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On the replicability of action-verb deficits in Parkinson's disease

Adolfo M. García^{1,2,3,4,*}, Agustín Ibáñez^{1,2,3,5,6,*}

¹Cognitive Neuroscience Center, University of San Andrés, Buenos Aires, Argentina

²Global Brain Health Institute, University of California San Francisco, US and Trinity College Dublin, Ireland

³National Scientific and Technical Research Council (CONICET), Buenos Aires, Argentina

⁴Departamento de Lingüística y Literatura, Facultad de Humanidades, Universidad de Santiago de Chile, Santiago, Chile

⁵Trinity College Dublin, Ireland

⁶Latin American Brain Health Institute (BrainLat), Adolfo Ibáñez University, Santiago, Chile

The study of action verb processing in Parkinson's disease (PD) represents a promising approach to identify specific neurocognitive biomarkers (Birba et al., 2017; Cardona et al., 2013; García et al., 2020; García & Ibáñez, 2018). We appreciate Holm Møller et al.'s effort to replicate and extend our original study (García et al., 2018), which showed that Spanish-speaking PD patients without mild cognitive impairment (PD-nMCI) were selectively impaired in processing actions evoked by naturalistic narratives. This finding reinforced the widely reported observation that motor-system alterations undermine grasping of verbal units denoting bodily motion (García & Ibáñez, 2018). Yet, Holm Møller et al. failed to replicate such a finding on a Danish-speaking cohort when using partly similar action and non-action texts (AT, nAT) and additional materials.

Holm Møller et al.'s effort is timely, as cross-linguistic studies represent a crucial milestone for cognitive research on PD (Calvo, Ibáñez, Muñoz, & García, 2018; García & Orozco-Arroyave, 2021), especially when focused on action verbs (Birba et al., 2017; Calvo et al., 2018). This is all the more valuable when discrepant outcomes arise. Juxtaposed to García et al.'s findings, Holm Møller et al.'s negative results motivate relevant methodological, typological, epistemological, and meta-theoretical considerations, as detailed next.

* **Corresponding authors:** Adolfo M. García (adolfo.garcia@gbhi.org); Agustín Ibáñez (agustin.ibanez@gbhi.org).

Conflict of interest

The authors declare no conflicts of interest.

Credit Author Statement

Adolfo M. García: Conceptualization, Writing - Original draft, Funding acquisition.

Agustín Ibáñez: Conceptualization, Writing - Review & Editing, Funding acquisition.

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Discrepancies between studies and the value of replications

Action verbs are predicted to yield deficits in PD due to their reliance on movement-related mechanisms (Birba et al., 2022; Birba et al., 2017; Cardona et al., 2013; Cervetto et al., 2021; García & Ibanez, 2016; García et al., 2019; Pulvermüller, 2013). Thus, the hypothesis presupposes marked motor symptomatology, as captured through part III of the Unified Parkinson's Disease Rating Scale (UPDRS-III). Patients in Holm Møller et al.'s study had a mean UPDRS-III score of 14.29, indicating very mild motor compromise. This seems unusually low, considering that large studies ($n = 653$) on patients in the same age range reveal a mean UPDRS-III score of 27.2 (Shulman et al., 2010), nearly identical to that of PD-nMCI patients in García et al. (2018). Of note, the difference of >10 points relative to Holm Møller et al.'s sample constitutes a large clinically important difference by current standards (Shulman et al., 2010). Therefore, in the absence of marked motor symptom severity, an important requisite of the study's hypothesis may not have been met.

Another methodological issue concerns the study's materials. Unlike the AT and the nAT in García et al.'s study, their Danish counterparts were not controlled for concreteness and imageability. As acknowledged by Holm Møller et al., this could represent a non-trivial confound. Non-action verbs, such as those used in nATs, tend to be less concrete and imageable than action verbs, rendering them harder to access. As shown by behavioral and neuroscientific evidence, abstract words are processed less efficiently than concrete words (West & Holcomb, 2000), even in the elderly (Roxbury, McMahon, Coulthard, & Copland, 2016). Indeed, in Holm Møller et al.'s study, the lowest scores for both groups corresponded to nAT verbs. If these factors are not matched between texts, the greater difficulty of nATs could mask between-text dissociations driven by other factors (i.e., action semantics).

Furthermore, Holm Møller et al.'s null results may reflect idiosyncrasies of the Danish language. As the authors note, motion direction and manner may be differently encoded by Danish and Spanish verbs and particles (Slobin, 1996; Talmy, 1985). Unlike Spanish (a verb-framed language with a rich repertoire of verbs and verb inflections), Danish is a satellite-framed language characterized by a small verb vocabulary with high polysemy, no person marking, and complex verbal syntax (Pedersen, 1999; Pederson, 2010). Accordingly, verb processing in Danish may distinctly benefit from the contextual support offered by naturalistic stories. That is, given that Danish verbs' correct interpretation critically depend on contextual anchorage (Pederson, 2010), full-blown narratives could facilitate their processing irrespective of the disruption of motor-system grounding. This language-specific feature, together with the patients' very mild motor compromise, could attenuate or nullify predicted disadvantages for action-verb processing.

A few studies align with Holm Møller et al. in failing to detect action-verb deficits following motor-system damage (Aiello et al., 2022; Argiris et al., 2020). Conversely, significant impairments have been amply reported in PD cohorts and other neurodegenerative movement disorders by different teams in several languages, through diverse tasks, and with stimuli of varying complexity (Bak, 2013; Birba et al., 2017; Cardona et al., 2013; García & Ibáñez, 2018; Ibáñez et al., 2022). Moreover, the very paradigm under discussion has revealed selective links between action-verb processing and motor systems in different

populations (Birba et al., 2020; Moguilner et al., 2021; Trevisan, Sedeño, Birba, Ibáñez, & García, 2017). Now, rather than signaling correct and incorrect approaches, positive and negative findings might well indicate that neurocognition in general and embodiment in particular are fundamentally situated and context-sensitive (Ibanez, 2022; Ibáñez et al., 2022). Results may be markedly impact by clinical, stimulus-related, linguistic-, and mainly context-specific factors (Ibáñez et al., 2022). Often overlooked, this point could represent an important aspect of the current replicability crisis, which is usually predicated on the unscientific assumption of stability and universality (Ibanez, 2022).

By the same token, we often endorse a *ceteris paribus* philosophy in conducting and interpreting replications. Yet, at least when dealing with humans, surrounding factors are rarely, if ever, equal. That is, precisely, why we need replications. By reprising some aspects of their antecedents while differing in others, such studies offer a usable amount of diversity to better understand the conditions under which certain effects may hold or not.

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