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A core deficit in Parkinson disease?☆

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Abstract
Introduction: Parkinson disease is a neurodegenerative condition involving motor, cognitive, and linguistic deficits. It is important to know why all these different deficits co-occur in the affected people. This paper aims to clarify whether these comorbid deficits result from the selective impairment of a computational primitive, namely, a context-sensitive computational ability according to Chomsky's Hierarchy (a well-established research tool in comparative neuroscience).
Patients and methods: A total of 15 medicated subjects with Parkinson disease and 15 controls were selected. They were matched in age and education. A battery of tasks was designed to test 3 different domains (motor capacities, cognition, and language) and 2 different computational abilities (context-free and context-sensitive operations).
Results: Significant differences between groups were observed only regarding the linguistic task involving context-sensitive computations (correferences).
Conclusions: The observed deficits in our patients with Parkinson disease cannot be explained in terms of the selective impairment of one only unspecific, low-level computational process. At the same time, differences between patients and controls are expected to be greater if the former are not medicated. Moreover, we should pursue in the search of (this kind of) computational primitives than can be selectively impaired in people with Parkinson disease, because they may help to achieve an earlier diagnosis of this condition.

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PALABRAS CLAVE
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¿Un déficit nuclear en la enfermedad de Parkinson?

Resumen
Introducción: La enfermedad de Parkinson es un trastorno neurodegenerativo que lleva aparejados déficits motores, cognitivos y lingüísticos. Es importante esclarecer las causas de esta comorbilidad. Este trabajo tiene como objetivo determinar si dichos déficits pueden interpretarse como el resultado de la disfunción selectiva de capacidades computacionales primitivas, en particular, de una capacidad computacional sensible al contexto o de tipo 1 en la Jerarquía de Chomsky (una herramienta usada habitualmente en estudios de cognición comparada).
Pacientes y métodos: Se seleccionó a 15 sujetos con enfermedad de Parkinson medicados y a 15 controles emparejados en edad y en años de escolarización. Se diseñó una batería de pruebas específicas para el experimento que evaluaban 3 dominios diferentes (motor, lingüístico y visuoespacial) y 2 tipos de capacidades computacionales distintas (sensible e insensible al contexto).
Resultados: Se obtuvieron diferencias significativas entre ambos grupos solo en la prueba de tipo lingüístico que evaluaba la capacidad de computación sensible al contexto.
Conclusiones: Los déficits de diferente naturaleza que caracterizan a la enfermedad de Parkinson no parecen explicarse por la afectación selectiva de una capacidad computacional básica que sería funcionalmente inespecífica. Resta por ver si las diferencias entre afectados y no afectados son significativas cuando se trata de sujetos no medicados y cuando las pruebas empleadas en la evaluación se ciñen a aspectos puramente formales. Idealmente, este tipo de primitivos computacionales podría ayudar a diagnosticar precozmente el trastorno.

Introduction

Parkinson's disease (PD) is a neurodegenerative disorder caused by a selective destruction of dopaminergic neurons of the substantia nigra and the accumulation of Lewy bodies. Although degeneration initially occurs in subcortical regions, it is also observed in the cortex in more advanced stages of the disease. PD typically manifests with a wide range of motor and non-motor symptoms.[1,2] Although psychological and cognitive disorders have traditionally been considered characteristic of later stages of the disease along with damage reaching the cortical regions,[3] there is increasing evidence that PD is associated with specific neuropsychological and neuropsychiatric traits even during the preclinical stage.[4] Language is a very good example of this. Speech impairment has traditionally been considered the main problem in this domain, and a consequence of motor impairment in PD.[5] However, current thought suggests that other structural levels of language are also affected (lexical semantics, syntax, morphology), even when performing comprehension tasks[6,7] and at very early stages of the disease.[8] As a general rule, these problems are regarded as a consequence of the impairment of basic cognitive abilities, especially executive function[9] and working memory.[7] Several models have been proposed to explain language dysfunction in PD. Some of these are based on language processing models in which subcortical structures play an especially relevant role,[10] while others regard the coexistence of language and motor problems as a result of the simultaneous impairment of parallel frontotemporal circuits which connect the basal ganglia and cortex.[11] Nevertheless, as stated by Bodis-Wollner and Jo,[12] ''a more encompassing linguistic and functional model of PD specific language impairments would be useful for evaluating language deficits in the context of motor dysfunction''.

Today, experts in neurolinguistics are starting to support the idea that successfully implementing these models requires language to be divided into computational primitives (units and operations) whose processing is compatible with the real-time processing ability of the brain. In other words, defining language and language-related disorders in terms of syntax, semantics, or phonology is no longer applicable, since these denominations, extensively used in linguistics (at least for describing the structure of languages), refer to numerous computations and representations of general domains.[13] Furthermore, it is to be expected that, once identified, these computational primitives would not be language-specific; instead, they would participate in other cognitive and even non-cognitive tasks. In the words of Poeppel and Embick,[13] ''the differently structured cortical areas are specialized for performing different types of computation, and that some of these computations are necessary for language but also for other cognitive functions''.

In a recent attempt to find these computational primitives, some researchers have applied the formal language theory, and more specifically the Chomsky Hierarchy,[14] to the characterisation of the computational processes inherent to language processing.[15–17] This hierarchy classifies formal languages according to the computational devices (grammars) necessary for their generation. Type-3 (finite-state) grammars generate linear sequences that lack an internal structure (for example, a list of words such as a list of the Spanish provinces). Type-2 (context-free) grammars enable the (recursive) generation of hierarchically organised