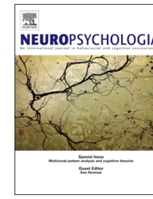
Neuropsychologia 56 (2014) 101–109

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia



Lateralized processing of novel metaphors: Disentangling figurativeness and novelty

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ARTICLE INFO

Article history:
Received 21 July 2012
Received in revised form
9 October 2013
Accepted 4 January 2014
Available online 11 January 2014

Keywords:
Metaphor
Figurative language
Right hemisphere
Salience
Coarse coding
Divided visual field

ABSTRACT

One of the intriguing and sometimes controversial findings in figurative language research is a right-hemisphere processing advantage for novel metaphors. The current divided visual field study introduced novel literal expressions as a control condition to assess processing novelty independent of figurativeness. Participants evaluated word pairs belonging to one of the five categories: (1) conventional metaphorical, (2) conventional literal, (3) novel metaphorical, (4) novel literal, and (5) unrelated expressions in a semantic decision task. We presented expressions without sentence context and controlled for additional factors including emotional valence, arousal, and imageability that could potentially influence hemispheric processing. We also utilized an eye-tracker to ensure lateralized presentation. We did not find the previously reported right-hemispherical processing advantage for novel metaphors. Processing was faster in the left hemisphere for all types of word pairs, and accuracy was also higher in the right visual field - left hemisphere. Novel metaphors were processed just as fast as novel literal expressions, suggesting that the primary challenge during the comprehension of novel expressions is not a serial processing of salience, but perhaps a more left hemisphere weighted semantic integration. Our results cast doubt on the right-hemisphere theory of metaphors, and raise the possibility that other uncontrolled variables were responsible for previous results. The lateralization of processing of two word expressions seems to be more contingent on the specific task at hand than their figurativeness or saliency.

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1. Introduction

In recent decades, experimental work on the neural processing of figurative language has been expanding rapidly. One of the main reasons for the broad interest is the finding that certain patient populations, including people diagnosed with right-hemisphere lesions, schizophrenia, Asperger's syndrome, and Alzheimer's disease, appear to have problems interpreting figures of speech, and specifically metaphors, while they retain mostly intact general language skills (Thoma & Daum, 2006). This observation has lead to the idea that regions beyond classical, left hemisphere (LH) language areas are computing the figurative meaning of metaphors and idioms. To date it remains uncertain if they need a special kind of "extra-linguistic" processing, and if the right hemisphere (RH) is necessarily involved in their comprehension, as has been postulated by the RH theory of metaphor (e.g., Coulson & Van Petten, 2007).

Another core question is the serial or parallel availability of figurative meaning. According to the direct access view by Gibbs (1994), metaphors are comprehended easily in a supportive context, since the literal and figurative meanings are available in parallel. The category assertion view (Glucksberg, 2003; Glucksberg & Keysar, 1990) also suggests that the figurative meaning of metaphors (or at least nominal ones, such as "My lawyer is a shark") is readily accessible as a result of the dual reference of the figuratively used term ("shark") to a literal subordinate category (*marine creature*), and a metaphorical ad hoc superordinate category (*predatory creature*). Bowdle and Gentner (2005), in their career of metaphor hypothesis, propose that only conventional metaphors have such a dual reference, and novel metaphors are processed serially, as a kind of comparison, like similes, following a failed categorization attempt. Nevertheless, beside the question of lateralization, the temporal course of metaphor comprehension is not entirely clear either. The available empirical evidence is inconclusive as to whether metaphors are understood as quickly as literal expressions due to parallel processing, or if they are comprehended slower as a result of serial processing of their figurative meaning.

Thus the two key questions that remain unanswered are (1) what computational steps metaphors require and how these are reflected in the timing of processing, and (2) whether the RH of the brain is necessarily involved in their comprehension. In the following section we are going to review previous findings on the

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0028-3932/$ - see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neuropsychologia.2014.01.003

individual hemispheres′ contribution to the understanding of metaphors, which are often contradictory.

1.1. Metaphors and the right hemisphere

The RH had been regarded as the "mute" hemisphere for decades (e.g., Sperry, 1985). However, accumulating evidence suggests that it plays an important role in language comprehension, and it has been associated with a large variety of linguistic functions (Van Lancker Sidtis, 2006). The most notable of these are related to communicational pragmatics (Pléh, 2000; Van Lancker, 1997), such as comprehending jokes (Bihrle, Brownell, & Gardner, 1986; Brownell, Michel, Powelson, & Gardner, 1983; Coulson & Williams, 2005; Coulson & Wu, 2005; Marinkovic et al., 2011; Shammi & Stuss, 1999), sarcastic statements (Kaplan, Brownell, Jacobs, & Gardner, 1990), irony (Eviatar & Just, 2006), and indirect requests (Brownell & Stringfellow, 1999; Foldi, 1987; Stemmer, Giroux, & Joanette, 1994; Weylman, Brownell, Roman, & Gardner, 1989).

Metaphorical expressions were among the first linguistic materials whose processing was linked to the RH. In an early experiment performed on individuals with brain injury, Winner and Gardner (1977) found that patients with right hemisphere damage (RHD) preferred the literal depiction of figurative expressions relative to patients with left hemisphere damage (LHD). These findings were replicated in further picture naming experiments (Kempler, Van Lancker, Merchman, & Bates, 1999; Rinaldi, Marangolo, & Baldassari, 2004; the latter also controlled for the patients′ visuospatial deficits). Another study found that RHD patients also experienced difficulties with metaphors in purely language-based tasks (Brownell, Simpson, Bihrle, Potter, & Gardner, 1990). A landmark PET study with healthy individuals by Bottini and colleagues (1994) presented novel metaphors to avoid the automatic processing associated with fixed expressions. They found activation in the right middle temporal gyrus, right prefrontal regions, and right precuneus. Subsequent studies also found RH involvement in metaphor comprehension using neuroimaging techniques (Ahrens et al., 2007; Diaz, Barrett, & Hogstrom, 2011; Mashal, Faust, & Hendler, 2005; Mashal, Faust, Hendler, & Jung-Beeman, 2007; Schmidt & Seger, 2009; Stringaris et al. 2006; Yang, Edens, Simpson, & Krawczyk, 2009), event-related potentials (ERPs) with source localization (Arzouan, Goldstein, & Faust, 2007; Sotillo et al., 2005), TMS (Pobric, Mashal, Faust, & Lavidor, 2008), and the divided visual field (DVF) paradigm (Anaki, Faust, & Kravetz, 1998; Faust, Ben-Artzi, & Harel, 2008; Faust & Mashal, 2007; Mashal & Faust, 2008; Schmidt, DeBuse, & Seger, 2007).

Other groups have found no evidence for the RH′s involvement in understanding metaphors (Chen, Widick, & Chatterjee, 2008; Coulson & Van Petten, 2007; Eviatar & Just, 2006; Kacinik & Chiarello, 2007; Lee & Dapretto, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2004, 2007; Stringaris, Medford, Giampietro, Brammer, & David, 2007). One possible explanation for these contradictory findings is that novelty was not systematically controlled in these experiments (Schmidt & Seger, 2009). In support of this hypothesis a recent meta-analysis of fMRI studies on figurative language (Bohrn, Altamann, & Jacobs, 2012) showed that metaphors evoked LH activations, and only novel metaphors – relative to conventional ones – activated RH areas.

1.2. Lateralized language processing models

The most relevant models attribute the RH′s involvement in language comprehension to slightly different, but closely related linguistic factors. The RH′s participation is generally not attributed to figurativeness per se, but to its sensitivity to novel and unusual meanings (Beeman, 1998; Chiarello, 1991, 2003; Giora, 2003; St. George, Kutas, Martinez, & Sereno, 1999). The graded salience hypothesis (Giora, 1997, 1999, 2003) proposes that, regardless of figurativeness, salient meanings are processed by the LH, while non-salient meanings are processed by the RH. According to this view, the LH processes conventional metaphors, since they have a salient meaning, even if it is figurative. Novel metaphors, on the other hand, have no salient meaning and are processed by the RH in a slower, serial manner. Only after their salient literal meaning has been rejected can the non-salient, figurative meaning be selected (Giora, 1997, 1999; Giora & Fein, 1999). Saliency is determined by the meaning being coded in the mental lexicon, its prominence, conventionality, frequency, familiarity, and prototypicality. An interesting implication of the theory is that even conventional idiomatic expressions may evoke RH activations when they are interpreted in a non-salient, literal sense. Indeed, this prediction was born out in an fMRI study (Mashal, Faust, Hendler, & Jung-Beeman, 2008).

The coarse semantic coding theory (Beeman, 1998; Beeman et al., 1994) is a language processing model that emphasizes the neural differences of hemispheric organization. The asymmetry in the micro-circuitry of the two hemispheres creates narrow semantic fields in the LH, which code concepts in a fine-grained manner, and broad semantic fields in the RH, which code concepts in a coarse manner. Since elements of conventional expressions are strongly associated, the LH′s narrow semantic fields code them. The comprehension of novel expressions requires the activation of a wide range of meanings, because their constituents are weakly associated, therefore the broad (and hence overlapping) semantic fields of the RH code them. In other words, the lateralization of processing depends on the semantic-feature overlap between constituents. Two factors have been posited to contribute to semantic feature overlap: (1) category membership and (2) strength of association. The RH has been argued to process category members that are not associated (arm-nose), while the LH to exhibit a processing advantage for category members that are also associated (arm-leg) (Chiarello, 1991). As a consequence, the degree of lateralization during processing expressions that do not involve category membership and have no overlapping semantic features (e.g. adjective–noun expressions in the present study) shall be determined by the strength of association.

The Bilateral Activation, Integration, and Selection (BAIS) framework (Jung-Beeman, 2005) is an extended version of the coarse semantic coding theory, which is more flexible in terms of lateralization of language processing. Jung-Beeman proposes that three finely tuned semantic systems work together in a highly interactive manner: the posterior middle and superior temporal gyri activate, the inferior frontal gyrus selects, and the anterior middle and superior temporal gyri integrate semantic information, bilaterally. The fine coding systems of the LH settle on rapid and focused solutions via close links, while the coarse systems of the RH maintain broader interpretations via distant semantic links, in accordance with specific task demands. As a result, any given semantic task might partially place demands on the LH and on the RH – for example, it is possible that activation spreads in a coarse manner, but selection or integration requires fine coding.

Taken together, these models of lateralized language processing do not consider the figurativeness of expressions to be a relevant factor. At the same time empirical studies often fail to point out that the RH processing is not specific to metaphors. The formulation of the conclusion that novel metaphors require RH processing lends itself to the interpretation that the cause is not solely novelty, but also figurativeness. Because of these contradictions the issue needs more clarification.

1.3. Novelty and figurative language

Most metaphor researchers did not study figurativeness independent of novelty, even though a number of groups compared novel metaphors with conventional ones. This is only a partial

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