

# Development and efficacy of a compensatory skill building program: Parkinson's disease cognitive rehabilitation for executive functioning (PD-CoRE)

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## ABSTRACT

**Objective:** Cognitive dysfunction is a major clinical feature of PD that contributes to disability, caregiver strain, and diminished quality of life over the disease course. Cognitive rehabilitation has mounting evidence as an intervention relevant for improving quality of life for people living with PD. The Parkinson's Disease Cognitive Rehabilitation of Executive functioning (PD-CoRE) program is a new cognitive rehabilitation program designed to teach compensatory skills that address daily struggles secondary to executive dysfunction and to break the cycle of cognitive impairment, depression, apathy, poor self-efficacy, reduced quality of life, and increased caregiver burden. The aim of the current study was to evaluate the efficacy of the PD-CoRE program in improving executive functions of individuals with PD and mild cognitive impairment.

**Methods:** Standardized neuropsychological tests and ecologically valid outcome measures were administered to assess executive functions in addition to mood, apathy, self-efficacy, life satisfaction, quality of life, and caregiver burden. A series of Wilcoxon signed-rank tests were performed.

**Results:** Results revealed initial improvements in immediate attentional capacity and long-term improvements in inhibition, delayed verbal recall, and verbal memory discrimination. 50% of participants reported subjective improvement in their ability to engage in daily activities, and 50% reported increased self-efficacy. Results from informants revealed that 40% of spouses perceived improvements in the participant's self-regulatory abilities, and 60% reported observing improvements in the participants' ability to manage activities of daily living.

**Conclusion:** Findings from the present study provide support for the feasibility and, if cross-validated, the efficacy of the PD-CoRE program in PD patients with executive dysfunction.

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## Introduction

The hallmark of Parkinson's disease (PD) is its motor features, but selective cognitive impairments are evident in over 40% of patients<sup>(1)</sup>. Cognitive dysfunction is now recognized as a major clinical feature of PD that contributes more to disability, caregiver strain, and diminished quality of life over the disease course than motor deficits<sup>(2-4)</sup>. Cognitive deficits associated with PD arise in part from neural changes in the frontostriatal circuits, leading to executive dysfunction<sup>(5)</sup>. Thus, difficulties in executive skills such as working memory, inhibition, and cognitive flexibility (or set-shifting) are some of the most prominent and early cognitive changes associated with PD<sup>(6-7)</sup>. With advances in medical interventions for motor symptoms, individuals with PD are living longer and facing greater disability related to cognitive impairments. Unfortunately, pharmacological treatments for PD cognitive changes are currently limited and have not demonstrated efficacy in reducing executive functioning impairments<sup>(8)</sup>. The importance of investigating non-pharmacological treatment options for cognitive dysfunction is clear.

Cognitive rehabilitation is one such behavioral technique with promising evidence to improve and maintain cognitive skills in those with PD-related cognitive impairment. This type of intervention was originally designed for traumatic brain injury but has been adapted for other neurological conditions. However, research is in its infancy and there are no standardized guidelines for treatment in PD. Cognitive rehabilitation programs generally seek to reduce functional impairment and increase engagement in activities of daily living through skills training. Calleo and colleagues<sup>(9)</sup> conducted a critical integrative review of the PD cognitive

rehabilitation literature at the time and found limited evidence for effectiveness across four studies (two of which were randomized controlled trials [RCTs])<sup>(11-12)</sup>. However, the authors noted numerous potential areas of improvement for future studies, such as the need for ecologically valid outcome measures and generalizability of findings to a larger sample of PD patients. A more recent review<sup>(13)</sup> found promising benefits for cognitive functioning in mild to moderate PD across seven RCTs, a reflection of both the growing attention to cognitive rehabilitation in this population and the increasing feasibility in this population. Five RCT studies have found statistically significant improvements with moderate effect sizes of cognitive rehabilitation on executive functioning in PD<sup>(11, 14-17)</sup>. While these emerging studies highlight the increasing centrality of non-pharmacological approaches in the care of PD, these findings are preliminary in nature. Participants in these studies tended to be cognitively intact, which limits our understanding of the role of cognitive rehabilitation among those who may benefit the most (i.e., PD patients with mild cognitive impairment). These studies examined a variety of cognitive domains, which limit the generalizability of treatment effects. Executive dysfunction is the most prominent cognitive change in PD, and is more strongly associated with deleterious motor and neuropsychiatric effects in PD<sup>(18)</sup>; therefore, it warrants targeted attention in the development of interventions.

In addition to findings that cognitive rehabilitation may ameliorate cognitive impairment associated with PD, growing attention has been paid to the generalizability of intervention effects to neuropsychiatric symptoms. However, even less research has been conducted in these domains, and the limited findings are inconclusive. Cognitive

rehabilitation appears to have a moderate effect on improving depression<sup>(11, 14-16, 19)</sup>, albeit with mixed findings. Even fewer studies have explicitly assessed quality of life, also with mixed findings<sup>(11, 16)</sup>. Apathy, or the reduction in goal-oriented behavior, often overlaps with depression and cognitive impairment but can be evaluated separately<sup>(20)</sup>. As such, apathy is prevalent in PD and associated with poorer quality of life and increased caregiver burden<sup>(21-22)</sup>. Apathy has only been assessed in one RCT<sup>(15)</sup>, with no change noted by authors. Therefore, little is known about potential improvements in apathy following cognitive rehabilitation. A related construct of self-efficacy, or the expectations one has around one's ability to successfully execute goal-directed behavior<sup>(23)</sup>, has also received limited attention in the PD literature. Self-efficacy is associated with social withdrawal, depression, and diminished functional capacity in patients with Alzheimer's disease<sup>(24)</sup>. It may operate similarly to the cycle in PD, in which physical deconditioning and cognitive deficits create a loop of helplessness and poor self-efficacy as patients increasingly cease to engage in hobbies, reduce physical activity, rely on others, and feel uncertain about their future. A decrease in self-efficacy may further accelerate physical and cognitive decline. Finally, executive dysfunction and related neuropsychiatric effects of depression, apathy, and poor self-efficacy have deleterious effects on caregiver burden and quality of life<sup>(25-27)</sup>. However, interventions to reduce caregiver burden and improve patient quality of life are scarce. No study to date has assessed all of these interrelated constructs, so it is unknown which of these neuropsychiatric and psychosocial factors are the most amenable to change following participation in a cognitive rehabilitation intervention.

Cognitive rehabilitation has mounting evidence as an intervention relevant for improving quality of life for people living with PD<sup>(28-29)</sup>. Using Calleo and colleagues' <sup>(9)</sup> recommendations as a foundation, we developed a novel PD group cognitive rehabilitation program to target the executive functioning impairments in PD, called the Parkinson's disease Cognitive Rehabilitation of Executive functioning (PD-CoRE) program. We addressed limitations of

previous studies by implementing ecologically valid outcome measures in our neuropsychological battery and targeting the intervention to the cognitive deficits most commonly demonstrated in PD patients (i.e., executive functions).

The aim of the current study was to evaluate the efficacy of the PD-CoRE program in building compensatory strategies to improve applied executive functioning in individuals with PD and mild cognitive impairment. Standardized neuropsychological tests and ecologically valid outcome measures were used to assess executive functions in addition to mood, apathy, self-efficacy, life satisfaction, quality of life, and caregiver burden. The goal of PD-CoRE is to teach compensatory skills that address daily struggles secondary to executive dysfunction and to break the cycle of cognitive impairment, depression, apathy, poor self-efficacy, reduced quality of life, and increased caregiver burden. With the skills learned in the PD-CoRE program, the following was hypothesized: 1) Participants would perform better on objective measures of executive functioning following the group; 2) Participants would report an improvement in problem-solving and adaptive abilities in their everyday lives, improved mood, increased quality of life, and greater sense of self-efficacy; and 3) Informants would report improved adaptive and self-regulatory abilities. .

## Study 1. Initial Feasibility Study

### Methods

#### Participants

A preliminary feasibility study was implemented in January 2016 in which PD-CoRE was delivered in a small group setting. The PD-CoRE program was created to be delivered via groups instead of individual sessions as groups are traditionally more cost-effective than individual sessions (e.g., less time intensive for therapists, require fewer resources; <sup>30</sup>). Nine participants (67% male, Age<sub>mean</sub> = 66.9, Education<sub>mean</sub> = 16.22 years), with mild PD (baseline Montreal Cognitive Assessment [MoCA<sub>mean</sub>] = 25.7/30) and self-reported executive dysfunction were successfully recruited and retained for the initial feasibility group.

### Process

The Baylor College of Medicine Institutional Review Board approved the study protocol and informed consent was obtained from all participants. The initial program consisted of 8 1.5-hour group sessions providing education and hands-on experiences targeting inhibition, working memory, and set-shifting abilities. Participants were recruited via flyers distributed in the corresponding author's clinic and via a posting in the Houston Area Parkinson Society (HAPS) newsletter. Potential subjects who expressed interest were contacted by a group leader and completed an eligibility screener to gather basic demographics (age, sex, race, handedness, and education) and to complete a baseline MoCA, Beck Depression Inventory, 2<sup>nd</sup> Edition (BDI-II), Columbia- Suicide Severity Scale (CSSR-S), and Parkinson's Daily Activities Questionnaire-15 (PDAQ-15). Participants were included if they had a diagnosis of idiopathic PD, were between the ages of 45 and 75 years old, were fluent English speakers, and were able to give informed consent. Exclusionary criteria included: active psychosis, significant depression (BDI-II > 14), impaired instrumental activities of daily living (PDAQ-15 < 60), concurrent cognitive rehabilitation treatment, and diagnosis of dementia. All participants completed at least 7 of the 8 weekly sessions. Participants underwent comprehensive neuropsychological batteries prior to the start of group and immediately following the completion of the group.

### Materials/instruments

Participants completed standardized measures pre- and post-treatment assessing global mental status (MoCA; <sup>31</sup>) and memory (Hopkins Verbal Learning Task- Revised [HVLTR]; <sup>32</sup>), as well as multiple aspects of executive functioning including working memory (Digit Span; <sup>33</sup>), verbal fluency (Delis-Kaplan Executive Functioning System [D-KEFS] Letter Fluency & Category Fluency; <sup>34</sup>), semantic set-shifting (D-KEFS Category Switching; <sup>34</sup>), visual scanning/tracking (Trail Making Test Part A, TMT A; <sup>35</sup>), psychomotor set-shifting (Trail Making Test Part B, TMT B; <sup>35</sup>), and inhibition

(Stroop Color Word Test; <sup>36</sup>). Participants also completed self-report measures of perceived cognition (Everyday Problems Test, EPT; <sup>37</sup>), perceived executive dysfunction (Dysexecutive Questionnaire, DEX; <sup>38</sup>), depression (Beck Depression Inventory, 2nd edition, BDI-II; <sup>39</sup>), anxiety (Generalized Anxiety Disorder, 7-item scale, GAD-7; <sup>40</sup>), impact of PD on functioning and well-being (The Parkinson's Disease Questionnaire, PDQ-39; <sup>41</sup>) and a patient satisfaction questionnaire.

### Statistical analysis

All neurocognitive measures were corrected based on appropriate normative data and converted to a common metric (i.e., T Score with  $M = 50$ ,  $SD = 10$ ). Examination of the data showed departure from normal distribution for most dependent variables, therefore nonparametric analyses were utilized. All analyses were run using SPSS (Version 24.0, IBM Corp., Armonk, NY). Wilcoxon signed-rank tests (nonparametric paired samples tests) were utilized to evaluate differences between testing prior to the start of PD-CoRE and immediately following the end of PD-CoRE treatment. Alpha was set at 0.10, one-tailed, for all inferential tests.

### Results

Preliminary analyses revealed an improvement in set-shifting ability (TMT B;  $t(8) = 2.14$ ,  $p = 0.06$ ,  $d = 0.73$ ;  $M_{T_1} = 43.89$ ,  $SD_{T_1} = 13.10$ ,  $MD_{T_2} = 49.56$ ,  $SD_{T_2} = 15.89$ ) and a decline in verbal learning (HVLTR Total;  $t(8) = 3.45$ ,  $p = 0.009$ ,  $d = 1.20$ ;  $M_{T_1} = 50.00$ ,  $SD_{T_1} = 7.91$ ,  $MD_{T_2} = 42.44$ ,  $SD_{T_2} = 9.77$ ). No other changes were noted on the outcome measures. Examination of mood variables revealed subclinical depressive symptoms at baseline and did not change following treatment ( $t(8) = -1.769$ ,  $p = 0.115$ ). Acceptability and satisfaction with the program was high on self-report evaluations; 100% of participants reported enjoying the social interaction with other PD patients, 89% agreed that the program provided them with ecologically valid skills for use in daily life, 78% reported improved problem-solving skills, and 89% would recommend it to other PD patients.

## Study 2. PD-CoRE Efficacy Study

Based on participant feedback and expert consensus, the structure and content of the PD-CoRE program was modified to include additional interactive activities and decrease the number of sessions. The expert consensus panel consisted of a Neuropsychologist, a Movement Disorders Neurologist, a Psychiatrist, a community Social Worker from the local Parkinson's community group, and an individual with Parkinson's disease. The consensus panel met on two occasions to discuss the development and revision of the manualized treatment program. The revised PD-CoRE format consisted of 6 weekly 1.5-hour group sessions. In the current study, a range of neuropsychiatric and psychosocial variables were assessed at three time-points (pre-group, post-group, and 3 months post-group) to extend preliminary findings identified by Leung and colleagues' <sup>(13)</sup> review. Spouse informants were also included to provide collateral ratings. In addition, more stringent inclusion/exclusion criteria were adopted to better assess intervention effects, including selectively targeting those with PD-related mild cognitive impairment (MCI; based on PD-MCI diagnostic criteria published by the Movement Disorder Society Task Force; <sup>42</sup>) who may stand to benefit the most from cognitive rehabilitation relative to those with intact abilities. The specific eligibility criteria are discussed below.

### Methods

#### Participants

Six patients with PD (50% male, Age<sub>mean</sub> = 68.3, Education<sub>mean</sub> = 15 years) were recruited along with six spouse informants via flyers distributed in the corresponding author's clinic and via a posting in the Houston Area Parkinson Society (HAPS) newsletter. Potential subjects who expressed interest were contacted by one of the group leaders and completed an eligibility screener to gather basic demographics (age, sex, race, handedness, and education) and to complete a baseline MoCA, BDI-II, CSSR-S, and PDAQ-15. Participants were included if they had a diagnosis of idiopathic PD, were between the ages of 45 and 75 years old, were fluent English speakers, were able to give informed consent, and had MoCA

scores between 21 and 25 with  $\geq 3$  items on delayed recall <sup>(43)</sup>. Exclusionary criteria included: active psychosis, significant depression (BDI-II  $\geq 14$ ), impaired instrumental activities of daily living (PDAQ-15  $< 60$ ), concurrent cognitive rehabilitation treatment, and diagnosis of dementia.

#### Process

All group members underwent a comprehensive neuropsychological battery prior to the start of the PD-CoRE program that included the original measures from the feasibility study (described above) as well as the Iowa Gambling Task (IGT; <sup>44</sup>; measure of decision-making), Satisfaction with Life Scale (SLS; Diener, <sup>45</sup>), Generalized Self-Efficacy Scale (SES; <sup>46</sup>), Apathy Evaluation Scale (AES; <sup>20</sup>), the self-report form of the Penn Parkinson's Daily Activities Questionnaire-15 (PDAQ; <sup>47</sup>; assessment of cognitive instrumental activities of daily living in PD), and the self-report Behavior Rating Inventory of Executive Functions, Adult Version (BRIEF-A; <sup>48</sup>). Informants completed the Zarit Burden Scale <sup>(49)</sup>, the informant version of the PDAQ, and the informant version of the BRIEF-A. Following the final group session, all group members underwent a repeat comprehensive neuropsychological battery with the above measures. Three months after the group ended, subjects returned to complete a second repeat neuropsychological evaluation.

#### Statistical analysis

Similar to the feasibility study, all neurocognitive measures were corrected based on appropriate normative data and converted to a common metric (i.e., T Score with  $M = 50$ ,  $SD = 10$ ). Wilcoxon signed-rank tests (nonparametric paired samples tests) were run to evaluate differences before and after the PD-CoRE treatment as well as before treatment and during the 3-month follow-up evaluation. Reliable Change Indices <sup>(50)</sup> were calculated based on information provided in the original test manuals to evaluate significant change over time for each participant. Given the small sample size, alpha was set at 0.10, one-tailed, for all inferential tests.



## Results

### Cognitive outcomes:

Comparison of neuropsychological performance at various time points (pre-group, post-group, and follow-up) revealed variable interim changes. As compared to their pre-group performance, participants demonstrated improvement (i.e., higher scores) on immediate attentional capacity (LDSF,  $z = -1.643$ ,  $p = 0.10$ ;  $M_{T1} = 44.83$ ,  $SD_{T1} = 7.41$ ,  $MD_{T2} = 49.50$ ,  $SD_{T2} = 7.45$ ) post-group. Participants demonstrated decline (i.e., lower scores) on measures of speeded word reading (Stroop Word Reading,  $z = -2.626$ ,  $p = 0.009$ ;  $M_{T1} = 32.50$ ,  $SD_{T1} = 11.20$ ,  $MD_{T2} = 27.67$ ,  $SD_{T2} = 10.09$ ), initial verbal learning (HVL-R Total Recall;  $z = -3.081$ ,  $p = 0.002$ ;  $M_{T1} = 54.17$ ,  $SD_{T1} = 6.08$ ,  $MD_{T2} = 41.67$ ,  $SD_{T2} = 9.48$ ), and delayed verbal recall (HVL-R Delay Recall,  $z = -1.886$ ,  $p = 0.059$ ;  $M_{T1} = 51.33$ ,  $SD_{T1} = 6.68$ ,  $MD_{T2} = 43.83$ ,  $SD_{T2} = 13.47$ ). Results from the three-month follow-up testing revealed improved inhibition (Stroop Color-Word,  $z = -1.633$ ,  $p = 0.10$ ;  $M_{T1} = 40.17$ ,  $SD_{T1} = 14.80$ ,  $M_{T3} = 34.50$ ,  $SD_{T3} = 12.12$ ), delayed verbal recall (HVL-R Delay,  $z = -1.826$ ,  $p = 0.068$ ;  $M_{T1} = 51.33$ ,  $SD_{T1} = 6.68$ ,  $M_{T3} = 42.75$ ,  $SD_{T3} = 14.52$ ), and verbal memory discrimination (HVL-R Discrimination,  $z = -1.604$ ,  $p = 0.10$ ;  $M_{T1} = 48.00$ ,  $SD_{T1} = 4.52$ ,  $M_{T3} = 37.50$ ,  $SD_{T3} = 11.85$ ) as compared to baseline performance. There were no significant changes between the post-group evaluation and the three-month follow-up.

### Affective/behavioral outcomes

Comparison of affective and behavioral measures at various time points (pre-group, post-group, and follow-up) on a group level revealed no significant differences. However, given the heterogeneity of patient presentation at group onset, analysis of the overall group may mask within participant changes. Table 4-1 provides patient level specifics on various affective/behavioral outcome measures. 50% of participants reported perceived improvement in their ability to engage in daily activities (as measured by the PDAQ) and 50% reported increased self-efficacy.

### Informant report

Comparison of informant ratings on a group level revealed no significant changes. Table 4-2 depicts the individual changes in participants as rated by the spouse informants. 40% of the spouses reported improvements in the participant's self-regulatory abilities, specifically with their ability to regulate thoughts and cognitions (i.e., metacognition) and their ability to regulate behaviors and emotions (i.e., behavioral regulation). 60% of spouses reported observing improvements in the participants' ability to manage activities of daily living.

**Table 4-1. Affective/Behavioral Outcomes of PD-CoRE Group 2**

ID #	Sex	Age	Edu.	BDI-II*			GAD-7*			PDAQ			DEX*			PDQ-39*			SES			SLS			AES*		
				T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ
1	M	57	16	8	10	–	2	1	–	33	31	–	22	36	↓	26%	27%	–	36	33	–	27	23	–	39	38	–
2	F	73	12	4	5	–	0	0	–	52	48	–	31	30	–	1%	5%	–	33	40	–	35	34	–	27	27	–
3	F	77	16	13	16	–	6	5	–	34	43	↑	46	43	–	39%	39%	–	22	29	↑	17	29	↑	31	27	↑
4	F	61	14	32	24	↑	19	12	↑	13	41	↑	57	47	↑	58%	46%	–	18	29	↑	9	11	–	57	51	↑
5	M	74	16	4	4	–	1	1	–	51	52	–	30	38	–	5%	10%	–	39	30	↓	33	35	–	22	30	↓
6	M	68	16	15	14	–	4	5	–	38	49	↑	42	55	↓	20%	27%	–	28	35	↑	18	22	–	33	40	↓

Note: Significant change (95% Reliable Change Index) denoted by: ↑ = Improvement, ↓ = Decline, – = Stable. Asterisk (\*) indicates a measure in which higher scores reflects worse outcomes. Abbreviations: BDI-II = Beck Depression Inventory, 2<sup>nd</sup> Edition; GAD-7 = Generalized Anxiety Disorder 7-item scale; PDAQ = Penn Parkinson's Daily Activities Questionnaire, Self-Report; DEX = Dysexecutive Questionnaire; PDQ-39 = Parkinson's Disease Questionnaire; SES = Generalized Self-Efficacy Scale; SLS = Satisfaction with Life Scale; AES = Apathy Evaluation Scale.

Table 4-2. PD-CoRE Group 2 Informant Ratings

	BRIEF- A MetaCognition*			BRIEF-A Behavioral Regulation*			PDAQ-I			Zarit*		
	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ	T1	T2	Δ
1	56	87	↓	43	57	↓	34	33	–	24	30	–
2	67	49	↑	64	48	↑	32	47	↑	8	11	–
3	53	47	–	52	51	–	50	59	↑	15	15	–
5	48	44	–	51	45	–	54	54	–	21	11	↑
6	67	50	↑	63	52	↑	40	48	↑	22	38	↓

Note: Significant change (95% Reliable Change Index) denoted by: ↑ = Improvement, ↓ = Decline, – = Stable; Asterisk (\*) indicates a measure in which higher scores reflects worse outcomes. Abbreviations: BRIEF-A = Behavioral Rating Inventory of Executive Functions- Adult Version; PDAQ-I = Penn Parkinson's Daily Activities Questionnaire, Informant Report; Zarit = Zarit Caregiver Burden Scale

### Patient satisfaction

All participants completed a post-group satisfaction survey. 100% of the group participants reported that they could apply the skills from the program to their daily life, they reported improved self-confidence and sense of self-efficacy, and also reported enjoying the social interaction with other PD patients. 100% of the participants indicated strong satisfaction with the program, interest in participating in similar programs in the future, and would recommend the program to other Parkinson's disease patients. Participants commented on the changes they noticed after participating in the group. Responses included "I don't feel as overwhelmed by trying to do a difficult task, now I can break it down," and "[I am] more deliberative, better organized, engaged, and more confident."

### Discussion

Cognitive dysfunction is a major clinical feature of PD that contributes more to disability, caregiver strain, and diminished quality of life over the disease course than motor deficits<sup>(2-4)</sup>. Unfortunately, pharmacological treatments for PD-related cognitive changes are limited and have not demonstrated efficacy in reducing executive functioning impairments<sup>(8)</sup>. As such, it is important to investigate non-pharmacologic treatment options for cognitive dysfunction. The present study evaluated the feasibility and efficacy of a novel cognitive rehabil-

itation program (PD-CoRE) in improving executive functions in patients with PD. Results from the initial feasibility study suggested that patients with PD enjoyed the program, believed the program provided them with ecologically valid skills for use in daily life, and improved their problem-solving skills. The small group setting also provided immediate emotional support and created a richer learning environment where participants were able to serve as role models for each other, learn from each other's experiences, and share resources.

Though the participants reported high satisfaction with the program, results from the neuropsychological measures were mixed. The PD-CoRE treatment did not have a significant impact on levels of depression or anxiety. As compared to their baseline performance, participants demonstrated slight improvement in immediate attentional capacity following the PD-CoRE treatment but demonstrated subtle declines on speeded word reading, verbal learning, and delayed verbal recall. Results from the three-month follow-up testing revealed slight improvement in inhibition, delayed verbal recall, and verbal recognition discrimination. The variable and subtle changes on neuropsychological outcome measures was, in the end, unsurprising. The PD-CoRE program focuses on building compensatory strategies to improve applied executive functioning in daily life and is not a form of cognitive training, therefore it does not attempt to improve the underlying cognitive

ability. A common issue within neuropsychology is the poor convergence between performance on executive functioning measures (unpracticed ability to execute cognitive processes) and application of executive functioning abilities within the context of real-life situations. As such, capturing changes within a person's ability to successfully use executive abilities day-to-day is difficult and often relies on patient or informant self-report. In order to address this issue in the current study, we included both patient and informant report.

A strength of the current study is the inclusion of quality of life, self-efficacy, and daily functioning measures in combination with informant ratings and objective neuropsychological data. Biundo and colleagues<sup>(51)</sup> highlight the disconnect between definitions of "successful" outcomes within the cognitive rehabilitation literature. Empirical research often considers an intervention successful if patients demonstrate improved performance on traditional neuropsychological measures; however, patients and families expect functional improvements or at least functional stability when considering whether a treatment was "successful." In the current study, 50% of participants self-reported improvement in daily functioning and 50% reported increased self-efficacy. Similarly, more than half of the informants reported noticing improvements in their spouse's ability to function on a daily basis and 40% reported noticing improved self-regulation.

### **Limitations**

There are several limitations in the present study that must be acknowledged. First, the sample was quite small and a larger sample would have increased the power to detect treatment effects. The small sample size also precluded more detailed analyses of relationships between variables. Second, participants in the feasibility study tended to be cognitively intact with self-report of mild executive functioning changes; therefore, ceiling effects may have limited detection of intervention effects. Third, the clinical characteristics of the patients in the efficacy study varied widely within the group. In fact, heterogeneity of patients is

often considered one of the main critiques of the cognitive rehabilitation for PD literature as the diversity of samples makes it difficult to understand the long-term effectiveness of the treatments<sup>(51)</sup>.

Another limitation of the present study is that changes associated with the group (both positive and negative) were presumed to be related to the group treatment. However, there were participants who reported acute stressors that were unrelated to PD and may have impacted self-report responses. These acute stressors may have impacted the participant's receptiveness to group teachings. Similarly, information on participant's medication regimen was not gathered and it is unclear whether any change to the regimen occurred during the course of treatment. As such, it is unknown whether the patient's pharmacological treatment impacted the cognitive and emotional outcomes.

It is also important to note that the measurement of treatment efficacy is limited to only the functions assessed within the current neurocognitive test battery. Future studies should include additional informant ratings (including informants' report of program satisfaction) and additional measures of self-regulation. An additional limitation is the lack of a non-treatment PD control group, which would be useful in further investigating the efficacy of the PD-CoRE program.

### **Conclusions**

Overall, the present study's findings provide support for the feasibility and, if cross-validated, the efficacy of the PD-CoRE program in PD patients with self-reported executive dysfunction. Clinically, professionals working with PD should be aware of potential executive function deficits and potential obstacles that might arise from such impairments within patients' daily lives as well as the possibility of improvement in executive functioning with appropriate compensatory skill building. By providing PD patients with psychoeducational information and ecologically valid compensatory strategies regarding executive functioning, PD-CoRE may be able to break the negative cycle of PD by improving mood, self-efficacy, and quality of life and reducing caregiver burden.



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**Appendix 1. Overview of PD-CoRE Program Content\***

Session No.	Session Title	Summary of Content
1	Introduction: Managing Life with Parkinson's Disease	<ul style="list-style-type: none"> <li>• Introductions</li> <li>• Overview of group processes/expectations</li> <li>• Overview of PD and Executive Functioning</li> <li>• Overview of Breaking the Cycle of PD</li> <li>• Homework for Session 2</li> </ul>
2	Inhibition	<ul style="list-style-type: none"> <li>• Review Session 1/Homework</li> <li>• Explain Inhibition</li> <li>• Introduce "I GOT IT" Model</li> <li>• In-Session Activity: Medication Management</li> <li>• Homework for Session 3</li> </ul>
3	Working Memory	<ul style="list-style-type: none"> <li>• Review Session 2/Homework</li> <li>• Use "I GOT IT"</li> <li>• Explain Working Memory</li> <li>• In-Session Activity: Bill Paying</li> <li>• Homework for Session 4</li> </ul>
4	Task-Shifting	<ul style="list-style-type: none"> <li>• Review Session 3/Homework</li> <li>• Use "I GOT IT"</li> <li>• Explain Task-Shifting</li> <li>• In-Session Activity: Errand Planning</li> <li>• Homework for Session 5</li> </ul>
5	Executive Functioning: Putting the Pieces Together	<ul style="list-style-type: none"> <li>• Review Session 4/Homework</li> <li>• Use "I GOT IT"</li> <li>• Review of Executive Functioning</li> <li>• In-Session Activity: Trip Planning</li> <li>• Homework for Session 6</li> </ul>
6	Maintenance and Wrap-Up	<ul style="list-style-type: none"> <li>• Review Session 5/Homework</li> <li>• Use "I GOT IT"</li> <li>• Review Breaking PD Cycle</li> <li>• Recap group aims and treatment goals</li> <li>• Process group experience and obtain feedback</li> </ul>