# Conceptual Metaphors of Science Prolegomena to a Cognitive History of Science

**David Dunér**

Lund University, Sweden

Submitted: 16.04.2014.
Accepted: 23.11.2014.

## Abstract

The cognitive abilities explained by cognitive science and cognitive semantics can inform us concerning the use of metaphors in science. The thesis is that abstract ideas rest on experiences of the concrete world. In this paper I will explain the use of conceptual metaphors in science, with examples from the mechanistic worldview of the 17th and 18th century. If we proceed from the way people think in general, their mental abilities, reason and cognition, we could get close to an understanding of how scientists during the scientific revolution shaped their ideas about the invisible geometry of matter. This is a cognitive history of ideas. What is called the 'cognitive turn' in the humanities has generated vigorous growth of research, for example, in cognitive poetics, neuroaesthetics, and cognitive anthropology. These approaches try to arrive at an understanding of creative processes. In the historical sciences there is also a growing interest in cognitive-historical analyses, particularly in archaeology and history of science. The aim of the cognitive history of science is to reconstruct scientific thinking on the basis of cognitive theories. The starting point for a cognitive history of ideas that I defend here is that philosophy, science, and mathematics do not really happen just in texts, in language, in laboratories, or in social contexts, but in brains and minds in interaction with the world around the subject, and are thus connected to the body, to perception, thoughts, and feelings. We humans are captured in our brains situated in the world, we are dependent on our thoughts and senses, our prior knowledge, our mental images, when we try to create a picture of the world. Science, in other words, is shaped by our distinctive way of reasoning, not least in metaphors.

**Keywords:** metaphors, cognition, cognitive history, Sweden

## Introduction

Cognitive history concerns how humans in the past used their cognitive abilities in order to understand the world around them and to orient themselves in it, but also

how the world outside their bodies affected their way of thinking. The objective of this paper is to lay the theoretical basis for a cognitive approach to history, providing the tools for a cognitive history that can be tested on the historical sources in order to providing new insights into how people in history perceived their world as a result of an interaction between mind and its environment. This approach has also interdisciplinary consequences. A cognitive history can provide empirical historical data to the research into the biocultural co-evolution of human cognition.

There are three steps towards a cognitive history. First, we have to lay the theoretical foundations for a cognitive approach to history, a new historical theory and method enlightened by cognitive science. If cognitive science is right in its claims concerning human thinking, then its theories must also be valid for people in history with whom we share same cognitive abilities. The second step would be to test the theories of cognitive science on the historical sources to ascertain whether they lead to new explanations and a deeper understanding of human cognitive creativity in history. By these cognitive theories we can open up the hidden thought processes of humans in the past and come closer to an understanding of *how* people thought, not only what they thought, and further study the interaction between the human mind and the surrounding world. The most ambitious step, the third step, is in the long run also to inform the research on the cognitive evolution of the human mind. History can, I believe, contribute to cognitive science and provide empirical historical data concerning how human cognition is a result of time, of history, personal and collective memories, and as a result of the human mind's interaction with its specific environment in time and space.

The first step, that of identifying plausible theories for a cognitive history, is not enough.These theories should also begin doing some work; it must be possible to implement themon the historical sources. A new theory for historical research is of no use if it cannot show any new results, give new explanations and enhance our understanding of the human past. In the long run, this enterprise can contribute to the research on the evolution of cognition, and, as it were, connect Palaeolithic man with the postmodern by studying the cultural evolution and its impact on human cognition.

In order to exemplify the concepts involved, I have chosen examples from the early modern period, that especially was crucial for the emergence of modern scientific thought, but I believe that it could and should be possible to implement a cognitive-historical method on any kind of historical period, topic or material. The early modern period was a time in human history when modern science began to take shape. During the seventeenth and eighteenth centuries, human beings showed a growing interest in the world around them. A new knowledge of nature was acquired,

efficient mathematical tools were constructed and inexorable mechanical laws were introduced. The labyrinths of the human body were mapped; merchants and explorers set foot in foreign lands, and plants and animals were classified in an all-encompassing system. Humankind sought an order in the world, an assumption that the effect followed the cause, and that nothing happens arbitrarily. In order to understand the world around them, they used their cognitive capacities that had gradually been evolving for millions of years.

## Metaphors of the mind

The cognitive abilities explained by cognitive science and cognitive semantics can inform us concerning the use of metaphors in science. The thesis, proposed in cognitive semantics, is that abstract ideas rest on experiences of the concrete world. If we proceed from the way people think in general, their mental abilities, reason and cognition, in other words, if we consider *how* people think, not just *what* they think, we could get close to an understanding of how they shaped their ideas about the world. This is a cognitive history of ideas, a history of thinking. What is called the 'cognitive turn' in the humanities has generated vigorous growth of research into different cognitive explanatory models of human expressions and cultural evolution, for example, in cognitive poetics, neuroaesthetics, and cognitive anthropology.[1] These approaches are combined in a theory of cognitive science in order to arrive at an understanding of creative processes. In the historical sciences there is also a growing interest in cognitive-historical analyses, particularly in archaeology and history of science.[2] The aim of the cognitive history of science suggested here is to reconstruct scientific thinking on the basis of cognitive theories.[3] Research in

[1] Scott Atran, *Cognitive Foundations of Natural History: Towards an Anthropology of Science* (Cambridge: Cambridge Univ. Press, 1990); Michael Tomasello, *The Cultural Origins of Human Cognition* (Cambridge MA: Harvard Univ. Press, 1999); Mark Turner, 'The Cognitive Study of Art, Language, and Literature', *Poetics Today*, 2002, 1:9–22; Alan Richardson & Francis F. Steen, 'Literature and the Cognitive Revolution: An Introduction', *Poetics Today*, 2002, 1:1–8; Michael Tomasello, 'Uniquely Human Cognition Is a Product of Human Culture', *Evolution and Culture: A Fryssen Foundation Symposium*, eds. S. C. Levinson & P. Jaisson (Cambridge MA: MIT Press, 2005), p. 203–217; Scott Atran & Douglas L. Medin, *The Native Mind and the Cultural Construction of Nature* (Cambridge MA: MIT Press, 2008); Brian Boyd, *On the Origin of Stories: Evolution, Cognition, and Fiction* (Cambridge MA: Belknap Press of Harvard University Press, 2009); Denis Dutton, *The Art Instinct: Beauty, Pleasure, and Human Evolution* (Oxford: Oxford Univ. Press, 2009).

[2] Steven Mithen, *The Prehistory of the Mind: The Cognitive Origins of Art, Religion, and Science* (London: Thames & Hudson, 1996); Colin Renfrew, Chris Frith & Lambros Malafouris (eds.), *The Sapient Mind: Archaeology Meets Neuroscience* (Oxford: Oxford Univ. Press, 2009).

[3] Nancy J. Nersessian, 'How do Scientists Think? Capturing the Dynamics of Conceptual Change in Science', *Cognitive Models of Science*, ed. R. N. Giere (Minneapolis MN: Univ. of Minnesota Press, 1992), p. 4–7, 36–38; Nancy J. Nersessian, 'Opening the Black Box: Cognitive Science and History of Science', *Osiris*, 1995, p. 194–211; Nancy J. Nersessian, 'Interpreting Scientific and Engineering Practices: Integrating the Cognitive, Social, and Cultural Dimensions', *Scientific and Technological*

cognitive history has generally dealt with the fundamental cognitive practices such as reading and counting, as well as scientific and religious perceptions.[4]

There are at least three assumptions about thought that a cognitive history of ideas can rest on. In cognitive science it has been ascertained, firstly, that our concepts and reason are associated with and structured by the body, the brain, and our everyday action in the world.[5] Mind is embodied, situated and distributed. Space, the environment in which we live, the registration of the senses, and the movement of the body through the physical landscape, all are significant for thought. Secondly, it has been shown that most of our thinking takes place without us being aware of it. There are unconscious cognitive processes to which the conscious mind has no access, such as memories, mental images, conclusions, and perceptions of meanings. The unconscious conceptual system structures our conscious thought. Thirdly, reason is metaphorical, that is, abstract concepts are understood in terms of concrete ones, as conceptual metaphors allow us to think about one thing with the aid of something else. Based on a knowledge of the known, we draw conclusions about the unknown.

*Thinking*, eds. M. E. Gorman et al. (Mahwah NJ: L. Erlbaum, 2005); see also E. Thomas Lawson, 'Counterintuitive Notions and the Problem of Transmission: The Relevance of Cognitive Science for the Study of History', *Historical Reflections/Réflexions Historique*, 1994, 3:481–495; David Gooding, 'Cognitive History of Science: The Roles of Diagrammatic Representations in Discovery and Modeling Discovery', *Theory and Application of Diagrams* (Berlin: Springer, 2000); Ryan D. Tweney, 'Scientific Thinking: A Cognitive-Historical Approach', *Designing for Science: Implications from Everyday, Classroom, and Professional Settings*, eds. K. Crowley, C. D. Schunn & T. Okada (Mahwah NJ: Lawrence Erlbaum Associates, 2001), p. 141–173; Peter Carruthers, Stephen Stich & Michael Siegal (eds.), *The Cognitive Basis of Science* (Cambridge: Cambridge Univ. Press, 2002); Christophe Heintz, 'Introduction: Why There Should Be a Cognitive Anthropology of Science', *Journal of Cognition and Culture*, 2004, 3:391–408; E. Thomas Lawson, 'The Wedding of Psychology, Ethnography, and History: Methodological Bigamy or Tripartite Free Love?', *Theorizing Religions Past: Archaeology, History, and Cognition*, eds. H. Whitehouse & L. H. Martin (Walnut Creek CA: AltaMira Press, 2004), p. 1–5; Harvey Whitehouse, 'Cognitive Historiography: When Science Meets Art', *Historical reflections/Réflexions historiques*, 2005, 2:307–318.

[4] David R. Olson, *The World on Paper: The Conceptual and Cognitive Implications of Writing and Reading* (Cambridge: Cambridge Univ. Press, 1996); Reviel Netz, *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (Cambridge: Cambridge Univ. Press, 1999); Hanne Andersen, Peter Barker & Xiang Chen, *The Cognitive Structure of Scientific Revolutions* (Cambridge: Cambridge Univ. Press, 2006); Luther H. Martin & Jesper Sørensen, *Past Minds: Studies in Cognitive Historiography* (London: Equinox Publishing, 2011).

[5] George Lakoff & Mark Johnson, *Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought* (New York NY: Basic Books, 1999), p. 3, 7, 10; Mark Johnson, *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason* (Chicago IL: Univ. of Chicago Press, 1987); Francisco J. Varela, Evan Thompson & Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge MA: MIT Press, 1991); John Krois et al. (eds.), *Embodiment in Cognition and Culture* (Amsterdam: John Benjamins, 2007); Paco Calvo & Toni Gomila (eds.), *Handbook of Cognitive Science: An Embodied Approach* (Oxford: Elsevier Science, 2008).

The starting point for a cognitive history of ideas that I defend here is that philosophy, science, and mathematics do not really happen just in texts, in language, in laboratories, or in social contexts, but in brains and minds in interaction with the world around the subject, and are thus connected to the body, to perception, thoughts, and feelings. We humans are captured in our brains situated in the world, we are dependent on our thoughts and senses, our prior knowledge, our mental images, when we try to create a picture of the world. Science, in other words, is shaped by our distinctive way of reasoning, not least in metaphors.

In cognitive semantics, as represented by George Lakoff, Mark Johnson, and others, certain conclusions have been drawn from assumptions in cognitive science about the way humans think. One feature that has been seized on is the fact that humans think metaphorically. Our basic concepts do not function beyond our everyday experiences. To conceptualize non-everyday phenomena or abstract thoughts requires conceptual metaphors. Metaphor can then mean understanding and experiencing something with the aid of something else, or that a structure in one domain is transferred to another, from a source (the sensorimotor domain) to a target (subjective experience) which simultaneously preserves the deductive structure. Metaphors entail conceptualizing something in terms of some other thing, and function in a way as models for less well-known areas. We transfer knowledge about the known to the unknown, from the familiar to the unfamiliar, from the commonplace world, society, human life, engineering and handicraft, to the invisible particle world, to the soul and God. One could say that metaphorical thought means finding similarities between things, but also forgetting dissimilarities, being able to generalize and abstract. The creation and use of metaphors requires creativity and imagination.

Many of our fundamental concepts are organized on the basis of one or more spatial metaphors.[6] There are metaphors that transfer a structure, or proceed from a spatial orientation that arises from the action of the body in physical reality. Our experiences of physical objects give rise to ontological metaphors, that is, seeing events, emotions, ideas, and states as objects, entities, substances, or containers. They can be metaphors such as imagining life as a journey or intellectual influence as a physical force. Time can be understood spatially as something flowing along a line or in a circle. Thinking can be described in terms of movement, moving forward step by step without skipping any stages, or taking the straightest course to the conclusion without going in circles or getting away from the subject. To think is to travel. It is a walk along a path, a voyage on the sea, a journey with or without a goal. The

[6]George Lakoff & Mark Johnson, *Metaphors We Live By* (Chicago IL: Univ. of Chicago Press, 1980), p. 14, 17, 25, 30; cf. Peter Gärdenfors, *Conceptual Spaces: The Geometry of Thought* (Cambridge MA: MIT Press, 2000), p. 2, 255.

researcher can get lost in the labyrinth of reality. He cannot find the narrow trail out of the jungle, he can be driven off course on the ocean of knowledge, or after much searching he may find the straight road towards the goal, 'truth'. The landscape with its settlement, habitability, shifts of light and shade, also gives conceptual patterns. Wilderness and darkness are ignorance and irrationality. Fortified castles and light represent sure knowledge and wisdom. To think is also to see. Knowledge is vision. What is unknown, difficult to comprehend, is obscure darkness. Without knowledge we grope in the dark. To acquire knowledge is to shed light on things, a knowledge that enables us to see and allows new findings to see the light of day. Knowledge brings enlightenment, we see, feel, everything is clear. What is significant and important is of greater weight or size. Similarity is understood as physical nearness, difficulties are burdens, and organizational structures are like physical structures. These metaphors are used unconsciously, automatically in everyday life and arise from our quotidian experience. Without metaphors, abstract reasoning would be impossible.[7]

Metaphorical concepts have their origin not just in our physical but also in our cultural experience. The more layers of metaphors we employ, the more abstract and culturally specific the concept becomes.[8] Some metaphors proceed from some special cultural knowledge, for example metaphors based on Euclidean geometry. People who live in cultures with no knowledge of Euclidean geometry would not understand such metaphors. Euclidean geometry gives the world a specific visual metaphorical structure, a world of relations between points, lines, and circles. In many cases, then, scientific theories and concepts about the world are founded on spatial metaphors with a physical and cultural origin. Philosophers and natural scientists use the same conceptual system as ordinary people in their own culture. In philosophical theories they incorporate the concepts available in the historical context and the general theories, models, and metaphors that are common and typical in the culture to which they belong, but they also rework these basic concepts, see new links, and draw new conclusions. It is the shared concepts and ideas that make a specific philosophical theory comprehensible to people within a particular culture. Philosophical theories can be interpreted as attempts to refine, expand, clarify, and make consistent certain common metaphors and 'popular' or 'general' theories shared by people in a culture. What a particular philosophical theory also does is to select the 'right' metaphors. Differences between philosophical views thus depend on different choices of metaphors. Each philosopher's metaphysics has its origin in what

[7] Lakoff & Johnson, *Philosophy in the Flesh*, p. 59; George Lakoff & Rafael E. Núñez, *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being* (New York NY: Basic Books, 2000), p. 41.
[8] Marcel Danesi, 'The Dimensionality of Metaphor', *Sign Systems Studies*, 1999, 27:60–87, on p. 73–74, 78.

he takes as central metaphors. A 'world-view' can therefore be regarded as a consistent constellation of concepts, especially metaphorical concepts, over one or more conceptual domains.[9] The world-view is the reality for the people of its time.
In philosophical analysis and scientific theory formation, then, metaphors play an important part. Philosophical and scientific texts are more or less strewn with metaphors, analogies, metonymies, similes, and comparisons. In the history of science they have often been dismissed as unscientific and uninteresting adornment.[10] They have mostly been regarded as poetic whims, educational and rhetorical devices, or simply as superfluous linguistic expressions that obscure the view of the true logical structure of the scientific arguments, the purely rational scientific and mathematical. Against this I claim that metaphors, the linguistic form, the tropes that modify the basic meaning of a word, are of crucial importance. They are not mere external ornament, but a major part of creative thought by establishing visual analogies and abstract ideas. For this reason they also provide valuable clues to how scientists think. Scientific reasoning uses metaphors to a great extent as conceptual tools or as theoretical models of the external world. Structural metaphors and process metaphors are particularly common in scientific reasoning, metaphors that try to get away from the emotional and subjective. In science one must form new concepts for the new phenomena one is describing, and this is often done with the aid of metaphors related to what is already known.

## Conclusion

We can divide the cognitive-historical agenda into three undertakings: i) to delve into the current theories of cognitive science, to evaluate and select the most useful theories for historical research; ii) to collect historical data that is representative, challenging and relevant; and iii) to implement the cognitive theories on the collected data, and through this produce new interpretations and theories, that push the field forward.

If this fails, then either (i) the theories and results of cognitive science are false, or (ii) the theories and results of cognitive science are not relevant for historical research. An answer to the first option is that the theories and results of cognitive science are well grounded; there are many experimental proofs that have been carefully checked. If we believe in the scientific enterprise, we can rule out the first explanation. If cognitive science turns out to be completely wrong in its

[9] Lakoff & Johnson, *Philosophy in the Flesh*, p. 338–341, 511.
[10] There are of course exceptions, see Alistair C. Crombie, *Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation Especially in the Mathematical and Biomedical Sciences and Arts* II (London: Duckworth, 1994), part IV; Marta Spranzi, 'Galileo and the Mountains of the Moon: Analogical Reasoning, Models and Metaphors in Scientific Discovery', *Journal of Cognition and Culture*, 2004, 3:451–483.

proclamations, human beings still use categories, metaphors and objects, etc. in their daily lives and in science. This fact still needs an explanation. Turning to the second option; if these theories and results of cognitive science are universal and valid for all humans, this must also include our immediate ancestors in our own species (they must reasonably have had brains). If this is not so, I cannot find any explanation for this other than that the cognitive historian has not yet convinced other historians about it by showing new results that inspire new research on other topics.

My conclusion is that cognitive history is a promising approach for future historical research. First, a cognitive approach to history will give us new tools for analyzing and interpreting ideas in history, explaining events and historical change, and enable us understand in greater detail how people thought, felt and believed as historical beings situated in time and space, and by this enlighten the interaction between the mind and its surroundings. In all, it will let us enter the black box of hidden cognitive processes of human minds in history.

Secondly, with a new cognitive-historical method, new sources will be sought and discovered; material that before seemed to be hard to use will now be useful, and well-known sources must be re-interpreted. Successful new methods provide not only new interpretations and explanations, they discover new facts, use known sources in a new way and discover new sources that can be used in historical research. An empirical cognitive history will explain the cognitive processes behind human encounters with the surrounding world, what happened to the mind in unknown environments, how mental images in science and technology were used, how objects and techniques enhanced thinking in science, and unveiling the metaphorical thinking behind concept formation and the categorization strategies in systematics and taxonomy. In all, such cognitive-historical studies will give new explanations to the emergence of human thinking as an interaction between the mind and the world.

Thirdly, with a cognitive theory, history will contribute to the ongoing research in cognitive science and on cultural evolution. We will arrive at an interdisciplinary historical theory integrated with our collected knowledge. History cannot only borrow and learn something from other disciplines; it will also contribute to the them, and provide important data that will give the clues as how our distant ancestors thousands of years ago gradually enhanced their cognitive abilities and techniques and finally gave birth to us, we postmodern thinking, feeling, and living beings.

The cognitive history outlined hereinrepresents an open field of possibilities. It will take time to explore its vast territory, that is for sure, and the enterprise will require hordes of historians to be occupied for decades. But this endeavor must begin

someday. A cognitive history of ideas relates to the basic human conditions; it unites people in history that we have the experience of living, that we register and participate in the world around us – the flowing in the veins, the storms of emotions, and the escaping thoughts. It provides an understanding of the thoughts and lives of people in history, as sentient and reflective beings. It unveils the hidden thought processes in the past.