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# Impaired semantic inhibition during lexical ambiguity repetition in Parkinson's disease

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## ABSTRACT

Impairments of semantic processing and inhibition have been observed in Parkinson's disease (PD), however, the consequences of faulty meaning selection and suppression have not been considered in terms of subsequent lexical processing. The present study employed a lexical ambiguity repetition paradigm where the first presentation of an ambiguity paired with a target biasing its dominant or subordinate meaning (e.g., bank – money or bank – river) was followed after several intervening trials by a presentation of the same ambiguity paired with a different target that biases the same (congruent) or a different (incongruent) meaning to that biased on the first presentation. Meaning dominance (dominant or subordinate weaker meanings) and interstimulus interval (ISI) were manipulated. Analyses conducted on the second presentation indicated priming of congruent meanings and no priming for the incongruent meanings at both short and long ISIs in the healthy controls, consistent with suppression of meanings competing with the representation biased in the first presentation. In contrast, the PD group failed to dampen activation for the incongruent meaning at the long ISI when the first presentation was subordinate. This pattern is consistent with an impairment of meaning suppression which is observed under controlled processing conditions and varies as a function of meaning dominance of the first presentation. These findings further refine our understanding of lexical-semantic impairments in PD and suggest a mechanism that may contribute to discourse comprehension impairments in this population.

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## 1. Introduction

There is growing evidence that aspects of language processing are impaired in Parkinson's disease (PD) (e.g., Longworth et al., 2005; Copland, 2003; Grossman, 1999). Performance on various off-line language tasks in PD suggests problems in aspects of lexical-semantic processing that may be influenced by various cognitive factors. For instance, tasks requiring demonstration of lexical-semantic knowledge for provision of word

definitions (Lewis et al., 1998) or judging semantic attributes or hierarchies (Portin et al., 2000) have proven difficult for people with PD. After earlier findings of altered semantic priming in PD (McDonald et al., 1996), Arnott et al. (2001) observed a delay in the timecourse of automatic semantic activation in PD, which appears to be exacerbated when off dopaminergic medication (Angwin et al., 2007). In addition, impairments in controlled or attentional semantic priming have been observed, including problems in inhibitory processing (Arnott

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et al., 2001; Copland, 2003; Longworth et al., 2005). Castner et al. (2007) recently demonstrated that such deficits in controlled priming in PD may be attenuated by deep brain stimulation of the subthalamic nucleus, suggesting that these priming mechanisms are modulated through frontal-subcortical circuitry.

One of the primary aims of the present study was to employ a variation of the semantic priming paradigm to further elucidate proposed impairments of lexical-semantic inhibition in PD. In the motor domain, PD has been characterised by a failure to select and inhibit competing motor representations (Mink, 1996), and there is emerging evidence that similar difficulties may occur with lexical-semantic representations. Earlier findings of larger-than-normal automatic semantic priming in PD have been recently interpreted as possibly reflecting difficulties in inhibiting irrelevant words (Mari-Beffa et al., 2005).

Attentional or controlled processing deficits in semantic inhibition have also been inferred from previous findings that individuals with PD maintain both dominant and subordinate meaning activation at longer ISI, while healthy controls show selective priming for dominant meanings at this stage (Copland, 2003). While inhibition of subordinate meanings at this stage is likely in the healthy controls, the lack of priming for subordinate meanings at this later time may also arise through mechanisms of decay or attentional withdrawal. It is not, therefore, possible to unequivocally interpret the sustained subordinate meaning activation found in PD as a failure of inhibition or active suppression, as other candidate mechanisms exist. In order to clarify these underlying mechanisms there is a need to study PD individuals using a paradigm which shows clear semantic inhibition in healthy controls. One of the clearest instances of semantic inhibition in a word comprehension task has been observed during a lexical ambiguity repetition paradigm (Simpson and Kellas, 1989; Simpson and Kang, 1994), which is highly relevant given our previous findings of impaired lexical ambiguity processing in a range of contexts (Copland et al., 2000, 2001).

Simpson and Kellas (1989) found that when participants were presented with a target related to one meaning of a lexical ambiguity they were slower to respond to subsequent targets that were related to that ambiguity than to unrelated targets. As an example, if the ambiguity were the word bank in, "I'm going to the bank." presenting the target "river" would result in a longer response time for the subsequently presented target "money". The response time for "money" would also be longer than for an unrelated target like "chicken". This pattern was affected by the order of dominant subordinate presentations and was found to be long lasting, remaining present even when the related targets were separated by 12 unrelated word pairs. Simpson and Kellas (1989) surmised that when an ambiguous word requiring a response is processed, competing meanings are actively suppressed to a degree where they are less available than unrelated meanings. In replicating and extending these findings, Simpson and Kang (1994) also showed that only information directly competing with the previously processed meaning is suppressed. Together these studies provide a strong rationale for employing lexical ambiguity repetition to further elucidate possible semantic inhibition deficits in PD.

Investigating lexical ambiguity repetition effects allows us to examine semantic processing in PD within a longer temporal window than is usually considered. Previous evidence of impaired semantic word-pair priming in PD (e.g., Arnott et al., 2001; Castner et al., 2007; Copland, 2003; Longworth et al., 2005) has been observed using a typical word-pair priming paradigm where the effects of a prime on a target are considered within a window of 1–2 sec maximum, and the later consequences of lexical activation or meaning selection are not examined. In everyday contexts, the effects of lexical processing and meaning selection are often considerably longer. Within discourse, a topic or concept is typically introduced and then maintained over several sentences. Simpson and Kang (1994) argue that the consequences of meaning selection for lexical ambiguities needs to be considered "downstream" as such processing has direct relevance to everyday communication and understanding discourse processing. The work of Simpson and colleagues demonstrates that in the case of lexical ambiguities, once one meaning is selected, the competing meaning is actively suppressed for a considerable period of time. This observation is consistent with an efficient use of meaning selection within ongoing discourse, where a meaning of an ambiguity that is introduced initially reduces the likelihood that an alternative meaning will need to be accessed in the subsequent discourse. Impairments in discourse processing have been observed previously in PD, including problems with generating or accessing inferences (Copland et al., 2001; Murray and Stout, 1999). By looking at the later effects of meaning selection, and tapping into processes relevant to discourse, this study can provide new insights into possible semantic inhibitory deficits that may contribute to discourse impairments in PD.

The present study employed a lexical ambiguity repetition task to examine the effects of processing a lexical ambiguity paired with a target biasing one of its meanings (e.g., bank – money) on the subsequent processing (several trials later) of the same ambiguity paired with a target biasing the same meaning or a competing meaning. Critically, the same targets are not used in the second presentation when the same meaning is biased, but a different word related to the same meaning is employed. Based on the proposal that PD reduces the ability to inhibit competing representations at both lexical (Copland, 2003) and motor levels (Mink, 1996), it was hypothesised that the PD group would show sustained facilitation for both meanings of lexical ambiguities presented on a second occasion, regardless of whether the meaning was congruent or incongruent with the first presentation of the ambiguity. This hypothesis is further based on the recent observation that individuals with vascular nonthalamic subcortical lesions showed evidence of reduced inhibition using this paradigm (Copland, 2006).

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## 2. Method

### 2.1. Participants

Twenty adult participants took part in this study. These were the same participants who participated in a previously reported study (Copland, 2003) which focused on a single

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