Annual Review of Applied Linguistics (2008) **28**, 113–127. Printed in the USA.
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doi:10.1017/S0267190508080100

6. LANGUAGE AND PARKINSON'S DISEASE

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Parkinson's disease, the most common progressive neurological movement disorder worldwide, causes slow deterioration of subcortical structures and dopamine deficiency, and the disruption of circuits connecting frontal lobe and basal ganglia regions. Although the motor and cognitive consequences of these structural and physiological changes have been well-documented, only a limited, albeit growing, empirical literature has examined the integrity of language abilities in individuals with Parkinson's disease. This article reviews recent advances in that literature that have furthered our understanding of the quantitative and qualitative changes in morphosyntactic, lexical-semantic, and discourse levels of language functioning associated with Parkinson's disease. This article also discusses the theoretical and applied implications of these linguistic symptoms and provides suggestions to forward this line of research.

Parkinson's disease (PD), the most common progressive neurological movement disorder worldwide, is estimated to affect at least 1% of individuals beyond the age of 60 (Samii, Nutt, & Ransom, 2004). In PD, deterioration of subcortical structures such as the substantia nigra and depletion of dopamine lead to disruption of several corticostriatal circuits and, subsequently, a myriad of symptoms (Delong, 2000; Mattay et al., 2002). Although a large empirical literature has delineated the motoric (e.g., resting tremor, rigidity, hypokinetic dysarthria, festinating gait) and cognitive (e.g., impaired attention, working memory deficits, executive dysfunction) consequences of PD, a less conspicuous, albeit growing, line of research indicates that the sequelae of PD also extend to the domain of language (e.g., Grossman et al., 2003; Whiting, Copland, & Angwin, 2005). Although language disorders were initially only identified in individuals with more advanced stages of PD and dementia, these early investigations typically examined basic language abilities such as confrontation naming or comprehension of single words or short sentences (e.g., Bayles et al., 1997; Cummings, Darkins, Mendez, Hill, & Benson, 1988). More recently, researchers have exploited tasks that evaluate more complex aspects of language processing and consequently have documented linguistic impairments in a much broader PD population, including those without dementia (e.g., Murray, 2000; Zanini et al.,

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

2003). Furthermore, although certain linguistic processes (i.e., morphosyntax comprehension) have received greater attention in the empirical literature, and debate persists regarding the nature of linguistic deficits in PD, evidence has accrued to suggest that PD can compromise most, if not all, aspects of language comprehension and expression including morphosyntax, lexical-semantic, and discourse or high-level language abilities. Accordingly, what follows is a review of recent advances pertaining to our understanding of the qualitative and quantitative affects of PD on language, including discussion of the theoretical and applied implications of these linguistic deficits and provision of suggestions to forward this line of research.

Morphosyntactic Processing

Data from studies using a variety of methodologies indicate that PD negatively affects morphosyntactic processing, although the nature of these deficits has yet to be resolved and most research has focused on comprehension rather than production. With respect to comprehension, understanding of complex syntactic structures (e.g., noncanonical constructions such as passives; sentences with center embedded clauses) appears most vulnerable in individuals with PD, as evidenced by their performance of offline listening or reading tasks such as sentence-picture matching and grammaticality judgment (Angwin, Chenery, Copland, Murdoch, & Silburn, 2006; Arnott, Chenery, Murdoch, & Silburn, 2005; Colman, Koerts, van Beilen, Leenders, & Bastiaanse, 2006; Hochstadt, Nakano, Lieberman, & Friedman, 2006; Terzi, Papapetropoulos, & Kouvelas, 2005; Whiting et al., 2005; Zanini et al., 2004). For instance, Hochstadt and colleagues required individuals with PD to complete a sentence-picture matching task in which the sentence stimuli varied in terms of complexity (i.e., simple vs. complex with center-embedded or final relative clauses), voice (i.e., active vs. passive), and semantic constraint (i.e., real word knowledge could vs. could not be applied to facilitate comprehension). The PD participants demonstrated greatest difficulty on sentences with complex syntax and for which real word knowledge could not be exploited to aid comprehension. Zanini et al. extended this line of research to bilingual individuals with PD and found poorer performance of sentence comprehension and grammaticality judgment tasks in the native language (L1) versus in the second-learned language (L2). This cross-linguistic performance difference was attributed to the different learning and memory processes involved in acquiring and using L1 (associated with more procedural skills) versus L2 (associated with more declarative or strategic skills).

Online sentence processing tasks also have been used to evaluate morphosyntactic comprehension in individuals with PD. These tasks allow investigating sentence processing in a context that minimizes the possible confounds of deficits in cognitive functions other than language (Whiting et al., 2005), which are prevalent among individuals with PD, even in the earliest stages of this progressive disorder (see Caballo, Marti, & Tolosa, 2007, for a review of cognitive status in PD). Data from studies involving priming, one online approach, suggest that early, automatic morphosyntactic processes remain relatively intact in PD as at fast interstimulus intervals (ISIs) individuals with PD perform similarly to their healthy,

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

age-matched peers (Friederici, Kotz, Werheid, Hein, & von Cramon, 2003; Longworth, Keenan, Barker, Marslen-Wilson, & Tyler, 2005). Similarly electrophysiological data support this contention as individuals with PD demonstrate the early left anterior negativity evoked potential associated with automatic syntactic processes, but either fail to show or demonstrate reductions in the later, more posterior evoked potential associated with the subsequent assimilation of syntactic and semantic information (Friederici et al.).

Most frequently, cognitive deficits, particularly those within the domains of executive functioning (e.g., inhibition, cognitive flexibility, or set-switching) and working memory, have been specified to underlie the morphosyntactic processing problems identified via off- and online tasks (Colman et al., 2006; Hochstadt et al., 2006; Longworth et al., 2005; Zanini et al., 2004). For example, Colman and colleagues had individuals with PD and a group of healthy, age- and education-matched peers complete a sentence-picture matching task. To evaluate the influence of working memory, short and long versions of the sentence stimuli were administered; standardized tests of executive functioning and memory were also given to evaluate cognitive status. The PD participants obtained their poorest sentence comprehension accuracies on long sentences with complex syntax (i.e., passives); furthermore, performance of this sentence type was significantly associated with performance on the executive function measures. These correlational data implicating executive cognitive abilities fit well with the neuropathology of PD, which not only affects the basal ganglia but also the neural circuits that connect the frontal regions and subcortical structures and that support executive cognitive abilities (see Delong, 2000 and Mattay et al., 2002).

Functional imaging studies have also begun to yield information pertaining to the nature of morphosyntactic comprehension changes in PD. For instance, Grossman et al. (2003) found that despite comparable performance patterns on a sentence comprehension task, individuals with mild PD demonstrated different activation patterns than their age and education-matched healthy peers. More specifically, compared to healthy participants, individuals with PD showed less striatal activation when processing long-linkage sentences (e.g., long: "The messy boy who Janet the very popular hairdresser grabbed was extremely hairy." vs. short: "The flower girl who Andy punched in the arm was five years old." p. 776), and less recruitment of bilateral anteromedial prefrontal and posterolateral temporal regions when processing a variety of sentence types (i.e., subject and object relative sentences with short or long linkages); furthermore, PD participants displayed increased activation of left temporoparietal and right frontal and posterior regions compared to the healthy seniors. Because the activation patterns of the PD and control participants did not differ when processing of subject and object relative sentences were contrasted, Grossman and colleagues proposed that PD does not impact the neural areas that directly support morphosyntactic processing. Instead, PD appears to affect neural regions (e.g., prefrontal cortex) associated with cognitive abilities such as working memory that help sustain sentence comprehension. Furthermore, increased activation in certain brain regions may reflect compensation for the decreased contributions of neural circuits compromised by PD.

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Although PD participants in the previously cited studies were most frequently examined when on a dopamine agonist regimen, some researchers have begun to compare morphosyntactic comprehension performances when participants take and withdraw their dopaminergic medications (McNamara, Krueger, O'Quin, Clark, & Durso, 1996; Skeel et al., 2001). Initial findings suggest that dopaminergic medications may influence morphosyntactic processing, albeit in a limited manner. For instance, McNamara and colleagues found improved detection of only certain forms of ungrammaticality when individuals with PD were taking their medications; similarly, some participants demonstrated poorer sentence comprehension when off their dopaminergic medications. Clearly this limited data set must be expanded to evaluate (1) the extent to which traditional PD drug regimens might facilitate general morphosyntactic comprehension abilities, aid understanding of a limited set of morphosyntactic structures, or both; and (2) what patient characteristics might modulate these effects (e.g., disease severity, age, length of time on dopamine agonists).

Although morphosyntactic production abilities have been less frequently examined, a growing database indicates impairments in individuals with PD, regardless of the presence or absence of dementia (Longworth et al., 2005; Terzi et al., 2005). For example, Longworth and colleagues found impaired performance among nondemented individuals with PD, particularly those with moderate disease severity, on a sentence completion task designed to evaluate affixation of past tense morphemes. Morphosyntactic production deficits have also been observed when discourse-level output tasks have been used (Murray, 2000; Murray & Lenz, 2001); most consistently, individuals with PD, even those without dementia, tend to produce a smaller proportion of grammatically complete utterances than their healthy peers, although the syntactic complexity of these utterances is comparable to that produced by their healthy peers. As with morphosyntactic comprehension deficits, researchers have proposed that morphosyntactic output problems appear to be related, at least in part, to cognitive issues (Ellis & Rosenbek, 2007; Longworth; Murray; Terzi et al., 2005); additionally, the influence of motor speech impairments (i.e., dysarthria) has also been acknowledged, although incompletely evaluated thus far.

There has been nominal examination of how medical treatments for PD affect morphosyntactic production abilities. Recently, Zanini and colleagues (2003) evaluated whether bilateral subthalamic nucleus stimulation would influence morphosyntactic output during a spontaneous speech task (which was not specified) in four participants with PD. Subthalamic nucleus stimulation involves the surgical implantation of permanent electrodes (i.e., stimulators) into the subthalamic nucleus (Coyne et al., 2006); stimulator settings can be manipulated after surgery to control the amount of stimulation or to turn the stimulators off. Zanini et al. observed that in terms of syntactic complexity, all of their participants demonstrated nominal change in use of subordinate clauses when their pre- and postsurgery samples were compared. Comparing samples taken at 2 weeks versus 1 year postsurgery, all participants showed declines in subordinate clause use; these declines, however, were not statistically significant. In contrast, use of free and bound grammatical morphemes appeared more responsive to subthalamic stimulation as all participants

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

made fewer morphosyntactic errors following surgery, both acutely and at 1 year out. Although Zanini et al. attributed these improvements to language-specific effects, they failed to include any measures of dysarthria (i.e., motor speech). That is, the significant motor function recovery demonstrated by all participants on a disease severity rating scale may have also extended to the domain of motor speech, which in turn could have facilitated linguistic formulation and execution. Additionally, these researchers did not compare the PD participants' spoken language samples to those of healthy peers, and thus, their data cannot address whether morphosyntactic difficulties, while improved, continued to persist following stimulator implantation.

Lexical-Semantic Processing

Several experimental tasks and clinical protocols have been used to evaluate lexical-semantic comprehension and production abilities in individuals with PD. Compared to the morphosyntactic PD database, however, priming methods have been less frequently used to examine lexical-semantic processing. Exceptions include a study by Copland (2003), in which individuals with PD who were taking dopaminergic medications were found to differ from healthy controls only at long ISIs, suggesting that PD compromises controlled or strategic rather than automatic semantic processing, a proposal similar to that forwarded to account for morphosyntactic impairments in PD (e.g., Longworth et al., 2005). Data from Copland's study also suggested that individuals with PD demonstrate abnormal activation of competing interpretations, which in turn could support that linguistic difficulties are related to cognitive deficits such as disinhibition. Additional priming research has corroborated the integrity of automatic spread of activation and semantic deficits related to inhibition impairments or delays in semantic activation (Angwin, Chenery, Copland, Murdoch, & Silburn, 2004; Friederici et al., 2003). Furthermore, Angwin, Chenery, and colleagues (2006) have contended that slow lexical-semantic activation might not only negatively affect lexical-semantic comprehension, but also underlie or contribute to PD individuals' difficulty comprehending sentences with complex syntax.

How PD medical treatments influence outcomes on priming protocols has also been investigated (Angwin, Copland, Silburn, Chenery, & Murdoch, 2006; Boulenger et al., 2008; Castner et al., 2007). Angwin, Copland, and colleagues found that when individuals with PD were not taking dopamine, a disrupted priming pattern was observed at the short ISI, suggesting that even automatic semantic activation may be compromised by PD. Similarly, Boulenger et al. reported that priming effects for verbs disappeared when individuals with PD were off their dopaminergic drugs. Castner et al. evaluated how implant surgery to stimulate the subthalamic nucleus might affect semantic priming task outcomes in individuals with PD (most of who were still on dopaminergic agonists). Although deep brain stimulation had no effect on priming at short ISIs (i.e., no effect on automatic semantic processes), it did produce semantic priming effects at long ISIs, suggesting a positive influence on controlled lexical-semantic processes; whether this intervention approach facilitates controlled semantic priming by ameliorating cognitive deficits or sustaining priming effects will require further investigation.

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Early research pertaining to word-retrieval abilities in PD was limited in scope as investigators primarily utilized picture-naming tests designed for the aphasic patient population (e.g., Cummings et al., 1988). Consequently, only those individuals with PD and significant dementia tended to display naming problems. More recently, investigators have employed more diverse naming tasks (e.g., action vs. just object naming; semantic and phonemic fluency tasks) and have identified lexical-semantic retrieval deficits, even among nondemented individuals (Cotelli et al., 2007; Demakis et al., 2003; Hough, 2004; Pignatti, Ceriani, Bertella, Mori, & Semenza, 2006). Results from these studies indicate that action naming is more vulnerable than object naming (Cotelli et al.; Henry & Crawford, 2004), although less so during spontaneous speech (Pignatti et al.). This discrepancy between action and object naming (and processing; see Boulenger et al., 2008) has been attributed to PD's negative effects on prefrontal areas, which have, within the left hemisphere, been associated with verb production and action representation (e.g., Shapiro et al., 2005); alternately, prefrontal involvement may compromise the executive functions not only supported by these neural regions (e.g., Zgaljardic et al., 2006) and frequently compromised by PD (e.g., Caballol et al., 2007), but also needed to bolster performance of verb-retrieval tasks because action naming may place greater demands on cognitive resources than object naming, particularly during picture naming (Cotelli et al.). Similarly, a cognitive basis to impaired performance on verbal fluency tasks has been specified (Demakis et al., 2003; Ellis & Rosenbek, 2007).

Another avenue of research has explored how pallidotomy (i.e., surgical destruction of part of the globus pallidus to reduce the excessive activity that PD causes within this basal ganglionic structure) and deep brain stimulator implantation influence word retrieval. Although both improvements and declines on naming tasks have been reported subsequent to pallidotomy, poorer postsurgery word retrieval is most frequent following left pallidotomy, and this naming deterioration has been attributed to the negative effects of pallidotomy on general cognitive functioning (Demakis et al., 2003; Troster, Woods, & Fields, 2003; York, Levin, Grossman, Lai, & Krauss, 2003); that is, following pallidotomy, regional cerebral blood flow changes are observed in not only frontal motor regions but also nonmotor prefrontal areas that subserve several cognitive skills including working memory and executive functioning. Implanting stimulators may produce either declines or nominal changes in verbal fluency (Rothlind, Cockshott, Starr, & Marks, 2007; Zanini et al., 2003), with declines more likely in cases of bilateral or left unilateral stimulation (versus right unilateral stimulation). Zanini et al. additionally evaluated spontaneous speech following stimulator implantation and observed fewer word-retrieval errors in some of their PD participants. Like pallidotomy, subthalamic nucleus stimulation effects may extend beyond the motor regions of this deep structure to evoke changes in nonmotor corticostriatal circuits, and thus possibly cognitive and linguistic skills (Castner et al., 2007). The variable lexical-semantic outcomes following surgical intervention reported to date no doubt relate to differences among participants (e.g., presence vs. absence of dementia; drug regimes; disease severity) and procedures (e.g., uni- vs. bilateral surgery; surgery site(s); acute vs. chronic recovery; verbal fluency vs. spontaneous speech).

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Discourse and High-Level Language Processing

Partaking in discourse requires efficient synthesis of basic linguistic processes (i.e., bottom-up processes) with other cognitive functions such as ambiguity resolution and story grammar identification (i.e., top-down processes) and includes skills pertaining to topic management, turn taking, integration of context, and communication repair (Copland, Chenery, & Murdoch, 2001; Kintsch & van Dijk, 1978; Murray & Clark, 2006). Because these skills depend on frontal lobe functioning and PD compromises frontal functioning (Caballol et al., 2007), investigators have begun examining the integrity of discourse and high-level language processing in PD.

In terms of comprehension, several PD studies have documented via on- and offline tasks impairments such as difficulties comprehending implied information or figurative content and problems integrating previously processed discourse or contextual information to interpret lexical ambiguity (Berg, Bjornram, Hartelius, Laakso, & Jonels, 2003; Copland et al., 2001; Monetta & Pell, 2007; Whiting et al., 2005). For example, Berg et al. administered a battery of high-level language tasks (e.g., Making Inferences, Comprehension of Ambiguous Sentences, Comprehension of Metaphors) to individuals with PD and no dementia and to age- and education-matched individuals with no brain damage. Although the PD participants consistently achieved lower scores compared to the control participants across the tasks, significant group differences were only identified on Sentence Analysis (i.e., listening to sentences and then specifying how many words are in each sentence) and Making Inferences subtests. Similarly, Monetta and Pell reported that individuals with PD responded less accurately and more slowly than their age- and education-matched peers on a metaphor comprehension task. Across this line of research, a robust relationship between cognitive abilities and the presence and extent of high-level language comprehension deficits has been consistently reported (Berg et al.; Monetta & Pell; Murray & Stout, 1999): PD participants with greater cognitive involvement, particularly in terms of working memory status, perform high-level language comprehension tasks more poorly than those with less compromised cognitive status. These findings in combination with data indicating only weak correlations between performance of high-level language comprehension tasks and performance of aphasia subtests that evaluate more basic language abilities (e.g., Murray & Stout) point toward a cognitive rather than purely linguistic basis to high-level language processing deficits in PD.

Few investigations have evaluated high-level language or discourse production abilities. Within this limited database, however, findings consistently indicate reductions in the informativeness or conciseness of discourse output following the onset of PD (Berg et al., 2003; Ellis & Rosenbek, 2007; McNamara & Durso, 2003; Murray, 2000); that is, individuals with PD tend to say as much as their healthy peers, but less of that output is rated as informative. For instance, McNamara and Durso rated the conversations of individuals with PD and healthy adults on the basis of 30 pragmatic skills (e.g., topic initiation, message specificity) and had another set of individuals with PD and their caregivers complete these pragmatic

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ratings about themselves (or in the case of the caregivers, about their loved one with PD). These researchers found that PD participants more frequently displayed inappropriate pragmatic behaviors (e.g., problems with conciseness, deficient feedback to the speaker) compared to their healthy peers, and that performance of inhibition and planning tests significantly correlated with these pragmatic outcomes. Furthermore, although individuals with PD self-reported some pragmatic difficulties, they consistently overestimated their pragmatic competence compared to their caregivers' ratings. McNamara and Durso concluded that PD compromises pragmatic abilities, and that collectively, awareness issues and significant associations between pragmatic and executive functions measures identify frontal lobe dysfunction as the basis of these pragmatic problems.

Initial data accrued by Zanini et al. (2003) suggest that subthalamic nucleus stimulation may facilitate the spoken discourse skills of individuals with PD. These researchers found significant increases in the number of words, sentences, or both in the spoken discourse samples of their four PD participants following device implantation. Further evaluation of the effects of this PD treatment as well as pharmacotherapy and other surgical treatments is clearly needed, particularly given that Zanini and colleagues did not (1) include a control group to allow determining if the pre- or postsurgery samples of the PD participants were deficient in terms of quantity of output or (2) examine whether postsurgery increases in quantity of output were associated with improved informativeness or actually represented decreased efficiency (i.e., participants required more words to convey information).

Conclusions and Recommendation for Future Research

A growing body of research has documented language changes in individuals with PD, even in the earliest stages of the disease process and prior to the onset of frank dementia (Bayles et al., 1997; Colman et al., 2006; Cotelli et al., 2007; Miller, Noble, Jones, & Burn, 2006; Monetta & Pell, 2007). Although individuals with PD who present with dementia may have difficulties with even basic language functions, those without dementia are most likely to experience morphosyntactic, lexical-semantic, and high-level language comprehension and production breakdowns when linguistic complexity, controlled processing demands, or both increase. Investigations designed to resolve the nature of these language impairments most frequently yield data implicating a cognitive rather than linguistic basis that is related, in turn, to progressive disruption of frontostriatal neural circuitry (e.g., Grossman et al., 2003; Monetta & Pell; Terzi et al., 2005; Whiting et al., 2005). More specifically, language deficits in individuals with PD, particularly those involving comprehension, appear most likely and most prominent when language processing is dependent on inhibition of completing alternatives or takes place within the context of high working memory demands. Investigators have also begun to examine how drug and surgical treatments, originally designed to address the motoric consequences of PD, influence language processing. Thus far, inconsistent outcomes have been observed (e.g., subsequent to treatment, some participants show linguistic improvements, others show no change, and some show poorer language performance), no doubt a reflection, at least in part, of the variation in methodology

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across these studies. Accordingly, despite these recent advances in quantifying and qualifying the linguistic consequences of PD, several lines of research require further explication.

First, the procedures and research designs used to document language deficits and to characterize the nature of these deficits in PD require refinement. For example, researchers have almost exclusively evaluated the language abilities of individuals with PD under ideal or favorable conditions (e.g., quiet environment, nominal time pressure, or while taking antidepressants). Therefore, current data may underestimate the extent of language limitations associated with PD, particularly in terms of the types and degrees of problems encountered by individuals with PD within their daily vocational and social environments and activities (e.g., cell phone conversations, group discussions). Another assessment weakness in the existing literature pertains to the evaluation of dysarthria: Few studies regarding language production abilities in PD have included dysarthria measures (e.g., Zanini et al., 2003), and those that have included such measures have frequently exploited only relatively crude measures of intelligibility (e.g., Murray, 2000). Accordingly, future use of acoustic or physiological measures of dysarthria may yield meaningful relations between language changes and motor speech status that have yet to be identified. Finally, longitudinal research designs have not yet been exploited to determine how linguistic abilities evolve within individual patients as their other PD symptoms progress over time; longitudinal data might contribute to understanding the relationship between linguistic changes and those in cognition, motor speech, or both, as well to identifying influential personal or environmental characteristics (e.g., age, access to health care) that moderate or exacerbate onset and progression of language disorders in PD.

Second, further examination of multilingual populations is needed, given the theoretical and clinical implications of extending this line of research. Thus far, this segment of the PD population has been included in few study participant samples, and when bilingual participants have been included, the investigations have focused on morphosyntactic processing (e.g., Cameli, Phillips, Kousaie, & Panisset, 2006; Zanini et al., 2004). Recent literature searches yielded no studies evaluating other linguistic functions in bi- or multilingual individuals with PD. Cross-linguistic comparisons of other language abilities (e.g., discourse or high-level language skills, lexical-semantic processing) have the potential to refine current neuro- and psycholinguistic models as well as guide clinicians who are managing the communication problems of this patient population.

Third, certain aspects of linguistic functioning have been nominally evaluated thus far. That is, although a substantial database has been established with respect to the morphosyntactic comprehension abilities of individuals with PD, few investigations regarding the integrity of morphosyntactic production and high-level language comprehension and production abilities have been published. In addition, utilization of a limited set of procedures (i.e., confrontation naming, verbal fluency, priming) has no doubt yielded a restricted view of the impact of PD on lexical-semantic processing.

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Fourth, it is critical to extend our understanding of how current and emerging PD medical treatments affect language. For example, few studies have systematically evaluated the influence of the hallmark PD treatment, dopamine agonists, by having participants complete experimental tasks while both on and off their PD medications. Moreover, most previous investigations, including those examining language outcomes following pallidotomy and stimulator implantation, failed not only to control for dopaminergic medications among their PD participants (e.g., some participants were taking these drugs, whereas others were not), but also to specify or control for the other medications (e.g., antidepressants) frequently prescribed to this patient population (e.g., Longworth et al., 2005; Monetta & Pell, 2007; Terzi et al., 2005; Zanini et al., 2003, 2004). Therefore, it is conceivable that at least some of the conflicting findings within the PD language literature are a product of this nominal control for the possible confounds of different medication protocols. Furthermore, because in many studies individuals with PD were evaluated during their on-state (i.e., while taking their dopaminergic medications) (e.g., Cotelli et al., 2007; Zanini et al., 2003, 2004), it remains plausible that linguistic deficits associated with PD as well as the effects of surgical PD treatments on language are currently underappreciated.

Last, the empirical literature has yet to identify management procedures that might help individuals with PD, their caregivers, and clinicians manage the linguistic consequences of this disabling progressive disorder. Most PD treatment research has concentrated on evaluating the motoric outcomes of unidisciplinary, neurology-based interventions (i.e., pharmaceutical or surgical treatments) (e.g., Horstink et al., 2006). Researchers have recently begun to explore the possible benefits of adopting multidisciplinary approaches, that is, those that assure and coordinate access to a variety of health care specialties (e.g., neuropsychology, occupational therapy, speech-language therapy) (Carne et al., 2005; Magee, Brumfitt, Freeman, & Davidson, 2006; Wade et al., 2003). Although initial data indicate that multidisciplinary approaches foster better outcomes than medication-only treatments, outcome measures have continued to focus on motor status. Furthermore, when communication interventions for individuals with PD have been investigated, they have been limited to treatment protocols (e.g., Lee Silverman Voice Treatment; music therapy) that remediate or focus on motor speech rather than language impairments (Magee et al., 2006; Sapir, Spielman, Ramig, Story, & Fox, 2007; Spielman, Ramig, Mahler, Halpern, & Gavin, 2007). Indeed, no published studies of language treatments for individuals with PD were identified in recent literature searches. Therefore, future PD research must (1) incorporate language measures when evaluating multidisciplinary approaches and (2) identify language treatments and compensatory strategies that will help individuals with PD improve or maintain their current level of linguistic functioning.

To conclude, a substantial research base has clearly established that PD can produce a myriad of language deficits. Given the prevalence of PD, however, there remains a need to establish the breadth and to delineate the nature of linguistic symptoms associated with this neurodegenerative disorder. Such research will not only foster further specification of theoretical models of language and brain behavior

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relations but also provide guidance in developing appropriate clinical management approaches for those living with PD.

ANNOTATED REFERENCES

Berg, E., Bjornram, C., Hartelius, L., Laakso, K., & Jonels, B. (2003). High-level language difficulties in Parkinson's disease. *Clinical Linguistics and Phonetics, 17*(1), 63–80.

Berg and colleagues completed one of the few investigations in which high-level language abilities in terms of *both* production and comprehension were evaluated in individuals with PD. They used a battery of seven high-level language subtests as well as measures of more basic language abilities (e.g., confrontation naming, morphological word-completion) and cognitive status to explore not only the presence but also the nature of high-level language impairments. Additionally, they collected data pertaining to the self-reported language difficulties of the PD participants to determine if their language measures captured the concerns of this patient population.

Friederici, A. D., Kotz, S. A., Werheid, K., Hein, G., & von Cramon, D. (2003). Syntactic comprehension in Parkinson's disease: Investigating early automatic and late integrational processes using event-related brain potentials. *Neuropsychology, 17*, 133–142.

This article represents an excellent example of how priming as well as evoked potential methods have been used to investigate the integrity of linguistic processes in PD. In their study, Friederici and colleagues examined early automatic and late controlled syntactic processes as well as lexical semantic processes to delineate how PD might influence temporal aspects of online language processing.

Grossman, M., Cooke, A., DeVita, C., Lee, C., Alsop, D., Detre, J., et al. (2003). Grammatical and resource components of sentence processing in Parkinson's disease: An fMRI study. *Neurology, 60*, 775–781.

Few investigators have employed fMRI paradigms to evaluate language in PD. Accordingly, Grossman and colleagues' study exemplifies not only the methodology frequently used to examine morphosyntactic comprehension in PD, but also extends this line of research to explore the brain activation patterns that underlie the morphosyntactic performances of individuals with PD and that may arise subsequent to the onset of the progressive neural deterioration associated with PD.

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

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Albeit an older article, this contribution to the PD literature remains somewhat unique, given that it represents one of the few studies to evaluate discourse-level language abilities. That is, connected speech samples were analyzed in terms of a number of syntactic, quantitative, and informativeness measures, and then correlational analyses were completed to examine relations between spoken language measures and performances of cognitive and motor speech. Additional relatively novel methods applied in this study include (1) contrasting the discourse profiles of PD participants with those of individuals with Huntington's disease, another progressive neurological disorder, to examine whether the frontostriatal circuits affected by each disease have differential contributions to spoken discourse; and (2) documenting motor speech involvement to examine the possible contribution of dysarthria on spoken discourse output.

OTHER REFERENCES

Angwin, A. J., Chenery, H. J., Copland, D. A., Murdoch, B. E., & Silburn, P. A. (2004). The time course of semantic activation in Parkinson's disease. *Brain and Language, 91*, 145–146.

Angwin, A. J., Chenery, H. J., Copland, D. A., Murdoch, B. E., & Silburn, P. A. (2006). Self-paced reading and sentence comprehension in Parkinson's disease. *Journal of Neurolinguistics, 19*(3), 239–252.

Angwin, A. J., Copland, D. A., Silburn, P. A., Chenery, H. J., & Murdoch, B. E. (2006). The influence of dopamine on semantic activation in Parkinson's disease: Evidence from a multipriming task. *Neuropsychology, 20*(3), 299–306.

Arnott, W. L., Chenery, H. J., Murdoch, B. E., & Silburn, P. A. (2005). Morphosyntactic and syntactic priming: An investigation of underlying processing mechanisms and the effects of Parkinson's disease. *Journal of Neurolinguistics, 18*(1), 1–28.

Bayles, K. A., Tomeoda, C. K., Wood, J. A., Cruz, R., Azuma, T., & Montgomery, E. (1997). The effect of Parkinson's disease on language. *Journal of Medical Speech-Language Pathology, 5*(3), 157–166.

Boulenger, V., Mechtouff, L., Thobois, S., Broussolle, E., Jeannerod, M., & Nazir, T. A. (2008). Word processing in Parkinson's disease is impaired for action verbs but not for concrete nouns. *Neuropsychologia, 46*(2), 743–756.

Caballo, N., Marti, M. J., & Tolosa, E. (2007). Cognitive dysfunction and dementia in Parkinson disease. *Movement Disorders, 22*(Suppl. 17), S358–S366.

Cameli, L., Phillips, N. A., Kousaie, S., & Panisset, M. (2006). Memory and language in bilingual Alzheimer and Parkinson patients: Insights from verb inflection. *Brain and Cognition, 60*, 304–323.

Carne, W., Cifu, D., Marcinko, P., Baron, M., Pickett, T., Qutubuddin, A., et al. (2005). Efficacy of multidisciplinary treatment program on long-term outcomes of individuals with Parkinson's disease. *Journal of Rehabilitation Research and Development, 42*(6), 779–786.

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

Castner, J. E., Chenery, H., Copland, D., Coyne, T., Sinclair, F., & Silburn, P. (2007). Semantic and affective priming as a function of stimulation of the subthalamic nucleus in Parkinson's disease. *Brain, 130*, 1395–1407.

Colman, K., Koerts, J., van Beilen, M., Leenders, K. L., & Bastiaanse, R. (2006). The role of cognitive mechanisms in sentence comprehension in Dutch speaking Parkinson's disease patients: Preliminary data. *Brain and Language, 99*, 120–121.

Copland, D.A., Chenery, H. J., & Murdoch, B.E. (2001). Discourse priming of homophones in individuals with dominant nonthalamic subcortical lesions, cortical lesions, and Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology, 23*(4), 538–556.

Copland, D. (2003). The basal ganglia and semantic engagement: Potential insights from semantic priming in individuals with subcortical vascular lesions, Parkinson's disease, and cortical lesions. *Journal of the International Neuropsychological Society, 9*, 1041–1052.

Cotelli, M., Borroni, B., Manenti, R., Zanetti, M., Arevalo, A., Cappa, S. F., et al. (2007). Action and object naming in Parkinson's disease without dementia. *European Journal of Neurology, 14*, 632–637.

Coyne, T., Silburn, P., Cook, R., Silberstein, P., Mellick, G., Sinclair, F., et al. (2006). Rapid subthalamic nucleus deep brain stimulation lead placement utilizing CT/MRI fusion, microelectrode recording and test stimulation. *Acta Neurochirurgica Supplementum, 99*, 49–50.

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

DeLong, M. R. (2000). The basal ganglia. In E. R. Kandel, J. H. Schwartz, & T. M. Jessell (Eds.), *Principles of neural science* (4th ed., pp. 853–867). New York: McGraw-Hill.

Demakis, G. L., Mercury, M., Sweet, J., Rezak, M., Eller, T., & Vergenz, S. (2003). Qualitative analysis of verbal fluency before and after unilateral pallidotomy. *Clinical Neuropsychologist, 17*(3), 322–330.

Ellis, C., & Rosenbek, J. C. (2007). The basal ganglia and expressive language: A review and directions for research. *Communicative Disorders Review, 1*(1), 1–15.

Henry, J. D., & Crawford, J. R. (2004). Verbal fluency deficits in Parkinson's disease: A meta-analysis. *Journal of the International Neuropsychological Society, 10*, 608–623.

Hochstadt, J., Nakano, H., Lieberman, P., & Friedman, J. (2006). The roles of sequencing and verbal working memory in sentence comprehension deficits in Parkinson's disease. *Brain and Language, 97*, 243–257.

Horstink, M., Tolosa, E., Bonuccelli, U., Deuschl, G., Friedman, A., Kanovsky, P., et al. (2006). Review of the therapeutic management of Parkinson's disease. Report of a joint task force of the European Federation of Neurological Societies and the Movement Disorder Society-European Section. Part 1: Early (uncomplicated) Parkinson's disease. *European Journal of Neurology, 13*, 1170–1185.

Hough, M. S. (2004). Generative word fluency skills in adults with Parkinson's disease. *Aphasiology, 18*(5–7), 581–588.

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85*, 363–394.

Longworth, C. E., Keenan, S. E., Barker, R. A., Marslen-Wilson, W. D., & Tyler, L. K. (2005). The basal ganglia and rule-governed language use: Evidence from vascular and degenerative conditions. *Brain, 128*, 584–596.

Magee, W. L., Brumfitt, S. M., Freeman, M., & Davidson, J. W. (2006). The role of music therapy in an interdisciplinary approach to address functional communication in complex neuro-communication disorders: A case report. *Disability and Rehabilitation, 28*(19), 1221–1229.

Mattay, V. S., Tessitore, A., Callicott, J. H., Bertolino, A., Goldberg, T. E., Chase, T. N., et al. (2002). Dopaminergic modulation of cortical function in patients with Parkinson's disease. *Annals of Neurology, 51*(2), 156–164.

McNamara, P., & Durso, R. (2003). Pragmatic communication skills in patients with Parkinson's disease. *Brain and Language, 84*, 414–423.

McNamara, P., Krueger, M., O'Quin, K., Clark, J., & Durso, R. (1996). Grammaticality judgments and sentence comprehension in Parkinson's disease: A comparison with Broca's aphasia. *International Journal of Neuroscience, 86*(1–2), 151–166.

Miller, N., Noble, E., Jones, D., & Burn, D. (2006). Life with communication changes in Parkinson's disease. *Age and Ageing, 35*(3), 235–239.

Monetta, L., & Pell, M. D. (2007). Effects of verbal working memory deficits on metaphor comprehension in patients with Parkinson's' disease. *Brain and Language, 101*, 80–89.

Murray, L. L., & Clark, H. M. (2006). *Neurogenic disorders of language: Theory driven clinical practice*. Clifton Park, NY: Thomson Delmar Learning.

Murray, L. L., & Lenz, L. P. (2001). Productive syntax abilities in Huntington's and Parkinson's diseases. *Brain and Cognition, 46*, 213–219.

Murray, L. L., & Stout, J. C. (1999). Discourse comprehension in Huntington's and Parkinson's diseases. *American Journal of Speech-Language Pathology, 8*, 137–148.

Pignatti, R., Ceriani, F., Bertella, L., Mori, I., & Semenza, C. (2006). Naming abilities in spontaneous speech in Parkinson's and Alzheimer's disease. *Brain and Language, 99*, 124–125.

Rothlind, J., Cockshott, R., Starr, P., & Marks, W. (2007). Neuropsychological performance following staged bilateral pallidal or subthalamic nucleus deep brain stimulation for Parkinson's disease. *Journal of the International Neuropsychological Society, 13*, 68–79.

Samii, A., Nutt, J. G., & Ransom, B. R. (2004). Parkinson's disease. *Lancet, 363*(9423), 1783–1793.

Sapir, S., Spielman, J. L., Ramig, L. O., Story, B. H., & Fox, C. (2007). Effects of intensive voice treatment (the Lee Silverman Voice Treatment [LSVT]) on vowel articulation in dysarthric individuals with idiopathic Parkinson disease: Acoustic and perceptual findings. *Journal of Speech, Language, and Hearing Research, 50*(4), 899–912.

Shapiro, K. A., Mottaghy, F. M., Schiller, N. O., Poeppel, T. D., Flub, M. O., & Müller, H. W. (2005). Dissociating neural correlates for nouns and verbs. *NeuroImage, 24*, 1058–1067.

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press

Skeel, R. L., Crosson, B., Nadeau, S. E., Algina, J., Bauer, R. M., & Fennell, E. B. (2001). Basal ganglia dysfunction, working memory, and sentence comprehension in patients with Parkinson's disease. *Neuropsychologia, 39*(9), 962–971.

Spielman, J., Ramig, L. O., Mahler, L., Halpern, A., & Gavin, W. J. (2007). Effects of an extended version of the Lee Silverman Voice Treatment on voice and speech in Parkinson's disease. *American Journal of Speech-Language Pathology, 16*(2), 95–107.

Terzi, A., Papapetropoulos, S., & Kouvelas, E. D. (2005). Past tense formation and comprehension of passive sentences in Parkinson's disease: Evidence from Greek. *Brain and Language, 94*(3), 297–303.

Troster, A. I., Woods, S. P., & Fields, J. A. (2003). Verbal fluency declines after pallidotomy: An interaction between task and lesion laterality. *Applied Neuropsychology, 10*(2), 69–75.

Wade, D. T., Gage, H., Owen, C., Trend, P., Grossmith, C., & Kaye, J. (2003). Multidisciplinary rehabilitation for people with Parkinson's disease: A randomized controlled study. *Journal of Neurology, Neurosurgery and Psychiatry, 74*(2), 158–162.

Whiting, E., Copland, D., & Angwin, A. (2005). Verb and context processing in Parkinson's disease. *Journal of Neurolinguistics, 18*(3), 259–276.

York, M. K., Levin, H. S., Grossman, R. G., Lai, E., & Krauss, J. (2003). Clustering and switching in phonemic fluency following pallidotomy for the treatment of Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology, 25*, 110–121.

Zanini, S., Melatini, A., Capus, L., Gioulis, M., Vassallo, A., & Bava, A. (2003). Language recovery following subthalamic nucleus stimulation in Parkinson's disease. *NeuroReport, 14*(3), 511–516.

Zanini, S., Tavano, A., Vorano, L., Schiavo, F., Gigli, G., Aglioti, S. M., et al. (2004). Greater syntactic impairments in native language in bilingual Parkinsonian patients. *Journal of Neurology, Neurosurgery and Psychiatry, 75*, 1678–1681.

Zgaljardic, D. J., Borod, J. C., Foldi, N. S., Mattis, P. J. Gordon, M. F., & Feigin, A. (2006). An examination of executive dysfunction associated with frontostriatal circuitry in Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology, 28*, 1127–1144.

https://doi.org/10.1017/S0267190508080100 Published online by Cambridge University Press