Metaphors in Cognitive and Neurosciences Which impact have metaphors on scientific theories and models?

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Abstract

In this article, I am going to explain how the most frequent metaphor types used in cognitive and neurosciences – reification and spatial metaphors, personification, and technological metaphors – are connected to theoretical problems that occur in these scientific disciplines. These theoretical problems include the idea of memory as space, which is connected with the difficulty of a realistic description of the mental lexicon, the problem of free will, and the mind-body problem. Because of some obvious parallels between metaphorical language and arguments made in the scientific description of the mind, I will argue that certain metaphors used in scientific language are not merely linguistic problems but deeply rooted in scientific arguments. This holds for metaphors that scientists are aware of as well as for unconsciously used metaphors. My observations are intended to highlight some characteristics of metaphors in science. Furthermore, they provide a possible approach to investigating the connection between linguistic and conceptual metaphors in complex cases as scientific models.

Ich werde in diesem Artikel beschreiben, wie die häufigsten Metapherntypen in den Kognitions- und Neurowissenschaften – Reifikation und Raummetaphern, Personifizierung und Technikmetaphern – mit theoretischen Problemen dieser Disziplinen verknüpft sind. Diese theoretischen Probleme sind die konzeptuelle Verbindung von Gedächtnis und „Raum“ (oder auch „Platz“), welches mit der Schwierigkeit einer realistischen Beschreibung des mentalen Lexikons verknüpft ist, das Problem des freien Willens und das Leib-Seele-Problem. Da es einige offensichtliche Kohärenzen zwischen metaphorischer Sprache und wissenschaftlichen Beschreibungen von Kognition und Gehirn gibt, werde ich zeigen, dass bestimmte Metaphern in der Wissenschaftssprache nicht nur sprachliche Probleme darstellen, sondern grundlegend mit entsprechenden wissenschaftlichen Argumenten verknüpft sind. Das gilt sowohl für von Wissenschaftlern bewusst eingeführte als auch für unbewusst verwendete Metaphern. Meine Beobachtungen sollen einige Charakteristika von Metaphern in der Wissenschaft deutlich machen. Außerdem zeigen sie eine Möglichkeit, die Verbindung von sprachlichen und konzeptuellen Metaphern in komplexen Fällen wie wissenschaftlichen Modellen zu untersuchen.

1. Introduction: Metaphors in scientific language and thought

The question of how to deal with metaphors and analogies in scientific arguments and theories is probably as old as the philosophy of science itself. Over the last two decades, different branches of research have been devoted to studies on metaphors in different discourses: everyday language, the media, politics, religion, and science. Interestingly, in the research on metaphors in science there are two strands of discussion: one is developing from Conceptual Metaphor Theory and focuses on the nature of language and thought, the other one is much older and dominated by philosophical arguments about the nature of truth and science.

The aim of this article is to bring together the two questions that have been crucial for these discussions: How are metaphors used in scientific language? What does that mean for scientific arguments and theories? In order to combine these two questions one has to face a serious problem: How are metaphorical language and metaphorical thought related?

1.1 Metaphors in science and Conceptual Metaphor Theory

Conceptual Metaphor Theory offers a clear answer to this question: our thinking is metaphorically structured, and so is language. Thus, science has to be metaphoric, too. Another main assumption of Conceptual Metaphor Theory is that metaphoric mapping is experientially grounded, especially bodily experience. Therefore, experience comes first. Our concepts are shaped by basic experiences, and these concepts are expressed in linguistic patterns. These assumptions are fleshed out in the work of George Lakoff and Mark Johnson (L&J) (1980, 1999). Yet L&J's arguments, however convincing, rely heavily upon linguistic data and often lack other empirical evidence. For L&J, language serves mainly as a source of material for their arguments on conceptual mappings. Various scholars have tried to bridge the explanatory gap between the conceptual and the linguistic level and have presented important evidence of a close connection between linguistic and conceptual metaphor from language acquisition and experiments (Boroditsky 2000, 2001, Casasanto 2004, Clark 1973). In their work, the connection between concepts and linguistic patterns in language is shown to illustrate very basic concepts – spatial and temporal relations. If one doesn't want to generalize these results and claim that this also holds for more complex concepts and metaphors, one faces the problem that these experimental methods and this approach to language acquisition are difficult to apply in the case of complex metaphors as they occur in scientific discourse (and others as well). For scientific metaphors, Gentner & Gentner present some evidence that metaphors used in scientific education can influence the student's thinking and ability to solve certain problems (Gentner & Gentner 1983).

But what is the impact of metaphors on scientific research? How important are they for the scientists' own concepts? This has been the concern of many philosophers of science.

1.2 Philosophical views on metaphor in science

The other strand of the discussion about metaphors in science has a very long tradition in the philosophy of science. The question that guided most of the scholars concerned about metaphors in science was: What role do metaphors play in science? Are they dangerous errors which divert from scientific truth, as has been argued by Aristotle or Locke? Or are they useful as heuristic tools in generating scientific questions, but also dangerous traps and obstacles which can lead to initial progress but later stagnation in science, which was Kuhn's argument in his theory of scientific revolutions (1967), where metaphors are an important part of scientific paradigms. Or are metaphors unavoidable in science, as various scholars (Brown 2003, Lakoff & Johnson 1999, Machamer 2000) claim? And if so, can science be truthful at all?

The linguistic aspect of metaphors in science has been of minor importance in this debate, as the focus has been on science and scientific ideas. Language came into the picture when it was argued that science couldn't possibly exist without language as a device for communicating scientific ideas. Therefore, some have claimed that the problem lies in the unbreakable bond between scientific facts and the description of them in language (Schneider 1997). From this point of view one could argue that scientific facts could be totally unmetaphoric when described not in language, but in pictures, tables, and figures. But this standpoint is hard to defend if one takes into account the fact that analogy can take place not only in the modus of language but also in pictures, tables, and figures. In fact, in recent years there has been increasing interest in the problem of pictures in science. This is partly due to new technology making it possible to generate pictures of things formerly not accessible to the human eye. These technologies do not show reality, but construct a certain view of scientific objects – and in this respect they are not unlike language. Nanophysics and neurosciences, in particular, are fields in which these new methods have changed the possibilities for research and the popularization of scientific observations. In neurosciences, pictures from ERP, PET, and fMRI studies are shown widely in newspapers, magazines, the internet, and on TV. At the same time, a critical view of these images and the conclusions drawn from them has been taken in the philosophy of science, as a great number of recent conferences and publications (Beyer & Lohoff 2005, Heßler 2006) on pictures and images in science show. Language and linguistic metaphors, however, are not as intensively discussed at the moment.

What do these two strands have in common? It is widely agreed that metaphors are ubiquitous in science. Conceptual Metaphor Theory predicts the ubiquity of metaphors in scientific language and thought: since it is a major claim of this theory that metaphors are used to structure things which are not part of our direct experience, they are necessary for every scientific explanation. Since we don't have direct experiental access to the structure of the brain or brain processes, it comes as no surprise that cognitive and neuroscientists use metaphors to explain their research subject.

The classic positions in the philosophy of science do not predict but observe the ubiquity of metaphors in science. The reasons they see for the frequent use of metaphors in scientific language are the metaphoric nature of language and / or the suggestive (and sometimes deceptive) power of metaphor and analogy.

Putting these two different points of view together, the ubiquity of metaphors in science seems obvious. But either way there are explanatory gaps: looking at scientific language, as cognitive linguists do, and drawing direct conclusions about the nature of scientific theories seems justified only if one takes the supposed direct connection between linguistic and conceptual metaphor for granted. When philosophers of science look at the nature of scientific theories, they tend to neglect the role of language, restricting their perspective to the metaphors people are aware of using, such as explicit analogies. That means that the combination of a linguistic analysis with an analysis of certain scientific arguments is necessary to come to more valid conclusions about the connection of linguistic metaphors in scientific language and metaphoric concepts of scientific theories.

2. Metaphors in the description of brain structure and processes

This is exactly what I intend to do for the field of cognitive and neurosciences. In my dissertation thesis (Goschler, in preparation) and an article on brain metaphors (Goschler 2005) I investigated the use of metaphors in these fields by analyzing a corpus of texts on the human brain, its structure and functions. The corpus consists of two volumes of the German popular science magazine *Gehirn & Geist* (Brain & Mind). After collecting and analyzing all the metaphors that were used in these texts, I argued that three major types of metaphors can be found in these texts: reification and spatialization, personification, and technological metaphors. But how exactly are these metaphors connected to the scientific arguments in which they are used? I propose that each major type of linguistic metaphor corresponds with some major theoretical problems in this field.

2.1 Reification, spatialization and the problem of memory and space

As I mentioned above, reification and spatial metaphors are a major type of metaphor used in texts on the human brain. "Path" and "container" are particularly frequently used source domains: the brain is described as a landscape or a container. Information, signals, memories, thoughts, and the like, are – at least linguistically – treated as "things", concrete objects that move around on "paths" inside the "container". The metaphorization of the brain as a container becomes obvious by looking at examples like these:

(1) *um im Gehirn abgelegt zu werden* (GG 4/02, 67)
…in order to be stored in the brain

(2) *... in ihrem Kopf schwirren nur […] Gedächtnisfragmente umher.* (Goschler 2005:29, GG5/03, 37)
… only [...] fragments of memories are buzzing around in her head.

(3) *Im Hirn trifft das Signal „Bewegung" ein.* (Goschler 2005: 29, GG 3/03, 60)
The signal "movement" arrives in the brain.

Metaphors like these which are based on the use of spatial prepositions and movement verbs are very frequent. Sometimes even more explicit container metaphors mentioning *gateways* can be found:

(4) *Der Hippocampus und der rhinale Cortex bilden das Tor zum Gedächtnis.* (GG 2/03, 71)

The hippocampus and the rhinal cortex form the gateway to memory.

(5) *Diese [...] Struktur gilt als das „Tor zum Großhirn“.* (Goschler, in preparation: 168, GG 4 / 03, 41)
This structure is said to be the “gateway to the cerebrum”.

Typical path metaphors mention *beaten paths*, *shortcuts* or *detours*:

(6) *… dass ein Neuron quasi über unzählige Trampelpfade das gesamte Gehirn mit einer einzigen Information überschwemmt.* (Goschler, in preparation: 168-169, GG 4 / 02, 29)
…that a neuron floods the whole brain with one piece of information via uncountable beaten paths.

(7) *Abkürzung zum Mandelkern* (Goschler, in preparation: 167, GG 4 / 03, 15)
shortcut to the …

(8) *…allerdings erst nach dem Umweg über die Großhirnrinde* (Goschler, in preparation: 167, GG 4 / 03, 15)
…though only after taking a detour via the cortex.

What do these metaphors have to do with the nature of certain scientific arguments, such as different concepts of memory? Memory is often described as a process of *storing* – in fact, spatial metaphors – many of them container metaphors – play a very important role in the description of memory (Draaisma 1999, Roediger 1980). Is this just a matter of language? Given that many theories of memory struggle with the problem of “space”, it is apparently not just a linguistic phenomenon. Let’s consider the concept of the mental lexicon. It is assumed that there must be an instance where all the words someone knows and uses are stored. The nature of this “lexicon” has been an important topic for linguistics. Are all words and all possible forms stored there? For example, if a noun like “rabbit” is stored there, is the plural form “rabbits” also stored? Many linguists, such as Chomsky and others, have argued that a regular plural form is not stored in the mental lexicon, but always produced anew by a simple rule for the plural form in English: add an “s”. The fact that children in the process of language acquisition can correctly produce the plural of a word they have never heard before (like a non-word such as “wug” in the so-called “wug-test” (Pinker 2000:18-19) is a strong argument for the claim that there is indeed such a rule.

But there is another logical consequence of the assumption that regular forms of stored words are produced by rules: it is then not necessary to explain how it can be possible to store such an enormous amount of words. An adult knows approximately 120,000 words in her / his native language (Pinker 2000:

3), but if one adds all the possible forms of those words, the number multiplies. For English this does not seem so drastic, but there are languages with hundreds of possible verb forms, such as Greek. Thus, Steven Pinker (1999: 18) argues:

> “The advantage of a rule is that a vast number of forms are generated by a compact mechanism. In English the savings are significant: The rules for *-ed*, *-s*, and *-ing* (the three regular forms of the verb) cut our mental storage needs to a quarter of what they would be if each form had to be stored separately. In other languages, such as Turkish, Bantu, and many Native American languages, there can be hundreds, thousands, or even millions of conjugated forms for every verb (for different combinations of tense, person, number, gender, mood, case, and so on), and the savings are indispensable.”

But is this true? I am not going to discuss the truth of the assumption of rules with which we are able to produce language. But is the argument that we need rules to save *storing space* really appropriate? I can’t answer this question myself. But I would like to point out that there is no empirical evidence I know of to suggest that storing space in the brain is a limited resource. Has anyone ever encountered a person with a brain that was “full” and who therefore couldn’t memorize one more thing? However one answers these questions: it is obvious that the concepts of “space” and “container” are not just a matter of language in the concept of memory. In fact, the concept of space has a huge influence on scientific theories of memory such as theories of the mental lexicon. Spatial metaphors are not just a linguistic but also a conceptual phenomenon. Often they seem to guide our thinking about the brain and mind although we are not necessarily aware of it.

These underlying metaphorical conceptualizations become very clear in a poem by Emily Dickinson. Here, poetry – that was traditionally seen as a realm of metaphorical and thus not exact or “truthful” language – reveals how container metaphors and reification work in our concept of the brain. By making the underlying spatial metaphor obvious, the poem shows how the concept of the brain as a container results in paradoxes as well as fascination with the brain:

THE BRAIN is wider than the sky,
For, put them side by side,
The one the other will include
With ease, and you beside.

The brain is deeper than the sea,
For, hold them, blue to blue,
The one the other will absorb,
As sponges, buckets do.
[...]
(Emily Dickinson 1976: 632)

Spatial metaphor is not only connected with the problem of memory and space but is also the basis for other conceptual metaphors that structure our concept of the brain, as will become obvious in the following observations.

2.2 Personification and the problem of free will

A second type of very frequently used metaphor in the description and explanation of the human brain is personification. These metaphors are largely ignored in discussions about metaphors in science. That might be due to their linguistic characteristics: most of these metaphors are based on the use of agentic verbs. Especially the verbs *to work* and *to communicate* are very common. But there are also a lot of very clear examples:

(9) *…war das Gehirn zunächst verwirrt.* (Goschler 2005: 27, GG 4 / 02, 72)
…the brain was confused at first

(10) *Manche Fehler macht das Gehirn sogar absichtlich.* (Goschler 2005: 27, GG 3 / 02, 68)
The brain even makes some mistakes on purpose.

Thus, the brain is described as an intentionally acting person. Sometimes it is even said to act against the person who owns the brain:

(11) *Unser Gehirn lässt uns bei komplexen Problemen oft im Stich.* (Goschler 2005: 27, GG 2 / 03, 22)
Our brain often lets us down when there are complex problems.

(12) *Könnte es nicht sein, dass wir alle gelegentlich unbemerkt dem eigenen* […] *Gehirn aufsitzen?* (Goschler 2005: 27, GG 3 / 03, 22)
Couldn't it be that we all are tricked by our own brain from time to time?

What is the consequence if one conceptualizes the brain or parts of it as living beings that can know, want, think, and act intentionally? With the trend toward looking for every human feature in the brain, the concepts of "person" or "human being" and "brain" are being confused. If everything a person knows, wants, thinks, remembers, and does is located in her / his brain, then it becomes likely that the person is in fact her / his brain, and nothing else. The body seems to be a mere container for the brain who is the person. That is in fact what is assumed in many strands of research in the neurosciences. This explains some of the discussions that have become popular in recent years.

One of them regards God and religion. A whole new branch of science called "Neurotheology" is based on the assumption that we can find the reasons for human religiosity in the brain and the evolution of cognition (Alper 2006, Atran 2004, Newberg & D'Aquili 1999, Newberg/D'Aquili/Rause 2001). But work on the neurological and psychological basis of human religion is often understood as something completely different: the assumption that the neurological findings provide proof that there is no "real" God. The idea is that if we find "God" in our brains, he can't be anywhere else, and therefore the gods of the various religions don't exist in reality (this idea is rejected by many theologists, though). This could be another instance of metaphorical conceptualization that has to do with the spatialization of the brain: God is personified and located in the brain (as a container), so the person "God" can't be in another container, for example in heaven. In Germany, headlines like this can be found in popular science magazines: "God inside the brain" ("Gott im Gehirn", *Bild der Wissenschaft* 7/2005) or "Attack on faith. How brain researchers challenge religion" ("Angriff auf den Glauben. Wie Hirnforscher die Religion herausfordern", *Gehirn & Geist* 7-8/2006). In German television the question is asked "Does God live in the brain?" ("Wohnt Gott im Gehirn?" in: *aspekte*, broadcast on 14/2/2002, ZDF; *W wie Wissen*: broadcast on 11/5/2005, ARD) or even explained "How the brain produced God" ("Wie das Gehirn Gott erschuf", *delta*, broadcast on 29/6/2006, 3sat). Thus, a combination of container metaphors and personification is able to stir up a lot of excitement about the nature of the brain and God.

Another discussion is that concerning free will. Here, the argument is reversed: if we can't find free will in the brain, then it doesn't exist. A few scientists pointed out that some problems in this discussion arise due to the confusion of neurological, psychological and sociological levels. For example, Peter Hacker argues that brain researchers often describe the brain as something with psychological qualities. This leads to some erroneous conclusions, for example that the Libet-experiments can be interpreted as proof of the non-existence of free will. The latter is assessed by Hacker as an error that is based on the idea that the brain could believe, think or know something. (*Gehirn & Geist*

5 / 04: 43-44). As I have shown, this idea is reflected linguistically in frequent personifications that occur in texts about the brain. Without offering an answer to the problem of free will: the reason why the confusion of "brain" and "person" came to exist in the first place lies in the conceptualization of the brain as an acting person – the personification of the brain which is not only frequent in language, but apparently also a conceptual matter.

2.3 Computer metaphors and the mind-body-problem

The computer metaphor of the brain / mind is one of the most controversial metaphors in science. Indeed, although most scientists now have a critical opinion of the analogy of computer and brain, linguistic examples where computer terms are used to describe brain processes can often be found:

(13) *... das Denken muss* online *erfolgen*. (GG 2 / 03, 41)
… thinking has to occur online*.*

(14) *Sogar die vollständige* Umprogrammierung *ganzer Areale der Großhirnrinde ist möglich*. (GG 2 / 02, 68)
Even a total re-programming *of whole areas of the cortex is possible.*

(15) *Das Gehirn erinnert sich und* ruft das Programm *„Fahrradfahren"* auf *...* (GG 2 / 03, 68)
The brain remembers und starts the program *"riding a bicycle".*

(16) *Denn die riesige Datenmenge eins zu eins auf der „*Festplatte*" zu speichern, würde unser Gehirn innerhalb kürzester Zeit an den Rand seiner Kapazität bringen*. (GG 2 / 03, 68)
*To store the huge amount of data on the "*hard-disk*" would exceed the capacity of our brain within a very short time.*

Certain parts of the computer (*memory storage*, *hard-disk*) and functions (*programs, RAM* and *ROM*) and the differentiation of *hard*- and *software* as well as *on*- and *offline*, in connection with more general electronic metaphors (*wires*, *circuits*, *switching on/off*) are prominent source domains for descriptions of the brain's structures and functions. What does this mean for the conceptualization of the brain?

The computer metaphor has not only been thoroughly discussed among philosophers of science and neuro- and cognitive scientists, it is already the subject of reflections on metaphors and analogies in the history of science. The main problem with computer metaphors is consciousness and the so-called qualia. These problems became obvious through the efforts of Artificial Intelligence.

The basic assumption of AI, at its inception, was that since the brain was a kind of computer, it should be possible to build a computer with intelligence equal to human cognitive abilities. However, although it was possible to construct computers whose abilities even exceeded human performance – especially in tasks involving rapid calculations – computers fulfil their tasks without any awareness of them. John Searle (1984) devised an interesting analogy to show the discrepancy between humans and the ability of computers. It is called the Chinese Room Argument. Searle imagines putting a man in a room with thousands of Chinese characters on pieces of paper. Now other pieces of paper with Chinese signs are put into the room. The man inside, not knowing any Chinese, has exact instructions how to react to every single sign with another sign. For a person outside the room it seems as if he is communicating in Chinese. This is also the principle of Turing machines. However, the man inside the room still doesn't know any Chinese – it doesn't matter how successfully he is communicating. To Searle, a computer works like a Chinese room – it has no consciousness and therefore no real "knowledge" either. Although much more has been added to this discussion, this is still the core of all arguments against the computer metaphor of the brain – the brain produces consciousness, the computer doesn't.

The computer metaphor leads not only to most of the knowledge about the brain that was acquired during the second half of the 20th century. It also leads to the assumption that a description of the brain's "hardware" and "software" can provide us with complete knowledge of the brain and all its aspects. This, AI researchers assumed, would at last enable the production of artificial brains that work just like humans'. However, this has not happened yet, and if we are willing to believe Searle's argument, it will never happen. Whatever position we prefer, it has become obvious that the computer metaphor is more than a linguistic phenomenon.

3. Conclusions

Metaphors in cognitive and neurosciences are indeed, as Conceptual Metaphor Theory predicts, not merely a matter of linguistics and rhetorics. Systematically occurring metaphors in texts about the brain are closely connected with theoretical arguments. As I have shown, certain metaphorizations can cause severe theoretical problems. This does not mean that metaphors in science are necessarily disturbances or errors. Certainly every metaphoric conceptualization offers some heuristic and theoretical advantages – they enable the researcher to understand and communicate his / her topic in a certain way. Metaphoric structuring might be unavoidable, as Lakoff & Johnson and other cognitive scientists have argued. Nevertheless, metaphoric conceptualizations don't come for free – they can also lead to theoretic one-way streets. In every metaphor, certain features are highlighted and others are hidden, as L&J (1980) pointed out. Therefore, a metaphor may be used to explain some features of a thing, but not others. For example, the path-metaphor of life emphasizes certain features of life, such as its lasting a certain time, starting at a certain point (birth) and ending at another point (death), the changes the "traveller" goes through over time and other aspects. The path-metaphor of life, however, can't explain other characteristics of the domain "life" – such as the fact that you never can go back, or that life can be "taken away" by others through killing etc. This is because the features are hidden by the path-metaphor. In science, however, not only the hidden features cause problems. The highlighted features can be the actual problem in some metaphors: spatial metaphors for memory, personification of the brain, the computer metaphor. Here, not the hidden features are at the core of the theoretical problems in question, but the highlighted ones.

Thus, in this case Conceptual Metaphor Theory seems right about the connection between linguistic and conceptual metaphors. A consideration of the language of texts on the brain and the scientific arguments made in the texts reveals distinct connections between those two different levels. Not only consciously invented and thoroughly discussed metaphors and analogies like the computer-metaphor have theoretical consequences. Conventionalized metaphors that most people are not aware of using while talking and writing about the brain, such as spatial metaphors, are also connected to theoretical problems.

The consequences of this observation, however, are not so clear. Does this mean that metaphors are indeed a problem for scientific discourse? It seems that the answer to this has to be a rather unsatisfying: Yes, metaphors cause serious theoretical problems. But metaphors are not fully avoidable. On the other hand, more than being unavoidable disturbances in science, they enable us to think about certain abstract matters in the first place and are therefore a useful tool that cannot be highly enough appreciated. Metaphoric thinking has provided us not only with many insights into the human brain, but also with Einstein's theory of relativity (Lakoff & Johnson 1999: 160), an image of the human DNA (Carlisle 1985), superstring theory (Lakoff & Johnson 1999: 229-230), and if we go as far as Lakoff & Johnson (1999), all scientific theories that have ever existed.

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