Parkinson's disease (PD) is one of the most common neurodegenerative diseases, afflicting approximately 1% of adults by age 65 (Shulman et al., 2011). Whereas PD typically presents with a variety of motoric symptoms, including rigidity and bradykinesia, a growing literature describes the cognitive and linguistic effects of PD. Within the limited language literature, however, there has been nominal investigation of reading abilities beyond the isolated word or sentence level even though several lines of evidence suggest this language modality may be vulnerable in PD.

First, PD patients have been shown to have difficulties with a variety of comprehension tasks. For example, in several studies a subset of PD patients have demonstrated difficulty with sentence-level comprehension (e.g., Geyer & Grossman, 1994; Grossman et al., 1991). PD patients also perform more poorly than age-matched controls on tasks requiring higher-level language, including comprehension of implied information and inferential reasoning (e.g., Berg et al., 2003; Murray & Stout, 1999). However, with few exceptions, comprehension deficits have been investigated through listening rather than reading tasks; thus, whether PD patients would experience similar difficulties with written material, particularly at the discourse level, remains unresolved.

Second, PD can cause cognitive deficits that in turn may negatively affect reading comprehension. For instance, PD patients may demonstrate deficits in working or verbal memory (e.g., Monetta & Pell, 2007), although such deficits are not seen in all PD patients (e.g., Grossman et al., 1992). The extent to which these memory deficits may influence performance on language comprehension tasks, however, has not yet been established. Whereas Monetta and Pell (2007) found that a subset of PD patients had impaired working memory and sentence comprehension (measured via syntax processing task), Grossman et al. (1992) found no impairment among their PD patients on memory tasks and no correlation between performance on these tasks and sentence comprehension. PD patients also often display difficulties with visual attention (e.g., Uc et al., 2005). The impact of visual attention difficulties may extend into the domain of reading: Coelho (2005) demonstrated that reading impairments in an aphasic patient showed improvement after therapy designed to improve attention skills. Similarly, in non-brain-damaged populations, reading comprehension is linked to working memory and inhibition (e.g., Borella et al., 2010; de Beni & Palladino, 2000), two of the cognitive domains in which PD patients have been shown to have deficits (e.g., Hochstadt et al., 2006). Difficulty with recall of written materials has also been identified in patients with mild cognitive impairment (Hudon et al., 2006), which may comprise a sizeable percentage of the PD population (Aarsland et al., 2009).

Accordingly, given that PD has been associated with language deficits as well as problems in cognitive processes that have been linked to reading in healthy as well as other patient populations, the purpose of the current project is to examine discourse-level reading comprehension in PD patients. The following hypotheses were tested:

1. PD patients without dementia will perform more poorly in terms of accuracy and speed than age- and education-matched controls on reading comprehension tests; and,

2. Performance on reading comprehension tests will be correlated with performance on cognitive measures (working memory, inhibition, and visual attention) for both PD and control groups.

Methods

Participants

Fifteen adult subjects with a diagnosis of PD and 15 healthy adults, age- and education-matched to the PD group will participate. PD participants completed a self-report *Unified Parkinson's Disease Rating Scale* (MUPDRS) to rate symptom severity. As of this writing, 11 PD patients and 6 controls have completed testing (Table 1).

Procedures

The following battery of language and cognitive tests was administered to each participant: (a) *Dementia Rating Scale-II* (DRS) to screen for dementia and establish global cognitive functioning; (b) *Discourse Comprehension Test* (DCT) and *Gray Oral Reading Test – 4* (GORT) to assess reading comprehension; (c) *Test of Adolescent and Adult Language – 4* (TOAL) to assess language production and comprehension skills; (d) Map Search subtest of the *Test of Everyday Attention* (TEA), to assess visual attention; (e) *Judgment of Line Orientation Test* (JLOT) to assess visual processing; (f) Sentence Span to assess working memory; (g) Flanker task to assess inhibition.

Preliminary Results

Results from the reading tests for the participant samples collected thus far were mixed (see Table 2 for test battery data). The results of Mann-Whitney U Tests, with alpha set to p=0.05, indicated no significant difference between the PD and control groups for accuracy (U=43.5, p<0.15) or speed (U=41.0, p<0.22) on the DCT. However, a significant difference was found between groups for accuracy (U=53.0, p<0.025) and maximum reading level (U=60.0, p<0.01) on the GORT. For cognitive measures, the PD patient group scored lower than the control group on the following: DRS Memory subtest (U=53.5, p<0.02) and Total Score (U=60.0, p<0.01); Sentence Span task (U=49.5, p<0.05); and, the TOAL Written (U=55.0, p<0.02) and Verbal Language (U=55.5, p<0.02) scales. The PD and control groups did not significantly differ on the TEA or JLOT.

Pearson's r was used to identify within-group correlations between the language and cognitive measures and reading comprehension test scores. The PD group demonstrated a correlation between DRS Memory and both DCT Total (r=0.799, p<0.05) and GORT Total scores (r=0.629, p<0.05). Sentence Span was also correlated with GORT total score (r=0.565,

$p<0.05$). A significant negative correlation was found between GORT Total score and UPDRS results ($r=-0.684$, $p<0.05$). The control group demonstrated a correlation between DRS Memory and DCT Total scores ($r=0.814$, $p<0.05$); a correlation was also found between their GORT total score and Flanker task average reaction time ($r=0.822$, $p<0.05$). No other significant correlations were found, keeping in mind that additional participants are currently being evaluated.

Discussion

The preliminary results thus far do not fully support the hypothesis that PD patients would demonstrate reduced accuracy and speed on reading comprehension tasks compared to the control group: No significant group differences were found for speed on either reading test or for accuracy on the DCT. However, the DCT stories may have been less linguistically demanding than those on the GORT (i.e., DCT stories have a Flesch-Kincaid reading level of 4.4-6.0, whereas GORT reading levels are 3.7-18.8). This is supported by the finding that PD patients overall had a lower maximum reading level than the control group on the GORT. These findings suggest, then, that basic reading skills at the paragraph level (i.e., DCT data) may remain intact longer in PD than the higher-level reading skills tested by the GORT. Consistent with our second hypothesis, reading comprehension, as measured by the GORT, was negatively impacted in PD patients who rated their symptoms as more severe on the UPDRS. This may reflect the influence of impaired memory, which was also correlated with reading comprehension, or it may reflect the influence of additional factors not evaluated in our current test battery. The correlation between working memory and reading comprehension for both groups supports previous results for healthy adults as well as other patient populations (e.g., Borella et al., 2010; Hudon et al., 2006). To conclude, completion of data collection will allow confirming the pattern of preliminary results described above. Regardless of final outcomes, our reading comprehension study will yield both important clinical and research implications by contributing to the literature quantifying and qualifying the breadth of language changes associated with PD.

Table 1a. Preliminary Participants' Demographic Data: Healthy Adults

Participant No.	Age (Years)	Education (Years)	Gender
2	66	12	female
3	60	16	male
6	65	14	female
8	64	18	female
14	68	14	female
17	67	20	Male
	Mean: 65.0 **SD: 2.8**	**Mean: 15.7** **SD: 2.9**	

Table 1b. Preliminary Participants' Demographic Data: PD Patients

Participant No.	Age (Years)	Education (Years)	MUPDRS Score	Gender
1	66	14	19	male
4	63	18	14	male
5	64	12	22	female
7	73	18	18	male
9	75	16	19	male
10	67	16	15	male
11	72	12	20	male
12	74	16	17	male
13	76	18	19	male
15	61	18	12	male
16	61	18	22	Female
	Mean: 68.4 **SD: 5.8**	**Mean: 16.0** **SD: 2.4**	**Mean: 17.9** **SD: 3.2**	

Table 2. Preliminary Test Battery Results

Variable		**PD Patients** (n = 11)	**Controls** (n = 6)
Dementia Rating Scale			
Attention	M	36.1	36.5
	SD	0.8	0.8
	Range	35-37	35-37
Initiation/Perseveration	M	34.5	36.5
	SD	6.4	0.8
	Range	16-37	35-37
Construction	M	6	6
	SD	0	0

	Range	6-6	6-6
Conceptualization	M	37	38
	SD	1.1	1.3
	Range	35-39	36-39
Memory	M	23.6	24.8
	SD	1.4	0.4
	Range	20-25	24-25
Total	M	137.3	141
	SD	6.2	0.9
	Range	120-142	140-143
Test of Adolescent and Adult Language			
Opposites	M	23.4	26.7
	SD	3.3	3.6
	Range	16-28	20-30
Derivations	M	35.7	45.2
	SD	9.0	5.3
	Range	19-46	35-50
Analogies	M	16.7	19.2
	SD	2.4	2.7
	Range	11-20	15-23
Similarities	M	21.2	26.5
	SD	6.3	5.2
	Range	9-30	19-32
Sentences	M	18.2	23.0
	SD	4.2	2.3
	Range	11-23	21-27
Verbal Total	M	75.8	91.0
	SD	13.2	11.0
	Range	47-94	70-101
Written Total	M	39.4	49.5
	SD	9.5	6.1
	Range	21-50	40-56
Judgment of Line Orientation Test			
	M	23.8	25.0
	SD	3.9	1.9
	Range	16-28	23-28
Discourse Comprehension Test			
Total Correct	M	98.2	103.8
	SD	11.5	7.7
	Range	74-113	91-113

Details, Implied	M	26.5	27.8
	SD	3.6	3.9
	Range	23-31	21-33
Details, Stated	M	28.0	30.8
	SD	5.8	3.2
	Range	16-35	27-34
Main Ideas, Implied	M	21.2	21.7
	SD	2.5	0.8
	Range	15-24	21-23
Main Ideas, Stated	M	22.5	23.0
	SD	1.7	0.9
	Range	20-24	22-24
Average Time Reading (s)	M	79.4	86.3
	SD	34.5	28.0
	Range	50-152	51-122
Average Time on Questions (s)	M	92.4	74.3
	SD	24.0	15.5
	Range	68-147	53-89
Gray Oral Reading Test			
Total Correct	M	35.4	40.5
	SD	5.0	2.9
	Range	27-44	36-44
Maximum Reading Level	M	10.7	13.5
	SD	1.7	0.8
	Range	9-14	12-14
Average Time Reading (s)	M	76.7	82.0
	SD	23.1	19.3
	Range	53-112	54-103
Average Time on Questions (s)	M	81.6	76.3
	SD	25.6	17.3
	Range	52-138	54-103
Flanker Task			
Average Reaction Time (ms)	M	722.5	600.2
	SD	165.2	80.4
	Range	485.0-1011.0	521.7-743.9
Average RT, Congruent	M	677.5	583.0
	SD	155.9	72.5
	Range	476.6-953.7	520.3-719.5
Average RT, Incongruent	M	756.3	617.5
	SD	160.2	94.6

	Range	494.6-956.1	523.3-768.7
Total Accuracy (%)	M	97.0	99.5
	SD	3.3	1.2
	Range	91-100	97-100
Accuracy, Congruent (%)	M	98.9	100.0
	SD	2.4	0
	Range	94-100	100-100
Accuracy, Incongruent (%)	M	95.0	99.0
	SD	6.1	2.4
	Range	81-100	94-100
Sentence Span			
	M	1.9	2.5
	SD	0.5	0.5
	Range	1-3	2-3
Test of Everyday Attention, Map Search			
Total, First Minute	M	24.9	29.0
	SD	11.9	6.3
	Range	10-46	18-35
Total, Second Minute	M	24.8	28.8
	SD	6.0	4.6
	Range	15-35	24-36
Total	M	49.7	57.8
	SD	15.4	8.3
	Range	26-74	42-66

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