Visual and Semantic Processing of Living Things and Artifacts: An fMRI Study

Gian Daniele Zannino¹, Ivana Buccione¹, Roberta Perri¹, Emiliano Macaluso¹, Emanuele Lo Gerfo¹, Carlo Caltagirone¹,² and Giovanni A. Carlesimo¹,²

Abstract

We carried out an fMRI study with a twofold purpose: to investigate the relationship between networks dedicated to semantic and visual processing and to address the issue of whether semantic memory is subserved by a unique network or by different subsystems, according to semantic category or feature type. To achieve our goals, we administered a word-picture matching task, with within-category foils, to 15 healthy subjects during scanning. Semantic distance between the target and the foil and semantic domain of the target–foil pairs were varied orthogonally. Our results suggest that an amodal, undifferentiated network for the semantic processing of living things and artifacts is located in the anterolateral aspects of the temporal lobes; in fact, activity in this substrate was driven by semantic distance, not by semantic category. By contrast, activity in ventral occipito-temporal cortex was driven by category, not by semantic distance. We interpret the latter finding as the effect exerted by systematic differences between living things and artifacts at the level of their structural representations and possibly of their lower-level visual features. Finally, we attempt to reconcile contrasting data in the neuropsychological and functional imaging literature on semantic substrate and category specificity.

INTRODUCTION

Since the seminal paper by Warrington (1975) on the “selective impairment of semantic memory,” a great deal of neuropsychological evidence has been accumulated supporting the view that semantic memory represents, to some extent, an isolable system at both the functional and the neuronanatomical level. In the early 1990s, major support for this view came from research on semantic dementia. This disease is characterized by a typical neuropsychological and lesion profile. It includes a selective impairment of conceptual knowledge and atrophic changes involving the anterior temporal lobe structures and is frequently more pronounced in the left hemisphere (Garrard & Hodges, 2000; Hodges, Patterson, Oxbury, & Funnell, 1992).

Within the functional system subserving conceptual knowledge, deficits are sometimes specific to items referring to particular semantic categories. Usually, in these cases, categories belonging to the living domain (such as animals, fruits, and vegetables) are more impaired, whereas nonliving categories (e.g., vehicles, tools, and furniture) are relatively spared. However, the reverse pattern of impairment (i.e., better performance on living than on nonliving things) has also been observed (see Capitani, Laiacona, Mahon, & Caramazza, 2003; Gainotti, 2000, for reviews). The finding that semantic impairments due to brain damage are sometimes category-specific suggests that semantic memory has an internal organization. According to the domain-specific hypothesis (DSH; Caramazza & Shelton, 1998), dedicated neural substrates might have evolved for effectively recognizing members of categories that are relevant for survival (i.e., conspecifics, plant life, animals, and possibly tools). According to a concurrent view (Warrington & Shallice, 1984), the first-order organizing principle of semantic memory is not category, but rather, type of knowledge. In keeping with the so-called sensory/functional theory (SFT), dedicated neural substrates store conceptual knowledge according to feature type. Perceptual knowledge, which refers to what things look like (e.g., that bananas are yellow), is segregated from functional knowledge, which refers to what things are used for (e.g., that knives are used for cutting). Based on the assumption that perceptual knowledge is more important for distinguishing living things from one another and functional knowledge for distinguishing nonliving things, selective damage to either the perceptual or the functional neural substrate is expected to have an unequal effect on items referring to the two semantic domains.

According to a different approach to category specificity (e.g., Funnell & Sheridan, 1992), a relatively more severe impairment for living things might arise because