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A core avenue for transcultural research on dementia: on the cross-linguistic generalization of language-related effects in Alzheimer's disease and Parkinson's disease

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Objective: Language is a key source of cross-cultural variability, which may have both subtle and major effects on neurocognition. However, this issue has been largely overlooked in two flourishing lines of research assessing the relationship between language-related neural systems and dementia. This paper assesses the limitations of the evidence on (i) the neuroprotective effects of bilingualism in Alzheimer's disease and (ii) specific language deficits as markers of Parkinson's disease.

Design: First, we outline the rationale behind each line of research. Second, we review available evidence and discuss the potential impact of cross-linguistic factors. Third, we outline ideas to foster progress in both fields and, with it, in cross-cultural neuroscience at large.

Results: On the one hand, studies on bilingualism suggest that sustained use of more than one language may protect against Alzheimer's disease symptoms. On the other hand, insights from the embodied cognition framework point to syntactic and action-verb deficits as early (and even preclinical) markers of Parkinson's disease. However, both fields share a key limitation that lies at the heart of cultural neuroscience: the issue of cross-linguistic generalizability.

Conclusion: Relevant evidence for both research trends comes from only a handful of (mostly Indo-European) languages, which are far from capturing the full scope of structural and typological diversity of the linguistic landscape worldwide. This raises questions on the external validity of reported findings. Greater collaboration between linguistic typology and cognitive neuroscience seems crucial as a first step to assess the impact of transcultural differences on language-related effects across neurodegenerative diseases. Copyright © 2017 John Wiley & Sons, Ltd.

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Introduction

Cross-cultural neuroscience aims to study the relationship between the brain and the social systems and anthropological heritage governing life in specific communities (Han *et al.*, 2013). By showing the impact of social values, shared practices, and ethnic profiles on neural mechanisms, this field has exposed the limitations of universal claims about cognitive function and dysfunction. However, these insights are mostly absent in studies assessing the relationship between dementia and a key source of cross-cultural variability: language. This is an unfortunate scenario, given that languages and linguistic experiences vary widely across the globe, recruiting subtly or markedly different neurofunctional circuits across speech communities (Evans and Levinson, 2009). Consequently, typological and language-specific factors may critically influence the forms in which cognitive systems function and collapse both before and after the onset of dementia. In this paper, we discuss how a widespread neglect of cross-linguistic variability may compromise the external validity of conclusions in two flourishing research trends assessing the connections between language-related neural systems and dementia.

In the last centuries, a combination of social, technological, and medical developments has greatly increased life expectancy (Oeppen and Vaupel, 2002). While this achievement is unquestionably desirable, it has also posed serious challenges to health systems, families, and societies worldwide: as the population reaches higher age ranges, the number of people suffering from neurodegenerative diseases is dramatically rising as well. Currently, more than 35 million people live with dementia, and this number is expected to increase in the following years (Wimo *et al.*, 2013).

Two of the most prevalent types are Alzheimer's disease (AD) and Parkinson's disease (PD), each estimated at more than 1% of the older population (Brookmeyer *et al.*, 2007; Samii *et al.*, 2004). AD is characterized by hippocampal and temporal atrophy, which then progresses to other subcortical and cortical regions, mainly compromising mnemonic and executive skills (Vickers *et al.*, 2000). On the other hand, PD involves early basal ganglia deterioration leading to widespread frontostriatal dysfunction and is characterized by deficits in motor function and high-level cognition (Samii *et al.*, 2004). Their causes are not yet fully understood, and their diagnosis is very difficult to establish, especially during initial phases (McKhann *et al.*, 2011).

Crucially, both diseases are characterized by a long preclinical phase, which provides opportunities for timely therapeutic intervention. In this sense, multiple research efforts are aimed at finding avenues to delay or minimize the impact of relevant physiopathological processes and to detect signs of the latter before dysfunctions become clinically manifest. While the broad mechanisms of dementia, their relation with environmental factors, and their sensitivity to specific tasks can be presumed to be similar across social groups worldwide, others can vary greatly depending on each group's cultural systems. Language, one of our species-specific social semiotics (Deacon, 1997), is not the exception. Indeed, one and the same physiopathological mechanism can have very different outward manifestations depending on the patient's language (e.g., Paradis, 2001).

Against this background, here, we discuss the contributions and limitations of two promising approaches to delay and diagnose dementia based on language-related effects. On the one hand, studies on bilingualism suggest that, under certain (and yet unspecified) conditions, sustained use of more than one language could boost executive functioning and foster protection against the symptoms of AD (Bialystok *et al.*, 2016). On the other hand, insights from the embodied cognition framework point to deficits in syntax and action-verb processing as early (and even preclinical) markers of PD (García and Ibáñez, 2014; Garcia et al., 2016; 2017). Both lines of research have attracted increasing attention in recent years, leading to novel theoretical (Bialystok *et al.*, 2009; Calvo *et al.*, 2015; Cardona *et al.*, 2013; Bak, 2013) and clinical (Bialystok *et al.*, 2007; Alladi *et al.*, 2015; García & Ibáñez, 2014; Melloni *et al.*, 2015) formulations of potential relevance for public health (Bialystok *et al.*, 2016; García et al., 2017; Bocanegra *et al.*, 2017).

However, empirical inconsistencies are present in each of these lines of research, and it is unclear which factors may impinge on the replicability of results (Bak, 2016b). Crucially, a key limitation of both fields concerns cross-linguistic generalizability, one of the key challenges underlying cultural neuroscience (Han *et al.*, 2013). In particular, available data come from only a handful of (mostly Indo-European) languages, which are far from capturing the full scope of structural and typological diversity of the linguistic landscape worldwide. Indeed, less than a dozen languages and language pairs have been systematically investigated in these fields, which fails to comprehensively represent the roughly 7000 languages actively spoken nowadays (Gordon, 2005). This raises important questions on the external validity of

reported findings. In the following sections, we critically review evidence from both research arenas, highlight their limitations to postulate universally valid claims, and advance recommendations to foster progress in each field. By focusing on this particular problem within cultural neuroscience, we aim to raise awareness of the gaps between population-specific research and the overarching conclusions which are often derived therefrom.

Bilingualism as a source of cognitive reserve in AD patients

The field's rationale and available evidence

More than half of the world's inhabitants are bilingual (Grosjean, 1994). During verbal communication, these individuals need to select which language to use depending on situational and interpersonal variables. Inhibition of the non-target language taxes cognitive control mechanisms (Green, 1998; Kroll *et al*., 2014), as both languages are simultaneously active even during single-language tasks (Costa *et al*., 2006; Jared and Kroll, 2001; Thierry and Wu, 2007). It has been proposed that these added demands would ultimately boost relevant executive functions (Bialystok *et al*., 2009).

In line with the aforementioned hypothesis, bilingualism has been associated with a number of cognitive benefits, such as enhanced inhibitory control, attention, and working memory (Bialystok *et al*., 2005; Bialystok and Martin, 2004; Calvo *et al*., 2016). Notably, some of these advantages have been documented in both young adults (Bialystok *et al*., 2005) and older adults (Bak *et al*., 2014; Bialystok *et al*., 2004). Admittedly, these effects are not exclusive to bilingualism. The development of other forms of non-verbal communication, such as music, also seems to modulate cognitive function in the older people (Hanna-Pladdy and MacKay, 2011). Yet the bilingual experience seems to exert distinctive and far-reaching influences on cognition. For example, in addition to its differential effects on executive performance (Bialystok and DePape, 2009), the acquisition of expert bilingual skills seems to modulate processing of non-verbal information from other specific domains, such as musical items (Elmer *et al*., 2014).

Findings along such lines have prompted the notion that bilingualism could contribute to cognitive reserve (CR), the brain's capacity for functional compensation following damage or throughout healthy aging (Stern, 2012). Indeed, it has been stated that lifelong bilingualism may delay the first symptoms of AD, especially if high proficiency levels are attained (Gollan *et al*., 2011). Retrospective studies, on the basis of inspection of clinical records, have shown that AD symptoms can manifest roughly 4 years later in bilinguals than in monolinguals. This has been shown in reports considering both immigrant (e.g., Bialystok *et al*., 2007; Chertkow *et al*., 2010) and non-immigrant (e.g., Craik *et al*., 2010; Woumans *et al*., 2015) bilingual samples, with some studies extending the results to certain forms of mild cognitive impairment (Bialystok *et al*., 2014; Ossher *et al*., 2013). Also, neuroimaging research comparing bilingual and monolingual patients has shown variations in brain structure related to brain atrophy (Schweizer et al., 2012), white matter integrity (Gold *et al*., 2013; Olsen *et al*., 2015), grey matter density (Abutalebi *et al*., 2015; Abutalebi *et al*., 2014), and brain glucose uptake (Kowoll *et al*., 2016).

However, several longitudinal studies on AD have not replicated such results. Sanders *et al*. (2012) examined older native and non-native English users and found no evidence of increased CR in the latter group. Also, Zahodne *et al*. (2014) tested 1067 AD participants at intervals of 18–24 months for up to 23 years. Almost 300 subjects developed dementia in the course of the study. Crane *et al*. (2010) studied 2520 second-generation Japanese-Americans (non-demented at baseline) on three occasions over 6 years and did not find lower cognitive declines rates in later life. Similarly, other authors were not able to demonstrate a delay of AD symptoms in Welsh/English bilinguals (Clare *et al*., 2014; Martyr *et al*., 2014).

Thus, the evidence is very inconsistent, with studies yielding both positive and null results. This may be largely due to the impact of many confounding variables (e.g., age of second-language acquisition, proficiency, and number of languages spoken), discrepancies in the instruments used to examine cognitive functioning, and poor control of other social variables known to modulate lifelong cognition (e.g., migration conditions, alcoholism, and education). While the role of these lurking variables has been widely discussed in previous works (Bak, 2016a, 2016b; Calvo *et al*., 2015), later, we will focus on another critical problem for the field: the lack of evidence supporting cross-linguistically and cross-culturally valid conclusions.

Reservations concerning the hypothesis' cross-linguistic generalizability

The neurocognitive profile of a bilingual speaker depends on several linguistic determinants, including

(but not limited to) the age of appropriation of, and proficiency level in, the second language (Paradis, 2009; Ullman, 2001). These and other factors can have a profound influence on the executive processes relevant to the CR hypothesis.

First, the cognitive operations engaged during processing of a second language are modulated by its level of formal similarity with the native language (García, 2014). In this sense, some of the studies assessing CR in bilinguals with AD included samples with typologically closer languages while others considered more distant pairs. Typically, the number of cognates (translation equivalents with major phonological/orthographic overlap) between close languages is greater than it is between more remote ones. This may have a dramatic impact on bilingualism studies: because cognate processing taxes control mechanisms to avoid activating similar lexical candidates in the non-target language, language pairs with more cognates are likely to impose higher inhibitory demands (Linck *et al.*, 2008).

So far, research on CR in bilinguals with AD has largely neglected this factor, as most samples included participants who spoke widely diverse language pairs. In the studies by Bialystok and colleagues, for instance, bilingual participants spoke any of several native languages (e.g., German, Yiddish, Polish, Farsi, and French)—for a review, see Calvo *et al.*, (2015). In particular, some of the studies reporting null results have assessed only distant language pairs (Crane *et al.*, 2010; Kousaie and Phillips, 2012; Zahodne *et al.*, 2014). Typological variability may thus be a critical source of discrepancies in this empirical corpus.

Similarly, it has been shown that same-script bilinguals (e.g., Spanish-English) have greater inhibitory control than different-script bilinguals (e.g., Chinese-English) (Linck *et al.*, 2008). Conceivably, this factor may have influenced the lack of both executive advantages and lower cognitive decline rates yielded in studies considering Japanese-English bilinguals (Crane *et al.*, 2010). By the same token, volumetric increases in the inferior parietal lobule (a hub implicated in various executive functions) of bilinguals did not correlate with naming performance in a Cantonese-English sample, but it approached significance in a Mandarin-Cantonese sample (Abutalebi *et al.*, 2015). Once again, the degree of formal similarity between the languages in each case may be a key contributing factor.

Also, sentential processing may involve greater executive load in some languages than others. For instance, comprehension of structurally complex sentences (e.g., those requiring long-distance dependencies) increases demands on working memory (Miyake and Friedman, 1998), and such dependencies modulate task-relevant event-related potentials (Phillips *et al.*, 2005). Accordingly, languages that more frequently involve long-distance dependencies during sentential processing could impose greater executive demands during daily verbal communication. Moreover, even the same executive task (e.g., digit span) can yield different results depending on idiosyncrasies of the assessed language (Ellis and Hennelly, 1980; Murray and Jones, 2002). In this sense, even the structural properties of the participants' individual languages could exert differential influences on their everyday executive demands.

Also, note that major individual differences in working memory performance are typical in the antilocality effects generally found in subject–object–verb languages (Nicenboim *et al.*, 2015). This point is relevant given that standard deviations from the mean play a critical role in determining whether statistical comparisons yield significant or non-significant differences (Norman and Streiner, 2008). So the results of studies including such languages (Alladi *et al.*, 2013; Crane *et al.*, 2010) could have been influenced by working memory variability across subjects in a non-universal fashion.

Finally, results for and against the hypotheses could be separately mapped onto different cultural variables (socioeconomic status, immigrant vs. non-immigrant status, and alcoholism). For instance, bilingual communities may come from different socioeconomic groups, and even those of the same socioeconomic status may widely vary in terms of customs and living conditions (Bak, 2016b). In addition, low education does not necessarily play the same role as a risk factor for dementia in Asia as in the Western World (Bak, 2016a; Iyer *et al.*, 2014).

Similarly, bilinguals who come from immigrant communities may have lower socioeconomic status, greater rates of mental illness (Bhugra and Becker, 2005), more congenital and acquired neurological disorders (White *et al.*, 2005; Zahuranec et al., 2006), and greater tendencies to develop eating disorders (Geller and Thomas, 1999; Bulik et al., 2006), bad sleeping habits (Voss and Tuin, 2008), and vices like smoking (Bethel and Schenker, 2005) and alcoholism (Szaflarski *et al.*, 2011; Caetano, 2008). All in all, these observations highlight the need to systematically consider cross-linguistic and cross-cultural differences in this field of research.

Syntactic and action-language deficits as a window into motor network integrity in PD

The field's rationale and available evidence

Several studies compatible with the embodied cognition framework have shown that linguistic information is grounded in neurocognitive mechanisms specialized for more basic or general functions (Gallese and Lakoff, 2005). In particular, networks specialized for sequencing hierarchically organized motor patterns (such as the basal ganglia) are critical for homologous linguistic operations—sequencing hierarchically organized lexical patterns, namely, syntax (Ullman, 2008; Ullman, 2004; García *et al.*, accepted)—while primary and supplementary motor regions are critical for processing action verbs (García and Ibáñez, 2016; Pulvermüller, 2005).

Accordingly, it has been proposed that syntax and action verbs could be distinctively impaired in movement disorders such as PD (Kargieman *et al.*, 2014; Bak, 2013). It follows that performance on relevant tasks could index the functional integrity of motor networks. Indeed, abundant evidence has been gathered in support of this hypothesis.

First, PD patients are impaired in processing sentences of varied syntactic complexity (Lee *et al.*, 2003; Lieberman *et al.*, 1992; Zanini *et al.*, 2004). Moreover, specific (and, arguably, compensatory) grammatical strategies deployed during spontaneous speech allow for automatic classification of PD patients with up to 75% accuracy (García *et al.*, 2016). Notably, syntactic disturbances in this population may emerge irrespective of the patients' overall cognitive profile (Bocanegra *et al.*, 2015), and they may also be present in asymptomatic individuals at risk for PD owing to genetic mutations (García et al., 2017).

Second, PD patients present action-language deficits with relative preservation of words, which do not necessarily involve physical movements, such as abstract verbs and nouns (García and Ibáñez, 2014). This pattern has been replicated through different tasks (Cardona *et al.*, 2013), including action-word naming (Bertella *et al.*, 2001; Cotelli *et al.*, 2007; Péran *et al.*, 2009), action-verb production (Crescentini *et al.*, 2008; Péran *et al.*, 2003), and action-verb identification (Boulenger *et al.*, 2008). Compatibly, neuroimaging evidence suggests that in PD, action verbs are selectively processed via alternative, disembodied pathways (Abrevaya *et al.*, 2017). Moreover, PD patients, as opposed to patients featuring musculoskeletal motor disorders (Cardona *et al.*, 2014), are impaired in their capacity to integrate action-verb information with ongoing manual movements (Ibanez et al., 2013)—a pattern that is accompanied by aberrant modulations of the motor potential and abnormal frontotemporal connectivity (Melloni *et al.*, 2015).

Overall, this field seems much more compelling than the one about bilingualism and AD. The hypotheses under consideration have been confirmed in various experimental tasks, and they are consistent with macroanatomical (Baez *et al.*, 2013; Cardona *et al.*, 2013; Ibanez et al., 2013) and microanatomical (García et al., 2017) language embodiment models. However, as is the case with the previous line of research, the evidence so far stems from only a few languages and proves completely blind to the impact of typological factors. Thus, as seen later, critical questions emerge concerning the generalizability of the results and ensuing conclusions.

Reservations concerning the hypotheses' cross-linguistic generalizability in PD research

Although seemingly robust, the evidence in this field has been produced in a very reduced number of languages. It remains unknown whether the effects would equally emerge across the linguistic spectrum.

First, results concerning syntactic deficits are largely dependent on idiosyncrasies of the languages involved. For example, testing Spanish-speaking participants, García *et al.* (2016) found that certain grammatical patterns in spontaneous speech allowed them to automatically classify PD patients with considerable accuracy. However, grammatical structure varies widely across languages, and some languages actually lack some of the structural categories behind the results reported by García *et al.* (2016). Indeed, studies comparing grammatical output with participants who spoke Belgian (Vanhoutte *et al.*, 2012) and English (Illes, 1989; Illes, *et al.*, 1988; Murray and Lenz, 2001) found no syntactic differences between PD patients and controls—except when speaking conditions were highly demanding or when cognitive deficits were too severe.

Similarly, the evidence for syntactic deficits in asymptomatic mutation carriers at risk for PD (García et al., 2017) emerged in a picture–sentence matching task involving verb phrases featuring different combinations of coordinators and prepositions. Accordingly, the results cannot be *a priori* assumed to be generalizable to languages that lack prepositions in their grammatical repertoire, as is the case with

Japanese. Also, no study has yet explored whether the results documented in subject–verb–object languages can be systematically reproduced in verb–subject–object languages, such as Welsh. In this language, for instance, the equivalent of the sentence "He is hitting him" would be "Mae ef yn ei daro" ("is he in 3SG.M hitting") (Haspelmath, 1999). This construction is anchored in a verb–noun, a lexical class that does not exist in several languages. For another example, consider Riau Indonesian (Gil, 2005; Gil, 1994), a language that lacks noun declensions as well as subject/object and singular/plural distinctions. So "Ayam makan" (in English "Chicken eat") can mean anything from the "Chicken is eating," "I eat the chicken," "I ate some chicken," "The chicken that is eaten," and so on (Cohen and Lefebvre, 2005). Under these circumstances, the traditional picture–sentence matching tasks used in most studies on PD may prove uninformative about the patients' impairments. More generally, insofar as syntactic processing is radically driven by the structural possibilities of the language in question, findings stemming from any given language can hardly be expected to be entirely (if at all) replicable in other languages.

Something similar concerns results from action-verb processing studies. Deficits in this lexical category have been mainly observed relative to nouns, with evidence coming from speakers of Romance (e.g., Spanish and Italian) and Germanic (e.g., English and German) languages. Crucially, such languages are characterized by a neural dissociation between verbs and nouns, such that the former category relies more critically on frontal and prefrontal regions, whereas the latter is subserved by middle/posterior temporal regions (Koenig and Lehmann, 1996; Martin *et al.*, 1995; Perani *et al.*, 1999; Shapiro *et al.*, 2006). However, this pattern of neurofunctional organization is not universally shared by all languages. For instance, no such anatomical dissociation exists between lexical categories in Chinese (Chan *et al.*, 2008; Li *et al.*, 2004; Yang *et al.*, 2011), a language that lacks explicit morphological distinctions between verbs and nouns —as is the case with other languages, such as Tongan (Cohen and Lefebvre, 2005). Accordingly, in Chinese PD patients, action-verb processing tasks may not afford reliable markers of motor network integrity.

Additional reservations come to mind upon considering sign languages. In particular, these may perhaps inextricably engage the motor system in processing the meaning of any word type, given the coactivation of motor circuits during execution or recognition of manual signs (Levänen *et al.*, 2001). In other words, as specific hand shapes are related to all lexical categories, it cannot be assumed that motor network damage will yield differential patterns of performance for action verbs or any lexical category. While all the issues raised in this section remain to be empirically determined, the point is that language-blind statements about the sensitivity of such tasks may be incurring overgeneralization.

Avenues for transdisciplinary cross-linguistic studies

Typological studies have shown that structural diversity can be seen at almost every level of linguistic organization across languages, highlighting the need to integrate this diversity into language-related research (Evans and Levinson, 2009). Indeed, recent works have stressed the need for linguistic typology research and cognitive neuroscience to engage in active crosstalk and to consider the reciprocal repercussions of their findings (Kemmerer, 2014). Thus, more transdisciplinary cross-linguistic research is needed to uncover the relationship between distinguishing properties of specific languages or language families and thus better understand their role in the two lines of research addressed earlier.

To date, studies on the relationship between AD, CR, and bilingualism have largely focused on cognitive control, which varies tremendously depending on the type of languages the bilingual speaks. Considering that explicit claims have been made for bilingualism to enter the public health agenda (Bialystok e*t al.*, 2016), it is crucial to systematically assess whether increased CR is contingent on distinctive properties of the languages used (e.g., typological distance between languages, different scripts, and structural features of each individual language). In particular, given that AD compromises declarative memory mechanisms subserving both lexico-semantic and grammatical aspects of a lately learned second language (Ullman, 2008; Ullman, 2004), it would be useful to test whether there is a relation between CR in bilingual patients and specific patterns of neural organization of their second language.

Also, PD research could widen its horizons by assessing syntactic and action-verb deficits in languages such as Welsh, Chinese, Japanese, and Hebrew, whose lexico-grammatical organization differs from that of the languages studied so far. Once again, to better understand the potential role of language tasks as potential windows into the functional integrity of motor networks across speech communities, it is crucial to differentiate between

universal and language-particular levels of analysis (Croft, 2000). Notably, languages that have a more complex morphology are generally found in relatively small speech communities (Lupyan and Dale, 2010), which suggests a key connection between language-specific structural features and the demographical representation of that language. More analyses along these lines could help determine to what extent we can generalize findings concerning the role of linguistic dysfunctions as potential windows into the physiopathology of PD.

Also, more research on signers is needed in both fields. Despite important progress in our understanding of the neurocognitive basis of sign languages (Campbell *et al.*, 2008), there is a dearth of evidence on their relationship with dementia and their role in the two lines of research discussed earlier. For example, it would be important to examine whether executive mechanisms distinctively taxed during linguistic communication in bimodal bilinguals show specific relations to CR. Moreover, signers also constitute a very unique population for PD studies, as they show strong cross-linguistic similarities in their morphological structures (Aronoff *et al.*, 2005). Accordingly, they would offer a novel framework to address the caveats enumerated elsewhere in this paper.

More generally, the key requisite to determine the generalizability of findings across languages and cultures is the replication of experiments via comparable instruments. Replication studies allow for a better examination of possible statistical errors (null hypotheses, type I or type II error), while partially addressing the impact of confounding variables (Little, 2013). To perform cross-cultural replication studies, it is crucial to develop valid adaptations of key tests in different languages. So far, success has been limited in this respect. Whereas some tests, such as the Anosognosia Questionnaire for Dementia (Gambina *et al.*, 2015), have yielded similar results in different cultures, others, like the Boston Naming test (Ardila, 2007) and the Mini Mental State Examination (Dodge *et al.*, 2009), seem to possess low transcultural generalizability. Moreover, despite few exceptions, such as the Bilingual Aphasia Test (Paradis, 1987), virtually to instrument has been massively adapted to multiple languages and language pairs. Therein lies a crucial challenge to foster progress in the field.

Conclusion

In sum, recent research has argued for the relevance of bilingualism as a factor of CR in AD and the usefulness of syntactic and action-language tasks as sensitive markers of motor network compromise in PD. However, insofar as the conclusions stem from less than 1% of the languages worldwide, sweeping statements tacitly assuming their universal validity may be unwarranted. There are major differences in the organizational structure of languages across the world and the neurocognitive mechanisms engaged by them. So overarching claims in either research field may prove to be instances of overgeneralization. More active dialogue between linguistic typology research and cognitive neuroscience is urgently needed to establish the external validity of findings in both lines of inquiry. Analyzing structural diversity among languages and its relation to cognitive processing paves the way for novel experimental paradigms and a better understanding about the relevance of language-related research to counter dementia in different speech communities. More generally, this is a critical step to understand the role of one of the main sources of evidence and variability in transcultural approaches to clinical neuroscience.

Conflict of interest

None declared.

Key points

- We discuss the role of language as a key source of cross-cultural variability in dementia research.
- Studies on bilingualism suggest that sustained use of more than one language may protect against Alzheimer's disease symptoms.
- Insights from the embodied cognition framework point to syntactic and action-verb deficits as early (and even preclinical) markers of Parkinson's disease.
- However, the generalizability of both findings may be markedly limited by their arguably low potential of replicability across typologically diverse languages.

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