IMAGING SYNTAX AND SEMANTICS IN THE BRAIN

STEFANO F. CAPPA

Vita-Salute University and San Raffaele Scientific Institute, DIBIT Via Olgettina 58, Milan, 20132, Italy

Functional imaging, in particular functional magnetic resonance, has been extensively applied in the last decades to the investigation of the neural substrates of language processing. In my talk I consider the study of semantic and syntactic processing in the human brain. The main emphasis is historical, with a special consideration of the mutual relationship between the traditional, lesion-based approach to the neurology of language and the contributions of the tremendous development of imaging techniques of the last decades.

1.1. Semantic processing

In psycholinguistics, word meaning is generally considered to be closely connected to conceptual representations. In his inaugural paper on the neurology of language, Wernicke felt the need to provide a theory of conceptual representations, which is in many ways similar to some contemporary models, assuming distributed representations in modality specific and heteromodal cortical areas. It is thus impossible to separate functional imaging studies of semantics from those investigating conceptual knowledge. Several reviews are available, providing an exhaustive coverage of what is now an impressive body of research (Binder, Desai, Graves, & Conant, 2009; Cappa, 2008). Overall, functional imaging has confirmed the concept that the neural system underlying semantic knowledge is distributed in the brain. Dynamic maps of conceptual and lexical-semantic representations appear to be modulated by at least three factors: modality of stimulus presentation (typically, words vs. pictures), category membership (for example, objects, actions, abstract concepts) and task requirements (naming, categorizing, monitoring, etc.).

1.2. Syntactic processing

While the assumption of a distributed semantic system was already present in the classical anatomo-clinical aphasia literature, the idea that syntax is localized in the brain, specifically in Broca’s area, was a direct consequence of the
relatively strong correlation between the clinical syndrome of agrammatism and damage to Broca’s area (see Cappa, 2012 for a review). Many of the early imaging studies dealt with single word processing. At this level, the only insight into the possible correlates of syntactic processing could be derived from studies contrasting nouns and verbs (for a review, see Vigliocco, Vinson, Druks, Barber, & Cappa, 2011). The complex pattern of results of these studies indicates that, once we take into account the confounding in most studies between semantic distinctions (objects vs. actions) and grammatical distinction (nouns vs. verbs), and the conflation between studies concerned with mechanisms of single word processing and those studies concerned with sentence integration, clear neural separability is observed between the processing of object words (nouns) and action words (typically verbs), while grammatical class effects emerge only for tasks and languages imposing greater processing demands. Sentence level processing has also been extensively investigated. As in the case of semantic processing, there are multiple aspects related to task requirements, which should be taken into proper consideration when interpreting the results of imaging studies. A complementary, productive line of investigation is based on the study of the brain correlates of the acquisition rules in artificial grammars, and specifically on the contrast between grammars at different ranking of Chomsky’s hierarchy (Chomsky, 1956). Some imaging studies investigated this subject extracting the rules of an artificial language (Tettamanti et al., 2002), or learning possible (hierarchical, non-rigid) or impossible (linear, rigid) rules of real languages they did not know (Musso et al., 2003). The comparison of the neuroanatomical correlates underlying the acquisition indicated that only hierarchical rules result in specific activation of Broca’s area. The processing of hierarchical dependency rules was specifically associated with activation of Broca’s area and neighboring ventral premotor cortex. This finding does not seem to be limited to the language domain. (Tettamanti et al., 2009) contrasted the acquisition by normal subjects of rigid (linear) and non-rigid (hierarchical) syntax in a visuo-spatial task consisting of linear sequences, confirming the crucial role of Broca’s area.

1.3. References and Citations

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References


