CORTEX 49 (2013) 2055–2066

Available online at www.sciencedirect.com

SciVerse ScienceDirect

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

Research report

The neural substrates of inferential and referential semantic processing

Diego Marconi [a,*], Rosa Manenti [b], Eleonora Catricalà [c,d], Pasquale A. Della Rosa [c,e], Simona Siri [c] and Stefano F. Cappa [c]

[a] Philosophy Department, Turin University, Turin, Italy
[b] IRCCS Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy
[c] Vita-Salute University, Division of Neuroscience, San Raffaele Scientific Institute, Milan, Italy
[d] Milano-Bicocca University, Milan, Italy
[e] University of Geneva, Geneva, Switzerland

ARTICLE INFO

Article history:
Received 1 July 2011
Reviewed 11 October 2011
Revised 7 December 2011
Accepted 1 August 2012
Action editor Rhonda Friedmann
Published online 28 August 2012

Keywords:
Semantics
Picture naming
Naming by definition
Matching
fMRI

ABSTRACT

Introduction: A distinction has been proposed, on theoretical grounds, between referential and inferential semantic abilities. The former account for the relationship of words to the world, the latter for the relationship of words among themselves. The hypothesis of, at least partially, different neurological underpinnings for this distinction has been supported by the presence of double dissociations in neurological patients between tasks that can be considered to tap the cognitive processes involving these two different classes of semantic knowledge, such as, for example, picture naming (referential) and naming to a verbal definition (inferential).

Methods: We report here the results of a functional magnetic resonance experiment, contrasting the pattern of brain activity associated with, respectively, "referential" (picture naming, word-to-picture matching) and "inferential" (naming to definition, word-to-word matching) tasks.

Results: All tasks activate an extensive set of brain areas involving both hemispheres, corresponding to the "common semantic network". In addition, left hemispheric temporal areas are selectively engaged by the inferential tasks. Conversely, a specific activation of the right fusiform gyrus is associated with the referential tasks.

Conclusions: These findings suggest that while inferential tasks, as compared with referential tasks, engage additional processing resources subserved by left hemispheric language areas involved in lexical retrieval, referential tasks (as compared with inferential tasks) recruit right hemispheric areas generally associated with nonverbal conceptual and structural object processing. These findings are compatible with the double dissociations reported in neurological patients.

* *Corresponding author*. Philosophy Department, University of Turin, S. Ottavio 20, 10124 Turin, Italy.
E-mail address: diego.marconi@unito.it (D. Marconi).
0010-9452/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.cortex.2012.08.001

1. Introduction

Competence on words involves phonological, morphological and syntactic abilities. In addition, it involves abilities that are usually characterized as "semantic". These appear to be of two kinds (Marconi, 1997). On the one hand, we know how to relate words to other words. We know that *cats* are *animals*, we can verbally describe the difference between *walking* and *running*, we understand that "a polished or smooth surface that forms images by reflection" is a *mirror*. On the other hand, we know how to relate words to the world out there, as presented to us in perception. We can tell cats from cows by calling the former *cats* and the latter *cows*, we can describe a man as *running* rather than *walking*, and we can pick up the appropriate tool if requested to obey the order "Bring me the hammer, not the pliers!". The former have been called 'inferential' and the latter 'referential' abilities. Inferential abilities lie at the basis of so-called "material inferences" (cf. Brandom, 1994), such as the inference from 'Felix is a cat' to 'Felix is a mammal' or from 'Milan is north of Rome' to 'Rome is south of Milan' (as distinct from *logical* inferences, such as the inference from 'If it's Thursday I have a class' and 'It's Thursday' to 'I have a class'). Referential abilities, in turn, cognitively mediate the relation of reference between words and things. The distinction between inferential and referential abilities should not be conflated with the distinction between inferential role semantics and referential (or truth conditional) semantics, familiar from the philosophy of mind and language (see Block, 1986). The latter is a distinction between different theoretical accounts of meaning, whereas the former concerns (lexical) semantic competence. While truth conditional semantics aims at determining objective truth conditions that may elude the abilities of every speaker in a linguistic community (Putnam, 1975), referential competence coincides with the ability a speaker has to relate words to the world thanks to perception and other cognitive faculties.

Relative to many ordinary words, most of us are quite competent both inferentially and referentially. However, for many other words competence varies widely from speaker to speaker. For example, a trained zoologist may be more competent than most of us on the word *manatee* (as she is more competent on manatees, the animals themselves). Moreover, an individual speaker may be more competent referentially than inferentially: a person may be extremely skilled at telling primroses from other flowers without knowing the first things about primroses, while a bookish scientist may know all there is to know about a rare tropical flower while having trouble to recognize one, as she never saw it in nature. Thus, the two sides of lexical semantic competence can be said to be relatively independent of each other (see Marconi, 1997 for further details).

In principle, there is no reason to expect that distinct abilities underlie the intuitive distinction between inferential and referential performances, or that they are implemented by distinct functional subsystems in the brain. The distinction might only be a classification of patterns of behavior involved in ordinary use of the lexicon. Some evidence from both neuropsychological case studies and (to a lesser extent) neuroimaging, however, seems to indicate that the distinction might be neurally implemented, i.e., that different subsystems with partly distinct neural realizations might be responsible for cognitive performances involving inferential and referential aspects of semantics, respectively. It is evident that, from the point of view of the access to information, referential semantics has a close connection to perceptual modalities, in particular to vision, but also to audition and somatosensory perception. An impairment in referential tasks may thus reflect defective access of perceptual information to the semantic system, as in the case of the classical "disconnection syndromes" (for a recent review see Catani and ffytche, 2005), while an apparent inferential impairment may be the consequence of a language disorder.

How could the distinction between referential and inferential performances be mapped on the tasks that have been used in neuropsychology? In clinical neuropsychology, a distinction is traditionally made between *naming* tasks (including production of a noun corresponding to a picture, or to a linguistic definition) and *matching* tasks (including selection of a picture or a word matching a word stimulus among alternatives), assessing, respectively, language production and comprehension at the single word level. From the point of view of the cognitive processes involved, all these tasks share the requirements for visual perceptual analysis, access to lexical and semantic information and lexical retrieval. According to the previous distinction (Marconi, 1997), however, picture naming and word-to-picture matching can be seen as *referential* performances, for they involve the language–world relation (=reference) as mediated by visual perception. In contrast, naming from definition and verbal matching are *inferential* performances, as they exclusively involve the semantic properties of words and sentences. In what follows, we shall use 'inferential naming' – InfNam for the definition-to-noun task, and 'referential naming' – RefNam for the picture-to-noun task. Accordingly, word-to-picture matching tasks (such as selecting the picture of a carrot as corresponding to the word 'carrot') are considered as referential tasks, while word-to-word matching tasks are considered as inferential. It could be remarked that written or spoken words, like pictures, must be perceived to be processed. This is, of course, correct; however, it does not follow that the tasks we regard as inferential are really referential or that there is no significant distinction between both kinds of task. It is one thing to relate (perceived) words to other words, and a different thing to relate pictures (or objects) to words or words to pictures, though perception is involved in both cases, at some stage.

Let us now consider the neuropsychological evidence in some detail.

1.1. *Spared inferential, impaired referential processing*

In a number of cases, impaired referential tasks (e.g., picture naming and/or word-to-picture matching) go together with good or even excellent inferential abilities. Most cases of "optic aphasia" fall within this category. For example, JB, a patient reported by Riddoch and Humphreys (1987b) scored 45.5% on naming from vision and obtained an accuracy of 70% on a word-to-picture matching with target and distractors which were visually and semantically similar (100% when