93 (0.25)	**0.02**	1.2
Inhibitory control	2.78 (0.41)	3 (0)	0.21	*
Go–no go	1.94 (1.17)	2.86 (0.44)	**< 0.01**	2.09
Prehension behavior	2.89 (0.31)	3 (0)	0.12	*
Memory				
Immediate	21.80 (6.33)	26.25 (7.43)	**0.01**	0.59
Delayed	17.5 (6.69)	21.51 (7.28)	**0.02**	0.55
Recognition	16.36 (2.87)	17.44 (2.27)	0.11	0.47
Language				
Boston Naming Test	18.25 (2.20)	19.70 (0.46)	**< 0.01**	3.15
Semantic fluency	17.05 (5.71)	21.75 (5.26)	**< 0.01**	0.89
Executive (Classical Tasks)				
Digit span backward	4.27 (0.84)	4.84 (1.09)	**0.01**	0.52
Letters and numbers	7.76 (2.28)	11.24 (2.74)	**< 0.01**	1.27
Phonological fluency	13.94 (5.13)	16.90 (4.82)	**0.01**	0.61
TMT-B (seconds)	127.67 (97.32)	79.75 (40.47)	**< 0.01**	1.18
WCST (total score)	4.48 (1.68)	5.73 (0.63)	**< 0.01**	1.98

Data are shown as mean (standard deviation).
Bold type indicates statistical significance.
*Glass's delta could not be calculated because the standard deviation is zero.
ACE-R = Addenbrooke's Cognitive Examination Revised. **MMSE** = Mini-Mental State Examination. **TMT** = Trail Making Test. **WCST** = Wisconsin Card Sorting Test.

PD (Chade et al, 2008). Attention and concentration were assessed with the digit span forward task (Wechsler, 1991) and the TMT-A (Partington and Leiter, 1949). Memory was assessed using the logical memory (story recall) subtest from the Wechsler Memory Scale-Revised (Wechsler, 1991). Naming difficulties were assessed with the adapted version of the Boston Naming Test (Kaplan et al, 1983).

Classical Executive Tests

Executive function tests in the cognitive battery were the following:

Frontal Assessment Battery (Dubois et al, 2000). This frontal screening includes six subtests: conceptualization, mental flexibility, motor programming, sensitivity to interference, inhibitory control, and environmental autonomy. Data were available for 34 of 39 patients.

Digit Span Backward (Wechsler, 1991). Participants were presented with sequences ranging in length from two to eight digits and asked to repeat the digits in the reverse order. This task assesses mental manipulation and working memory. Data were available for 37 of 39 patients.

Letters and Numbers (Wechsler, 1939). Participants were presented with an increasing number of letters and digits and asked to repeat them in such a way that numbers are ordered in an ascending fashion and letters arranged alphabetically. This test also assesses mental manipulation. Data were available for 31 of 39 patients.

Verbal Fluency (Benton et al, 1994). In verbal fluency tasks, participants were asked to generate as many items as possible from a given category in a specific period of time. We used the standard Argentinean phonological version (Butman et al, 2000), prompting participants to generate words beginning with the letter "P" during a 1-minute block. Score was the total number of correct words generated. Data were available for 37 of 39 patients.

Trail Making Test-B (Partington and Leiter, 1949). Participants were instructed to draw lines sequentially connecting

13 numbers and 12 letters distributed on a sheet of paper. They were to join the encircled letters and numbers in alternating fashion (eg, 1, A, 2, B, 3, C, etc). Score was the total time required (measured in seconds) to complete the task. Data were available for 38 of 39 patients.

Wisconsin Card Sorting Test (Nelson, 1976). For the WCST, we used Nelson's modified version of the standard procedure. Cards featuring various colors, shapes, and number of items were to be sorted according to one feature at a time. The participants' first sorting choice became the correct feature, and once a criterion of six consecutive correct sorts was achieved, participants were told that the rules had changed, and instructed to sort cards according to a new feature of their choice. After all three features had been used as sorting criteria, participants cycled through them again in the same order as they did before. Each time the feature shifted, the next one was to be discovered by trial and error sampling by the participant. Score was the total number of categories achieved. Data were available for 36 of 39 patients.

Executive and Social Cognition Battery

Our ESCB consisted of five tests, including some tests of ecological validity, selected to detect executive-social dysfunction.

Hotel Task (Manly et al, 2002; Torralva et al, 2009). The task comprised five primary activities related to running a hotel. Individual activities are described in more detail elsewhere (Roca et al, 2010; Torralva et al, 2009). Participants were told to execute at least some of all five activities during a 15-minute period, so that, at the end of this period, they would be able to give an estimate of how long each would take to complete. It was explained that the time available was not enough to complete any of the tasks; the goal, instead, was to ensure that each task was attempted. In addition to the five primary activities, participants were also asked to remember to open and close the hotel garage doors at particular times (open at 6 minutes, close at 12 minutes), using an electronic button. Score was time allocation: for each primary task we assumed an optimal allocation of 3 minutes, and measured the summed total deviation (in seconds) from this optimum. Total deviation was given a negative sign so that higher scores meant better performance. As an example, if the patient remained in a task for exactly 3 minutes, the time deviation for that task was 0; if he or she remained in the task for 2 minutes (120 seconds), the time deviation was −60 (seconds). Data were available for 34 of 39 patients.

Iowa Gambling Task (Bechara, 2007). During the IGT, participants were required to pick cards from four decks and received rewards and punishments (winning and losing abstract money) that depended on the chosen deck. Two "risky" decks yielded greater immediate wins but major occasional losses that, if systematically picked, would lead to negative outcomes over time. The other two "conservative" decks yielded smaller wins but negligible losses, thus resulting in net profit over time. Participants made a series of selections from these four available options, from a starting point of complete uncertainty. Reward and punishment information acquired on a trial-by-trial basis was presented on the screen by means of sounds and faces, and was to be used to guide behavior toward a financially successful strategy. Control participants tend to increasingly choose conservative decks over the 100 trials of the task. Our score was the total number of conservative minus risky choices. Data were available for 30 of 39 patients.

Mind in the Eyes (Baron-Cohen et al, 1997). This task consisted of 17 photographs of the eye region of different human faces. Participants were required to make a two-alternative forced choice that best described what the person was thinking or feeling (eg, worried versus calm). The score was total number of correct stimuli. Data were available for 35 of 39 patients.

Faux Pas (Stone et al, 1998). On each trial of this test, the participant was read a short paragraph-long story. To reduce working memory load, a written version of the story was also placed in front of the participant. In 10 stories, there was a faux pas, involving one person unintentionally saying something hurtful or insulting to another. In the remaining 10 stories, there was no faux pas. After each story, the participant was asked whether something inappropriate was said and, if so, why it was inappropriate. If the answer was incorrect, an additional memory question was asked to check that basic facts of the story were retained; if they were not, the story was reexamined and all questions repeated. The score was 1 point for each faux pas correctly identified, or non–faux pas correctly rejected. Data were available for 35 of 39 patients.

Multiple Errands Test Hospital Version (Knight et al, 2002). Subgroups of patients (n = 10) and controls (n = 14) were also assessed with an extra test, the MET-HV (Knight et al, 2002). Given the complexity of the test, the MET-HV could be evaluated at only one of the sites where the batteries were run, where 10 patients completed the task. This test, which is frequently administered at the hospital and its surroundings, requires participants to carry out a number of tasks simulating "real life" situations, where minor inconveniences can take place (Knight et al, 2002). While still inside the hospital, participants were given a card with four sets of simple tasks, totaling 12 subtasks. The first set required participants to attain six specific goals and the second set involved obtaining and writing down pieces of information. In the third set, participants were required to call the proctor 20 minutes after the test had begun and state the time over the phone. The fourth task required the participant to inform the proctor (in person) when every task had been completed. Nine rules were clearly stated in the instruction sheet, and the participant's behavior while carrying out the tasks was monitored. At the end of the test, each participant had to indicate, on a 10-point scale, how well they thought they had done. Performance in this test was scored counting the number of inefficiencies (where a more effective strategy could have been applied), rule breaks (where a specific rule—a social rule or one of the explicitly defined rules within the test—was broken), interpretation failures (where the requirements of a task had been misunderstood), task failures (where any of the 12 tasks had not been fully completed), and total fails (the sum of all the previous items) made by each subject (Shallice and Burgess, 1991; Torralva et al, 2009).

Neuropsychiatric Assessment

In view of prior research suggesting that behavioral and neuropsychiatric symptoms present in PD correlate with deficits in executive functions (Alzahrani and Venneri, 2015; Leroi et al, 2013; Papagno and Trojano, 2018; Solla et al, 2011; Zgaljardic et al, 2003), we evaluated patients with either the Neuropsychiatric Inventory (Cummings et al, 1994) (data were available for 15 of 39 patients) or the Cambridge Behavioral Inventory (Nagahama et al, 2006) (data were available for 8 of 39 patients). We observed that 7 patients had stereotypic or aberrant motor behavior; 6 had difficulties in everyday activities or self-care; 15 suffered from depression or anxiety; 7 had irritability, aggression, or defiant conduct; 6 had disinhibition; 11 suffered from apathy or loss of motivation; 11 had sleep or eating alterations; 6 had insight or beliefs alterations; and only 1 presented with delusions. Almost all of the patients presented these symptoms infrequently, and severity was mild, as graded by the questionnaires. Because depression is the most common neuropsychiatric symptom in PD (Aarsland et al, 2009), we administered the Beck Depression Inventory (Beck et al, 1961) (data were available for 34 of 39 patients). Twenty-eight patients had minimal depression, four had mild depression, and only two suffered from moderate symptoms. Depression has frequently been associated with cognitive deficits, with some studies suggesting that it exacerbates baseline impairments and others showing no significant difference in executive function performance between depressed and nondepressed patients (Silberman et al, 2007; Troster et al, 1995) or based on depression severity (Costa et al, 2006). To test this, the Beck Depression Inventory score was introduced as a covariable in group comparisons. Results showed that significant group differences in cognitive and executive function measures did not dissipate after controlling for depressive symptoms, except for semantic fluency ($F_{1,48}=2.44$; $P=0.12$; $\eta_p^2=0.04$).

Statistical Analysis

To analyze the differences in neuropsychological, executive, and social cognitive performance between patients and controls, we performed *t* tests for independent samples for each of the tasks.

RESULTS

Demographic and Neuropsychological Profile

Patients and controls were successfully matched for age ($P=0.10$) and years of education ($P=0.07$). As expected, a significant difference between the groups was found for Addenbrooke's Cognitive Examination Revised scores ($P < 0.01$) and Mini-Mental State Examination ($P=0.02$). Attention was significantly different between patients and controls, as measured by the digit span forward test ($P<0.01$) and performance on the TMT-A ($P < 0.01$).

Group differences were also found for three of six variables of the Frontal Assessment Battery: fluency ($P=0.02$), motor series ($P=0.02$), and go–no go ($P<0.01$).

Performance on memory tasks showed significant differences for immediate ($P=0.01$) and delayed recall ($P=0.02$). No differences were found, however, for recognition ($P=0.11$). Performance by patients also differed significantly from that of controls in language tasks, particularly the Boston Naming Test ($P < 0.01$) and semantic fluency ($P < 0.01$).

Table 1 shows that, with respect to classical executive tests, the groups differed significantly on every task: digit span backward ($P=0.01$), letters and numbers ($P<0.01$), phonological fluency ($P=0.01$), TMT-B ($P<0.01$), and WCST (total score) ($P<0.01$).

TABLE 2. Executive and Social Cognition Battery (ESCB) Performance of Patients and Controls

ESCB Task	Patients	Controls	*P*	Glass's Delta
Faux Pas	17.54 (2.07)	18.93 (1.14)	**< 0.01**	1.21
Mind in the Eyes	13.28 (1.65)	14.33 (1.27)	**< 0.01**	0.82
Multiple Errands Test Hospital Version				
Inefficiencies	0.6 (0.69)	0.78 (1.05)	0.06	0.17
Rule breaks	3.4 (2.27)	1.07 (1.20)	**< 0.01**	1.94
Interpretation failures	0.3 (0.67)	0 (0)	0.10	*
Task failures	0.7 (0.94)	0.14 (0.36)	**0.05**	1.55
Hotel Task				
Tasks attempted	4.45 (0.83)	4.56 (0.50)	0.57	0.02
Tasks correct	4.39 (0.82)	4.48 (0.50)	0.64	0.18
Time deviation	476.30 (229.01)	318.80 (135.91)	**< 0.01**	1.15
Button pressing	1.63 (0.60)	1.92 (0.27)	**0.03**	1.07
Iowa Gambling Task (total score)	0.88 (21.66)	17.66 (25.27)	**0.02**	0.66

Data are shown as mean (standard deviation).
Bold type indicates statistical significance.
*Glass's delta could not be calculated because the standard deviation is zero.

TABLE 3. Comparison of Frequency of Impairment on Classical Tests Between Patients and Controls

	Frequency of Impairment			
Classical Task	Patients	Controls	*P*	χ^2
Digit span backward	5.41%	0%	0.17	1.83
Letters and numbers	40%	2.08%	**< 0.01**	19.11
Phonological fluency	24.32%	2.08%	**< 0.01**	9.95
Trail Making Test-B (seconds)	31.58%	4.17%	**< 0.01**	11.69
Wisconsin Card Sorting Test (total score)	44.44%	4.17%	**< 0.01**	19.82

Bold type indicates statistical significance.

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TABLE 4. Comparison of Frequency of Impairment on the ESCB Between Patients and Controls

	Frequency of Impairment			
Task	**Patients**	**Controls**	***P***	χ^2
Faux Pas	40%	12.50%	**< 0.01**	8.36
Mind in the Eyes	25.71%	12.50%	0.12	2.38
Multiple Errands Test Hospital Version, task failures	50%	14.29%	**0.05**	3.60
Hotel Task, time deviation	37.14%	8%	**0.01**	6.60
Iowa Gambling Task (total score)	4%	5.56%	0.81	0.05

Bold type indicates statistical significance.

Executive and Social Cognition Battery (ESCB) Performance

As shown in Table 2, performance on tests of theory of mind was significantly different between patients and controls, both in the Faux Pas test ($P<0.01$) and the Mind in the Eyes test ($P<0.01$). The subscale of rule breaks of the MET-HV revealed significant differences between the groups ($P<0.01$), and we found a borderline effect for task failures ($P=0.05$). Inefficiencies and interpretation failures were nonetheless not significantly different ($P=0.06$ and 0.10, respectively). In addition, time deviation ($P<0.01$) and button pressing ($P=0.03$) measurements of the Hotel Task, as well as the overall IGT score ($P=0.02$), were significantly different between patients and controls.

Comparison Between the Classical Tests and the ESCB to Yield Frontal Deficits

In order to examine the usefulness of the ESCB as a complementary battery to assess frontal dysfunction, we determined how many patients presented deficits on the classical executive tests (digit span backward, letters and numbers, phonological fluency, TMT-B, and WCST total score) and on the ESCB (Faux Pas, Mind in the Eyes, MET-HV task failures, Hotel Task time deviation, and IGT). Impaired performance was determined by patients scoring 1.5 standard deviations below the average of the controls' performance on at least any one test of either battery (ie, classical or ESCB). The frequency of impaired controls and patients was compared using χ^2 analysis (Tables 3, 4).

Twenty of the 39 patients (51.3%) did not present deficits on any of the five executive tasks included on the classical battery. The remaining 19 patients (48.7%) were impaired on four (n = 4), three (n = 6), two (n = 5), or one (n = 4) of the classical tests. On the other hand, only 10 patients showed no deficits whatsoever on any of the five ESCB tasks (Figure 1). For those who did show some degree of impairment, 4 patients presented deficits on three tasks, 4 other patients performed poorly on two tests, and 21 patients had deficits on only one test. Of note, five patients did not present deficits on any of the tests (from both batteries). Fourteen patients presented deficits on some tests of either battery (Figure 1). Five patients presented deficits only on some tests of the classical battery, but not on the ESCB; 15 patients presented deficits only on some of the ESCB tests, but not on the classical battery. Disregarding the number of tasks completed by each patient, of the 15 patients who presented deficits only on the ESCB, 14 completed all of the tests from the classical battery, suggesting that the ESCB is able to detect deficits that are not detected by classical executive tests.

DISCUSSION

PD is a neurodegenerative condition characterized by motor and nonmotor symptoms associated with a dopamine depletion in the substantia nigra and progressive degeneration of other subcortical regions, affecting frontostratial circuits (Blaszczyk, 2017; Jahanshahi and Rothwell, 2017). Around 40% of patients present with cognitive impairment, particularly frontal deficits such as executive dysfunction and impaired social cognition (Bora et al, 2015; Dirnberger and Jahanshahi, 2013).

Despite the consensus in the neuropsychological community that frontal dysfunction requires a specific, ecologically

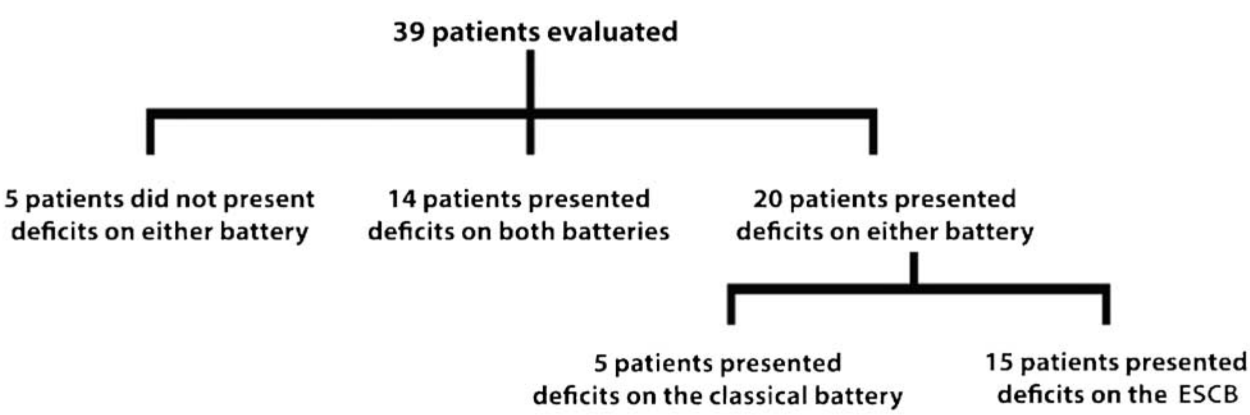

FIGURE 1. Number of patients who showed deficits on neither battery (neither classical nor ESCB), on both batteries, and on either battery. **ESCB** = Executive and Social Cognition Battery.

valid and sensitive evaluation, the most common assessment of executive functions tends to include only classical executive and neuropsychological tests, which fail to detect subtle yet relevant changes in frontal functioning (de Frias et al, 2009; Godefroy et al, 2010). In the present study, we investigated how the use of the ESCB, already tested in behavioral variant frontotemporal dementia (Gleichgerrcht et al, 2010b; Torralva et al, 2009) and other neurologic disorders with frontal involvement (Caletti et al, 2013), could be useful in detecting frontal deficits in early PD. The ESCB consists of five tests (Faux Pas, Mind in the Eyes, MET-HV, Hotel Task, and IGT) and provides a more sensitive and realistic assessment of frontal functioning that may contribute to the early diagnosis of cognitive impairment in PD.

In this study, we found that the executive and social cognition deficits in patients with early PD are better recognized using the ecological ESCB along with traditional executive function batteries. The administration of the ESCB helped to obtain a more detailed cognitive profile of patients with early PD, showing significant differences for executive functioning and social cognition. In addition, when comparing the reliability of classical tests and the ESCB to detect frontal dysfunction, we observed that using both batteries in a complementary fashion yielded better results.

This new battery provides the advantage of evaluating a full range of deficits that can occur in PD patients and are not routinely assessed with the executive tests, yet are crucial to competent everyday life performance. These include, particularly, functions associated with the rostral prefrontal cortex such as decision making, prospective memory, multitasking, and mentalizing.

Furthermore, contrary to classical social cognition and executive function batteries, the scores derived from the ESCB's tests are not influenced by slowing mental or motor processing. For example, even if motor skills are needed to perform the tasks in the Hotel Task, the score is based on the deviation of time spent on each subtask from the ideal time rather than the number of items accomplished in each one.

In summary, this study portrays how the cognitive deficits in patients with early PD encompass a series of dysfunctions that go beyond the ones measured by classical neuropsychological evaluation—such as attention, language, and memory—and that involve specific executive and social cognition variables that require more sensitive tasks for their assessment.

We believe that traditional measures of frontal executive function may be insufficient to detect subtle executive and social cognition deficits, as they fail in reproducing real-life activities. Thus, their results may not be generalized to the patient's everyday functioning. Therefore, we propose that classical executive and neuropsychological batteries should be complemented with the ESCB when possible. Naturally, this is a time-demanding battery of tests, but it may prove particularly useful specifically among patients with subjective complaints of cognitive impairment in real life who perform otherwise normally on classical tests. The results of this battery may thus help us to understand better the cognitive deficits that underlie the everyday difficulties experienced by patients with PD, as well as to design improved rehabilitation strategies.

The findings of this study must be interpreted in the context of some limitations. First, given the lengthy nature of this battery, our sample is relatively small and confined to patients in the early stages of the disease. This means that generalizability of the results is limited, especially to patients in the more advanced phases of PD. In this sense, we also acknowledge that the ESCB battery is rather long, which may challenge its widespread implementation, but abbreviated versions of the ESCB have been studied and may become useful in contexts where human or time resources are limited (Gleichgerrcht et al, 2010b).

Another limitation in testing PD patients is that some of the classical executive tests can be affected by motor-verbal performance (Frontal Assessment Battery's fluency, go–no go, and motor series). However, as previously stated, none of the tests included in the ESCB are influenced by motor disabilities, which could be considered an advantage of the ESCB for its use in PD. In fact, this characteristic makes our ecological battery a suitable and more reliable tool to evaluate executive and social cognition deficits in these patients. This is further supported by the fact that no significant differences were found between patients with Hoehn and Yahr stages I and II. Future studies should evaluate the utility of shorter combinations of ESCB tasks particularly in PD to assess executive and social cognition impairments in settings that recreate everyday challenges and that are not influenced by slowing of motor-verbal performance.

We strongly believe that studying executive and social cognition dysfunction in PD—as in other neurodegenerative diseases—is of great importance, not only in consolidating the early detection of cognitive deficits in this patient population, but also as it may shed light on how the neural substrates that support advanced cognitive skills may be altered with progression of the disease (Bora et al, 2015).

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