Budapest University of Technology and Economics

Department of Cognitive Science – Psychology Doctoral School

FIGURES OF LANGUAGE IN COGNITIVE SCIENCE IN THE LIGHT OF FIGURATIVE LANGUAGE PROCESSING IN THE BRAIN

Thesis Points

Bálint Forgács

Supervisor:

Professor Csaba Pléh

Budapest, 2014

Abstract

Metaphors play an important role in scientific language, however it is still not clear how they are computed in the brain. In two empirical studies I provide evidence that if relevant psycholinguistic factors are controlled for, the left and not the right hemisphere is processing novel metaphors, which is not delayed relative to novel literal expressions, suggesting no specific computations. Metaphors are probably understood via an abstract property substitution, as a unique kind of polysemy. In a theoretical paper I propose that they could fulfill two main pragmatic functions: either to cover up, or to highlight information. Finally, in the last paper I explore how particular choices of metaphors in cognitive science can drive research, and can shed light on personal processing preferences of scientists.

Introduction

Metaphors are pervasive in everyday language as a result of their expressive power, and perhaps because of the pragmatic functions they fulfill. They infiltrate, together with analogies, scientific language as well. Elucidating novel, abstract ideas, or explaining phenomenon from a new perspective is often carried out via a mapping of existing concepts, relations, or functions. One example in cognitive science is the THOUGHT IS LANGUAGE metaphor of LOT by Fodor (2008), and another is the THOUGHT IS SENSORIMOTORIC metaphor of embodiment by Lakoff & Johnson (1999). Yet, it is not clear whether mappings between cognitive domains activate subserving brain systems as well (e.g., sensorimotor or language areas), or whether they are epiphenomenal to the transfer of abstract relations, structures, and representations with no actual computations taking place in the neural processors of the source domains.

Understanding the neural underpinnings of metaphor comprehension is crucial to answer such epistemological questions, and to learn more about the nature of mappings across knowledge domains from scientific to everyday contexts. At the same time, a number of profound questions are still unanswered. What are the processing steps in metaphor comprehension, and what role saliency and associatedness plays exactly? Is the right cerebral hemisphere (RH) necessarily involved in, and is there a specific neural substrate dedicated to their comprehension?

The neuroscience of figurative language can shed light on what makes metaphors so prevalent and useful in everyday communication, and also on how scientific metaphors influence understanding or, in other words, how the brain is involved in interpreting itself.

The neuroscience of metaphors

There are two major unsettled debates in the neuroscience of metaphors: (1) the role of the RH, and (2) processing steps necessary for comprehension. Experimental results obtained by psycholinguistic and cognitive neuroscience methods are indecisive so far. One important dimension that has been identified to influence both laterality and computational steps is novelty.

Early neuropsychological (e.g., Winner & Gardner, 1977) and imaging studies (e.g., Bottini et al., 1994) found the RH to be involved in metaphor processing. Several subsequent experiments brought contradictory evidence, and could not confirm the RH's role. One suggestion to solve the puzzle was that idiomatic, or conventionalized metaphorical expressions could be stored as lexical units, and the RH should be expected to process novel metaphors only (e.g., Schmidt & Seger, 2009). This proposal has been confirmed in a recent meta-analysis by Bohrn, Altmann, & Jacobs (2012), who showed that the RH has been activated indeed only in studies where novel metaphors were also presented to participants.

Intriguingly, the argument for the RH's involvement gradually shifted, and eventually has been transformed significantly. It is not the RH processes metaphors – albeit only novel –, but it is novelty that requires RH neural resources, irrespective of figurativeness. Both of the key models of lateralized language processing, the graded salience hypothesis (Giora, 1997, 2003), and the coarse semantic coding theory (Beeman, 1998; Jung-Beeman, 2005) predict that hemispheric processing is independent of figurativeness, and in fact it is novelty that matters (either because of the saliency of the meaning of, or the associatedness of the constituents of expressions). Nevertheless, studies that compared conventional and novel metaphors could not comprehensively address the questions of processing: holding figurativeness constant, they ended up comparing novelty, and results could not provide detailed evidence on metaphor comprehension per se.

One way to aim at metaphor processing directly is holding novelty constant by introducing a novel literal condition. Both studies in Thesis points I & II used this approach, the first in an event-related fMRI paradigm, and the second in a divided visual field paradigm, where lateralized presentation was ensured by an eye-tracker. A further goal of these studies was to control for potential RH processing demands, such as sentence context (expressions were presented in isolation), word imageability, emotional valence and arousal (by including these variables in the statistical analysis as covariates). RH processes for novel metaphors, and in fact for novel expressions in general, were not evident in these experiments.

Such an experimental paradigms also enabled us to scrutinize the question of processing steps. The first models, following Aristotle, proposed a serial processing for metaphors (e.g., Grice, 1975; Searle, 1979), as a result of a necessary transformation into a literal comparison. Reading time experiments did not confirm the prediction, and a number of models have been developed later on, such as the parallel access view (Gibbs, 1994), or the category assertion view (Glucksberg, 2003; Glucksberg & Keysar, 1990), which propose that the figurative meaning of idioms and metaphors is readily available.

While the latter theories assume no essential (qualitative) processing difference between novel and conventional metaphors, the career of metaphor hypothesis (Bowdle & Gentner, 2005) tries to synchronize the above approaches based exactly on such a distinction. Bowdle and Genter's (2005) theory is that conventional nominal metaphors are understood as category statements (because of the grammatical concordance, as proposed by Glucksberg, 2003), but categorization fails with novel metaphors, and they are, in fact, transformed into comparisons – literal similes –, which makes processing slower. (Note that similes are figures of speech that have a literal interpretation, hence sometimes they are labeled as figurative, and sometimes as literal.) Serial processing postulated by the standard pragmatic model lives a second life in disguise in the graded salience hypothesis as well (Giora, 1997, 2003): the non-salient, figurative meaning of novel metaphors should be accessible only following the rejection of the salient, literal meaning.

The results related to Thesis point I & II do not confirm such a serial processing for novel metaphors: they were processed just as fast as novel literal expressions, yet the latter expressions should not require any kind of sequential processing either of salience, or categorization. These studies suggest that other processes might lie in the background of metaphor comprehension, which could be carried out (1) rapidly, or at least not slower than for (novel) literal meanings, and (2) by the left hemisphere's (LH) fine coding systems, which bring the RH metaphor theory into question.

Based on the above results I propose a new model for metaphor comprehension, abstract property substitution. The idea is that neither a literal paraphrasing (into a comparison or a categorization), nor a conceptual mapping is necessary to understand metaphorical expressions. Instead, vehicle terms could go through a rapid semantic filtering, where all concrete, physical properties are suppressed, and form the remaining, enhanced abstract candidates the contextually most relevant one is selected and conceptually substituted. Emergent properties, conceptual mappings, or structural alignment follow optionally as a consequence of elaborating on the metaphor, but for an initial interpretation an abstract property, referred to covertly by the vehicle, is sufficient. This view is close to looking at metaphors as a special kind of polysemy, similarly to what has been partially suggested by Murphy (1996, 1997) – adding that metaphors rather than identifying it, probably create structural similarity, and eventually polysemy.

Why to express something in such a cognitively costly manner, requiring the hearer to carry out extra computations and derive (possible) inferences based on a metaphor? Would it not be simpler to say everything literally? According to Sperber & Wilson's (1995) Relevance Theory this option is not plausible since extra effort yields extra cognitive effects in communication. In fact this principle renders figurative language not paraphrasable into literal equivalents – the effects are just not identical. The theoretical paper related Thesis point III explores tow major possible cognitive effects that the extra computational effort could evoke.

First, metaphors seem to be suitable for indirect speech, utilized to communicate socially risky intentions, beliefs, and desires covertly (Pinker, Nowak, & Lee, 2008). Because the conceptual substitution and consecutive inferences are carried out by the hearer, the intended meaning is up for negotiation, and the speaker is in a position to deny them. Therefore metaphor vehicles can veil a figurative meaning (and perhaps an emotional attitude), especially when there is a possible literal interpretation as well (cf. Cameron, 2007). Second, metaphors could be very useful to elucidate the properties of a given topic by transferring one or more abstract properties via a specific vehicle. The vehicle can serve as a good basis for further relation transfers, eventually enabling the creation of (structure-)mappings, even though it is not a necessary condition for a metaphor to work well – sometimes a single abstract property can shed light on a specific matter sufficiently. The point is that a vehicle can bring along more than a single property, and can serve as a vantage point to infer further abstract properties, such as hidden relations and inner dynamics.

Thesis point IV scrutinizes this feat of metaphors by in a way reversing the issue. When researchers propose models or frameworks they might not simply look for a felicitous metaphor or analogy, but might propose one that in fact reflects their own cognitive architecture. Novel theories could reveal a personal inclination to perceive and interpret phenomenon using a certain set of cognitive operations that are transformed into scientific analogies. There are always aspects of theoretical frameworks that should not be taken literally, or into account at all, but the scientific community might need considerable time to be able to establish the scope of a specific model.

The metaphors of cognitive science

Metaphors have been playing a central role in the language of science, from physics to philosophy. Many expressions might not seem metaphorical anymore (e.g., "electric current" or "sound waves"), since gradually they have become literalized (Gergen, 1990), even though analogies expressed by figures of speech often (mis)led research. However, the state of the neural reality of such systematic mappings across knowledge domains is not well established. Should we take them literally, and expect for example language areas to be active when we conceive the mind in terms of the LOT's metaphor THOUGHT IS LANGUAGE (Fodor, 2008), or should we take them metaphorically, lacking concrete properties specific to language?

Schools and approaches to the mind's workings in cognitive science probably do involve neural activation patterns across knowledge domains and relational structures organized around preferred core brain systems (manifested in complex analogies and scientific metaphors), but as a result of thorough comprehension and elaborated interpretation, not automatic (embodied) activation. A framework that has the potential to address such mechanisms is the Global Neuronal Workspace (Dehaene & Changeux, 2011; Dehaene, Kerszberg, & Changeux, 1998). It proposes that five major cognitive domains (perceptual, motor, attentional, and evaluating systems, together with long term memory) are integrated in a unified workspace, primarily via the recruitment of neurons with long-range horizontal axons across the whole of the cortex. The main system (thought to be responsible for consciousness as well) not simply activates subsystems, but connects them together with all their neural resources to the workspace, and to each other. Such a configuration might enable the cross-domain utilization of systematic relational structures, complex patterns of analogies, and problem solving templates for elaborated understanding and for the reinterpretation of information. In this workspace, however, it is probably the representations of representations that are entertained, not direct experiences, as perceptual and motor systems are only two of the five major domains.

The history of cognitive science (and perhaps science in general) might be a history of borrowing from various brain areas – but not in a literal manner. Sometimes the dominance of people and ideas of a certain neural function or region is transcended by the dominance of people and ideas of other neural functions or regions. A paradigm shift (Kuhn, 1962) is a complete transformation of the institutions, the worldviews, the frameworks, and the metaphors on the one hand, but also it could be a return to a previously visited (neural) perspective on the world, on the other. Most of the time perspectives exist parallel, dating back to the birth of scientific psychology, to the rivalry and between the "imageless thoughts" of the Würzburg School and the structuralists of Leipzig (Pléh, 2009). Even today there seem to be some highly similar, and still unresolvable debates, for example between Fodor (2008) and Pylyshyn (1984), proponents of THOUGHT IS LANGUAGE, and Kosslyn (1994), a proponent of THOUGHT IS MENTAL IMAGERY metaphor, or Lakoff and Johnson (1999), proponents of THOUGHT IS SENSORIMOTORIC. Following the footsteps of Woodworth (1915), these perspectives could be viewed not as incompatible or mutually exclusive, but complementary ones – even in neural terms. The emphasis of a specific take on cognition, such as connectionism's process-defiesrule approach, might actually add to and not take away from Chomskyan, rule based conceptualizations. Extending the more language like, more grey matter based LH processes with the more intuitive, heuristic computations of the RH's dense connections of white matter could be a way to utilize and integrate a great variety of neurocognitive systems into the board understanding of the matter of cognition. Metaphors could help us to view the mind from a perspective unfamiliar to us, but if they are taken figuratively, they could enable a comprehensive perspective on cognition, and allow for arranging various approaches within cognitive science as modules in a metaphorical brain.

Thesis points

Thesis point I

It is the left hemisphere that processes metaphorical noun noun compound words, specifically, the left inferior frontal gyrus (LIFG), if they are conventional, and the left temporal pole and left posterior superior temporal sulcus, if they are novel. The right hemisphere theory of metaphor is challenged by fMRI results. The graded salience hypothesis (Giora, 2003) is unable to account for hemispheric activations evoked by literal and metaphorical, conventional and novel expressions in the experiment. All novel noun noun compound words activated the LIFG, whereas all conventional noun noun compound words activated right temporoparietal areas. Results are interpreted in the light of combinatorial semantic processing (cf. Graves et al., 2010), the extended version of the coarse semantic coding theory (Jung-Beeman, 2005), and semantic 'meaning making' (Bruner, 1990).

The study related to the Thesis point:

Forgács, B., Bohrn, I., Baudewig, J., Hofmann, M. J., Pléh, Cs., & Jacobs, A. M. (2012). Neural correlates of combinatorial semantic processing of literal and figurative noun noun compound words. *Neuroimage, 63*(3), 1432-1442.
DOI: 10.1016/j.neuroimage.2012.07.029

Thesis point II

According to the results of a divided visual field experiment the left hemisphere processes two-word adjective-noun expressions faster, be they metaphorical and/or novel, while conventional metaphorical and literal expressions are processed also more accurately by the left hemisphere. Semantic integration might be the primary computational challenge when comprehending novel expressions, and it seems to be carried out by the left hemisphere. Conventional metaphors take more time to process relative to conventional literal expressions, suggesting some kind of extra processing, perhaps due to the parallel activation of literal and figurative meanings and semantic selection. Novel metaphors are not processed slower than novel literal expressions, arguing against serial processing of figurativeness, but salience as well, which suggest a remarkably fast computation of a relevant metaphorical meaning. The results bring the graded salience hypothesis (Giora, 2003) into question.

The study related to the Thesis point:

Forgács, B., Lukács, Á., & Pléh, Cs. (2014). Lateralized processing of novel metaphors: disentangling figurativeness and novelty. *Neuropsychologia, 56*, 101-109. DOI: 10.1016/j.neuropsychologia.2014.01.003

Thesis point III

Pragmatics could play a key role in metaphor production and interpretation. Metaphors might be especially important in optimizing relevance by, on the one hand, making meaning more concrete via source domains, thus revealing and highlighting hidden relations; and on the other, creating a subtext where intentions and desires can be communicated covertly by indirect speech, concealing risky offers and enabling social bargains. These two pragmatic functions of metaphors are explored in a theoretical study in the light of Relevance Theory (Sperber & Wilson, 1995).

The study related to the Thesis point:

Forgács, B. (2009). Verbal metacommunication – Why a metaphorical mapping can be relevant? (In Hungarian) *Hungarian Psychological Review, 64*(3), 593-605.
DOI: 10.1556/MPSzle.64.2009.3.8

Thesis point IV

Scientific metaphors, and more specifically, particular choices of conceptual source domains (to explain the mind for example) could tell about personal cognitive preferences and the underlying neural architecture of scientists. Scientific models, theories, and schools might be talking about a preference for a specific neural stance, a kind of ease at understanding, driven by cognitive domains such as language or vision, etc. Epistemological traditions might not be viewed necessarily as competing with, but as complementing each other. Major approaches to the mind in cognitive science could be interpreted as metaphorical mappings across knowledge domains, motivated by individual preferences in cognition. As they emphasize one neural system over another, it is possible to arrange them in a comprehensive framework of human epistemology on the basis of neural domains of the brain.

The study related to the Thesis point:

Forgács, B. (2013). The right hemisphere of cognitive science. In Cs. Pléh, L. Gurova, and L. Ropolyi (Eds.), *New Perspectives on the History of Cognitive Science*. Budapest: Akadémiai Kiadó.

References

Beeman, M. J. (1998). Coarse semantic coding and discourse comprehension. In Beeman, M. & Chiarello, C. (Eds.), *Right hemisphere language comprehension: Perspectives from cognitive neuroscience* (pp. 255-284). Mahwah, NJ: Erlbaum.

Bohrn, I. C., Altmann, U., & Jacobs, A. M. (2012). Looking at the brains behind figurative language – A quantitative meta-analysis of neuroimaging studies on metaphor, idiom, and irony processing. *Neuropsychologia, 50*(11), 2669-2683.

Bottini, G., Corcoran, R., Sterzi, R., Paulesu, E. S. P., Scarpa, P., Frackoviak, R. S. J. (1994). The role of the right hemisphere in the interpretation of the figurative aspects of language: A positron emission tomography activation study. *Brain, 117*(6), 1241-253.

Bowdle, B., & Gentner, D. (2005). The career of metaphor. *Psychological Review, 112*, 193-216.

Bruner, J. S. (1990). *Acts of Meaning.* Harvard University Press.

Cameron, L. J. (2007). Patterns of metaphor use in reconciliation talk. *Discourse & Society, 18*(2), 197-222.

Changeux, J. P. (2008). *Az igazságkereső ember*. [L'Homme de vérite] Translated by Csaba Pléh. Budapest: Gondolat. (Original work published 2002)

Dehaene, S., Kerszberg, M., & Changeux, J. P. (1998). A neuronal model of a global workspace in effortful cognitive tasks. *Proceedings of the National Academy of Sciences, 95*(24), 14529-14534.

Fodor, J. A. (2008). *LOT 2: The Language of Thought Revisited*. Oxford University Press.

Gergen, K. J. (1990). Metaphor, metatheory and the social world. In Leary, D. E. (Ed.), *Metaphors in the history of psychology* (pp. 267-299). Cambridge: Cambridge University Press.

Gibbs, R. W. (1994). *The Poetics of Mind: Figurative Thought, Language, and Understanding.* Cambridge University Press, Cambridge, UK.

Giora, R. (1997). Understanding figurative and literal language: The graded salience hypothesis. *Cognitive Linguistics, 8,* 183-206.

Giora, R. (2003). *On our mind: Salience, context and figurative language*. New York: Oxford University Press.

Glucksberg, S. (2003). The psycholinguistics of metaphor. *Trends in Cognitive Sciences, 7*(2), 92-96.

Glucksberg, S., & Keysar, B. (1990). Understanding Metaphorical Comparisons: Beyond Similarity. *Psychological Review, 97*(1), 3-18.

Graves, W. W., Binder, J. R., Desai, R. H., Conant, L. L., & Seidenberg, M. S. (2010). Neural correlates of implicit and explicit combinatorial semantic processing. *Neuroimage, 53*(2), 638-646.

Grice, H. P. (1975). Logic and conversation. In Cole, P. & Morgan, J. (Eds.), *Syntax and semantics 3: Speech acts* (pp. 41-58). New York: Academic Press.

Jung-Beeman, M. (2005). Bilateral brain processes for comprehending natural language. *Trends in Cognitive Sciences, 9*(11), 512-518.

Kosslyn, S. M. (1994). *Image and Brain: The resolution of the imagery debate.* Cambridge, MA: MIT Press.

Kuhn, T. S. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Lakoff, G. & Johnson, M. (1999). *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought.* New York: Basic Books.

Murphy, G. L. (1996). On metaphoric representation. *Cognition, 60*(2), 173-204.

Murphy, G. L. (1997). Reasons to doubt the present evidence for metaphoric representation. *Cognition, 62*(1), 99-108.

Pinker, S., Nowak, M. A., & Lee, J. J. (2008). The logic of indirect speech. *Proceedings of the National Academy of Sciences, 105*(3), 833-838.

Pléh, Cs. (2009). *History and Theories of the Mind.* Budapest: Akadémiai.

Pylyshyn, Z. W. (1984). *Computation and cognition: toward a foundation for cognitive science*. Cambridge, MA: MIT Press.

Schmidt, G. L. & Seger, C. A. (2009). Neural correlates of metaphor processing: The roles of figurativeness, familiarity and difficulty. *Brain and Cognition, 71*(3), 375-386.

Searle, J. (1979). *Expression and meaning: Studies in the theory of speech acts.* Cambridge University Press.

Sperber, D. & Wilson, D. (1995). *Relevance: Communication and cognition.* Oxford: Blackwell. (Second edition with Postface).

Woodworth, R. S. (1915). A revision of imageless thought. *Psychological Review, 22*(1), 1-27.

Winner, E., & Gardner, H. (1977). The processing of metaphor in brain damaged patients. *Brain, 100*(4), 717-729.