

Metaphor Comprehension and the Right Hemisphere and the Connectionist Paradigm

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Abstract

Objective: To review the current status of the contribution of connectionism to the understanding of the participation of the right cerebral hemisphere in metaphor interpretation and semantic processing.

Materials and methods: Literature review and discussion of recent advances in the field. The subject is illustrated with a real case of a right-handed man in whom an ischemic stroke was at the origin of metaphor interpretation impairment.

Results: The interpretation of new, previously unknown, metaphors seems particularly sensitive to lesion of the right cerebral hemisphere. Both hemispheres and different cortical zones are implicated, however, their engagement does not appear to be static and vary according to the requested task. Impairment in working memory can also influence the clinical performance on metaphor interpretation after cerebral damage.

Conclusion: The participation of the right cerebral hemisphere to metaphor processing highlights the necessity to conceive the semantic processing in the form of a system of distributed networks. The clinical consequences of right hemisphere damage are detectable and quantifiable in the acute setting.

Keywords: Right cerebral hemisphere • Metaphor • Lexical-semantics • Language • Memory • Naming

Introduction

Language is one of the bases of the human intellect and plays a critical role in the construction of thought. It is an advanced cognitive function, involving the ability to decode messages and express complex ideas in a variety of contexts. During the 19th and 20th centuries, the study of human language was highly influenced by topographic theories, which proposed that cognitive functions were mediated by specific areas. These neural models were grounded on works on acquired cerebral lesions, including the seminal ones performed by Broca, Wernicke and Geschwind [1].

One of the fundamental concepts of localizationist theories is the dominance of the left cerebral hemisphere in language processing. Current models have supported the participation of contralateral cortical and subcortical structures and challenged the classical ones. The acknowledgement of simultaneous recruitment of hierarchically organized networks disputes the validity of attributing static functions to specific cerebral sites, such as Broca's or Wernicke's areas in the left hemisphere [2].

In the same line, certain acquired language deficits may not correspond to what is expected in classic diagrams. In this paper, these concepts were illustrated in the case of a right-handed man in whom an ischemic stroke involving the right cerebral hemisphere gave rise to semantic disturbances, especially difficulties in interpreting metaphors. The anatomical and functional features of the aforementioned areas and their importance in semantic processing were revisited, with a focus on metaphor processing [3].

Case Presentation

A 77-year-old right-handed man presented with sudden left hemiparesis, labial commissure deviation to the right and asthenia. His family brought him to the emergency department where he was diagnosed with a stroke. At admission, dysarthria was noticed. Directed examination also revealed difficulties in naming, lexical evocation and metaphor interpretation. Neuroimaging investigation revealed an ischemic lesion in the right insular, temporal and parietal lobes (Figure 1) [4].

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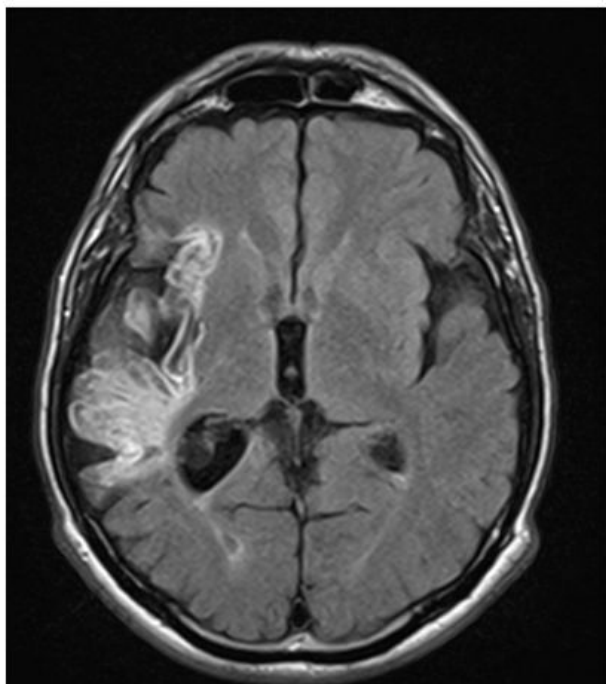


Figure 1. Magnetic resonance imaging, axial T2 FLAIR (Fluid Attenuation Inversion Recovery) revealed an ischemic lesion in the right insular, temporal and parietal lobe.

The patient was assessed and followed by a speech therapist. He was a retired truck driver who completed middle school education. His language disturbances did not significantly impair performance of simple activities of daily living. There was no clinical evidence of hearing loss and the distortion product otoacoustic emissions testing

was normal. The montreal communication evaluation battery was applied for the characterization of persistent impairments 6 months after hospital discharge. This battery comprises 14 tasks that evaluate four domains of linguistic processing: Discursive (narrative discourse), pragmatic (interpretation of metaphors, interpretation of indirect speech acts and conversational discourse), lexical-semantic (lexical evocation, semantic judgment, and interpretation of metaphors) and prosodic (linguistic and emotional prosody).

Conversational discourse was evaluated for 5 minutes. It was noted constant and reproductive difficulty in the metaphor comprehension. The metaphor interpretation test is a trial comprising 20 metaphors. Ten of them are new (non-lexicalized) and 10 are idiomatic expressions (lexicalized). He was able to match only six, all of which were idiomatic expressions. He also affirmed having difficulty in understanding metaphorical constructions from his interlocutors during spontaneous conversations.

For lexical-semantic processing, verbal fluency tests were used. The patient was instructed to close his eyes and recall the maximum possible number of words in two and a half minutes, not including forenames or numbers. There were no evident differences between his performance and what was expected considering his age and level of education, regardless of whether the task was or was not constrained by orthographic or semantic criteria. During the assessment of listening comprehension, repetition, naming, reading and writing abilities, only rare episodes of anomia were observed. The patient maintained his ability to describe characteristics and utility of objects. An informed consent was obtained to the proposal of this report. The complete results of montreal battery are available in the supplemental material along with reference values (Table 1) [5].

Task	Goal	Stimuli	Score (reference value)
Questionnaire about awareness of difficulties	Investigating how conscious they are of the linguistic disturbances and how it affects their daily life	Seven yes or no questions	(5/7)
Conversational discourse	Examining verbal and non-verbal behavior in conversations	Four possible options of topics to discuss, two are chosen	22 (34)
Metaphor interpretation	Verifying understanding of metaphorical sentences	Twenty sentences: First 10 are new metaphors, last 10 are idiomatic expressions	6 (40)
			6 (20)
Lexical evocation	Assessing verbal fluency ability through the emission of the biggest amount of words	Free	6
		Orthographic criteria for the letter p	4
		semantic criteria: Clothing category	4
Linguistic prosody	Investigating the understanding and repetitive production of two interrogative, affirmative and negative intonations	Understanding of 12 sentences, 3 interrogative ones, 3 affirmative and 3 negative	(9/12)
		Repetition	(12/12)
Emotional prosody	Assessing the understanding and production of two intonations that indicate joy, anger and sadness	Understanding of 12 sentences; three indicating joy, three indicating anger, and three indicating sadness	(9/12)
		Repetition	(12/12)
		Spontaneous production	(13/18)

Narrative discourse	Examining partial and complete retelling of narrative discourse and its comprehension	Partial retelling	Essential (10/18), Presents (13/29)
		Complete retelling, with comprehension questions	(10/13)
		Titles	(9/12)
Interpretations of indirect speech acts	Ascertain the comprehension of indirect speech acts (implicit requests)	Ten situations: 10 with direct speech acts	(30/40)
		10 with indirect speech acts	(17/20)
Semantic judgment	Analyzing ability of semantic judgment (verifying existence of relation between two words)	Twenty-four pairs of words: 12 with semantic relations	Existence (23/24)
		12 with no semantic relations	Compr. (07/12)

Table 1. Performance in the montreal communication evaluation battery.

Results and Discussion

The participation of the right hemisphere in processing metaphors was proposed to be related to the activation of broad semantic fields and integration of concepts that may have distant relations. This integration would require distant sites for the performance of complex mental tasks, such as the interpretation of metaphors. Difficulties are generally more evident when new, previously unknown, metaphors are presented. In a meta-analysis of functional magnetic resonance studies, Yang et al., associated processing of new metaphors with broad activation of right fronto-temporal areas. This was the case for the middle and inferior frontal gyri, superior temporal gyrus, insula, superior and middle temporal gyrus. The complexity of the message behind a new metaphor may require activation of several semantic fields and dynamically influence the engagement of the right hemisphere. fMRI results during metaphor processing in four conditions: Literal sentences, familiar and easy to understand metaphors, unfamiliar and easy to understand metaphors and unfamiliar and difficult to understand metaphors. They noticed stronger right hemisphere activation for unfamiliar sentences containing distant semantic relationships. In a recent meta-analytic review right hemisphere involvement was confirmed for novel metaphors only [6].

The conceptual metaphor theory establishes three general principles underpinning the ways interpretations are obtained. The first states that interpretation relies on cognition. The second describes two interpretation domains: The source-domain, more concrete and accessible and the target-domain, related to abstract concepts, more difficult to access. The third principle considers that semantics is an experiencing process of the individual. Ultimately, it comes down to a perspective that comprises not only linguistic issues, but also cognitive and social aspects. As such, there are figures of speech that have been established in the linguistic culture of speakers as idiomatic metaphors, in which the left hemisphere is strongly activated by the literal meaning. New metaphors would demand, however, more acute cognitive processing and difficulties in interpretation may be a consequence or enhanced by misunderstanding of infrequent ambiguous terms.

Metaphor interpretation have associated to the role of the right hemisphere in evocation of concrete words independently of their grammatical classes. This would explain interpretation difficulties in certain right hemisphere lesions. Besides interpretation perse, the integrity of some related systems may be required for adequate completion of the task.

This is the case, for instance, of the visual system. The ability to recognize visual representations is a requirement for adequate interpretation of written metaphorical language. Other structures such as the right middle temporal gyrus, inferior portions of the temporal lobe and the inferior parietal lobule are important for understanding albeit not classical language areas, as their lesion may have significant impact attention, cognitive control and working memory. Interestingly, in the illustrative case described above, the patient was required to elevate his reading level for that of a more complex narrative text and to explain his understanding of it. He did not perform the task satisfactorily with great difficulty on retaining information.

In the clinical setting patients are often asked to recall the highest number of words in a limited period of time in verbal fluency tests. It is worth noting that the integrity of working memory is a necessary condition for maintenance of non-verbal semantic activation. As a consequence, poor performance in semantic testing (even non-verbal) can be, at least partially a result of difficulties in maintaining semantic representations. Evoking words is a process of editing memory fragments, which are organized by working memory and executive functions. Evoking memories involves spontaneous or voluntary return of stored information, requiring organization of memory traces in a sequence that is also coherent with time (temporary integration). Working memory abilities enable the individual to contextualize and manage information.

Memory integration and semantic processing

The observation of semantic-lexical evocation difficulties in patients with right hemisphere lesions is heterogeneous and subject of discussion. When a formal criterion was used (such as words starting with a predetermined letter), abnormal performance was reported in certain studies but not in others. It was suggested that patients with right hemisphere lesions present with worse performance when a semantic criterion is used [7].

The lexical-semantic process of evoking a word involves the integration of cognitive, emotional, linguistic and memory aspects. For this integration to occur, several brain areas must interact. The inferior fronto-occipital fasciculus, an associative bundle that connects the occipital lobe, parietal lobe and postero-temporal cortex to the frontal lobe, has being directly associated with the semantic system and pointed as a strong candidate for the anatomical substrate of these connections.

Deficiencies in semantic memory may produce difficulties in evoking and naming, since these are aspects that involve information retrieval. This difficulty may be seen in trauma or stroke patients due to impaired access to lexical storage. Long term storage is influenced by integrity of hippocampus and is highly influenced by the individual's experiences or learned concepts. Further, humans establish a long term correspondence with the event and the importance of what has happened. To establish the importance of an element, the degree of attention is a primary factor. Individuals with the capacity to maintain attention and concentration are favored in the learning process.

Naming requires previous validation of learnt words. Since, human language learning is established through social activities, it is the result of a socio-historical and cultural process. As a consequence, language is supported by a dynamic, flexible and variable functional system. Our descriptions of the language-processing network based mainly on location its elements have a high risk of being reductionist, given the difficulty to take into account historical and socio-cultural specificities [8].

Insula, emotion and language processing

The individual-environment interaction can modify responses to the environment stimuli with time through neuroplasticity mechanisms. A role in coordinating higher-order cognitive aspects of speech or other forms of language production has been proposed to the insular lobe. It may serve as a language area for both propositional comprehension of emotionally charged sensory input (posterior insula) and emotionally intoned or motivationally charged verbal output (anterior insula) As a consequence, the insula may be the anatomical substrate of a language-limbic link, which serves to attach emotional and motivational value to incoming verbal information [9].

A recent meta-analysis of 42 fMRI studies has shown right-sided insular activation in the ventral granular zone during speech perception and expressive language stimuli. The right anterior insula could be functionally engaged during language tasks thanks to the existence of functional (and anatomical) connections with frontal right-hemisphere regions that support language functioning. Alternatively, its activation could be related to simultaneous, parallel, cognitive processes related to the tasks. Less effortful tasks seem to preferentially recruit posterior parts of the insula, while metaphors and unusual language recruit more anterior parts [10].

Conclusion

Activation of the insula in the fMRI during speech and semantic decision-rest tasks is not rare. It has also been attributed to the insula, albeit sporadically, functions of naming, word location and articulation. Damage to the precentral insular gyrus has also been reported as a possible cause of speech apraxia. The participation of the right cerebral hemisphere to metaphor processing highlights the necessity to conceive the semantic processing in the form of a system of distributed networks. The clinical consequences of right hemisphere damage are detectable and quantifiable in the acute setting.

Declaration of Significance

In the present paper, the participation of the right hemisphere in lexico-semantic aspects of language was revisited, with a special attention to metaphor interpretation. The necessity to conceive the semantic processing system in the form of distributed networks is highlighted, in which both cerebral hemispheres and different cortical zones participate. Moreover, the recruitment of different cortical areas does not appear to be static but varies according to the requested task, as is the case of interpretation of new or previously known metaphors. These observations have direct clinical applications, as illustrated in the present case of acute cerebral ischemia.

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Conflict of Interests

The authors declare they have no conflict of interest.

Statement of Ethics

The study was approved by the Southwest Bahia State University-UESB/Ethics committee.

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