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Lexical-retrieval and semantic memory in Parkinson's disease: The question of noun and verb dissociation ☆

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ABSTRACT

The dissociation between the processing of verbs and nouns has been debated in light of the Embodied Cognition Theory (EC). The objective of this paper is to verify how action and verb processing deficits of PD patients are modulated by different tasks with different cognitive demands. Action and object lexical-semantic processing was evaluated in patients with Parkinson's Disease (PD) and cognitively healthy controls through three different tasks (verbal fluency, naming and semantic association). Compared to controls, PD patients presented worse performance in naming actions and in the two semantic association tasks (action/object). Action verbal fluency performance was significantly associated with PD severity whereas object semantic association deficits and noun verbal fluency scores were associated to lower scores in measures of global cognitive functioning. Our data suggest that semantic deficits are related to the type of cognitive processing and this is in the line with more flexible EC accounts.

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1. Introduction

In the last decades, the study of neural representations of the semantics of verbs has been increasingly linked to the Embodied Cognition Theory (EC) (Binder & Desai, 2011; Pulvermüller, 2013). This theoretical framework has also been useful to explain the mild lexical difficulties found in patients with diseases affecting the motor system, such as Parkinson's Disease (PD). The Embodied Cognition theory assumes that the body plays a fundamental role in cognition, being the cause or condition to cognitive development. This theory also establishes a relationship of interdependency between cognitive processes and body experiences with the world (Shapiro, 2011). Focusing on body parts that are involved in performing particular movements, this approach proposes different networks for the processing of actions that are related to

mouth, hands or legs movements (Pulvermüller, Härley, & Hummel, 2001). In the Embodied Cognition account, words that represent actions are connected to sensorimotor experiences and their representations are fully integrated to their corresponding action: when a person says "walk" the mental *homunculus* actually "moves" (Pulvermüller, 2013). It also proposes an integration of perceptual, attentional, linguistic and motor functions during several activities such as talking about an action, performing the action or simply planning it.

Parkinson's Disease (PD) is an interesting model to test EC assumptions due to the possibility of investigating the role of the motor system (and the impact of its deterioration) on performance in cognitive and language tasks. PD is a neurodegenerative disease characterized by bradykinesia (slowness of movement), rigidity, tremor, and gait and posture problems. It is caused by a progressive loss of dopamine in the nigrostriatal tract, reducing the projections of the basal ganglia to frontal motor regions (Goetz, 2008). The deficits in the dopaminergic pathways cause hypoactivation of the supplementary motor area and of primary motor cortex, and hyper-activation of the ventral premotor cortex, reflecting a compensatory mechanism (Jankovic, 2013). Nigrostriatal impairment affects basal ganglia circuitry in motor and cognitive cortical

pathways. Relative to cognition, basal ganglia are thought to have a facilitation role in the selection of specific cognitive abilities while at the same time suppressing competing ones (Crosson, Benjamin, & Levy, 2007). Their activity is supported by circuits that originate in frontal cortical regions, including the primary motor cortex, orbitofrontal cortex, ventral and dorsal premotor cortex and that involve temporal and parietal loops. This cortical network system guides intention and attention for language and other cognitive functions (Crosson et al., 2007; Kemmerer, 2015a).

Regarding language and speech, dysarthria, slowness and difficulty to initiate speech are the features that draw more attention to PD patients' communication. In a literature review, Pell and Monetta (2008) noted that when patients are compared with controls, they also displayed mild deficits in sentence comprehension performance, lexical retrieval tasks, grammatical processing and nonverbal skills, such as prosody and contextual cues. However, these mild deficits are not sufficient to impair language performance in everyday life (Pell & Monetta, 2008).

The dissociation between verbs and nouns (or actions and objects) has been frequently described in patients with cerebral lesions but has been criticized by a number of studies employing neuroimaging techniques (for a review, see Vigliocco, Vinson, Druks, Barber, & Cappa, 2011). Differences in psycholinguistic variables (such as word frequency and imageability) and semantic attributes of the stimuli are the principal bias in these studies. In spite of that, action and object dissociation have been helpful to clinical characterization and differential diagnosis (Bak, Yancopoulou, & Nestor, et al., 2006).

Among word classes verbs are considered the ones with the most complex semantic organization (Jackendoff, 1983; Miller & Fellbaum, 1991). Relative to PD, noun and verb dissociation studies have presented conflicting results. Different methodological approaches have been used and most studies have drawn conclusions from findings in a single task, usually involving lexical retrieval (Bertella et al., 2002; Cotelli, Borroni, Manenti, et al., 2007; Herrera & Cuetos, 2013; Piatt, Fields, Paolo, Koller, & Tröster, 1999a; Rodrigues, Ferreira, Coelho, Rosa, & Castro-Caldas, 2015; Rodríguez-Ferreiro, Menéndez, Ribacoba, & Cuetos, 2009; Silveri et al., 2012). Although these tasks are sensitive to mild cognitive-linguistic deficits in neurodegenerative diseases (Giffard et al., 2008; Miller, Rogers, Siddart, & Small, 2005; Monsch et al., 1992; Piatt, Fields, Paolo, & Tröster, 1999b; Piatt et al., 1999a), they are inconclusive in terms of the nature of the deficits since failures can be due to a dysfunction affecting the lexical and/or semantic processing levels (for a complete review on language tasks investigating verb processing in PD see Carthery-Goulart, Salmazo-Silva, Machado, Baradel, & Parente, 2015; Salmazo-Silva, Machado, Cravo, Parente, & Carthery-Goulart, 2014).

Therefore, most studies in PD focused on lexical retrieval and only a few investigated semantic processing employing different tasks such as semantic similarity judgments (Fernandino et al., 2013; Kemmerer, Miller, MacPherson, Huber, & Tranel, 2013) and semantic association tests (Bocanegra et al., 2015; Ibáñez, Cardona, Santos, et al., 2013; Melloni et al., 2015). In addition, studies comparing objects and actions in semantic association tasks are scarce. Differences in methodological issues (discussed below) justify new studies with comparisons between lexical retrieval (such as naming and verbal fluency) and semantic association tasks, which can give stronger support to findings about lexical and semantic deficits in PD language performance.

1.1. Lexical retrieval tasks in PD patients

Naming is the most usual task to verify lexical access. In some situations it is performed in an automatic fashion, since it is very difficult to look at a familiar object or picture without accessing its name. Studies that have employed picture naming have elucidated that PD patients had a greater impairment to name actions and these deficits were observed in ON (ON Levodopa - Bertella et al., 2002; Cotelli et al., 2007; Rodríguez-Ferreiro et al., 2009) and OFF (OFF Levodopa – Herrera, Cuetos, & Ribacoba, 2012; OFF Deep Brain Stimulation – Silveri et al., 2012) states. The nature of the deficits, however, remains inconclusive, with controversies regarding deficits being due to retrieval difficulties or related to semantic memory deterioration.

The verbal fluency task, besides requiring executive functions, needs semantic, phonological or grammatical analyzes for the selection of appropriate words in a period of time (Shao, Janse, Visser, & Meyer, 2014). Different neuroanatomical circuits were suggested according to the task: the semantic fluency of noun categories has been proposed to be primarily mediated by left temporo-parietal areas; lexical retrieval for a given letter has been associated to left frontal circuits and action fluency to left fronto-triatal circuits together with the posterior temporal region and underlying white matter (Piatt et al., 1999a,b; Rodrigues et al., 2015). The cognitive correlates of the task were addressed by Piatt et al. (1999b) who concluded that the action fluency task evaluates executive functions and is unrelated to semantic and episodic memory measures.

Findings about the effects of PD in action verbal fluency tasks are inconsistent. A recent study reported that compared to controls, PD patients were significantly more impaired in action fluency but presented no differences in categorical (animals/min) and lexical (letter fluency) tasks (Rodrigues et al., 2015). Another study didn't find differences in PD patients without dementia and suggested that action fluency decline could be used to identify the conversion to an early stage of dementia in PD patients (Piatt et al., 1999a,b). Finally, another study verified a deficit in the number of items retrieved in action and initial letter but not semantic fluency when patients were OFF medication. A recover to control levels was found in ON state (Herrera et al., 2012). In that study word frequency was analyzed and the authors found that higher frequency verbs were retrieved in OFF state.

In sum, the studies using naming and verbal fluency tasks have usually shown a greater impairment of actions/verbs, especially in OFF conditions. The nature of the deficits remain unclear, with controversies regarding the impact of semantic properties of verbs (i.e. manipulability and motion content) and their relationship with executive dysfunction in PD.

1.2. Semantic tasks in PD patients

Semantic association tasks put greater demand over semantic resources and do not necessarily require oral or verbal responses (e.g. "pointing to a picture among two or more alternatives"). Investigating the semantic level is important to understand whether the deficit is restricted to lexical retrieval or not. In PD an isolated retrieval deficit could be explained both by an executive dysfunction and by reduced processing speed. On the other hand, deficits in semantic tasks can lend stronger support to EC assumptions, being relatively less dependent of those factors.

Two different tasks requiring deeper semantic processing have been used to investigate verb/action processing in PD: semantic judgment of similarity of words (Fernandino et al., 2013; Kemmerer et al., 2013) and semantic association of pictures (Bocanegra et al., 2015; Ibáñez et al., 2013; Melloni et al., 2015). In the former, patients need to judge the semantic similarity of two among three items (i.e. "to stroke" versus "to embrace" or "to caress"). In the later, patients need to choose among some options the picture which is more associated to a target picture (i.e. for the target picture "lion", "elephant" should be chosen and not "dog").