Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special issue: Editorial

# When embodiment breaks down: Language deficits as novel avenues into movement disorders

*Adolfo M. García* [a,b,c,*] *and Agustín Ibáñez* [a,b,d,e,f,*]

[a] *Laboratory of Experimental Psychology and Neuroscience (LPEN), Institute of Cognitive and Translational Neuroscience (INCYT), INECO Foundation, Favaloro University, Buenos Aires, Argentina*
[b] *National Scientific and Technical Research Council (CONICET), Buenos Aires, Argentina*
[c] *Faculty of Education, National University of Cuyo (UNCuyo), Mendoza, Argentina*
[d] *Universidad Autónoma del Caribe, Barranquilla, Colombia*
[e] *Center for Social and Cognitive Neuroscience (CSCN), School of Psychology, Universidad Adolfo Ibáñez, Santiago, Chile*
[f] *Centre of Excellence in Cognition and Its Disorders, Australian Research Council (ACR), Sydney, Australia*

ARTICLE INFO

*Article history:*
Received 5 December 2017
Reviewed 11 December 2017
Revised 14 December 2017
Accepted 18 December 2017

If cognition is broadly shaped by an interplay of embodied mechanisms (Barsalou, 1999; Gallese & Lakoff, 2005; Gentsch, Weber, Synofzik, Vosgerau, & Schutz-Bosbach, 2016; Pulvermüller, 2005; Zwaan, 2014), then cognitive deficits could be profitably reinterpreted as *disruptions of embodiment* (Birba et al., 2017). Despite its simplicity and obviousness, this straightforward implication has not been systematically assessed in the literature, let alone with a focus on specific target populations featuring systematic disturbances in circumscribed higher-order domains. The present Special Issue seeks to bridge such a gap by delving into the intimate links between movement disorders and impairments of syntax and action language (namely, verbal expressions alluding to bodily movements).

For years, these connections have been gaining momentum in the literature. Different authors (e.g., Pulvermüller, 2010; Ullman, 2001) have set forth embodied accounts of syntactic processing, emphasizing its dependence on cortical and subcortical motor mechanisms. Similarly, the role of the latter circuits in action-verb processing has long been recognized in neuropsychology (e.g., Miceli, Silveri, Nocentini, & Caramazza, 1988; Neininger & Pulvermuller, 2003; Shapiro & Caramazza, 2003), cognitive psychology (e.g., Gentilucci & Gangitano, 1998; Glenberg & Kaschak, 2002; Glenberg & Robertson, 2000; Glenberg & Gallese, 2012; for a review, see; García & Ibáñez, 2016a), and neuroscience (Grossman et al., 2002; Pulvermüller, Preissl, & Lutzenberger, 1999; Shapiro, Moo, & Caramazza, 2006). All these seminal and more recent developments support embodied accounts of neurocognitive functions, in general, and linguistic subdomains, in particular.

In line with this perspective, our lab has committed to examining translationally viable links among diverse cognitive functions from an embodied and situated stance. In addition to our epistemological and theoretical works (Cosmelli & Ibáñez, 2008; García & Ibáñez, 2016a, 2016b; Ibáñez, Kuljis, Matallana, & Manes, 2014, Ibáñez et al., 2016), we have integrated neuroscientific, neuropsychological, and behavioral tools to assess context-sensitive cross-domain processes in key target populations, such as racial prejudice

* *Corresponding authors*. Institute of Cognitive and Translational Neuroscience (INCYT) & CONICET, Pacheco de Melo 1860, Buenos Aires, 1126, Argentina.
E-mail addresses: adolfomartingarcia@gmail.com (A.M. García), aibanez@ineco.org.ar (A. Ibáñez).
https://doi.org/10.1016/j.cortex.2017.12.022

between minority and majority ethnic groups (Ibáñez & Manes, 2012; Ibáñez, Haye, González, Hurtado, & Henríquez, 2009), distinctive patterns of moral cognition in extreme terrorists (Baez et al., 2017a), and the anticipation of others' movements in expert tango dancers (Amoruso et al., 2014, 2016). Moreover, we have employed multidimensional approaches to assess the disruption of specific cognitive skills in diverse mental conditions (Baez, García, & Ibáñez, 2016; Baez et al., 2014, 2015, 2016, 2017b; García-Cordero et al., 2016; Hesse et al., 2016; Ibáñez et al., 2011, 2013, 2017; Ibáñez & Manes, 2012; Melloni et al., 2016; Santamaría-García et al., 2017), especially including *motor diseases*.

In particular, our research on the latter has been largely focused on syntactic and action-language deficits, with a view to constraining neurolinguistic models and identifying potentially sensitive cognitive biomarkers (Birba et al., 2017; Cardona et al., 2013; García & Ibáñez, 2014). In this sense, our studies on Parkinson's disease (PD) have shown that such impairments are primary (i.e., not epiphenomenal to domain-general dysfunctions) (Bocanegra et al., 2015, 2017), proportional to the level of basal ganglia atrophy (Abrevaya et al., 2017), traceable in spontaneous discourse (García et al., 2016a), and significant even in asymptomatic subjects carrying mutations in vulnerability genes (García, Sedeño et al., 2017). We have also demonstrated the selectivity of such alterations in Huntington's disease (HD) patients and their asymptomatic relatives (García, Bocanegra et al., 2017; Kargieman et al., 2014). Furthermore, we have reported unprecedented evidence of action-language deficits in cerebellar ataxia, specifying associated abnormalities at genetic, neuroanatomical, and functional levels (García et al., 2016b). Also, we have shown that at least some of these abnormalities are absent in patients with peripheral (i.e., predominantly musculoskeletal) motor disorders (Cardona et al., 2014). Of note, such findings align with multiple reports of selective or differential alterations of syntax and/or action-language processing in other movement disorders, including motor neuron disease (e.g., Bak & Chandran, 2012), amyotrophic lateral sclerosis (ALS) (e.g., Ash et al., 2015), progressive supranuclear palsy (e.g., Bak, O'Donovan, Xuereb, Boniface, & Hodges, 2001), corticobasal degeneration (e.g., Cotelli et al., 2006), and cerebral palsy (Geytenbeek, Heim, Knol, Vermeulen, & Oostrom, 2015), in addition to several other studies on PD and HD (for a review, see Birba et al., 2017).

Considering this empirical corpus, and extending our previous work on language embodiment (Aravena et al., 2010; García & Ibáñez, 2016b, 2016c), our team has recently advanced the so-called "disrupted motor grounding hypothesis" (DMGH) (Birba et al., 2017). The proposal is actually simple: the very lesions which compromise the mapping and sequencing of hierarchically organized movement patterns also disturb the lexico-semantic mapping of movement (action language) and the sequencing of hierarchically organized lexical patterns (syntax). We surmised that these (and potentially other) impairments were not merely anatomo-clinical coincidences. On the contrary, they seemed to constitute higher-level manifestations of abnormalities in functionally akin lower-level mechanisms –that is, predictable consequences of the embodied nature of cognition. As shown by the works reviewed below, this Special Issue constitutes a powerful platform to test the DMGH through a coordinated, multi-center effort and explore its theoretical and clinical implications as well as its ramifications.

## 1. The issue, at a glance

The issue comprises 15 papers, organized in two parts. Part I deals with disruptions of embodied language functions in movement disorders. It consists of six research reports, two reviews, and a viewpoint article, all of which directly target the core notions described above. Then, Part II explores ramifications of our proposal through five empirical studies and an additional literature review.

### 1.1. *Part I: Disruptions of embodied language functions in movement disorders*

The bulk of Part I focuses on particular lexical categories, namely, action verbs and nouns. In both cases, we first present reviews of relevant evidence and then introduce new empirical studies. Next comes an experiment targeting syntactic markers, followed by a viewpoint article on the translational possibilities of extant findings.

The majority of the contributions focus on PD, the most prevalent neurodegenerative motor disorder worldwide (Samii, Nutt, & Ransom, 2004). To begin, Gallese and Cuccio (2018) consider reports of action-verb difficulties in this population from the perspective of the "neural exploitation hypothesis" (Gallese, 2008). According to the authors, such impairments reflect the dependence of action semantics on sensorimotor systems, positing that the latter were ontogenetically recruited to extend their original functions and subserve particular linguistic domains. The article closes with a discussion of how embodied principles should be incorporated in a comprehensive account of the links between language and movement disorders.

New insights into such links are offered by several original reports. Introducing a novel behavioral approach, García et al. (2018) inquired whether the appraisal of action-related meanings in PD is also compromised in the face of ecological textual materials. Specifically, they assessed patients with and without mild cognitive impairment (PD-MCI and PD-nMCI, respectively) through questionnaires for two naturalistic narratives which differed in their action load. In PD-MCI, action appraisal deficits were the only ones that proved uninfluenced by domain-general dysfunction and that robustly classified patients from controls via multiple group discriminant function analyses. More strikingly, in PD-nMCI such deficits were selective and they allowed classifying patients and controls with higher accuracy than a sensitive executive battery. This suggests that action-semantic impairments may constitute early primary markers of PD, even despite the contextual support offered by integrated discourse.

In the following study, Quilico Cousins, Ash, and Grossman (2018) combined behavioral and magnetic resonance imaging (MRI) data to investigate differential patterns of embodied disturbances in two contrastive motor disorders. They recruited patients with PD (characterized by basal ganglia compromise) and ALS (characterized by motor cortex