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Altruism in Parkinson's Disease

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Objective: Reward-based decision-making is a growing area of research in Parkinson's disease (PD), a disorder characterized by alterations in dopamine and cortico-striatal circuits. While reward is typically operationalized as a gain, altruistic decisions also engage the reward system in fMRI studies. Although altruism comes at a cost, individuals may be motivated by the social reward associated with benefitting another. At present, it is unclear how PD affects altruism because both increased egoistic tendencies and increased generosity have been documented. ***Method:*** To address this, 32 individuals with PD and 32 age-matched healthy controls completed two tasks of implicit and explicit altruism. First, in an intertemporal choice task, participants chose between a smaller immediate or larger later outcome. Outcome types included gains, losses, and donations, and an implicit altruism measure was derived. Second, participants completed two versions of the dictator game, which assesses nonreciprocal giving and yields an explicit measure of altruism. ***Results:*** Patients and controls showed similar altruism in the intertemporal choice task and in a dictator game for a charity, but patients were more generous than controls in the dictator game in which the recipient was a stranger. Among patients, altruism measures were moderated by laterality of hemispheric burden and medication type. ***Conclusions:*** This study was the first to examine altruistic decision-making in PD patients using both implicit and explicit measures. PD patients were neither overly generous nor egoistic in their decisions, although some disease and treatment characteristics may have a modest association with altruism in PD.

Key Points

Question: How does advanced PD and its treatment relate to implicit and explicit financial measures of altruism? ***Findings:*** PD patients make similar altruistic decisions as controls when donating. PD patients gave more to strangers on a dictator game task. Certain disease characteristics of PD patients relate to altruism. ***Importance:*** Intact financial decisions offer reassurance to PD patients and their caregivers. ***Next Steps:*** Deeper investigation into the relationships between characteristics of PD patients and prosocial motivation is an interesting avenue for future research, with translational potential in domains such as health, social functioning, and financial competence.

Keywords: Parkinsonism, decision-making, delay discounting, beneficence, aged

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Parkinson's disease (PD) is a neurodegenerative disease characterized by the loss of dopaminergic neurons in the substantia nigra pars compacta leading to basal ganglia dysfunction. While motor symptoms are the cardinal features, cognitive decline is common. One area of increased interest in the PD literature is reward-based decision-making, which is closely linked to dopamine and cortico-striatal circuits (Voon & Dalley, 2011). This is strongly motivated by evidence of increased impulsivity in PD patients who develop impulse control disorder (ICD) (Weintraub et al., 2010). Impulsive decisions are also assessed experimentally using economic paradigms involving financial gains for the individuals, but emerging literature also implicates the reward system in altruistic decisions

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(Wake & Izuma, 2017). Altruistic decisions come at a cost to the individual (e.g., charitable donations, volunteer hours), but despite these losses, the individual may be motivated by the social reward associated with promoting another's welfare. It is unclear how PD and its treatment affect altruism because both increased egoistic tendencies and increased generosity have been documented in past studies. Our goal is to investigate altruism in advanced PD using implicit and explicit measures in a financial context.

Reward-based decision-making is frequently assessed in the laboratory using intertemporal choice paradigms in which individuals are given the choice between receiving a smaller sooner reward or a later larger reward. While the delayed choice is economically superior, choosing the smaller sooner reward reflects impulsivity and is thought to occur because delays reduce the subjective value of a reward, a concept widely known as temporal discounting (Frederick et al., 2002). Greater impulsivity in intertemporal choice has been documented in PD patients with ICD relative to healthy controls but with mixed findings relative to PD without ICD (Averbeck et al., 2013; Housden et al., 2010), and in PD patients tested ON dopamine agonist or levodopa versus OFF medication (Antonelli et al., 2014; Foerde et al., 2016), although another study showed increased impulsivity in PD patients irrespective of whether they are ON or OFF dopaminergic medication (Milenkova et al., 2011). However, some studies also yielded null findings between PD and healthy controls (de Rezende Costa et al., 2016; Joutsa et al., 2015; Nombela et al., 2014; Simioni et al., 2012). While the PD literature on discounting has been limited to rewards, loss conditions have also been used with other groups. Intertemporal losses are typically discounted less than gains, in keeping with the theory of loss aversion such that individuals have a greater propensity to avoid losses than to obtain equivalent gains (Kahneman & Tversky, 1979). Importantly, we argue that individual losses are not necessarily "unrewarding," for instance, if they result in a benefit for another, and hence carry potential social reward. Recent work demonstrates that older adults' decisions related to charitable donations on an intertemporal choice paradigm closely resembled those of gains, while these decisions in young adults were more similar to losses (Sparrow & Spaniol, 2018), providing support of increased altruism in healthy aging. This is consistent with emerging literature implicating the reward system in prosocial decisions (Wake & Izuma, 2017).

Experimentally, altruism is commonly assessed using the dictator game (Kahneman et al., 1986), which is a behavioral economic paradigm that pits altruistic against egoistic decisions. The participant receives an endowment and asked how much they would like to keep for themselves or give to another. It is designed to probe whether individuals will act purely out of egoism, or whether they will act prosocially because they are choosing to benefit another with no expectation of reciprocation. To our knowledge, only one small study used a dictator game in PD and found giving behavior to differ significantly between PD patients and controls. However, whether patients acted more generously or egoistically depended on the laterality of their hemispheric compromise as inferred from the severity of lateralized motor symptoms. Specifically, relative to controls, patients with greater right hemisphere compromise (more severe left-sided motor symptoms) gave more to the stranger, and patients with greater left hemisphere compromise (right-sided symptoms) kept more money for themselves (Arshad et al., 2017).

With respect to real-world giving behaviors, an earlier case report (O'Sullivan et al., 2010) described three PD patients treated with dopamine agonists who were acting in a "recklessly generous" or irrationally altruistic manner in that they would give resources to others when the cost of doing so was harmful to them (e.g., not being able to afford utility payments). Lastly, egoistic versus prosocial decisions in PD were also investigated in an everyday moral dilemma decision task (e.g., Do you hang a picture painted by your mother that you don't like?). On this task, PD patients "ON" medication made more egoistic decisions than their healthy counterparts (Rosen et al., 2015). In sum, the relationship between PD and altruism is still limited but evidence to date is mixed with both thriftless giving tendencies and increased egoistic decisions having been documented, which may be due to differences between paradigms and patient characteristics.

Given that PD has been shown to influence both intertemporal preferences and altruistic giving, the current study sought to examine these domains jointly in a financial context. Using an intertemporal choice paradigm (Löckenhoff et al., 2011; Sparrow et al., 2019; Sparrow & Spaniol, 2018), PD patients and age-matched controls completed a series of smaller immediate and larger later decisions for actual gains, losses, and charitable donations. Intertemporal losses and donations have the same economic impact on the decision-maker (i.e., choosing to lose money now or later). As a result, the difference between these two conditions signals prosociality (is an individual willing to forgo more money when a charity is the recipient?). This paradigm yields both the classic measures of temporal discounting (gains and losses) as well as an "altruism index" which is the difference between the loss and donation condition for each individual. Second, participants completed two short versions of the dictator game as a measure of altruism; one involving giving money to a stranger without any information on their economic needs, and one involving giving money to a charity of their choice. These two conditions likely differ in terms of social reward. The dictator game assesses altruistic perceptions that are explicit in nature (i.e., would you rather choose the altruistic or egoistic alternative?), whereas the altruism index from the intertemporal choice paradigm addresses prosocial tendencies from a more implicit angle because individual choices involve "now versus later" options, rather than "selfish versus altruistic" options. Given the scarcity of research in this area and evidence of both reckless generosity and increased egoistic decisions, we do not have any clear predictions as to whether altruism will differ between PD patients and controls, or whether a different pattern of results will emerge from these implicit and explicit measures. Our secondary aim is to explore the relationships between our altruism measures and patient characteristics thought to contribute to reward-based decision-making and prosociality, including whether they take dopamine agonist medications, whether they demonstrate evidence of cortico-striatal cognitive dysfunction as suggested by a diagnosis of PD-related mild cognitive impairment (PD-MCI), and whether they have greater left versus right hemispheric compromise as indicated by the side of motor symptom onset. The laterality question was included based on prior reports of greater prosociality in the dictator game among left-sided onset patients relative to right-sided patients (Arshad et al., 2017).

Practically, findings of altered altruistic decision-making in PD would provide basis for further inquiry of such behavior during clinical care and contribute to the psychoeducation provided to individuals with PD, their family, and their treatment team.

Method

Participants

Participants included 32 individuals with advanced PD (60–77 years old) and 32 age-matched healthy controls (61–78 years old). PD patients were recruited at Toronto Western Hospital—University Health Network and completed multidisciplinary clinical evaluations in consideration for deep brain stimulation surgery. Healthy older adults were recruited through the Ryerson University Senior Participant Pool. A subsample of the control group was used in a previous study (Sparrow & Spaniol, 2018), and the remainder were recruited to match the demographics of the PD group. All participants gave written informed consent, and all study procedures were approved by the Research Ethics Board at Ryerson University (healthy controls) and the University Health Network (PD patients). Participants received $12 for their participation in the 90-min experiment (healthy controls) or a $10 gift card (patients), as well as an individually variable bonus payout for the intertemporal choice task ranging from $12.50 to $27.50 ($M$ = $17.83). PD patients also completed tasks related to a different research project (not reported here).

All participants were fluent English speakers and had no history of severe psychiatric conditions or concomitant neurological conditions other than PD. No patients met diagnostic criteria for dementia. Based on a comprehensive neuropsychological assessment conducted 2.2 months prior to the current study on average, eight patients had a diagnosis of PD-MCI based on the Movement Disorder Society diagnostic criteria (Litvan et al., 2012), and 24 had intact cognition. Healthy controls had no suspected cognitive decline (i.e., MoCA > 26; Nasreddine et al., 2005). Disease characteristics collected from the patients included disease duration (years since diagnosis), Levodopa Equivalent Daily Dosage (LEDD), Unified Parkinson's Disease Rating Scale (UPDRS) Part 3 when patients were OFF medication, cognitive status (PD-MCI or intact), and whether they were taking dopamine agonists. The presence of impulse-control disorders was also documented based on a chart review and multidisciplinary assessment that included a psychiatric assessment, and two participants met this diagnosis. Participants also indicated their annual household income (Canadian dollars) on a 7-point scale (from 1 = *less than $25,000* to 7 = *greater than $150,000*). Participant characteristics are shown in Table 1. All PD patients were tested ON their dopaminergic medications.

Table 1
Participant Characteristics

Measures	Patient (N = 32)	Control (N = 32)	Cohen's d
Demographics			
Age	66.06 (5.00)	67.88 (3.53)	.42
Education (years)	15.13 (2.62)	16.25 (1.98)	.50
% Female	37.50%	46.88%	
Annual income	5.07 (1.55)	3.84 (1.93)	.70**
VAS ratings			
Self-relevance	60.69 (16.53)	70.53 (29.24)	.41
Confidence in bonus payout scheme	66.45 (18.25)	88.34 (13.68)	1.36**
Clinical characteristics			
PD duration (years)	11.12 (5.16)	—	—
UPDRS Part 3 OFF	47.72 (19.64)	—	—
LEDD	1482.09 (663.96)	—	—

Note. VAS = visual analogue scale; UPDRS = unified Parkinson's disease rating scale Part 3; LEDD = levodopa equivalent daily dosage.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Tasks and Stimuli

Charity Selection

Following Sparrow and Spaniol (2018), participants were presented with a list and asked to choose one local charitable organization that they most strongly support (e.g., local shelter, children's hospital, local public library), excluding any PD-specific charities. Following the selection, participants used a visual analog scale (VAS) to indicate the self-relevancy of the chosen charity to them from 0 to 100, with 0 being *not self-relevant*, 100 being *very self-relevant*.

Dictator Game

We evaluated altruism (explicitly) with two hypothetical trials of the dictator game (Kahneman et al., 1986), to assess voluntary levels of other-regarding behavior. First, participants were asked to decide how much of a $10 endowment to keep for themselves and how much to donate to the charity of their choice. Next, participants were asked to do the former, but this time the recipient was a stranger (i.e., they were told no demographic or socioeconomic information about the person). All possible whole-dollar combinations by which $10 can be divided were presented to the participant.

Altruistic Intertemporal Choice Task

Twenty-eight trials were presented to participants three times for each reward-type condition (gain, loss, donate) consisting of a choice between a smaller immediate and a larger delayed reward (for more detail see Sparrow & Spaniol, 2018) resulting in 84 unique trials. Reward-type was blocked, counterbalanced, and within-block trials were randomized. The computerized task was self-paced, but participants were encouraged to respond as quickly as they could and not to overthink their choices.

Procedure

First participants completed the hypothetical dictator trials. Next, the experimenter presented participants with a $20 starting capital divided equally across two envelopes, labeled "now" and "later," thus introducing a realistic element to the intertemporal task. Participants were instructed they would complete 84 choices, one of which would be randomly selected by the computer when the task was complete (e.g., "you chose Gain $5 Now over Gain $7 in 90 Days"). If the randomly selected choice was from a gain trial, participants gained money on top of the starting capital either now or

later (depending on their chosen option). If the randomly selected choice was from a loss or donation trial, money was deducted from the starting capital either now or later (again contingent on the chosen option). Money that was deducted for a donation was donated online by the experimenter on the participant's behalf, either immediately ("now") or after the appropriate delay period ("later").

Participants were guided through six practice trials (two for each reward-type condition) to ensure they understood and were comfortable with the task format. One of these practice trials was pseudorandomly selected by the computer and the researcher demonstrated how the option the participant had chosen on that trial would affect their starting capital. Following this brief tutorial, participants completed one last practice trial. This time they were asked to reverse roles with the experimenter and to indicate (verbally or by taking money out of envelopes) how their earnings would be affected by the chosen option (Quiz 1). The experimenter provided feedback on the participants' responses, repeating the payout instructions if needed. Participants then completed the experimental trials. At the end, one trial was selected at random and the participant was asked to demonstrate the payout (Quiz 2).

Given that deception is a common occurrence in psychological experiments, participants were asked to rate their confidence level toward the realism of the payout after the intertemporal choice task. Participants completed a second VAS rating (0–100) to indicate how confident they were that the option selected by the computer would be applied to the envelopes and paid out as instructed.

Data Reduction

We calculated three *reward indices* (Benoit et al., 2011) based on the responses in the gain, loss, and donation conditions of the intertemporal choice task. For the gain condition, the reward index reflects the degree to which the sum of all chosen options exceeds the minimum. The reward index was calculated as follows in the gain condition: [actual − minimum]/[maximum − minimum]. Reward index values range 0–1, with the constant selection of the smaller immediate gain yielding a reward index of 0, and constant selection of the larger delayed gain yielding a reward index of 1. For the loss and donation conditions, the reward index was calculated as (1 − [actual − minimum]/[maximum − minimum]). This was done so that, for all three reward types, a reward index of 1 would indicate choices that maximized personal earnings, and a reward index of 0 would indicate those which minimized overall personal earnings.

The *altruism index* was derived by subtracting the reward index in the donation condition from the reward index in the loss condition (Sparrow & Spaniol, 2018). The rationale for this subtraction was that both loss and donation conditions involved financial losses for the participant, differing only in the potential for a charitable contribution. A difference in the reward index thus signaled an effect of altruism on choice behavior.

Statistical Analysis

We examined group differences in the demographic measures and intertemporal indices. Due to violations of normality, nonparametric comparisons were used for all analyses. For the main analysis of the intertemporal choice task, we ran three Quades tests for nonparametric ANCOVA, with the between-subjects factor group type (patient vs. control) and the within-subjects factor reward type (gain, loss, and donation) and income as the covariate. To test differences in altruism, we performed a Mann-Whitney test on the altruism index. Contrary to Sparrow and Spaniol (2018), excluding participants who did not pass the final check of task understanding (Quiz 2) did not change results, therefore we report the results using the full sample of participants. Second, Mann-Whitney comparisons were conducted for the dictator game measure of prosocial motivation. As part of our exploratory analysis in the patient group, we examined how the presence of dopamine agonists, lateralized motor symptoms (lateralized hemispheric dysfunction), and a diagnosis of PD-MCI influenced performance on the intertemporal reward indices and dictator games (see Tables 2–4, respectively).

Results

Demographics

Table 1 presents the participant demographics. The age of the patients (Mdn = 66.00) did not significantly differ from controls, (Mdn = 67.00), U = 628.50, z = 1.57, p = .12, r = .20, and the ratio of males to females was similar for patients and controls, $\chi^2(1, 64) = .58$, p = .45. Additional demographic characteristics such as education and income were variables of interest that have been

Table 2
Dopamine Medication and Outcome Measures for Patients

	Agonist (N = 21)		Nonagonist (N = 11)					
Tasks	M (SD)	Mdn	M (SD)	Mdn	U	Z	p	R
ITC								
Gain	.61 (.31)	.55	.52 (.44)	.53	130.00	.58	.58	.10
Loss	.85 (.24)	.95	.88 (.11)	.90	126.00	.70	.70	.12
Donate	.43 (.33)	.44	.53 (.42)	.70	93.50	−.87	.39	−.15
Altruism	.42 (.39)	.42	.35 (.40)	.14	128.00	.50	.64	.09
DG								
Other	5.33 (3.37)	5.00	7.73 (2.94)	10.00	69.00	−1.90	.07	−.34
Charity	7.24 (3.96)	10.00	8.36 (2.34)	10.00	103.00	−.57	.64	−.10

Note. Mdn = median; ITC = Intertemporal choice; Gain = reward index for gains; Loss = reward index for losses; Donate = reward index for donations; Altruism = Altruism Index; DG = dictator game. $U(31)$, nonparametric two-tailed test for group differences.

Table 3
Side of Motor Symptom Onset and Outcome Measures for Patients

	Right body (N = 16)		Left body (N = 15)					
Tasks	*M* (*SD*)	*Mdn*	*M* (*SD*)	*Mdn*	*U*	*Z*	*p*	*R*
ITC								
Gain	.42 (.32)	.42	.76 (.33)	.92	186.50	2.63	.01	.47
Loss	.84 (.24)	.93	.87 (.15)	.95	123.50	.14	.89	.03
Donate	.61 (.36)	.64	.32 (.31)	.31	63.50	−2.24	.02	−.40
Altruism	.23 (.36)	.03	.55 (.35)	.64	180.50	2.39	.02	.43
DG								
Other	5.69 (3.07)	5.00	7.00 (3.51)	8.0	145.00	1.02	.34	.18
Charity	7.56 (3.41)	10.00	7.53 (3.76)	10.00	125.00	.23	.86	.04

Note. *Mdn* = median; ITC = intertemporal choice; Gain = reward index for gains; Loss = reward index for losses; Donate = reward index for donations; Altruism = Altruism Index; DG = dictator game. $U(30)$, nonparametric two-tailed test for group differences.

shown to be associated with charitable giving (e.g., Nakavachara, 2018). Years of formal education were similar for patients (*Mdn* = 15.50) and controls (*Mdn* = 16.00), $U = 647.59$, $z = 1.85$, $p = .07$, $r = .23$. Annual household income was significantly higher for patients (*Mdn* = 5.00) than for controls (*Mdn* = 3.00), $U = 287.00$, $z = -2.60$, $p = .01$, $r = -.33$.

Dictator Game

Figure 1 presents the results from the two dictator trials. Patients (*Mdn* = 10.00) allocated a larger hypothetical amount of money in a stranger version of the dictator game relative to controls, (*Mdn* = 5.00), $U = 346.50$, $z = -2.27$, $p = .02$, $r = -.28$. In contrast, there was no group difference on the charity version of the dictator game, PD: *Mdn* = 5.00; Controls: *Mdn* = 4.50; $U = 416.00$, $z = -1.41$, $p = .16$, $r = -.18$.

Altruistic Intertemporal Choice

Figure 2 presents the results from the intertemporal choice task. The altruism index of patients (*Mdn* = .37) did not differ from that of controls (*Mdn* = .25), $U = 483.50$, $z = -.38$, $p = .70$, $r = -.05$. When controlling for annual household income, patients did not differ from controls on the reward index for gains, PD: *Mdn* = .54; Controls: *Mdn* = .84, $F(1, 59) = 1.23$, $p = .27$, losses, PD: *Mdn* = .95; Controls: *Mdn* = .94; $F(1, 59) = .05$, $p = .83$, or donations, PD: *Mdn* = .49, Controls: *Mdn* = .47, $F(1, 59) = .05$, $p = .83$.

Additional and Exploratory Analyses

Charity self-relevance was significantly lower for patients (*Mdn* = 66.00) than controls, (*Mdn* = 79.50), $U = 718.50$, $z = 2.78$, $p = .006$, $r = .35$. Patients also reported lower confidence (*Mdn* = 75.00) that they would receive their bonus payout relative to controls, (*Mdn* = 91.50), $U = 875.50$, $z = 5.17$, $p < .001$, $r = .65$. We also explored nonparametric correlations between disease severity (i.e., UPDRS part 3 OFF, PD duration, LEDD) and the task measures across PD patients and found no significant associations. Table 2 presents the differences in altruism measures between patients taking dopamine agonists versus nonagonists. Although there was a trend ($p = .07$) in the stranger version of the dictator game such that patients taking dopamine agonists were willing to give marginally less to a stranger relative to patients not taking dopamine agonists, there were no group differences on the other measures of altruism.

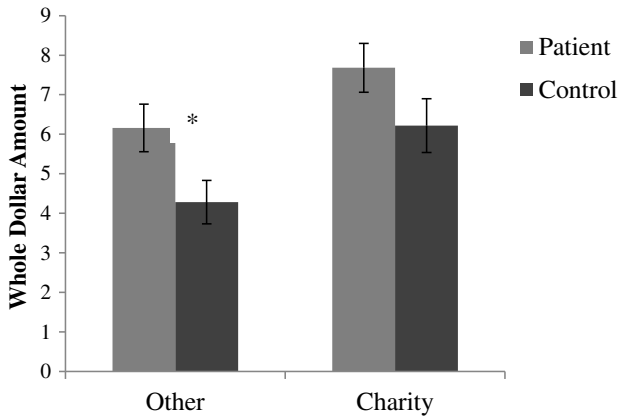
Table 3 presents the altruism measures separately for patients with left-sided motor onset (right hemisphere) and patients with right-sided motor onset (left hemisphere). There were no group differences on the dictator game, but the altruism index was

Table 4
Cognitive Status and Outcome Measures for Patients

	MCI (N = 8)		Intact (N = 24)					
Tasks	*M* (*SD*)	*Mdn*	*M* (*SD*)	*Mdn*	*U*	*Z*	*p*	*R*
ITC								
Gain	.38 (.36)	.36	.65 (.34)	.74	139.00	1.88	.06	.33
Loss	.89 (.10)	.92	.85 (.23)	.96	106.00	.44	.69	.08
Donate	.50 (.39)	.52	.45 (.36)	.46	86.50	−.41	.69	−.07
Altruism	.40 (.39)	.35	.40 (.40)	.39	96.00	.00	1.00	.00
DG								
Other	6.00 (3.74)	5.50	6.21 (3.34)	5.00	98.50	.11	.92	.02
Charity	6.21 (3.34)	10.00	7.75 (3.44)	10.00	100.50	.23	.85	.04

Note. *Mdn* = median; MCI = mild cognitive impairment; ITC = intertemporal choice; Gain = reward index for gains; Loss = reward index for losses; Donate = reward index for donations; Altruism = Altruism Index; DG = dictator game. $U(31)$, nonparametric two-tailed test for group differences.

Figure 1
Average Money Allocated in the Dictator Trials Shown Separately for Patients and Controls



Note. Higher values indicate more money given. Error bars indicate *SEM*.

significantly higher in left-sided (right hemisphere) patients than in right-sided patients ($p = .02$). The reward index for gains was also significantly higher in left-sided patients than in right-sided patients ($p = .02$).

Table 4 presents the group differences between patients with MCI and those with intact cognition on the altruistic measures. No significant differences emerged on the altruism measures, although the reward index for gains was marginally higher for intact patients than those with PD-MCI ($p = .06$).

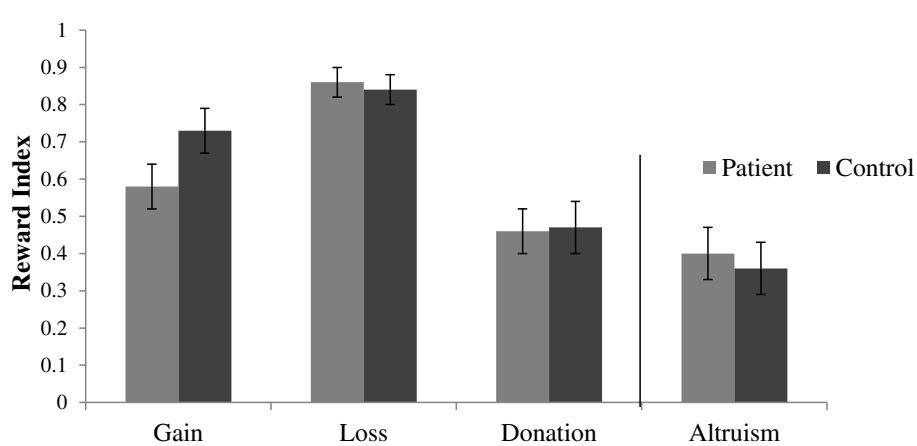
Discussion

The current study employed two measures of altruism. In the first explicit task, there were no group differences in the charity version of the dictator game, but PD patients were willing to give more money to a stranger than controls. In the second implicit altruistic intertemporal task, patients and controls made similar choices when decisions involved charitable donations, and there were also no group differences for gains or losses, suggesting no increased impulsivity. Narrowing in on the patient group, there was a trend such that patients taking dopamine agonists were more likely to give more to a stranger, but no other differences on altruism measures were found. When exploring lateralization of motor symptom onset as an index of lateralized hemispheric dysfunction, left-sided patients (right hemisphere) had a higher altruism index relative to right-sided patients. Lastly, there was no difference in the dictator game nor in the altruism index between patients with MCI and intact cognition, but we found a trend that patients with MCI made less optimal intertemporal gains (more impulsive) than patients of intact cognition. We discuss each finding in more detail below.

Altruism in Parkinson's Disease

The main finding of our study is that there was no difference in altruistic intertemporal choice and in donation to a charity on a dictator game paradigm between PD patients and age-matched controls, but PD patients were willing to give up more of a hypothetical endowment to a stranger than controls. Previous findings on prosociality and PD are limited to moral decision-making and inconsistent, perhaps due to methodological heterogeneity, with one study finding no differences in everyday moral decision-making (Rosen et al., 2013), and another (using a modified everyday moral decision-making task) finding an increase in egoistic tendencies (Rosen et al., 2015). In the current study, PD patients and controls displayed a similar level of altruism when asked to relinquish a portion of their financial endowment to the charity of their choice (now or later), in comparison to when the money lost had no recipient. However, the increased altruism of PD patients' vis-à-vis a stranger in the dictator game version is reminiscent of previous case work on "reckless generosity" in PD patients (O'Sullivan et al., 2010). An important caveat is that patients were not necessarily

Figure 2
Intertemporal Choice for Gains, Losses, and Donations, Measured by the Reward Index Shown Separately for Patients and Controls



Note. Higher reward index values denote choice preferences that optimize personal earnings. Altruism is defined as the difference between the loss and donation conditions, with higher values indicating higher altruism. Error bars indicate *SEM*.

behaving in an "altruistically harmful" manner given the small monetary amounts at stake in the current study. One could argue, however, that PD patients' generosity toward a complete stranger is inconsistent with rational decision-making (Kahneman et al., 1986). This carefree giving behavior in the PD patients is an interesting topic that would benefit from further inquiry.

Altruism and Disease Characteristics

The mixed results in the literature may not only relate to the different paradigm used, but also to patient characteristics and individual differences that have been noted to relate to reward-based decision-making. A trend was observed within the PD group such that patients taking dopamine agonists gave less money in the stranger version of the dictator game relative to patients who are not treated with dopamine agonist, and kept more money for themselves. However, this "egoistic" tendency was not found on our other altruism measures wherein the recipient was a charity of the patient's choice, which we hypothesize may carry a greater social reward value than a donation to a stranger. In addition, the amount given to a stranger was similar to that given by healthy controls highlighting that it was PD patients not treated with dopamine agonist that differed in that they showed increased generosity. Overall, patients on dopamine agonists did not display greater generosity as documented in a small case study of "reckless generosity" (O'Sullivan et al., 2010). Although dopamine agonists have been related to more impulsive decisions, which we discuss below, the effect of dopamine agonist in regard to altruistic motivation is unexplored and deserves future study.

With respect to hemispheric asymmetries in PD, we demonstrated that left-sided motor symptom onset patients (greater right hemisphere burden) had a significantly higher altruism index (similar to controls) relative to patients with right-sided onset. While this higher altruism index for left-sided onset patients supports the increased giving behavior in the stranger version of the dictator game observed in Arshad et al.'s study, we found no difference between left and right-sided onset on the dictator game. One important distinction between studies is that we administered only one trial on the stranger version, while Arshad et al. had 20, therefore more trials may be necessary to get a clearer picture of the role that hemispheric asymmetries play in common economic games. Nevertheless, it is interesting that left-sided patients show this increase in prosociality both in the altruistic intertemporal choice tasks (implicit) in the present study and in the stranger version of the dictator game in the study by Arshad et al. (2017). The underlying mechanism for this hemispheric asymmetry is unclear. Arshad et al. (2017) suggested that this effect was due to biased numerical cognition, but this should have resulted in group differences in all conditions of the intertemporal choice task and the dictator game. Furthermore, while some evidence supports greater involvement of the right hemisphere in various prosocial tasks (Hare et al., 2010; Morishima et al., 2012), a recent meta-analysis of fMRI studies reported bilateral involvement (Cutler & Campbell-Meiklejohn, 2019). Importantly, while patients in the current study likely have bilateral dysfunction due to their advanced disease state, the side of onset carries greater disease burden. Thus, while both subgroups have bilateral dysfunction, they are asymmetrical even at longer disease duration and stages.

We also explored cognitive status within the patient group and its potential association with prosociality. Patients with intact cognition and those with MCI displayed similar levels of generosity on both implicit and explicit measures of altruism, although these results should be interpreted with caution given the uneven and small sample sizes. Future work would benefit from employing larger group sizes to test the potential cognitive heterogeneity in altruism and the relationship to performance in different cognitive domains.

Intertemporal Gain Versus Loss

Although not the main focus of the present study, our results also contribute to the literature on intertemporal decision-making in PD, which has been limited to gains and yielded mixed findings. The present study revealed no differences between PD patients and control groups for gains, and no differences between patients taking dopamine agonists and those who did not. Although similar null findings have been reported (PD vs. controls: de Rezende Costa et al., 2016; Simioni et al., 2012; agonists vs. OFF medication: Milenkova et al., 2011), other studies did find increased impulsivity in PD versus controls (Milenkova et al., 2011) and ON versus OFF medication (Antonelli et al., 2014; Foerde et al., 2016). Our null findings are surprising given the long disease duration of our patients, the fact that they were tested on high doses of dopaminergic medications (which is common in presurgical PD patients), and many were taking dopamine agonists. Importantly, only two patients had a diagnosis of ICD, which prevented us from conducting subgroup analyses, and this patient characteristic has been shown to relate to increased discounting (Averbeck et al., 2013; Housden et al., 2010). ICD may mediate medication effects on discounting rates as demonstrated in a study by Voon et al. (2010) in which dopamine agonist increased impulsivity on an intertemporal choice paradigm relative to testing in the OFF state only in patients with ICD, but not in PD patients without ICD. Thus, this highlights the importance of considering patient heterogeneity. Further exploration of intertemporal choice in PD would be an interesting future direction.

In addition to examining intertemporal decisions about gains, this was the first study to explore intertemporal decisions about losses in PD patients. When collapsed across groups, the reward index for losses appeared descriptively higher than the reward index for gains. This gain–loss asymmetry observation is consistent with earlier studies (e.g., Löckenhoff et al., 2011; Sparrow & Spaniol, 2018), coinciding with the theory of loss aversion such that individuals have a greater propensity to avoid losses than to obtain equivalent gains (Kahneman & Tversky, 1979). With respect to group comparisons, PD patients and controls made a similar level of optimal choices between intertemporal losses, as indexed by a higher loss index. In other words, both groups were willing to lose less money in the present, rather than pay more at a later time, in line with the standard economic assumption of maximizing utility. Adaptive decision-making relies heavily on executive functioning (e.g., Del Missier et al., 2012), suggesting that both groups were able to use these processes to adjust their gain and loss decision preferences.

Limitations and Future Directions

The current study had several strengths including a large sample size compared to other studies on PD and moral decision-making

(e.g., Rosen et al., 2015, patients $N = 20$, controls, $N = 23$) and temporal discounting (e.g., Milenkova et al., 2011, patients $N = 17$, controls $N = 17$). Another forte was the altruistic intertemporal choice design, for two main reasons. First, we employed an implicit measure of prosociality, which served as an indirect way of looking at altruism compared to other studies or tasks such as the dictator game where altruistic and egoistic alternatives are clearly presented. Many tasks of prosociality have been criticized for this exact reason, as their transparency introduces potential confounds (e.g., social desirability; Jiménez-Buedo, 2015). Second, our intertemporal choice task included a realistic element, since monetary earnings/donations were given/made in real time. Although there is some debate as to whether hypothetical rewards are discounted differently (e.g., Hinvest & Anderson, 2010), the realistic nature of the task strengthens its ecological validity.

Despite these methodological strengths, several limitations should be noted. PD patients reported significantly higher income relative to controls. However, both groups were well above the poverty line, the rewards at stake were of small magnitude, and income did not correlate with the behavioral measures although wealth can be a determinant for increased prosociality (Nakavachara, 2018). Additionally, we only administered two trials of the dictator game, and these trials were not counterbalanced, since all participants completed the stranger version first then the charity version. Therefore we cannot be certain that order effects influenced the pattern of results for the dictator game. Another limitation is that controls expressed greater payout confidence than patients, but this is unlikely to have influenced their intertemporal preferences given the absence of group differences. In light of the null findings, we did not exclude participants who did not pass the final check of task understanding (Quiz 2). In previous work, the final check of understanding was a critical determinant in age differences for the intertemporal indices (see Sparrow & Spaniol, 2018). The altruistic intertemporal choice task is complex, and can be cognitively taxing to some older adults, especially to those with neurodegenerative disorders. Although it is possible that being unable to adequately explain the payout structure explicitly by some participants would not change their individual decision preferences given the implicit nature of the decisions. Future studies could explore altruism in PD patients using a simpler task, while maintaining an implicit approach. Additionally, patients were tested "ON" medication, which could influence intertemporal preferences, although patients have been found to have similar discount rates irrespective of medication status (Milenkova et al., 2011). In advanced PD, most cognitive data are acquired "ON" medication as the "OFF" state can be associated with discomfort and distraction from motor symptoms. Lastly, both patient and control samples may not be generalizable to the greater population since individuals who dedicate their time to participate in research are already acting in an altruistic manner.

Conclusion

The current study is the first to examine altruism using explicit and implicit measures in older adults with PD, and overall, our data indicate that PD patients make similar prosocial decisions as healthy age-matched controls, and are neither egoistic nor overly generous. These findings may be reassuring to PD patients, their families, and their care providers as they demonstrate that even patients with long disease duration, mild cognitive impairment, and high doses of dopaminergic medication can make reasonable and advantageous financial decisions which are comparable to their healthy peers. However, certain characteristics of PD patients may be associated with altruism including brain hemispheric burden and medication type although these effects were small. Deeper investigation into the relationships between characteristics of PD patients and prosocial motivation is an interesting avenue for future research, with translational potential in domains such as health, social functioning, and financial competence.

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