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# Effects of verbal working memory deficits on metaphor comprehension in patients with Parkinson's disease

Laura Monetta *, Marc D. Pell

*School of Communication Sciences and Disorders, McGill University, 1266 avenue des Pins ouest, Montreal, Que., Canada H3G 1A8*

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**Abstract**

This research studied one aspect of pragmatic language processing, the ability to understand metaphorical language, to determine whether patients with Parkinson disease (PD) are impaired for these abilities, and whether cognitive resource limitations/fronto-striatal dysfunction contributes to these deficits. Seventeen PD participants and healthy controls (HC) completed a series of neuropsychological tests and performed a metaphor comprehension task following the methods of Gernsbacher and colleagues [Gernsbacher, M. A., Keysar, B., Robertson, R. R. W., & Werner, N. K. (2001). The role of suppression and enhancement in understanding metaphors. *Journal of Memory and Language, 45*, 433–450.] When participants in the PD group were identified as "impaired" or "unimpaired" relative to the control group on a measure of verbal working memory span, we found that only PD participants with impaired working memory were simultaneously impaired in the processing of metaphorical language. Based on our findings we argue that certain "complex" forms of language processing such as metaphor interpretation are highly dependent on intact fronto-striatal systems for working memory which are frequently, although not always, compromised during the early course of PD.


*Keywords:* Language processing; Parkinson's disease; Pragmatics; Cognitive resources; Fronto-striatal dysfunction; Basal ganglia

## 1. Introduction

Parkinson disease (PD) is a chronic, progressive nervous disease linked to decreased dopamine production in the basal ganglia, particularly in the *substantia nigra*. In the early stages of the disease, many PD patients display cognitive impairments in the absence of dementia, including difficulty with executive functions such as working memory (WM), planning, and selective attention (Brown & Marsden, 1991; Lewis et al., 2003; Taylor, St-Cyr, & Lang, 1986). Frequently, PD patients who present cognitive impairments exhibit concurrent language difficulties (see Berg, Bjornram, Hartelius, Laakso, & Johnels, 2003; Lewis, Lapointe, Murdoch, & Chenery, 1998). In some cases, these observations have led researchers to study PD patients, as a neuropsychological model for determining how the basal ganglia contribute to language processing and social cognition (Friederici, Kotz, Werheid, Hein, & Cramon, 2003; Grossman et al., 2003; Kotz, Frisch, Cramon, & Friederici, 2003; Pell & Leonard, 2003; Tettamanti et al., 2005; Ullman et al., 1997). However, it is likely that many of the language processing deficits observed in PD patients are linked to basic limitations in executive resources such as WM, due to the compromise of fronto-striatal pathways in PD (see Grossman et al., 2003 for a general review on this topic).

Certain language abilities are likely more dependent on an intact cognitive resource capacity, especially the "pragmatic" functions of language (McDonald & Pearce, 1998; Monetta & Champagne, 2004; Stemmer, Giroux, & Joanette, 1994). Pragmatics is at the interface of linguistic and non-linguistic cognitive systems (Perkins, 1998), where the capacity to communicate does not only rest on an intact language system but also on the knowledge of a specific

* Corresponding author. Fax: +1 514 398 8123.
*E-mail address:* Laura.monetta@mail.mcgill.ca (L. Monetta).

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communicative exchange context and high-level capacities (Martin & McDonald, 2003). For example, pragmatic language functions include the ability to generate appropriate inferences from linguistic material, to interpret metaphors and non-literal language, and to interpret language in the context of paralinguistic, non-verbal, and situational cues which inform intended meanings. To date, pragmatic communication abilities have been evaluated mostly in adults with focal right or left brain damage (Joanette, Goulet, & Hannequin, 1990; Myers, 2001), traumatic brain injury patients (McDonald, 1993), and schizophrenic patients (Titone, Holzman, & Levy, 2002). However, a small number of studies have recently explored these abilities in the context of PD by administering a general battery of tests presumably sensitive to pragmatic language functions (Berg et al., 2003; McNamara & Durso, 2003; Natsopoulos et al., 1997).

Natsopoulos and colleagues (1997) compared individuals with PD with healthy control (HC) participants on five deductive reasoning tasks (e.g., interpreting syllogisms) and three inductive reasoning tasks (e.g., interpreting metaphors). They found that relative to healthy controls, both types of reasoning abilities were significantly impaired in the PD patient group, especially in patients with bilateral motor signs. More recently, McNamara and Durso (2003) evaluated PD patients using a formal pragmatic communication skills protocol (Prutting & Kirchner, 1987). This battery examined features of verbal behavior (e.g., speech acts, message specificity, cohesion), non-verbal behavior (e.g., facial expressions, eye gaze, gestures), paralinguistic behavior (e.g., fluency, prosody, vocal quality), and the participants' conversational and social skills. In addition, traditional tests of frontal lobe functioning were administered (e.g., Tower of London, Stroop color-word test). Their results again demonstrated that pragmatic communication skills were impaired in the PD group and that these deficits were predicted by impairments on frontal lobe tasks. Finally, using a distinct battery of tests, Berg et al. (2003) reported that PD patients exhibit "high-level" language difficulties which affect the ability to generate inferences, recreate sentences, and comprehend ambiguities and metaphors in language.

It is noteworthy that, although none of these initial investigations evaluated specific pragmatic skills in extensive detail, difficulties in the comprehension of *metaphorical language* in PD were highlighted by more than one study. Metaphor comprehension is one dimension of pragmatic processing that has been presumed in the literature to be highly resource demanding (see Monetta, Ouellet-Plamondon, & Joanette, 2006). As previous studies have shown that PD participants were particularly impaired in comprehending metaphors within a general battery of pragmatic language tasks (Berg et al., 2003; Natsopoulos et al., 1997), a detailed study of this pragmatic dimension could help to better determine whether an important relationship exists between metaphor processing abilities and the individual resource capacity of the patients tested.

Different assumptions have been made about the normal processes that contribute to metaphor comprehension. According to the theory of Gernsbacher (see Gernsbacher, Keysar, Robertson, & Werner, 2001), understanding the meaning of a metaphor such as, "*That tiny mosquito was a vampire*" involves both the suppression of irrelevant information activated by the stimulus (e.g., *Vampires wear black*) and the enhancement of relevant information which pertains directly to the metaphorical interpretation (e.g., *Vampires suck blood*) (see Kintsch, 2000; for alternative perspectives on this process). These researchers have tested the enhancement and suppression of relevant and irrelevant information during metaphor comprehension using the timed property-verification task (Gernsbacher et al., 2001). In this procedure, participants read a series of sentences one at a time and must decide following each sentence whether or not it makes sense. "Prime" sentences which promote metaphorical processing (e.g., "*That tiny mosquito was a vampire*") are followed by a "target" sentence that is either relevant (e.g., *Vampires suck blood*) or irrelevant (e.g., *Vampires wear black*) to the metaphorical interpretation presumably generated by the prime. The accuracy and latency of responses are then compared across key conditions to infer whether metaphorical meanings are being activated during sentence verification as a function of the prime-target relationship.

The results of studies involving young healthy individuals (Gernsbacher et al., 2001), and those which have compared young and older adults without brain damage (Newsome & Glucksberg, 2002), indicate that listeners tend to enhance metaphor-relevant information and to filter metaphor-irrelevant information (irrespective of age), based on results obtained from the timed property-verification task. These data imply that the suppression mechanism is especially crucial for eliminating potentially confusing (irrelevant) information during metaphor processing in healthy listeners. Given the emerging evidence that high-level pragmatic abilities such as metaphor comprehension are adversely affected by the neurodegenerative course of PD (Berg et al., 2003; Natsopoulos et al., 1997), we adopted the timed property-verification task to evaluate metaphor comprehension functions in a well-defined sample of adults with PD using the same set of materials that have been used successfully on healthy, elderly subjects (see Newsome & Glucksberg, 2002).

Our goals were to: verify whether PD patients exhibit abnormalities in the comprehension of metaphorical language based on a comprehensive assessment of these abilities; explore whether metaphor impairments reflect specific deficits of suppression or enhancement of metaphor-related information (Gernsbacher et al., 2001); and determine whether an important relationship exists between metaphor processing abilities and the individual resource capacity of the patients tested (with a particular focus on WM, which is a critical measure of cognitive/executive resources). We anticipated that metaphor comprehension would be problematic for PD patients as a group (Berg et al., 2003; Natsopoulos et al., 1997) but that performance would be