Journal of Neurolinguistics 46 (2018) 37–68

Contents lists available at ScienceDirect

Journal of Neurolinguistics

journal homepage: www.elsevier.com/locate/jneuroling

A case study about the interplay between language control and cognitive abilities in bilingual differential aphasia: Behavioral and brain correlates

Lize Van der Linden[a,*], Laurence Dricot[b], Miet De Letter[c], Wouter Duyck[d], Marie-Pierre de Partz[b], Adrian Ivanoiu[b,e], Arnaud Szmalec[a,b,d]

[a] Psychological Sciences Research Institute, Université catholique de Louvain, Place Cardinal Mercier 10, Louvain-la-Neuve, Belgium
[b] Institute of Neuroscience, Université catholique de Louvain, Avenue Hippocrate 10, Brussels, Belgium
[c] Department of Speech, Language, and Hearing Sciences, Ghent University, De Pintelaan 185, Ghent, Belgium
[d] Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, Ghent, Belgium
[e] Neurology Department, Saint Luc University Hospital, Avenue Hippocrate 10, Brussels, Belgium

ARTICLE INFO

Keywords:
Differential aphasia
Non-linguistic control
Inhibition
Bilingualism
Language control
Functional connectivity

ABSTRACT

The current study examines the hypothesis that differential aphasia may be due to a problem with language control rather than with language-specific impairment and how this is related to non-linguistic cognitive control abilities. To this end, we report a case study of an L2 dominant French-English bilingual aphasia patient with larger impairments in French than in English. We assessed cross-language interactions using cognates in three lexical decision (LD) tasks, and non-linguistic cognitive control with a flanker task. We also examined functional connectivity between brain regions crucial for language control and language processing. We observed the preservation of cognate effects in a generalized lexical decision task requiring little language control, which indicates intact functionality (and cross-lingual interactivity) of lexical representations. On the other hand, we found diminished linguistic as well as non-linguistic control abilities, suggesting a domain general control impairment. Resting-state functional Magnetic Resonance Imaging (rs-fMRI) analysis revealed altered connectivity between the patient's language control and processing network, consistent with the behavioral data. Altogether, these results are in line with the hypothesis that differential aphasia may originate from general cognitive control difficulties.

1. Introduction

In these times of globalization and cultural exchange, the prevalence of bilingualism is constantly increasing and today more than half the world's population is considered to be bilingual (Grosjean, 2010). It is well documented that bilinguals experience cross-language activation when conducting a task that in essence only requires one language (Colomé, 2001; Costa & Caramazza, 1999; Costa & Santesteban, 2004; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Kaushanskaya & Marian, 2007; Meuter & Allport, 1999; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009). Most of these studies have included experiments using cognates. Cognates are

* Corresponding author. Psychological Sciences Research Institute, Université catholique de Louvain, Place Cardinal Mercier 10, B-1348 Louvain-la-Neuve Belgium.
E-mail addresses: lize.vanderlinden@uclouvain.be (L. Van der Linden), laurence.dricot@uclouvain.be (L. Dricot), miet.deletter@ugent.be (M. De Letter), wouter.duyck@ugent.be (W. Duyck), marie-pierre.departz@uclouvain.be (M.-P. de Partz), adrian.ivanoiu@uclouvain.be (A. Ivanoiu), arnaud.szmalec@uclouvain.be (A. Szmalec).

https://doi.org/10.1016/j.jneuroling.2017.12.011
Received 21 March 2017; Received in revised form 22 November 2017; Accepted 27 December 2017
Available online 04 January 2018

words that share their meaning and their orthography and/or phonology between two different languages (e.g., the Dutch-English example *film-film* (shared orthography and phonology) or *appel-apple* (shared phonology and large orthographic overlap)). Typically, bilinguals are faster in recognizing cognates compared to noncognates, a phenomenon known as the cognate facilitation effect (Duyck et al., 2007; Van Hell & Dijkstra, 2002), which reveals activation of multiple languages during word recognition.

1.1. Consequences of bilingualism for the cognitive system

Bilingualism, and the resulting continuous activation of multiple languages, has positive consequences for the cognitive system, above and beyond the advantage of speaking more than one language (e.g., Bialystok, 2010, 2011; Bialystok & Barac, 2012; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008; for review see; Bialystok, Craik, Green, & Gollan, 2009). According to the inhibitory control model (Green, 1998), this bilingual advantage is a consequence of the continuous need to inhibit the (lexical) activation of the non-target language while producing or comprehending speech in the target language. How this language control is accomplished, however, is still under debate (Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; Dijkstra & Van Heuven, 2002; Gray & Kiran, 2016; Green, 1998; Hermans, Bongaerts, De Bot, & Schreuder, 1998). It is still not clear whether the mechanism that controls this cross-language activation is specific to the language domain or whether it extends to the entire cognitive system. Bilingualism has been shown to increase language abilities, like novel word learning (Kaushanskaya & Marian, 2009; Papagno & Vallar, 1995), but many researchers observed an advantage outside the language domain for bilinguals over monolinguals as well. For instance, bilingualism has been found to improve non-verbal cognitive control skills (e.g., Bialystok, 2010, 2011; Bialystok et al., 2004; Bialystok et al., 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Costa, Hernández, & Sebastián-Gallés, 2008) and to protect against cognitive decline by aging or Alzheimer's dementia (Bialystok et al., 2004; Craik, Bialystok, & Freedman, 2010; Woumans et al., 2015). Although some authors contest the bilingual advantage (e.g., Paap & Greenberg, 2013; Paap & Sawi, 2014; Paap, Johnson, & Sawi, 2015), perhaps the strongest evidence available for a non-linguistic control advantage is the meta-analysis of de Bruin, Treccani, and Della Sala (2015), who reported a modestly-sized, but significant difference between monolinguals and bilinguals. The observation of a bilingual advantage suggests that linguistic and non-linguistic control abilities are linked to an at least partly shared system, although some researchers also argued for two distinct control processes (Calabria, Branzi, Marne, Hernández, & Costa, 2015; Calabria, Hernández, Branzi, & Costa, 2012; Magezi, Khateb, Mouthon, Spierer, & Annoni, 2012; Weissberger, Wierenga, Bondi, & Gollan, 2012). Altogether, these findings seem to suggest that language control and non-linguistic cognitive control are not fully independent, but it is still a matter of debate whether they refer to a single, domain-general control mechanism or whether they can be considered as two domain-specific mechanisms.

1.2. The control hypothesis in differential aphasia

In the present study, we aimed to investigate the above concepts of language control and non-linguistic control in a bilingual patient with differential aphasia. Aphasia is defined as a disturbance in understanding, formulating or using verbal messages and it is caused by a brain dysfunction in language-related brain areas (Damasio, 1992). Until recently, most research on aphasia focused on the representation and use of one single language. Also in neuropsychological or logopaedic practice, knowledge or impairments in other known languages are often not considered, neither in diagnostics nor in therapy. However, as more and more people nowadays are bilingual, also the number of bilinguals suffering from aphasia is growing (Faroqi-Shah, Frymark, Mullen, & Wang, 2010). Research conducted so far showed that bilingual patients with aphasia do not always recover their native (L1) and second language (L2) to the same degree (Giussani, Roux, Lubrano, Gaini, & Bello, 2007) in the sense that different recovery or impairment patterns can be identified (Paradis, 1977, 2004). One such pattern, which is the focus of the current study, is differential aphasia. In bilinguals with differential aphasia, the patients have difficulties in both languages, but one language is more severely impaired than the other.

Given the important assumption that bilinguals have one integrated lexicon that contains word representations of both languages that are always simultaneously active (Van Heuven, Dijkstra, & Grainger, 1998), it seems hard to conceive how brain damage to a language area could result in more pronounced impairments in one of the languages in particular, or why bilinguals with aphasia sometimes better recover one language than the other. A number of researchers therefore proposed that better recovery of one language may be a consequence of language control deficiencies rather than of the loss of linguistic knowledge or lexical representations (e.g., Abutalebi & Green, 2007; Abutalebi, Rosa, Tettamanti, Green, & Cappa, 2009; Aglioti, Beltramello, Girardi, & Fabbro, 1996; Pitres, 1895; Verreyt, De Letter, Hemelsoet, Santens, & Duyck, 2013). Accordingly, a control-related brain lesion may affect the activation and inhibition levels of (words in) one language more than the other, so that the preserved functionality of languages differs.

Although this control hypothesis has the potential to explain how languages may be affected in a different way in bilingual aphasia, thus far there has only been sparse evidence for preserved linguistic knowledge and loss of language control in bilingual aphasia. At least, some evidence of preserved linguistic representations was found in patients with parallel aphasia, a recovery pattern of aphasia where both languages are equally impaired (Detry, Pillon, & De Partz, 2005; Roberts & Deslauriers, 1999; see Verreyt et al., 2013; for a review). These studies reported better recognition of cognates compared to noncognates, which indicates that, although a language might be impaired, it may still be sufficiently active to influence the processing of the other language.

Evidence for the impact of cognitive control on (differential) aphasia is more rare. According to Abutalebi and Green (2007), language control involves the same neural network as non-linguistic cognitive control. This language control network consists of the anterior cingulate cortex (ACC), the pars orbitalis (Brodmann area (BA)47) and the head of caudate (HC). The ACC has been shown to contribute in response monitoring, but also in language switching, language selection and in cross-linguistic conflict resolution. BA47