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Word selection processing in Parkinson's disease: When nouns are more difficult than verbs

Q5 **Q4** Maria C. Silveri ^{a,*}, Daniela Traficante ^{a,b}, Maria R. Lo Monaco ^c,
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ABSTRACT

Patients with Parkinson's disease (PD) are impaired in verb production. Interpretations range from grammatical deficits to semantic-conceptual decay of action representation. The verb production deficit in PD can also be considered a dysexecutive disorder, specifically, a deficit of selection processing during word production, due to corticostriatal damage. Producing verbs is "more difficult" than producing nouns, because verb-forms must be selected from a large set of word-forms which share the verb-root, and the set of possible verb-forms is larger than the set of possible noun-forms when a noun has to be produced. However, if we devise a condition in which a noun must be selected from a set of alternatives larger than the set of alternative forms from which a verb must be selected, we expect an opposite pattern, with nouns becoming more difficult than verbs. We used morphological tasks varying in the number of alternative responses during word production. Fourteen PD patients and 14 healthy Controls participated in the study. Participants performed a noun-from-verb (observation from to observe) and a noun-from adjective derivation task (kindness from kind), and a verb-from-noun (to observe from observation) and an adjective-from-noun generation task (kind from kindness). Input-stimuli were presented singularly on a screen and participants produced the response as fast as possible. Response latencies were longer in derivation tasks (several alternative responses) than in generation tasks (one possible response), irrespective of the grammatical class of the target word, with no difference between groups. PD patients were significantly less accurate than Controls only in the noun-from-verb derivation task, that is, in the task with the highest number of alternative responses (PD: 60%; Controls: 81%). Results suggest that the verb production disorder in PD patients may reflect disturbed selection processes among competitors: the higher the number of alternative responses the more severe the impairment.

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1. Introduction

A dissociable deficit for different classes of words, such as nouns and verbs, is supported by enduring evidence in the neuropsychological literature, suggesting that these two classes of words can be supported by segregated neural substrates (Caramazza & Hillis, 1991; Daniele, Giustolisi, Silveri, Colosimo, & Gainotti, 1994).

Noun-verb dissociation has been occasionally reported in comprehension (Miceli, Silveri, Nocentini, & Caramazza, 1988) and in lexical decision tasks (Boulenger et al., 2008), but most evidence comes from production tasks. Impaired production of nouns is consistently associated with lesions of the left temporal lobe (Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004; Daniele et al., 1994; Silveri & Di Betta, 1997), whereas a verb deficit may become apparent following a wider range of lesions in the frontoparietal regions (Cappa et al., 1998; Hillis, Oh, & Ken, 2004; Silveri, Perri, & Cappa, 2003; Silveri, Salvigni, Cappa, Della Vedova, & Puopolo, 2003; Thompson-Schill et al., 1998) and connected subcortical structures, first of all the basal ganglia (Bertella et al., 2002; Bocanegra et al., 2015; Colman et al., 2009; Cotelli et al., 2007; Fernandez et al., 2013a; Fernandez et al., 2013b; Piatt, Fields, Paolo, & Tröster, 1999; Péran et al., 2003; Rodríguez-Ferreiro, Menéndez, Ribacoba, & Cuetos, 2009; Signorini & Volpato, 2006).

The deficit in verb production has received different interpretations over time: as a grammatical class disorder (Caramazza & Hillis, 1991; Péran et al., 2003; Zingeser & Berndt, 1990), a morphological deficit (Shapiro, Shelton, & Caramazza, 2000), or a degraded conceptual representation of the actions the verbs denote (Boulenger et al., 2008; Rodríguez-Ferreiro et al., 2009), the last interpretation consistent with the hypothesis that information about verbs might be grounded in the neural motor system (Cardona et al., 2014). However, this latter interpretation should be limited to verbs that express actions (action verbs) and principally physical actions as opposed to mental or abstract actions.

Some studies also suggested that the verb deficit can be an expression of the dysexecutive disorder produced by damage to the anterior regions of the brain (Silveri et al., 2003) or the corticostriatal circuits (Cotelli et al., 2007), connecting the prefrontal cortex and basal ganglia.

Evidence from activation studies corroborates this view, as higher activation of the left prefrontal cortex (inferior frontal gyrus – IFG) has been demonstrated during verb compared to noun processing (Perani et al., 1999; Shapiro, Moo, & Caramazza, 2006).

Thompson-Schill, D'Esposito, Aguirre, and Farah (1997) found, by means of a functional MRI study, that the IFG is active when selection of information among many competing alternatives was requested in a verb-from-noun generation task based on semantic association (e.g., wheel → turn), and that activation was dependent on selection demand. Impaired generation of verbs from nouns has been confirmed in patients with lesions in this area (Thompson-Schill et al., 1998; Tippett, Gendall, Farah, & Thompson-Schill, 2004), but only for stimuli with high selection demand (that is, with many appropriate associated responses without any clearly dominant response).

Crescentini, Shallice, and Macaluso (2010) obtained activation of the mid part of the inferior prefrontal cortex in a production task in a high selection condition, irrespective of grammatical class. Other studies confirmed that verb generation is sensitive to selection demands and that selection demands activate substrates of the IFG (Snyder, Banich, & Munakata, 2011) and basal ganglia (Persson et al., 2004).

Thompson-Schill and Botvinick (2006) suggested that the role of the left IFG in language tasks is to resolve competition among incompatible representations. In this perspective, any variable that can influence activation of competitors can modulate IFG activation as well. The authors proposed Usher and McClelland's (2001) network to model their view of processes involved in verb-generation task and concluded that a response is produced when only one representation crosses an activation threshold. Reaction times are assumed to reflect the time a node needs to cross the threshold.

In this framework, the probability distribution over response candidates (nodes) would be influenced by several variables, including number of word competitors. In this framework, it can be assumed that the higher the number of competitors, the stronger is the inhibition among nodes and the response selection is bound to be slowed down. If this is the case, then verb processing is expected to be more demanding than noun processing, because, in most languages, the set of inflected and derived words for verbs is larger than for nouns or adjectives. For instance, in a language with rich morphology such as Italian, there are about 50 inflected verb forms (with different suffixes to differentiate forms by tense, mood, person, and number), 2–4 noun forms, and 2–4 adjective forms (with different suffixes for gender and number). For this reason, distributional properties of noun, adjective, and verb forms have been considered as one of the main features that may generate differences between grammatical classes in word recognition tasks (e.g., Deutsch, Frost, & Forster, 1998, for Hebrew; Kostić & Katz, 1987, for Serbo-Croatian; Traficante, 2012; Traficante & Burani, 2003, and Traficante, Marelli, Luzzatti, & Burani, 2014, for Italian).

Siri et al. (2008) provided evidence that activation of the left IFG is modulated by selection demands during morphological processes rather than by verb-specific processing. In an event-picture naming task (e.g., a girl reading a book), they found higher activation of the IFG when the production of an action noun (e.g., the derived noun 'lettura' [reading]) is required rather than when the production of an inflected verb (e.g., 'legge' [she reads]) or an infinitive verb (e.g., 'leggere' [to read]) is required. The authors interpreted this result claiming that when pictures depicting actions are presented, the production of a verb (both inflected and infinitive form) is the most automatic response, whereas the production of an action noun involves the selection of a less favorite response. They suggested that left IFG activations are affected by the complexity of the morphological processes and/or by the selection demands of the task, rather than being associated with verb-specific processing.

These results are consistent with the findings by Marangolo, Piras, Galati, and Burani (2006). These authors used a noun-from-verb and noun-from-adjective derivation task, that is, they required the production of a derived noun from the corresponding verb or adjective bases (e.g.,

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