Introduction:
The effects of Parkinson's disease on non-motor systems have become an area of increased interest. There is a paucity of research investigating the effects of PD on language functioning. Of those which do exist, most are in the area of receptive language abilities. Receptive language abilities of those with PD are somewhat impaired and findings show impairment in comprehension of complex commands (i.e. Cummings, Darkins, Mendez, Hill, & Benson, 1988) and complex sentences (i.e. Grossman et al., 1991; Grossman, Carvell, Stern, Gollomp, & Hurtig, 1992). Expressive language deficits with PD include impaired word fluency, especially when asked to name items from specific categories (i.e. Huber, Shuttleworth, & Paulson, 1986; Massman, Delis, Butterns, Levin, & Salmon, 1990), and impaired confrontation naming (i.e. Globus, Mildword, & Melamed, 1985; Lees & Smith, 1983). Likewise, in higher level language there is a reduction in the amount of informational content (Cummings et al, 1988; Bayles, 1990; Small, Lyons, & Kemper, 1997), and spontaneous language production is grammatically simplified relative to healthy older adults (Murray, 2000). Further investigation of expressive language functioning (specifically complex language) is necessary in this population with significant decrements in communicative effectiveness.

Repeating a sentence requires verbatim recall of words and sentence structure and working memory resources. The generation of novel sentences is more resource intensive requiring the generation of an idea, lexical retrieval, and syntactic planning, which are not necessary in a repetition task. Current research shows that conceptualization and grammatical complexity of a novel sentence tax the working memory system (e.g. Kemper, Herman, & Lian, 2003; Kemper, Herman, & Liu, 2004). It is know that persons with PD exhibit deficits in executive function and working memory (i.e. Huber et al., 1986). Therefore, we predicted that when comparing a sentence repetition to novel sentence generation task in PD we would find more difficulty in generating rather than repeating sentences and in complex language rather than simple language.

Methods:
Participants:
20 non-demented persons with PD and 20 healthy age-matched controls between the ages of 60 and 80 years participated. The following criteria for participation were established:
Inclusionary criteria: Capable of providing informed consent or having caregiver consent; Age range: 60 to 85 years; Diagnosis of Idiopathic Parkinson's Disease (either tremor-predominant or rigid-predominant) by certified movement disorders neurologist at the University of Florida Movement Disorders Center (UFMDC; M. Okun); Hoehn & Yahr Stages II-III; Dementia Rating Scale (DRS; Jurica, Leitten, & Mattis, 2001) scores no lower than 130; normal hearing thresholds for the participant's age or appropriately aided; and stabilized medication state for at least a month.
Exclusionary criteria: History of: deep brain stimulation, pallidotomy, or thalamotomy; other neurodegenerative disease; developmental or acquired speech or language disorder; and diagnosis of Alzheimer's disease (AD) or semantic dementia. Presence of inclusion and exclusion criteria were assessed using medical record review and participant interview.
Diagnostic Criteria: Fellowship trained Movement Disorders Neurologists from the UFMDC provided the diagnosis of PD using the UK brain bank criteria. Lewy Body Dementia (DLB) was distinguished from PD using clinical signs, including the presence of visual hallucinations, delusions, and minimal effect of levodopa treatment on symptoms. Utilizing the research criteria for DLB from the International Consortium for DLB further enhanced the differential diagnosis.

Individuals were screened for co-morbid AD using NINCDS-ADRDA criteria. Many of these patients also underwent comprehensive neuropsychological assessment by the Neuropsychologists affiliated with the UFMDC.

Experimental Procedures: The central aim of this study was to explore the effects of task complexity *(i.e., sentence repetition vs. sentence generation)* and conceptual complexity *(number of actors involved and grammatical complexity)* on sentence production in individuals with PD. Participants were tested at their homes and those with PD were tested one hour after taking their PD medications in order to assess them in the on medication condition. Participants completed several tests of cognitive functioning (i.e. DRS, stroop test, digit span forward/backward, digit ordering, trails test) and two experimental language tasks.

Language Tasks:

Picture Description: Forty line drawings depicting a variety of common events were designed specifically to elicit two sentence types varying in complexity (i.e., one and two clause sentences). The 40 pictures were randomized for each participant. These pictures have been effective stimuli for testing comprehension of these complex structures and for eliciting sentences of varying grammatical complexity in healthy older and young adults (Altmann & Efros, 2006, Altmann, Mullin & Mann, 2004; Kempler, Almor, Tyler, Andersen, & MacDonald, 1998).

Sentence Repetition: The sentence repetition task included 30 standardized sentences of the two target grammatical complexities. The standardized sentences were matched in number of syllables and words, word frequency, and semantic density (Small, Kemper, & Lyons, 2000).

Recording Procedures: A SONY digital audio recorder and calibrated head-worn cardioid condenser microphone recorded all language samples.

Outcome measures:

All responses were transcribed verbatim following recording. The quality of language produced was assessed using a strict binary coding, based on dimensions adapted from previous studies (i.e. Altmann et al., 2004) and listed below.

- fluent (response is free of “ums” and “uhs”, repeated words, restarts and reformulations),
- complete (response included all actors and actions of stimuli),
- grammatical (response was grammatical),
- gist meaning (the response captures the gist meaning of the stimulus).

Results:

A repeated measured ANOVA revealed significant main effects of task, error type, complexity and group on quality of language production. For participants with PD, language quality was significantly more impaired for the sentence generation task than the sentence repetition task. As grammatical complexity increased, language quality decreased in both tasks. Significant interactions were found between task and error type, and error type and grammatical complexity. Participants with PD were equally good at reproducing gist meaning in both tasks; however they showed significant impairments in completeness and grammar in the picture description task. Fluency was poor in both tasks and was severely affected by sentence complexity.

Stepwise regression was used to elucidate the variables which might be influencing change in quality of language production within those with PD. The variables of DRS and age were forced into the model and accounted for approximately 30% of the variance in both repetition and generation, but these models were not significant. Subsequently, in the model of repetition, digit span forward accounted for an additional 18% of the variance. However, in the model of

generation digit span backward accounted for an additional 18% of variance. Both of these models were significant.

Conclusions:

The results of this study suggest that working memory deficits contribute to impaired sentence production in PD, and these language deficits in PD may be masked by the common single word production tasks currently used for assessment. These results also suggest that individuals with PD may have particular difficulty expressing complex concepts, which may limit the effectiveness of their attempts at communication.

References:

Altmann, Lori J.; Efros, David B. (2006). Understanding Complex Sentences: Answer Position Interacts with Relative Clause. A poster to be presented at the 2006 International Neuropsychological Society, February 2006.

Altmann, L. J. P., Mullin, D. A., & Mann, T. (2004). Minimal effects of order of activation on sentence production. Presented at the 2004 meeting of the Psychonomic Society, November 18, 2004, Minneapolis, MN.

Bayles, K. (1990). Language and Parkinson' disease. *Alzheimer Disease and Associated Disorders, 4*, 171-180.

Cummings, J.L., Darkins, A., Mendez, M., Hill, M.A., & Benson, D.F. (1988). Alzheimer's disease and PD: comparison of speech and language alterations. *Neurology, 38*, 680-684.

Grossman, M., Carvell, S., Gollomp, S., Stern, M.B., Vernon, G., & Hurtig, H.I. (1991). Sentence comprehension and praxis deficits in PD. *Neurology, 41,* 1620-1626.

Grossman, M., Carvell, S., Stern, M.B., Gollomp, S., & Hurtig, H.I. (1992). Sentence comprehension in PD: the role of attention and memory. *Brain and Language, 42,* 347-384.

Globus, M., Mildword, B., & Melamed, E. (1985). Cerebral flow and cognitive impairment in Parkinson's disease. *Neurology, 35,* 1135-1139.

Huber, S.J., Shuttleworth, E.C., & Paulson, G.W. (1986). Dementia in Parkinson's disease. *Archives of Neurology, 42,* 987-990.

Jurica, P.J., Leitten, C.L., & Mattis, S. (2001). Dementia Rating Scale-2 (DRS-2): Professional Manual. Lutz, FL: Psychological Assessment Resources.

Kemper, S., Herman, R.E., & Liu, C. J. (2004). Sentence production by younger and older adults in controlled contexts. *Journals of Gerontology: Psychological Sciences, 58B,* P220-P224.

Kemper, S., Herman, R., & Lian, C. (2003). Age differences in sentence production. *The Journals of Gerontology: Series B, Psychological Sciences and Social Sciences, 58,* P260-268.

Kempler, D., Almor, A., Tyler, L.K., Andersen, E.S., & MacDonald, M.C. (1998). Sentence comprehension deficits in Alzheimer's disease: a comparison of off-line vs. on-line sentence processing. *Brain and Language, 64(3),* 297-316.

Massman, P.J., Delis, D.C., Butters, N., Levin, B.E., & Salmon, D.P. (1990). Are all subcortical dementias alike: verbal learning and memory in Parkinson's and Huntington's disease patients. *Journal of Clinical and Experimental Neuropsychology, 12,* 729-744.

Murray, L.L. (2000). Spoken language production in Huntington's and Parkinson's diseases. *Journal of Speech, Language, and Hearing Research, 43,* 1350-1366.

Small, J.A., Lyons, K., & Kemper, S. (1997). Grammatical abilities in Parkinson's disease:

evidence from written sentences. *Neuropsychologia, 35(12),* 1571-1576.
Small, J.A., Kemper, S., & Lyons, K. (2000). Sentence repetition and processing resources in Alzheimer's disease. *Brain and Language, 75,* 232-258.