Journal of Neurolinguistics 25 (2012) 139–149

Contents lists available at SciVerse ScienceDirect

Journal of Neurolinguistics

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

Establishing the relationship between cortical atrophy and semantic deficits in Alzheimer's disease and mild cognitive impairment patients through voxel-based morphometry

Javier Rodríguez-Ferreiro [a,*], Fernando Cuetos [b], Asunción Monsalve [b], Carmen Martínez [c], Ana Julia Pérez [c], Annalena Venneri [d,e]

[a] University of Barcelona, Spain
[b] University of Oviedo, Spain
[c] Cabueñes Hospital, Gijón, Spain
[d] University of Sheffield, UK
[e] San Camillo Hospital (IRCCS), Venice, Italy

ARTICLE INFO

Article history:
Received 1 July 2011
Accepted 11 October 2011

Keywords:
Objects
Faces
Fluency
Naming
Semantic association
Semantic retrieval

ABSTRACT

The aim of this study was to determine the brain areas responsible for the semantic impairment observed in Alzheimer's disease (AD) and Mild Cognitive Impairment (MCI) patients. Thirteen AD, 14 MCI patients, and 13 matched healthy older adults were assessed with a test battery aimed to study their semantic competence. Different subtasks were designed to study their semantic knowledge related to objects and faces in the context of semantic retrieval- and semantic association-dependent tasks. Aggregate scores obtained in the different tests were entered into voxel-based regression analyses with grey matter volume values obtained from three-dimensional brain MRI scans. Areas of significant correlation between volume loss and poor semantic scores were restricted to the temporal lobe in the AD group, while in the MCI and control groups significant associations were found with lower grey matter volume values in a widely distributed network of bilateral fronto-temporo-parietal regions. Our results suggest that degradation of partially overlapping and widely distributed neural networks, mainly including temporal regions, subserve semantic deficits related to objects and faces in AD and MCI patients.

* Corresponding author. Dept. Psicologia Bàsica, Universitat de Barcelona, Mundet, Ponent, Desp. 3509, Pg.Vall D'Hebron, 171, 08035, Barcelona, Spain. Tel.: +34 933125151; fax: +34 934021363.
E-mail addresses: rodriguezferreiro@ub.edu, xabelferreiro@gmail.com (J. Rodríguez-Ferreiro).

0911-6044/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jneuroling.2011.10.001

1. Introduction

The brain atrophy that occurs in ageing, and especially in pathological ageing, involves loss of the cognitive functions dependent on that tissue. In Alzheimer's disease (AD), the most common and best known of the neurodegenerative dementias, the earliest symptoms concern episodic memory, particularly difficulties in new learning (Fox, Warrington, Seiffer, Agnew, & Rossor, 1998). This is unsurprising given the well established connection between anterograde amnesia and the hippocampus and entorhinal cortex which are seriously affected in AD even in its early development (Braak & Braak, 1991).

However, recent findings have shown that not only episodic memory but also semantic memory, i.e. knowledge about the world, facts, concepts and beliefs, deteriorates in the early stages of the disease (Albert, Moss, Tanzi, & Jones, 2001; Dudas, Clague, Thompson, Graham, & Hodges, 2005). Alterations in semantic memory manifest in these patients as difficulties in tasks like naming (Rodríguez-Ferreiro, Davies, González-Nosti, Barbón, & Cuetos, 2009) or semantic fluency (Cuetos, Martínez, Martínez, Izura, & Ellis, 2003; Venneri et al., 2008). These difficulties are more dramatic in the case of memory for public events or people, information that is shared by all members of a culture, as shown by the evidence of poor performance in tasks that involve famous people naming (Cuetos, Rodriguez-Ferreiro, & Menéndez, 2009; Green & Hodges, 1996). Moreover, even in the asymptomatic stage of the familiar form of Alzheimer's disease, carriers of the E280 mutation in the Presenilin-1 gene had significantly lower scores than non-carriers on tasks requiring famous people naming (Arango-Lasprilla, Cuetos, Valencia, Uribe, & Lopera, 2007).

In mild cognitive impairment (MCI), a condition that is often considered a transitional stage between normal ageing and dementia, deficits in semantic memory have also been found (Cuetos et al., 2009). Several studies have reported that the performance of MCI patients in typically semantic tasks, such as picture naming, semantic fluency or semantic association, is severely affected (Duong, Whitehead, Hanratty, & Chertkow, 2006). Similarly to what happens in AD patients, the most damaged semantic component in MCI seems to be memory for public events or people. In fact, naming of famous faces appears to be one of the tasks that best discriminates MCI patients from healthy older adults (Cuetos et al., 2009; Dudas et al., 2005).

From a neuro-pathological viewpoint, the finding of early alterations in semantic memory in MCI and in the early stages of AD might be unexpected since brain atrophy in these patients is said to be confined to the hippocampus and entorhinal area and it is assumed that semantic memory depends on other cortical regions, particularly on the lateral temporal gyri (Martin, Wiggs, Ungerleider, & Haxby, 1996), which, according to Braak and Braak (1991) are affected in more advanced stages of the disease. Studies carried out with neuroimaging techniques in non-demented adults have found that object naming results in activation of the inferior and middle temporal cortices (Moore & Price, 1999). For specific knowledge of people and faces, the literature indicates that the temporal pole and fusiform regions are the brain areas responsible for processing of this type of information (Gorno-Tempini et al., 1998). However, other areas like the medial frontal cortex also appear to be involved in their processing, especially in faces and names of famous persons (Gorno-Tempini et al., 1998), and a relation between frontal lobe lesions and memory for faces has been established (Rapcsak et al., 2001).

The aim of this study was to examine the relationship between atrophied brain areas and alterations in semantic knowledge through volumetric analysis of the brains of older adults with cognitive decline, more specifically, patients suffering from MCI or AD. Some studies have shown that MCI and AD patients follow a different cognitive deterioration course. It is a well known fact that the MCI label is applied to a very heterogeneous group of patients, with some being diagnosed AD in a short period of time (Petersen et al., 2001) whereas others will never develop the disease. The question, therefore, remains to be addressed of which patterns of cortical atrophy are responsible for the performance in semantic tasks of these two populations. In order to respond to this question, a group of patients diagnosed with probable AD, a group of patients with MCI, and a matched control group were assessed. They were presented with several cognitive tasks aimed to assess the degree of semantic impairment, and to clarify whether variance in their scores on these tasks correlated with regional atrophy in areas associated with the processing of semantic information obtained from grey matter volumes extracted from three-dimensional brain MRI scans.