## SHORT REVIEW

# Beyond Laterality: A Critical Assessment of Research on the Neural Basis of Metaphor

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**Abstract**

Metaphors are a fundamental aspect of human cognition. The major neuropsychological hypothesis that metaphoric processing relies primarily on the right hemisphere is not confirmed consistently. We propose ways to advance our understanding of the neuropsychology of metaphor that go beyond simple laterality. Neuropsychological studies need to more carefully control confounding lexical and sentential factors, and consider the role of different parts of speech as they are extended metaphorically. They need to incorporate recent theoretical frameworks such as the career of metaphor theory, and address factors such as novelty. We also advocate the use of new methods such as voxel-based lesion-symptom mapping, which permits precise and formal tests of hypotheses correlating behavior with lesions sites. Finally, we outline a plausible model for the neural basis of metaphor. (*JINS*, 2009, 1–5.)

**Keywords:** Figurative language, Right hemisphere, Career of metaphor, Novelty, Salience, Abstraction

## INTRODUCTION

Since Aristotle, metaphor has been regarded as a poetic and rhetoric tool distinct from ordinary language use (Ortony, 1993). However, recent work suggests that metaphors are used pervasively in human communication (Lakoff & Johnson, 1980). Cognitive processes underlying metaphor comprehension may reflect the unique nature of human intelligence (Gentner, 2003) and can break down in common disorders such as schizophrenia (Kircher, Leube, Erb, Grodd, & Rapp, 2007), autism (Norbury, 2005), and stroke (Winner & Gardner, 1977). Understanding the neural basis of metaphor and the forms of its breakdown is clearly an important goal for neuropsychology. Yet recent research in the neural basis of figurative (nonliteral) language, and in particular metaphor, has been fraught with inconsistencies.

To pave the way forward in neuropsychological studies of metaphors, we address several key questions in this review. How have methodological issues contributed to conflicting laterality results? Can theoretical approaches to metaphor inform the study of its neural basis? Are there principled differences between different kinds of metaphors? How can recent methodological advances in functional imaging and lesion analyses refine our brain–behavior investigations? Finally, can extant observations be compiled into a plausible model for the neural basis of metaphor?

## A BRIEF REVIEW OF LATERALITY OF METAPHOR HYPOTHESES

Language, including its abstract and pragmatic aspects, has historically been associated with the left hemisphere (LH), as seen in the work of early neuropsychologists. Goldstein (1878–1965) introduced the concept of *abstract attitude*, an abstract, conceptual structure of thought separate from language (Noppeney & Wallesch, 2000). This emphasis on abstract conceptual structure is echoed in current theories of metaphor comprehension, which are also based on abstract categories. In the metaphor *My job is a jail*, we assign *job* to a newly defined abstract category of unpleasant, confining situations (Glucksberg, 2001). Goldstein linked impairment of abstract attitude to left temporoparietal lesions (Noppeney & Wallesch, 2000). Thus, early LH attributions of abstractions could apply to metaphor processing.

Consideration of right hemisphere (RH) contributions to language processing was rooted in clinical observations that

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patients with RH brain lesions have subtle but undeniable difficulties with abstract language (Eisenson, 1962). Subsequently, metaphor was shown to have a primary role in RH language. In a seminal study, Winner and Gardner (1977) reported that patients with RH, more than LH, injury had trouble matching metaphorical sentences (*A heavy heart can really make a difference*) to pictures, a finding subsequently replicated (e.g., Mackenzie, Begg, Lees, & Brady, 1999).

Jung-Beeman's coarse coding hypothesis is commonly used to explain this RH bias for metaphor processing (Jung-Beeman, 2005). According to this hypothesis, the RH activates, integrates, and selects semantic items in a more distributed, or *coarser*, manner than the LH. Thus, the RH is particularly adept at associating words that are less closely related compared to the LH. Such an organization could explain the RH's importance for metaphor processing. Metaphors, as compared to literal sentences, link words with distant semantic relationships (e.g., A *camel* is a desert *taxi* compared to A *camel* is a desert *animal*).

## METHODOLOGICAL ISSUES

Despite early theories and findings, subsequent work has not been consistent in implicating the RH in metaphor comprehension. These inconsistencies can be attributed to both methodological and theoretical issues.

### Subject Selection

Early work did not differentiate lesion sites within the RH, nor did it always control for time since injury or age-related cognitive decline independent of injury. Other studies controlling for these factors did not support the RH dominance hypothesis. For example Giora, Zaidel, Soroker, Batori, & Kasher (2000) report that participants with RH injury did not perform differently than controls on a test of metaphor comprehension and actually did better than patients with LH injury.

### Task Selection

Differences in task have also likely contributed to discrepant findings. Patients are usually tested with sentence–picture matching tasks. However, patients with RH lesions perform better than LH patients when asked to provide oral explanations of metaphors (Winner & Gardner, 1977; Giora et al., 2000). This reversal suggests that the material (visual *vs.* verbal) rather than the figurative nature of the early tasks may account for the impairments observed in patients with RH injury. Indeed, Zaidel, Kasher, Soroker, & Batori (2002) reported no significant differences between LH and RH injured patients on metaphor comprehension tests when controlling for visuospatial and language deficits.

### Stimulus Selection

Researchers have also examined metaphor comprehension at the word rather than sentence level, comparing words

associated metaphorically (*warm-loving*) and literally (*warm-blanket*). Some reported that patients with RH injury rely more on literal meaning relationships than patients with LH injury (e.g., Brownell, Simpson, Bihrle, Potter, & Gardner, 1990), while others reported no differences between these patient groups (e.g., Tompkins, 1990). Such discrepant findings may be due to uncontrolled lexical confounds. For example, Brownell et al. (1990) used adjectives in the metaphor condition and nouns in the control condition.

Work with healthy participants has also used stimuli with potential confounds. The first visual hemifield study of metaphor reported a selective advantage to left visual field presentations for processing metaphorically primed words (Anaki, Faust, & Kravetz, 1998), suggesting a RH processing advantage. More carefully controlled hemifield studies (Coulson & Van Petten, 2007; Kacinik & Chiarello, 2007) fail to show clear laterality. These later studies controlled for several psycholinguistic variables known to impact ease of lexical access (e.g., final word imagability, frequency, and cloze probability), as well as the interpretability of the sentences. Thus, lateralized effects observed in the past may have reflected lexical and sentential factors rather than figurativeness.

Imaging studies are also plagued by lack of stimulus controls. An early study reported that right frontal and temporal regions have unique roles in metaphor comprehension (Bottini et al., 1994). While some recent studies report right temporal (e.g., Arzouan, Goldstein, & Faust, 2007; Mashal, Faust, & Hendler, 2005; Pobric, Mashal, Faust, & Lavidor, 2008) or frontal (e.g., Stringaris et al., 2006) involvement in processing metaphoric sentences or word pairs, others report only LH involvement (Eviatar & Just, 2006; Lee & Dapretto, 2006; Mashal et al., 2009; Rapp et al., 2004). These studies have used different kinds of stimuli, including word pairs (e.g., Arzouan et al., 2007; Lee & Dapretto, 2006; Mashal et al., 2005; Pobric et al., 2008), conventional metaphorical sentences (e.g., Eviatar & Just, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2004), and unusual or novel sentences (Bottini et al., 1994; Mashal, Faust, Hendler, & Jung-Beeman, 2009). Examining neural differences in processing metaphorical relations in word pairs compared to sentences is clearly warranted. In addition, these studies do not consistently control for differences in difficulty between metaphoric and literal conditions. Given the sensitivity of functional magnetic resonance imaging data to differences in time taken to perform a task, these likely confounds make results difficult to interpret.

## THEORETICAL ISSUES

Most cognitive neuroscience research treats all metaphors as essentially equivalent, assuming that findings from one class of metaphors extend to all others. Studies sometimes mix various types of metaphors together, again implicitly assuming some core metaphoric process is engaged by all forms of metaphor. We suggest two aspects of metaphor need to be considered. First is the lexical class (part of speech) of the

words being used metaphorically, and second is how the processing of a metaphor changes over time.

## Abstraction

Psycholinguistic accounts of metaphor tend to focus on nominal (noun-based) metaphors (*That baby is an* angel). However, metaphors based on verbs (*She* ran *for president*), prepositions (*Chandelier earrings are* out), and adjectives (*He has a* warm *heart*) are used commonly. When verbs and prepositions are used metaphorically, no explicit comparison or mapping of a target word to a base word (*angel* and *baby* in *That baby is an angel*) occurs as in nominal metaphors. For example, the semantic concept of kicking includes a particular manner of moving the foot forward as well as conceptual attributes of changing the position or state of the kicked item. We propose that in a predicate (verb-based) metaphor like *kick the habit*, the concrete sensory and motor attributes of the meaning (moving the foot forward) are shed, leaving the conceptual attributes of kicking (a change of state) to do the metaphoric work (Chen, Widick, & Chatterjee, 2008).

We hypothesize that the brain areas mediating metaphorical uses of nouns and verbs may be different because objects and actions (e.g., Kable, Lease-Spellmeyer, & Chatterjee, 2002), like nouns and verbs (e.g., Damasio & Tranel, 1993), have different neural instantiations. One possibility is that semantic concepts are neurally processed in close proximity to areas that subserve related sensory or motor functions (e.g., Simmons & Barsalou, 2003). For instance, the concept of *kicking* would recruit neural areas overlapping with or adjacent to the relevant motor area. Extended to metaphor, the abstraction of a metaphorical meaning from an action such as *kicking a habit* may also recruit relevant motor or sensory neural regions (Gibbs, 2006). Thus, metaphors based on different sensory–motor concepts may have distinct neural substrates, depending on the sensory–motor features underlying each metaphor. Alternatively, if predicate metaphors work precisely by shedding their sensory–motor features, then their neural organization might not clearly follow a sensory–functional organization. Instead, metaphorical use of action words may activate regions associated with the abstraction of perceptual motion (Chen et al., 2008). Two studies report that, while processing literal verbs recruits corresponding motor areas related to hand, foot, and mouth actions, processing metaphorical abstractions of these verbs does not (Aziz-Zadeh & Damasio, 2008; Raposo, Moss, Stamatakis, & Tyler, 2009).

Unless lexical differences are taken into consideration, investigations into the neural bases of metaphors may continue to yield mixed results. Distinguishing and comparing metaphors based on nouns (Rapp et al., 2004; Schmidt, DeBuse, & Seger, 2007), verbs (Chen et al., 2008), and adjectives (Lee & Dapretto, 2006; Mashal et al., 2005), and avoiding mixed lists of metaphors (Eviatar & Just, 2006) is important in future experiments. In addition, metaphors based on different modalities may be subserved by different neural substrates. Contrasting metaphors based on different sensory qualities (e.g., audition *vs.* vision), including olfaction (*That idea stinks*) and taste (*She has a sweet personality*), might reveal at least partially unique neural instantiations.

## Conventionalization

The career of metaphor theory (Bowdle & Gentner, 2005) suggests that metaphors have a natural history: they start as novel expressions, evolve into familiar or conventional metaphors, and eventually may become dead metaphors that have lost all sense of being figurative. In this view, the conventionalization of a newly coined metaphor is a gradual process, but ultimately novel and conventional metaphors are processed in fundamentally different ways. Novel metaphors may be processed using comparisons in which the semantic attributes (most often relational) of one concept are mapped onto another concept (Bowdle & Gentner, 2005). In the metaphor *Socrates was a midwife,* the structured semantic representation of a midwife helping a woman give birth (produce a child) is mapped onto a representation with an equivalent relational structure (i.e., Socrates helping a student produce ideas). Conversely, conventional or familiar metaphors may be processed by categorization. In the metaphor *My job is a jail*, *job* and *jail* are assigned to a category of unpleasant, confining situations (Glucksberg, 2001).

While both novel and conventional metaphors use words figuratively, the career of metaphor hypothesis anticipates that their underlying processing and neural instantiations would be different. Most neuroimaging studies that use highly familiar or conventional metaphors fail to find RH activation (Eviatar & Just, 2006; Lee & Dapretto, 2006), while those that use novel metaphorical relations do (e.g., Arzouan et al., 2007; Bottini et al., 1994; Mashal et al., 2005; Stringaris et al., 2006). This observation means that RH activations in metaphor studies could be mediated by novelty rather than figurativeness, *per se*. A study directly manipulating metaphor novelty supports this view (Schmidt et al., 2007). One possible explanation is that as metaphors become highly familiar, they are categorized and rely more on left hemisphere lexical processes (Glucksberg, 2001).

Giora includes novelty in her concept of *salience*. Salience is a composite construct determined by several factors, including novelty, context, conventionality, and frequency (Giora et al., 2000). Analogous to novelty, the hemispheres may differ in their sensitivity to salience, with a RH bias to process less salient meanings. However, a few studies of novel, nonsalient metaphorical sentences have not found RH involvement (Mashal & Faust, 2009; Rapp et al., 2004). Disentangling effects of salience and novelty, in both metaphorical and literal sentences, remains an important area for future research.

## ADVANCES IN BRAIN–BEHAVIOR METHODS

For research investigating the neural basis of metaphor processing to mature, approaches to anatomy need to be brought in line with contemporary methods.

Several studies on the neural basis of metaphor have been conducted with visual hemifield presentation techniques. There has been some question about the reliability and validity of such techniques (Voyer, 1998; but see Hunter & Brysbaert, 2008). In addition, visual hemifield studies are blind to the details of what is likely to be a complex distributed network underlying metaphor processing. Given imaging, lesion analyses, and transcranial magnetic stimulation methods, there is less ongoing role for visual hemifield research as a probe for the neural bases for cognitive processes.

Neuropsychological studies in the past have also focused on hemispheric differences, an anachronistically coarse level of analysis. Our understanding of metaphoric processing would benefit greatly by adopting more granular approaches to brain–behavior investigations. For example, voxel-based lesion–symptom mapping (VLSM) allows more precise mapping of behavioral impairments to brain lesion location (e.g., Wu, Waller, & Chatterjee, 2007). Adapting such statistical methods from functional neuroimaging to lesion analysis is critical to being more precise about the neuroanatomy of metaphor and allows for the testing of finer grained anatomic hypotheses.

## A PLAUSIBLE MODEL FOR THE NEURAL BASIS OF METAPHOR

The structural mapping theory (Bowdle & Gentner, 2005), suggests that entities and relationships across disparate domains are aligned when comprehending novel nominal metaphors. If the RH codes semantics coarsely (Jung-Beeman, 2005), then alignment of entities would engage the RH. Such alignment might be necessary but not sufficient for novel nominal metaphor processing. The extraction of relationships common across domains might engage the LH. For example, understanding the metaphor *Socrates was a midwife* would entail extracting the relationship common to the two pairs of entities *Socrates - student,* and *midwife - mother.* We have shown that injury to left peri-Sylvian cortices results in deficits of relational knowledge (Wu et al., 2007). Thus, the LH may also be necessary for relational extraction in metaphor processing.

While novel nominal metaphors might engage both the RH and LH, comprehension of predicate metaphors may have a different, but related, pattern of neural organization. While they might not require an explicit mapping of one semantic domain onto another as with nominal metaphors, their comprehension still entails the abstraction of conceptual attributes. For example, the literal motion sentences *The man entered the office* and *The lion entered the cave* share few intrinsic attributes. Yet, the term *enter* highlights a relational structure that can be extended to predicate metaphors, such as *Fear entered my mind.* In the LH, we propose a posterior-to-anterior neural organizational principle whereby abstract motion knowledge increasingly engages more anterior portions of the corresponding motion perception region (Chatterjee, 2008). The metaphorical use of a verb is more abstract than its literal use, which in turn is more abstract

than perception of the concrete features associated with a word's referent. Thus, metaphorical use of action-based verbs would recruit regions anterior to those associated with the abstraction of perceptual motion in the left posterior middle temporal gyrus (Chen et al., 2008). Predicate metaphors when novel may also engage the RH, but for potentially different reasons than nominal metaphors. While novelty may be directly related to RH coarse semantic coding (Schmidt et al., 2007), novelty may have an independent role in the RH.

Our model also takes into account the process of conventionalization based on the career of metaphor theory (Bowdle & Gentner, 2005). RH involvement in metaphor comprehension should be reduced over the course of conventionalization (Mashal & Faust, 2009). For novel predicate metaphors, we propose that as they are first encountered, the sensory–motor properties of the literal meanings of the words may be the basis for meaning abstraction. However, this neural basis might be mitigated as the metaphor becomes conventionalized (Aziz-Zadeh & Damasio, 2008).

## CONCLUSIONS

The dominant neuropsychological hypothesis that the RH processes metaphors is not supported consistently. In addition, this hypothesis remains relatively coarse in its neural claims. By integrating advances in the theoretical approaches to metaphors with contemporary probes of brain–behavior relations, we are poised to make significant advances in our knowledge of the neural bases of metaphor.

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