

The Aesthetics and Heuristics of Analogy

Model and Metaphor in Chemical Communication*

Heinz L. Kretzenbacher

Abstract: This paper suggests a sufficiently consistent, if preliminary, sketch of the semiotic structure and the aesthetic and heuristic functions of metaphor in science, particularly in chemistry. A propositional concept of metaphor, as underlying previous theories, is disputed. Metaphor is instead semiotically explained as a form of semiosis by way of semasiotropy – a concept developed out of Leopold Kretzenbacher's research in iconotropy. The function of scientific metaphor as an aesthetic agent of creative inference is discussed in terms of Harald Weinrich's image field theory (*Bildfeldtheorie*). In science, the increase in complexity through the heuristic process is subsequently reduced by strict selection of accepted research.

Keywords: *metaphor, aesthetics, semiotics, semasiotropy, creativity.*

1. Introduction: *Captatio benevolentiae*, or: 'Where are you coming from?'

In order to avoid such misunderstandings as written communication is prone to, disadvantaged as it is compared to oral face-to-face communication,¹ it is customary to state the general purpose of an academic publication and some basic assumptions from which it starts in an introduction. I shall also undertake to state where it is situated professionally and epistemically.

This paper seeks to provide a consistent, if somewhat impressionistic (since still evolving), sketch of the semiotic structure and the interdependent aesthetic and heuristic functions of metaphorical communication in science, particularly in chemistry. It does not lay claim to making any general statements about human cognition or philosophy of science, let alone about the nature of metaphor, beyond clearly defined limits of linguistic research.

As to whether it is more appropriate to use or to avoid metaphorical language while discussing metaphor, I remain agnostic. It seems as forced as fu-

tile to try and talk about metaphor without using it.² That should, however, not easily scare a linguist who admits to a moderately constructivist attitude, while still keeping in mind that this very epistemic viewpoint itself is subliminally metaphorical (cf. Spivey 1997). But then, so is aesthetics (cf. Zangwill 1991). It appears that some things can hardly be communicated other than in analogical form, or, if you will, in semiotic form. Linguistics is, after all, just another branch of human semiotics, and analogy is just one of the more frequently used forms of semiosis, the symbolic use of something for something else – *aliquid, quod stat pro aliquo* is an ancient minimal definition of the sign.

Talking about metaphor, one is tempted to cast a glance back to the first instance of theorizing it that we know of, to Aristotle. As it happens, the same philosopher also triggered three basic as well as interdependent assumptions about the human condition that I will have to take for granted for the purposes of the following text.

- 1.1 Humans are sociable beings, *zoa politika* (Aristotle, *Polit.* I.2). From a linguistic viewpoint, this implies that by being humans we normally cannot help seeking communication with other humans.
- 1.2 Humans have language as a means of making sense to themselves and to other humans. Instead of Aristotle's own phrasing of the human as a *zōon logon ekhon*, which has always been tricky to translate from the original Greek,³ I would prefer a description of humans as *zoa dialogizoumena* (cf. Kretzenbacher 1994a, p. 158).
- 1.3 Humans use language not only as a foremost means of, but also as a model for other strategies of making sense to themselves and to other humans through systems of signs. In a Peircean tradition, one could call humans *zoa semeiotika* (or 'semiotic animals', cf. Merrell s. d.)

As a linguist, I must not be frightened of natural language or condescending towards it. Natural language has proven to be the most adequate medium for human communication and conceptualization – that is: interpreting the incessant and chaotic torrent of sensory impressions that we are subjected to; ordering it into consistent and intersubjectively negotiable categories; and calling this subjective, if intersubjectively transmissible, interpretation 'the real world'. There may be linguists who assume that language is secondary to human thought and reason, even building a whole theory of metaphor on that per se a-linguistic (since a-semiotic) foundation.⁴ As a mere linguist, I can neither assume that the material I am dealing with is anything but linguistically structured (*i.e.* language, as we encounter it in utterances), nor that linguistics is a discipline to explain the world. I certainly cannot claim to make any statements about truth. Logicians, priests, and possibly even philosophers might deal with truth. As a linguist I deal with language.

Given my professional and epistemic background, I cannot avoid approaching chemistry from a viewpoint Peter Janich and like-minded philoso-

phers of chemistry would call “culturalist” (*cf.* Janich 1992, pp. 167-168; Hartmann & Janich 1996, pp. 31-36; Psarros 1996a, pp. 121-122). If that makes me liable to be called a dogmatic neo-anti-realist (*cf.* Norris 1995), I suppose I have to grudgingly suffer it.

Given also the fact that I agree with greater minds than my own, such as Plato’s Socrates (see the *Phaidros* dialog mentioned in Note 1) and Harald Weinrich (1993, pp. 17-18) on the communicative dyad being the natural habitat for human language, and finally given the fact that the ideal form for academic discourse is the argumentative dialogue (*cf.* Paek 1993, pp. 11-18; Kretzenbacher 1998a, pp. 136-137), I am trying to emulate a sufficiently critical dialogue at least by phrasing the section headings as questions.

2. Metaphor and Model in Sciences, or: ‘Haven’t we been there and done that?’

A discussion about the identity/equivalence or otherwise of models and metaphors in the scientific episteme has indeed been going on for the last fifty years or so. The concepts in question, to be precise, were not just those two, but implicitly or explicitly completed by the third (if not *tertium*) of analogy. Since the discussion was first given a boost by Max Black’s (1962) and Mary Brenda Hesse’s (1963) contributions in the early 1960s, it has never quite died down. Amongst the applications in the philosophy of chemistry, the contributions of Nikos Psarros (1993), and more recently those in the special issues of *Hyle* 5.2 (1999), 6.1 and 6.2 (both 2000) have kept the discussion very much alive.

My own contribution to this continuing discussion amongst philosophers of science about the epistemic status of metaphors as compared to models in science might not amount to much. I should just like to state that I agree with a lot of what Daniela Bailer-Jones (*cf.* 2000, 2001) recently said about the epistemic status of scientific models⁵ and the relationship between models and metaphors in science. Just for the purposes of this paper, let me unscramble a small number of the hypotheses that have been discussed in that context, in order to add them to the basic assumptions we need for what follows:

- 2.1 Not all metaphors are scientific models.
- 2.2 Some, but not all scientific models are metaphors (Bailer-Jones 2000, p. 195).
- 2.3 Scientific models are ways of linking theories to empirical observations by “embodying the application of theories to a specific class of objects or phenomena” (Bailer-Jones 2000, p. 183; *cf.* Bailer-Jones 2001, pp. 1-2)

- 2.4 Scientific models are capable of representing empirical entities and thus of making valid statements about the empirical reality (Bailer-Jones 2001, p. 5). The particular way in which models fulfil such a representative function can only be described and analyzed using a concept of representation that goes beyond a strictly propositional concept. (Bailer-Jones 2001, pp. 9-10.). That does not, however, automatically mean that this also applies to scientific metaphors.
- 2.5 Some, but not all scientific models employ analogy (Bailer-Jones 2000, pp. 188-190). This is not just a different phrasing of assumption 2.2, since until further consideration we cannot just subscribe to the Aristotelian suggestion that all metaphors are basically analogies by 'resemblance'.⁶

We will deal with scientific metaphors (or more precisely, metaphors applied in scientific contexts) in the following. Whether whatever we can state about such metaphors also applies to scientific models remains open to further discussion.

Already in this short list of statements about scientific metaphors and their relation to scientific models and analogy, which I shall take for granted for the remainder of this paper, two different sorts of statements can be distinguished, representing two different approaches. Some of the statements, such as 2.1 and 2.2, are about what metaphors or models *are* or *are not*. Such statements represent an approach that I refer to as *structural*. A structural approach is interested in questions such as 'What is it?', 'What does it consist of?', 'Which of its elements are typical/necessary/basic for it to be a part of the category of what it is, and which ones are individual/additional in this particular individual representative of the category it belongs to?' Other statements, such as 2.3 and 2.4, are about what metaphors and models are *potentially capable of doing*. Such statements represent a *functional* approach, exemplified by questions such as 'What can it do?', 'What is it good for?', and 'How can I use it?'

In the history of linguistics, structural and functional approaches have too often been seen in a simplistic way as antagonistic rather than complementary ways to guide and channel curiosity about language. For our purposes suffice it to say that, while the distinction between a structural and a functional approach is an artificial one and neither of the two approaches hardly ever exists in a 'pure' form, the distinction between the two approaches can be useful as an epistemological tool.

3. Mind your p's and q's, or: 'Are we talking about equals signs or about quotation marks?'

There are plenty of colorful etymological theories concerning the origin of the charmingly Victorian expression 'Mind your p's and q's!' The one I wish to activate here has its roots in Scholastic logic where *p* stands for *propositio* and *q* for *quaestio*.⁷ Starting from a purposeful distinction between structural and functional approaches to the semiotic analysis of scientific metaphor, the distinction between a 'p-explanation' (as in 'Metaphors are propositions', focussing on state or identity) and a 'q-explanation' ('Metaphors are doing this-and-that', or 'Metaphors trigger/work by these-and-those processes', focussing on function or procedure) is not trivial.

Chemists deal with symbols that abbreviate (or, in a semiotic sense, stand for/signify) logical operations, as do mathematicians and linguists, amongst others. It is a semiotic axiom that signs can only be attributed signifying value within a given system. In isolation, a red light does not signify anything particular. Within the ternary system of the traffic light (red/amber/green), its signifying value is the instruction to stop. Over the door of a doctor's surgery (at least in Australia), it signifies that *the doctor* is in and thus has apparently a different signifying value than a red light over the door of a house of ill repute. The didactics of mathematics (cf. Behr *et al.* 1980, pp. 15-16) tells us that even within the mathematical system, it is difficult to teach children the difference between signs that signify a proposition, such as the equality between *a* and *b* in ' $a=b$ ', and signs that signify operations or instructions to perform operations, such as the subtraction operator $-$ in ' $a-b$ ' or the equation operator $=$ in ' $3+2=x$ ', which refer to a question purpose.

The semiotic (and, according to our assumption 1.3, therefore epistemic) value of the equals sign differs between the different systems of mathematics, everyday language, physics, and chemistry (cf. Schoenfeld 1989, pp. 102-103; Psarros 1996b; Lechleiter 2002, pp. 83-89). Mathematical mapping implies the system of mathematical set theory; its symbols, such as $+$ or \rightarrow , have defined signifying values, as, for instance, in the following statement of a mathematical fixed point theorem:⁸

Let f be a function which maps a set S into itself; *i.e.* $f: S \rightarrow S$. A fixed point of the mapping is an element x belonging to S such that $f(x)=x$. If the system equation for which a solution is sought is $g(x)=0$, then if the function g can be represented as $f(x)-x$, a fixed point of f is a solution to $g(x)=0$.

We can assume that the symbol $=$ here is a 'p symbol', stating identity of mathematical values on both sides, while the symbol \rightarrow is an operator or 'q symbol', instructing us to perform a mapping operation. By taking symbols of mathematical mapping out of the system they originally belong to and

using them for, say, explaining how metaphors work and what they are, one performs a step of analogical transfer across systems boundaries. Not every listener or reader of such a metaphor theory might wish to imitate or even accept the transfer without further questioning. It does not help if one insists on formulating a ‘q explanation’ in a natural language ‘p sentence’, such as ‘love is a journey’, and then to blame the reader for mixing up propositions with mappings (*cf.* Lakoff 1993, pp. 206-207). I do not think that is fair.⁹ I would rather like to approach metaphor from a semiotic basis, first from a structural and then from a functional angle, hoping to reach an integrated view in a third step. Semiotically speaking, if I had to choose a typographic symbol to use for metaphor theory, the attention provoking instruction of the quotation mark (*cf.* Günther 1992) would spring sooner to my mind than the equals sign with its strong propositional fragrance.

4. Metaphor as semasiotropy, or: ‘On the shoulders of which giants are you standing now?’

In a recent conference paper, I have outlined an adaptation of the semiotic model that linguistic structuralism was based upon:¹⁰

Ferdinand de Saussure’s binary model of the sign has been constantly reworked by different linguistic schools according to their particular needs and to the ongoing evolution of linguistic theory. The design of another integrative model of the sign therefore appears legitimate.

Such a model should comprise three dimensions or aspects of the sign:

- a systemic aspect, taking into account the inseparable binary unit of *signifiant* and *signifié* on the one hand and the determination of the value of the sign for the process of reference within a given paradigmatic network and a syntagmatic contextual fabric on the other hand,
- an interactional aspect, taking into account the agreement of sender and receiver about the rules of their concrete ‘*Sprachspiel*’ (‘linguistic game’ in Wittgenstein’s sense) on the anthropological basis of the communicative dyad (*cf.* Weinrich 1993: 17-18), and
- a cognitive aspect.

Still, in the overwhelming majority of the reworkings and developments of the basic Saussurean model, the binary nature of the (linguistic) sign has not been shattered. According to this binary model, the sign consists of the inseparable, if (within the framework of social convention and mostly, but not always) arbitrary, pairing of an abstract concept, the *signifié* (the ‘signified’), on the one hand, and the concrete, sensually perceptible form in which this *signifié* is made manifest, the *signifiant* (‘signifier’), on the other. Both *signifi-*

ant and *signifié* have sufficiently fuzzy edges as well as sufficiently determined core qualities. Thus the pitch and speed of a sequence of sounds, or the handwritten or typographic sequence of letters in a *signifiant* such as

tree / TREE / *tree* / tree / TREE

does not challenge the function of the *signifiant* to transport the concept of a certain category of plants within the system of English. It does so, however, in the series

tree / true

where a minimal difference in pronunciation or spelling serves as a sufficient feature to differentiate between two separate signs within the same system. The *signifié* that is linked to the *signifiant* 'tree' is, in turn, sufficiently fuzzy to accommodate such different sub-concepts as palm, gum, and fir trees, respectively, yet sufficiently determined to exclude daisies, even potential gigantic, tree-high ones, say, within a fairytale or a genetic engineer's nightmare.¹¹

Our very human condition as taken for granted under 1.3 (humans as *zoa semeiotika*) provides us with a very low tolerance for phenomena that we do not immediately recognize as *signifiants* of a sign known to us. We compulsively try to attribute *signifiés* to such phenomena. From Rorschach's inkblots to Proust's *madeleine*, a large number of examples are at hand. The apparently arbitrary and purely conventional link between *signifiant* and *signifié* is not only handy for cheap jokes and puns (of the type: 'A man walks into a bar. – Of course that hurts! He should have looked out where he was going!' or 'Have you heard the one about the dyslexic walking into a bra?'). The point here is that the expected *signifié/signifiant* pairing as suggested by the familiar contextual pattern of such jokes is unexpectedly broken up and you have to apply a particular re-combination to 'get' the joke. Sometimes this is referred to with a spatial metaphor as 'lateral thinking' or 'thinking outside the square'. Riddles also work that way, as in the one that the sphinx gave Oedipus to solve. The riddle (what is it that walks on four legs in the morning, on two at noon, and on three in the evening?) can only be solved by a double dose of such semiotic recombination. You have to sever the *signifiants* 'morning', 'noon', and 'evening' from *signifiés* restricted to the times of day and to recombine them with *signifiés* from the conceptual field of the ages of human individuals. In the same way, you have to recombine the *signifiant* 'leg' with a *signifié* that is usually paired with *signifiants* such as 'walking stick', 'cane', 'hiking stave', 'crutch', etc.

Of course, 'evening' for 'old age' is one of the original examples Aristotle gave for metaphors. In the form of social wordplay and metaphor, as in all other forms, this mechanism of semiosis is also a convenient and promising way for a sign community to increase their seme-pool.¹² The combination of

our own human condition and the double-edged nature of the sign allows us to recombine signs of originally unrelated *signifiants* and *signifiés*.

4.1 ‘And at what stage were you planning to eventually talk about chemistry?’

Now would be as good a time as any. Chemists are great recombiners of originally unrelated modules of normally otherwise combined molecules. (‘Now what is going to happen if I split this O₂ molecule and add two hydrogen atoms to each of the oxygen atoms? Let’s see...’). *Tua res agitur*.

Back from chemical to general semiotics: In a certain field of cultural studies, the recombination of formerly unrelated *signifiants* and *signifiés* has been thoroughly described, if not in terms of semiotics. Iconography and iconology have long been aware that artworks such as pictures exist as a linkage between a material entity (a *signifiant* such as paint on a canvas) and a conceptual entity (a *signifié* such as ‘portrait of individual X’ or ‘protest against social phenomenon Y’, or ‘venerable symbol of supernatural entity Z’). Different beholders or groups of beholders do not necessarily combine one and the same *signifiant* with identical *signifiés*. An Australian Aboriginal dot painting can mean (*i.e.*, imply the *signifié* of) a representation of sacred and otherwise inexpressible (or even secret) spiritual knowledge to a certain sign community, such as the initiated members of a particular Aboriginal people. To a group of Non-Aboriginal gallery visitors, it can mean a spiritually uplifting expression of beauty (or, since that is in the eye of the beholder, a meaningless piece of aesthetic junk). To a community of art collectors, it might mean a prized or coveted possession or a clever investment, and so on.

Certainly, a sign community can re-interpret a given visual *signifiant* by replacing a *signifié* seen as obsolete with a new one. The cultural anthropologist Leopold Kretzenbacher has published a large number of thorough and detailed studies on European religious iconography where he found such (religious and secular) re-interpretations of religious depictions whose original *signifié* was lost, forgotten, or even ignored on purpose. In his publications since 1970, Leopold Kretzenbacher has consistently described such phenomena as *iconotropy*.¹³ The term, derived from the Greek elements *eikon*, ‘image’, and *tropein*, ‘to turn (around), to change’, and developed in an argumentative co-operation chain from mythology research via psychoanalysis to cultural anthropology, seems appropriate enough. To my knowledge, no one has come up with a better term up to now.¹⁴

Structurally identical processes of semiosis can be encountered far beyond the boundaries of visual art. The very phenomenon of synesthetics is a good example, insofar as sensory concepts are re-combined with *signifiants* from other sensory fields, as is the case with people who claim they ‘taste’ sounds or

'hear' colors. The re-combination of a sensory impression with a linguistic expression even had its defined place in classical rhetoric under the term of *ekphrasis* ('*ut pictura poesis*'). The semiotic mechanism we are talking about actually allows and even encourages precisely such crossing of borders between different media of perception. The mechanism works in both directions, which is in accordance with the binary model of the sign that does not have a 'preferred' direction of relating the *signifiant* and the *signifié* to each other.

One good example, known to many historians and sociologists of science, is the wanderings back and forth across the border between the visual and the linguistic medium of the *signifiant*, representing the cultural concept 'standing on the shoulders of giants' as described in Robert K. Merton's probably most popular publication, the 'Shandean postscript' *On the shoulders of giants* (first published as Merton 1965). From a semiotic viewpoint, iconotropy is just a specific application of a more fundamental type of semiosis for which I would like to suggest the term 'semasiotropy'.

Another specific application of semasiotropy, though much more frequent and fundamental than iconotropy, is metaphor. This structural-semiotic approach to metaphor is consistent with the categorization of metaphor as a subcategory of the tropes in ancient rhetoric (along with such other tropes as metonymy, irony, oxymoron, etc.).¹⁵ And the general rhetorical strategy of the trope is conventionally described by the etymological metaphor of changing/turning/moving (Gr., *tropein*) the expression (the *signifiant*) away from its 'proper' place in 'literal' language, while leaving the concept (the *signifié*) unmoved.

Beyond this superficial consistency, and keeping in mind that etymology is rarely a good guide for linguistic analysis (*lucus a non lucendo*), this view of metaphor is consistent with Max Black's 'interaction theory' of metaphor. This theory no longer tries to explain metaphor as a way of substitution or analogy between a 'literal' and a 'figurative' meaning, but rather as the interaction of two dynamic systems of meaning, thus actually creating new analogies rather than exploiting pre-existent ones (*cf.* Kretzenbacher 1997, p. 131). Black's interaction theory is arguably the most momentous new view of metaphor since Aristotle. Its appeal is that it allows us to think outside the millennia-old square of a perceived binary antagonism between the 'literal' and the 'figural' that had burdened discourse about metaphor since Aristotle's time.

So this is my suggestion for a structural description of metaphor from a semiotic viewpoint: Metaphor is a specific subclass of semiosis by semasiotropy.

5. Metaphor as multimedial channeling, or: ‘What about aesthetics: Are we there yet?’

Yes, we are. We have arrived at the functional or ‘q problem’: What is metaphor good for?¹⁶ According to a conventional code of professional behavior, it appears appropriate for scientists to compartmentalize their life in a way that their allegedly impartial and objective professional *persona* is kept strictly apart from their naturally (com-)passionate and subjective private *persona*. Provoked by the very phenomenon of scientific metaphor, the physicist Alan Lightman (1989, p. 100) voiced his amazement by the almost schizophrenic separation of scientists’ private and professional attitudes towards reality:

Physicists have a most ambivalent relationship with metaphor. We desperately want an intuitive sense of our subject, but we have also been trained not to trust too much in our intuition. We like the sturdy feel of the earth under our feet, but we have been informed by our instruments that the planet is flying through space at a hundred thousand miles per hour. We find comfort in visualizing an electron as a tiny ball, but we have also been shocked to discover that a single electron can spread out in ripples, like a water wave, occupying several places at once. We crave the certainty of our equations, but we must give names to the symbols.

Likewise, chemists of course have to suspend their professional attitude, *e.g.* towards substance purity, in everyday life, or they would have to seriously mistrust the label in their shirt that says ‘100% cotton’ even if that shirt has buttons that are definitely not cotton, not to mention the crass impurities that a chemical analysis of the fabric would show. Generally speaking, in science it appears to be only allowed to admit an interference between the two spheres in anecdotal contexts (*cf.* Mistichelli 1998). The extent to which an individual scientist is expected to adhere to this implicit code of professional manners appears to be inversely related to her or his professional standing and distinction. As a rule of thumb, almost any admittance to your own human condition in professional discourse is accepted once you are a Nobel Prize laureate (*‘Quod licet Jovi* [Roald Hoffmann, Erwin Chergaff, James Watson...] *non licet bovi* [first year undergraduate chemistry students]’).

Not that there is really anything wrong with that: Communities function by rules, and arriving at the generally more favored end of the food chain has its benefits. As far as aesthetics is concerned, the interesting fact is that manners are a result of behavioral choice and therefore matters of style. From a linguistic viewpoint, what interests me most is linguistic style. And in that respect, scientists, in what Mistichelli (1994, p. 257) calls an originally noble “intent to purge scientific thought of non-measurable and non-quantifiable influences”, are generally expected to strive for an emotionally extremely restrained and unobtrusive style. The stylistic ideal is transparency; the concept

behind it is that the linguistic medium allows the recipient to perceive an allegedly underlying message (e.g. empirical data) as clearly and distinctly as possible without distorting it beyond the least irreducible amount of personal, subjective style.

Three stylistic elements are particularly seen as threatening to cloud this “window pane style”¹⁷ with the mists of subjectivity:

- The personal involvement of the researcher as a human communicator, most clearly perceptible in the use of the first person singular pronoun *I*,
- the linguistic mode of storytelling as opposed to reporting facts: *narrative*,
- and the use of analogy as a means of scientific argumentation, particularly frowned upon in the form of *metaphor*.

Harald Weinrich (1989, pp. 132-139) has phrased these unwritten rules in three negative commandments or prohibitions (*Verbote* in German) which I render here in my own translation from the German original:

First commandment: *A scientist does not say ‘I’.*

Second commandment: *A scientist does not tell stories.*

Third commandment: *A scientist does not use metaphors.*

Kretzenbacher took up this trinity of academic conventions of stylistic restraint, though suggesting to replace Weinrich’s term *Verbot* with the Freud-inspired term ‘taboo’:

Taking into account what Sigmund Freud wrote about the difference between prohibition and taboo, I should propose to speak of three stylistic *taboos* instead: the narrative taboo, the ego taboo, and the metaphor taboo. Prohibitions are relative restrictions that can be refuted by rational argumentation. Taboos are absolute restrictions that can be broken knowingly or unknowingly, but not called into question.¹⁸

Indeed scientists do not readily bow to bans or prohibitions. From Galilei to Sacharov and Havemann, many of them have not reacted in an overly accommodating or even obedient way to prohibitions. After all, in the world of scientific research, there is no such thing as an authority that would grant immunity to scientific questioning. To my knowledge, no scientist has ever seriously accused Einstein of regicide for beheading Newton’s physics. A large number of laws of nature formulated in the early time of the Royal Society have long been falsified or fundamentally changed in further scientific discourse, and consequently pushed from their thrones and ushered to the back benches of the history of sciences. The stylistic conventions for discussing those laws however, which were developed by the same founding generation of ‘Natural Philosophy’ in the form of experimental science, have never had to undergo a thorough checkup.¹⁹ Laws, even if seemingly signed by Queen Nature herself, appear to be perceived by scientists as preliminary

results of scientific research at a given point in the history of science. Therefore, it is the duty of scientists to regularly scrutinize these laws to find out if they still apply. This is similar to laws in a human society that lose their applicability when the society no longer takes them for granted, such as when, for instance, death penalty is considered in opposition to this society's idea of civilization.

Taboos work in a different way within communities, and they come in a different semiotic form. In societies that accept the values of the Enlightenment tradition, taboos are subjected to scrutiny in similar, though not exactly the same, ways as laws. Societies that reject the assumption that individual freedom of choice is generally a solid basis of collective welfare tend to consider taboos as just that: unquestionable. I certainly do not wish to portray the professional community of scientists as anything but appreciative of the personal freedom aspect of Enlightenment. It might just be the case that scientists in their incarnations as professional *personae* lack the sensory apparatus that allows them to perceive professional taboos as a form of historical rules in a similar way as 'laws of nature'. After all, humans have a restricted sensory apparatus.

As for the metaphor taboo, mockingly carved at the bottom edge of Moses' tablets as another commandment by Max Black (1962, p. 25) in the form "Thou shalt not commit metaphor", there are very few scientists of Puritan-strict observance. Fortunately, there is an unbridgeable difference between a gas chromatograph displaying an output of data and a chemist interpreting such data and communicating them to other human beings. Of course, chemists are not any less human in their incarnation as professional *personae*. They make human choices, focus on this or that aspect of analytical data, interpret data, and hypothesize with an amount of human creativity that may be contained by professional standards of behavior, but will arguably never be emulated by a machine. The same double-thinking that allows all of us to apply different standards in our private and in our professional lives leads to a conscious or subconscious agreement amongst scientists to comply with the metaphor taboo only to the extent the French are said to comply with their strict anti-smoking legislation. Certainly, scientists would not like to be perceived as communicators of metaphors by the general public. The word 'linguist' in English can refer to an academic qualified in linguistic theory as well as to someone who has acquired some skills in languages other than their native tongue; linguists (the real, upper-case initial ones) have learned to live with that. Physicists seemingly wish to be perceived as clearly something different from para-physicists, and chemists as clearly different from alchemists. Since alchemy is characterized by a highly metaphorical, even allegorical discourse style, chemists appear to shrink from the public use of metaphor even more than physicists do.

For the sake of a sober and respectable professional image in the wider community, scientists perform the mental trick of not only splitting themselves up into a professional and a private *persona*, but also to split up their linguistic activities into a ‘message’ (their professional ‘concepts’) and a ‘medium’ (their linguistic ‘style’). Neatly fitted into the old and popular topos of “style as the clothes of thought” (*cf.* Müller 1981, p. 52), even a highly creative and human scientist such as Albert Einstein feels compelled to quote Ludwig Boltzmann’s quip about ‘elegance’²⁰ as something that, in the interest of a clear presentation of thoughts, should be left to cobblers and tailors. The quote is printed in the preface to that particular publication on his theory of relativity addressed to all interested members of the general public who have completed secondary level education (Einstein 1917). I quote the short paratext completely:

Das vorliegende Büchlein soll solchen eine möglichst exakte Einsicht in die Relativitätstheorie vermitteln, die sich vom allgemein wissenschaftlichen, philosophischen Standpunkt für die Theorie interessieren, ohne den mathematischen Apparat der theoretischen Physik zu beherrschen. Die Lektüre setzt etwa Maturitätsbildung und – trotz der Kürze des Büchleins – ziemlich viel Geduld und Willenskraft beim Leser voraus. Der Verfasser hat sich die größte Mühe gegeben, die Hauptgedanken möglichst deutlich und einfach vorzubringen, im ganzen in solcher Reihenfolge und in solchem Zusammenhange, wie sie tatsächlich entstanden sind. Im Interesse der Deutlichkeit erschien es mir unvermeidlich, mich oft zu wiederholen, ohne auf die Eleganz der Darstellung die geringste Rücksicht zu nehmen; ich hielt mich gewissenhaft an die Vorschrift des genialen Theoretikers L. BOLTZMANN, man solle die Eleganz Sache der Schneider und Schuster sein lassen. Schwierigkeiten, die in der Sache begründet liegen, glaube ich dem Leser nicht vorenthalten zu haben. Dagegen habe ich die empirischen physikalischen Unterlagen der Theorie absichtlich stiefmütterlich behandelt, damit es dem der Physik ferner stehenden Leser nicht ergehe wie dem Wanderer, der vor lauter Bäumen keinen Wald sieht. Möge das Büchlein manchem einige frohe Stunden der Anregung bringen!

Dezember 1916

A. EINSTEIN

So that is for the glossy brochure and could be paraphrased as: “In science, we condescendingly reduce aesthetic choice in linguistic communication, *i.e.* style, to ‘elegance’ and refrain from its use, because science is the disinterested pursuit of knowledge, as opposed to anything we know from the outside world. Out there people are human, concepts are as messy as natural language logic is fuzzy, and semasiotropy is rife, as you all know.” Most colleagues from other faculties have never quite bought that; particularly the part where language is considered to be a mere means of transporting scientific thought that can be chosen almost at random and is independent of thought itself. Ernst Cassirer’s considerations (Cassirer 1942) provide an early example,

though by no means the earliest one. Linguists who actually take the glossy brochure at face value are few and far between.²¹ Whether admittedly or without wasting a thought to it, scientists themselves know that they are very passionate in their calling (*cf.* Thagard 2002). Certainly, creativity is a basic condition for science to no less extent than for other highly demanding intellectual pursuits.

Research in scientific creativity is a hot spot in philosophy, cognitive sciences, and AI research.²² Some articles even promise “serendipity equations” (Figueiredo & Campos 2001). If we see metaphor as a sub-category of the semiosis mechanism of semasiotropy, we can hardly be amazed by the fact that metaphor is a prime suspect in the search for an agent that can help us think creatively.²³ It is also relatively little disputed that metaphors somehow fulfil the function of triggering or guiding cognitive inference (*cf.* Steinhart 2001, pp. 183-208). The hypothesis of conceptual blending has been developed as an additional function of metaphor out of the mapping theory of metaphor. This hypothesis states that two or more metaphorical mappings can be combined (blended) to a sort of overlapping super-mapping. Tim Rohrer exemplifies that quite well with the discussion about ‘Cyberspace’ as a spatial metaphor within which sub-metaphors such as the ‘information highway’ fit neatly. Since time metaphors are often linked to ‘source domains’ with a spatial meaning, a different metaphor such as ‘Cyberfuture’ can be created in which “the information highway is a road through time rather than through space” (Rohrer 1997, p. 187). Both metaphors can be ‘blended’ to create a wider scope of the ‘information highway’ metaphor. The ‘conceptual blending’ hypothesis has been eagerly applied as an answer to the question how metaphor functions as a trigger for conceptual inference.²⁴

I agree with Joseph Grünfeld’s view of metaphor as a specifically *aesthetic* way of triggering cognitive inference (Grünfeld 2000, 173-216). I wish, however, to suggest a manner in which this cognitive inference by way of the aesthetic function of metaphor works. It is much simpler than most hypotheses presented in the texts that are mentioned in this section so far; yet, I am still optimistic that it is not simplistic. It is related to the fact that scientists are much more akin to everybody else than their public image would suggest. Scientists love tinkering as much as the every human. It is difficult to publicly admit, however, that what they do in their backyard shed over the weekend is not that different from what they do in their labs and at their desks. In that respect, the example given for a chemical parallel to semasiotropy in Section 4.1 is not trivial. Neither is the fact that I have heard chemists referring to their laboratory work in shoptalk jargon as ‘cooking’. Cooking (though not necessarily if done for a living) is a highly creative activity. Apart from the basic ingredients, it involves creative experimenting with the things immediately at hand in the kitchen: a pinch of this and a teaspoon full of that and,

oh, there is that rest of that wine from dinner – what if I added that? Metaphors combine the thinker and the tinker in the scientist, because they particularly allow to link sensory and therefore aesthetic perceptions to seemingly purely theoretical reasoning, which is allegedly completely detached from sensory and emotional influences. And exactly this combination – logic and tinkering – has been suggested as an auspicious cognitive recipe for scientific discovery (cf. Kantorovich 1993).

Tinkering, by the way, is an excellent translation for the French *bricoler* which Claude Lévi-Strauss (1962, p. 27) advocates as a means for researchers of culture. It has also been variously described as a particularly linguistic strategy of cognition, not only by Heinrich von Kleist almost 200 years ago (cf. Kleist 1990), but also more recently in linguistics proper (cf. Hopper 1987, pp. 144-145). Chemists tinker – guided by theory – with substances in their laboratories and – guided by theory as well – with thoughts in their heads. Of course, substances (as matter) have an aesthetic quality accessible to human senses that thoughts lack – or do they? Much of what chemists have to deal with in their practical work is hardly accessible to human senses in a direct way. I have not seen an electron lately, neither have I seen much sunshine lately while I have been working on this paper. Both phenomena are accessible to my eyes, although the electron only so in the form that a machine extending my senses presents it to them. Language as a machine extending my cognitive abilities does not work in an entirely different way. But can abstract concepts in linguistic form become accessible to a sensory as well as a purely theoretical perception?

All signs are abstract. Or rather, since they represent ideas rather than concrete phenomena, the antagonism between abstract and concrete is suspended in signs. Both *aisthesis* and *noesis* ('sensation' and 'thought', respectively, in the terms of Aristotelian epistemology) are different yet equivalent forms of semiosis. This is where the particularly metaphorical form of semasiotropy comes in. With its help, we can playfully – by way of creative tinkering²⁵ – suspend the epistemological difference between knowledge and feeling, thought and sensation. Thus semasiotropy is capable of opening up and occupying 'image fields' – '*Bildfelder*' in Harald Weinrich's theory (cf. Weinrich 1976, pp. 276-290) – that transgress, or rather ignore, distinctions between the concrete and the abstract, the sensual and the intellectual, the 'real' and the 'unreal'.²⁶

We now have a theory of the structure and of the function of metaphor: Metaphor, being a form of semasiotropy, is capable of connecting noetic and aesthetic spheres of human perception. This is a function that lends itself easily to the world of chemistry, understood as the theory and practice of the research into matter.

6. Integration of structural and functional views of metaphor, or: ‘But how does it do that?’

Metaphor is a very effective (if by no means the only linguistic) way of creating an image field that bridges the gap between sensual and intellectual spheres. An abstract concept such as a name can be put into an image field that includes aural, visual, or olfactory impressions in Juliet’s fashion:

What’s in a name? That which we call a rose
By any other name would smell as sweet.
(Shakespeare, *Romeo and Juliet*, II, 1)

or in Faust’s metaphor:

Name ist Schall und Rauch, / Umnebelnd Himmelsglut.
(‘Names are but noise and smoke / obscuring heavenly light.’)
(Goethe, *Faust I*, ‘Marthens Garten’)

Of course, both Juliet and Faust have their respective agendas for blurring the distinction between a theoretical concept and a sensation. Scientific metaphors such as the chemical concept of aromaticity, historically developed out of a sensory metaphor (*cf.* Neus 2002, pp. 4-6) have different agendas²⁷ altogether. Certainly, ‘aromaticity’ has never been used in chemical theory to create a category of matter that smells nice. So is its use as a chemical term not a contradiction in just those terms?

Yes, it is. Harald Weinrich (1976, pp. 306-310) alerts us to the fact that the phenomenon called ‘contradiction in terms’ (*‘contradictio in adiecto’*) in logic, signifying a contradiction between the subject and the predicate of a proposition, is closely connected to the way metaphors work. Oxymora, paradoxa, and other tropes are even more obvious contradictions in terms. Weinrich (1976, p. 306) convincingly explains the contradiction in terms as a particular case of metaphor.

Contradictions in terms provoke any receiver who wants to make sense of them. By processing a contradictory utterance such as ‘Achilles is a lion’ or ‘a dyslexic walks into a bra’, one’s first semiotic browsing check comes up with an error message: there seem to be two signs whose *signifiants* are linked by grammatical means while their *signifiés* are mutually exclusive! This does not make sense! This is not only an insult to our intelligence, but rather a provocation of our human condition as semiotic sense-makers. We can either dismiss the whole utterance or switch on our sense generator which allows us to emulate a possible semasiotropy such as the sender of the message might have made in its encoding. Thus we decode the contradiction by laterally thinking around it.

Also metaphors provoke our semiotic tolerance, though on a sliding scale of intensity. There are metaphors that are so weak (‘I really look up to you’,

‘The sun is setting’) that they are automatically processed in our fuzzy semiosis without stretching the semiotic inconsistency tolerance. If for any (e.g. comical or pedantic) reason we wish to exploit even this minimal provocation, we can do so by emphasizing it (‘But how can you look up to me when I am sitting here and you are standing there?’ – ‘Well, as a matter of fact, what is actually setting is planet Earth rather than the sun.’). Other metaphors really challenge our tolerance with a very strong provocation, annoying us into making a leap out of conventional semiosis. In the rhetorical tradition, such metaphors are referred to as “daring” or “audacious” (cf. Weinrich 1976, pp. 295-316). Since the pursuit of knowledge is also often a daredevil enterprise (*‘sapere aude!’*), semasiotropy by metaphor provides us with an appropriate mechanism for the provocation of thoughts by (e.g. aesthetic) stimulation of creative inference across the boundaries of well-mannered reasoning. We just do not care about our p’s and q’s any more.

If we set such a thought-provoking mechanism in motion within a group of people mutually provoking each other’s semiotic tolerance, it is called a brainstorming session (cf. Liebert 1997). If we do it all by ourselves, we have to emulate at least a communicative dyad by setting the ‘rational’ me up against the ‘emotional’ or ‘aesthetic’ or ‘silly’ me. In any case, the effect is that our conventional trust in the seeming transparency of language is disturbed by the provocative opacity of metaphor. Suddenly, there is counter-evidence against things that, until now, have appeared self-evident – language has a word to say in things that we used to think go without saying. This surprising passive resistance of the ‘medium’ language is what makes academic semasiotropy²⁸ and artistic semasiotropy twins separated at birth. They do, however, recognize each other immediately if they meet.²⁹

The famous creative process that led to August von Kekulé’s suggestion of the structure of benzene (1865), including his the equally famous reminiscing about it (in 1890), presents an opportunity to do a detailed linguistic study of chemical metaphor (cf. Kretzenbacher 1996 and 1998b). From his studies on the ‘daring’ metaphor, Harald Weinrich has drawn an anti-conventional and seemingly paradoxical, but nonetheless stringent, conclusion: the audacity of a metaphor (or in our terms, its provocative potential) is inversely related to the mental distance between the two concepts or images that the metaphor brings together (Weinrich 1976, pp. 303-310).

Chemical metaphor use supports the conclusion as shown by an analysis of Kekulé’s texts (Kretzenbacher 1996 and 1998b): It is not the spectacular ‘*Schlangen*’ metaphor that Kekulé himself named as the trigger for his idea of benzene bearing a circular structure. There is in fact no evidence that Kekulé’s contemporary audience even decoded this German metaphor in the sense of a zoomorphic snake, in spite of the English translation of the metaphor strongly suggesting that. The contemporary comments on Kekulé’s autobiographical

anecdote show nothing of that sort of understanding, indicating instead an understanding in terms of dancing anthropomorphic atoms and molecules joining each other in changing combinations to chains and circles of dancers. Besides that, I have argued (Kretzenbacher 1996, pp. 188-189; 1988b, pp. 280-284) that it is the metaphorical representation of atoms and molecules linked to (open and potentially also closed) *chains* in Kekulé's writings in 1865 which led to his representation of the benzene structure as a *ring*.

The representation of a group of atoms or molecules as linked to chains or even rings, which seems quite self-evident today (an image agreeing with modern conventions of the graphic representation of molecules), was certainly original and creative in 1865. Compared to the 'snake' metaphor, the distance that has to be crossed to imagine a molecule as a chain or a ring is not great. The provocative potential for mental tinkering that this metaphor offered Kekulé, however, must have been as enormous for him as his theory has proven to be momentous for the subsequent development of organic chemistry. Thus, we can in fact call the seemingly modest 'chain' metaphor a daring conceptual challenge at the time.

7. The analogue and the digital, or: 'Who can bring such scientific flights of fantasy on the wings of metaphor back to earth?'

According to our assumption 1.2 (humans as *zoa dialogizoumena*), no individual is a cognitive island. We constantly have to check the validity of what our semioses result in by bouncing them off fellow humans. Communicating our constructions of 'reality' to others, we take the step from a merely subjective to a potentially intersubjective validity: we negotiate meaning in communication. Different sorts of discourses apply differently strict criteria before granting the seal of intersubjective approval. In art, those criteria are rather lenient, at least in open societies. In academic communication, they are extremely strict. Academic reasoning can only reach the professional mainstream by passing the gates of publication in accepted media. Those gates are guarded by peers who are willing and capable of scrutinizing a particular contribution to the discourse of their discipline thoroughly (*cf.* Daniel 1993). Gatekeepers of that sort, however, are just representatives of the general academic duty of critical appraisal of all relevant communication in the discipline. This is the way by which theories are collectively developed further or, as soon as their value for the discipline seems to be exhausted, dismissed (*cf.* Paek 1993, pp. 11-13).

Corradi Fiumara (1995, pp. 64-83) has suggested the terminological dyad of digital and analogic forms of academic communication. In conjunction with this, we can now re-assess and rework my former (Kretzenbacher 1994a, pp. 175-178) independently developed, if less well defined, terminological dyad consisting of the same terms. Corradi Fiumara considers the discreteness and rigidity of the digital style approach as perfect for categorizing purposes but less suitable for creative thinking. On the other hand, the analogic approach, because of its continuity, its decided perspectivity, and oscillating flexibility, provides a complementary rather than a contradictory instrument for cognition and evaluation processes both in the general and specifically academic contexts.

By subjecting them to digital rephrasing within the discrete categories of the discipline, analogic constructions of knowledge can be examined for validity, which allows weeding out intersubjectively invalid hypotheses and claims. Controlling (and protecting) metaphors, representing the 'green valleys of silliness' from the elevated perspective of the 'barren heights of cleverness'³⁰ towering over them, is as much part of the entire process that we call science as leading the creative mind to pasture in the green valleys below. Metaphoric semasiotropy by its nature vastly increases complexity. In its thought- (or fantasy-) provoking way, it opens up possibilities, virtualities, and non-propositional modes of thought (*cf.* Miller 2000, p. 147). The pruning shears of falsification reduce complexity by giving digitally selected hypotheses and claims room to grow once they have gained intersubjective approval.

In the understanding of the dynamics of knowledge, the hand of epistemic change fits all too snugly in the gardening glove of a biologicistic theory of 'meme evolution'. A purely metaphorical explanation of metaphor is not good enough in science. In the nick of time, Maasen and Weingart (2000, pp. 143-150) alert us to the fact that analogic meta-discourse must not be immune from controlling assessment by digital reconstruction. Metaphoric semasiotropy suggests different ways of thinking, but those have to be tested by digital recoding in order to find out how valid their results are.

8. Conclusion, or: 'Can I please draw my own?'

Everyone has to. There is hardly a way around it, short of blissful ignorance. Let me just tie the loose ends of the few *poetic* threads together that are interwoven with the basic expository fabric of this text.

As we know, Aristotle was the teacher of Alexander the Great. Amongst other achievements, Alexander is famous for slashing the Gordian knot with his sword. In an epigram 'On posthumous fame', first published in 1948 in a Germany thoroughly destroyed by nationalistic and militaristic hubris along-

side with the rest of Europe, Erich Kästner (1998, p. 275) was musing about the fame of the slasher as opposed to the anonymity of the artist who had so skillfully tied the Gordian knot:

Über den Nachruhm
oder *Der gordische Knoten*

Den unlösbaren Knoten zu zersäbeln,
gehörte zu dem Pensum Alexanders.
Und wie hieß jener, der den Knoten knüpfte?
Den kennt kein Mensch.

(Doch sicher war es jemand anders.)

Digital reasoning tends to apply the sharp wit of Ockham's Razor to the seemingly chaotic entanglement of epistemic riddles in science. Recently, there has been some reconsideration of the epistemological value of the Razor in chemistry (*cf.* Hoffmann, Minkin & Carpenter 1997).

Even Dr. Faustus, the scientist well-versed in chemistry in Goethe's eponymous tragedy, in spite of having rejected his own father's alchemical heritage, still has to suffer the alchemical spells of the old witch in order to get the rejuvenating concoction from her that will improve his chances with Gretchen. With caustic sarcasm this witch enjoys seeing Faust at his rational scientific wit's end and at the mercy of her magic potions. Triumphantly she argues that it is exactly her own blissful ignorance of scientific method, her lack of thought, which provides her so generously with powers that science is incapable of achieving:

DIE HEXE (fährt fort).
Die hohe Kraft
Der Wissenschaft,
Der ganzen Welt verborgen!
Und wer nicht denkt,
Dem wird sie geschenkt,
Er hat sie ohne Sorgen.
(Goethe, Faust I "Hexenküche")

It is certainly not coincidental that August von Kekulé quoted the last three lines in his famous anecdotal narrative of 1890 about how he had envisaged the solution to the riddle of the benzene structure in a trance-like state of drowsiness.³¹ Why did the then famous man of science quote an alchemist-witch from Goethe's drama in the context of one of the most spectacular achievements of chemical science in the 19th century? What happened to the neat distinction between the two cultures of the Arts and the Sciences in modern Western culture?

I do not know what happened to it. I do not even believe that there are in fact two, or three, or more cultures. There is just this one human culture, and

that is probably more about tying knots and playing with language than slashing through beautifully and skillfully crafted real or imaginary knots with deadly weapons of individual destruction such as swords or razors. What was it Alexander Pope, in his *Essay on Man*, addressed explicitly to the proud representatives of the Newtonian paradigm in his contemporary science? Oh yes, it was the merciless ‘*gnothi s’authon*’ that keeps gnawing away at intellectual pride:

Know then thyself, presume not God to scan;
The proper study of Mankind is Man.

Notes

* Mit antipodischer Verspätung, aber nicht minder herzlich meinem Vater Leopold Kretzenbacher zum 90. Geburtstag am 13. 11. 2002 sowie meinem Doktorvater Harald Weinrich zum 75. Geburtstag am 24. 9. 2002 zugeeignet: “Was du ererbt von deinen Vätern hast, / Erwirb es, um es zu besitzen. / Was man nicht nützt, ist eine schwere Last; / Nur was der Augenblick erschafft, das kann er nützen.” (Goethe, *Faust I*). Vgl. in unserem Zusammenhang dazu neuerdings auch das Kapitel ‘Chemisches in Goethes Dichtungen’ in Schwedt 1998.

¹ Cf. Plato: *Phaidros*, 274b6 - 275b4; 275c5 - 275e6.

² Indeed the meta-metaphorical discourse has always been deeply metaphorical, from Aristotle to the modern concept of metaphorical ‘mapping’ which itself is a transferral (*meta-phora*) from a mathematical concept (see Lakoff 1993, pp. 206-207; Fauconnier 1997, p. 1).

³ The Greek noun ‘*logos*’ can refer to all sorts of things, such as words, concepts, language, reason, etc. (cf. Böhme 1988, p. 36), a translation quandary that famously drove Dr. Faustus into a severe academic midlife crisis in Goethe’s drama. In the 20th century, Aristotle’s respective phrase has also been so thoroughly Heideggered that we should hang it out to air for a few more decades.

⁴ Cf. the section entitled ‘Metaphors are not mere words’ in Lakoff 1993, p. 208ff., where one finds statements such as “The metaphor is not just a matter of language, but of thought and reason. The language is secondary” (p. 208), or “This view of metaphor is thoroughly at odds with the view that metaphors are just linguistic expressions. If metaphors were merely linguistic expressions, we would expect different linguistic expressions to be different metaphors” (p. 209). As a linguist, I am alerted not only by the hidden presuppositions in the text (such as the implicit suggestion that language consist of words as primary elements, or the gradient adverbs such as “just” or “merely”), but also by the attempt to sell the subjective conclusion in the conditional construction (“If metaphors were [...], we would expect [...]” as a conclusion already agreed upon by the author and the reader (suggested by the inclusive “we” in “we would expect”). Sometimes not only one’s terms (cf. Batstone 2000) but even one’s conditionals appear to be capable of defying one’s arguments. We really have to mind our p’s and q’s, particularly in ‘if p, then q’ statements.

- ⁵ Particularly comforting is her statement “that there is no watertight definition of what *counts* as a model” (Bailer-Jones 2000, p. 182, her own emphasis).
- ⁶ Cf. Nimis 1988, p. 215. This question is inseparably linked to the Aristotelian suggestion that metaphors are epistemically closely related to similes, possibly even a subcategory of them (popularized, above all, by Quintilian), which has been very much disputed in philosophy (Tirrell 1991) as well as in cognitive science (Gentner *et al.* 2001; McGlone 2001, pp. 29-51). Of course, the problem applies to scientific metaphors as well as to metaphors in general (Gentner 1982).
- ⁷ The symbol *p* for *proposition* has survived in contemporary logic reasoning, while *q* is often used to signify something that follows from *p*, as in ‘if *p*, then *q*’.
- ⁸ I took this from <http://www.sjsu.edu/faculty/watkins/econ104.htm> (9 Jan. 2003).
- ⁹ Apart from other criticisms that have been directed towards Lakoff’s and Johnson’s successfully marketed re-invention of the wheel (Jäkel 1999), which, however, does not really seem to turn quite as smoothly as the original (cf., among others, Baldauf 1996; Glucksberg & McGlone 1999; McGlone 2001; Jäkel 2002). Gibbs (1998) gives a re-assessment of the place of Lakoff *et al.* within cognitive sciences research in metaphor today.
- ¹⁰ Kretzenbacher 2002, p. 4 of the typescript.
- ¹¹ This last paragraph owes very much to Harald Weinrich’s remarks about what he called “*Randschärfe*” vs. “*Kernprägnanz*” (Weinrich 1989, pp. 124-126).
- ¹² I apologize for that one, too. The closeness of metaphor to the comic has long been acknowledged (cf. Schäfer 1996, pp. 75-78). In Gestalt theory all of this is discussed under the terms of ‘figure’ and ‘ground’, including a number of studies on metaphor from this theoretical angle (e.g. Glicksohn & Goodblatt 1993 or Tsur 2000). This is, however, not the place to discuss advantages and disadvantages of different approaches.
- ¹³ ‘*Ikonotropie*’ in the German original. See L. Kretzenbacher 1970 and also numerous more recent texts, such as L. Kretzenbacher 1986, p. 88; 1989; 1991; 1994, p. 51, up to and beyond L. Kretzenbacher 1999. Unfortunately, there is not enough space here to pay sufficient attention to L. Kretzenbacher’s development of this semiotically exciting concept, so that this remains to be done in a more detailed study on semasiotropy which I am working on at this stage.
- ¹⁴ Cf. L. Kretzenbacher 1991, p. 217, where the author acknowledges the inspiration for his own further development of the concept by Schmidbauer (1969, p. 144). Schmidbauer himself traces the term back to Robert von Ranke-Graves (cf. 1984, pp. 19-20). In the same article, L. Kretzenbacher (1991, pp. 229-230) discusses and eventually dismisses a suggested terminological change to ‘*epithetotropy*’, which had been suggested by a colleague but has indeed never really been taken up by the academic community.
- ¹⁵ That might also explain why metaphor lends itself so easily to combination with other tropes, such as the oxymoron (cf. Gozzi 1999).
- ¹⁶ This functional question has been asked before, of course, e.g. by Cacciari 1998. My task here is to link the focus of the question to the semiotic focus of the ‘p question’ in the preceding section as well as to aesthetics.
- ¹⁷ In a long tradition of visual metaphors for style (of the type: ‘*Loquere, ut te videam!*’), this catchy term was first used by Joseph Gusfield (1976, p. 17) and explained in the following form: “In keeping with the normative prescriptions of

scientific method, language and style must be chosen which will approximate, as closely as possible, a pane of clear glass”.

- ¹⁸ Kretzenbacher 1994b, pp. 91-92. He continues to use this concept of ‘stylistic taboo’ in subsequent publications.
- ¹⁹ Cf. Kretzenbacher 1992 and 1995.
- ²⁰ For the position of ‘elegance’ within the stylistic discussion, cf. Stammerjohann 2002.
- ²¹ Theodor Ickler (1993, p. 108), however, maintains that metaphors in expository texts (including scientific texts) are nothing but “stylistic means without cognitive consequences”.
- ²² Cf. Yang & Cheng 2000; Campos & Figueiredo 2001; Campos & Figueiredo 2002.
- ²³ For more recent examples for such an attitude in research starting from different backgrounds, cf. Gentner & Wolff 2000, Miller 2000, and Stern 2001. The suggestion that metaphors *create* by themselves (as in the title Glucksberg *et al.* chose for their 1997 article) almost seems to underestimate humans by making them appear as a sort of carrier material for metaphors.
- ²⁴ Cf. Fauconnier & Turner 1998, 2001; Turner & Fauconnier 1999; Pereira & Cardoso 2002.
- ²⁵ An aspect of intellectual work not entirely unfamiliar to chemists (cf. Laszlo 2000).
- ²⁶ One could argue that in metaphorical semasiology we ignore the boundaries between the ‘literal’ and the ‘figural’ as well.
- ²⁷ Such agendas, which could be understood as concrete sub-functions in our model, are dealt with in detail by Solja Paek (1999, pp. 249-59).
- ²⁸ For a similar attitude towards the part metaphor plays in scientific innovation, see some of the contributions to Danneberg *et al.* 1995.
- ²⁹ Cf. Hoffmann & Torrence 1993, Hoffmann 1996 (and other contributions to that issue of *Art Journal*), Levrier 2000.
- ³⁰ Corradi Fiumara herself (1995, p. 82) applies these words by Wittgenstein.
- ³¹ Cf. the text of his speech reprinted in Kretzenbacher 1998b, pp. 285-6.

References

- Bailer-Jones, D.M.: 2000, ‘Scientific models as metaphors’, in: F. Hallyn (ed.), *Metaphor and analogy in the sciences*, Kluwer, Dordrecht *et al.*, pp. 181-198.
- Bailer-Jones, D.M.: 2001, ‘Naturwissenschaftliche Modelle: Von Epistemologie zu Ontologie’, in: A. Beckermann & C. Nimtz (eds.), *Argument und Analyse – Sektionsvorträge. Ausgewählte Sektionsvorträge des 4. internationalen Kongresses der Gesellschaft für Analytische Philosophie Bielefeld, September 2000*, Mentis-Verlag, Paderborn, pp. 1-11.
- Baldauf, Ch.J.: 1996, ‘Konzept und Metapher – Präzisierung einer vagen Beziehung’, *Linguistische Berichte*, **166**, 461-482.
- Batstone, K.: 2000, ‘»One’s terms defy one’s arguments«: The metaphoric framing of »university as community« and »university as business« in the Second Report of the Task Force on Strategic Planning at the University of Manitoba’, *Metaphor and Symbol*, **15** (4), 241-251.

- Behr, M.; Erlwanger, S. & Nichols, E.: 1980, 'How children view the equals sign', *Mathematics Teaching*, **92**, 13-16.
- Black, M.: 1962, *Models and metaphors*, Cornell UP, Ithaca, NY.
- Böhme, H.: 1988, 'Denn nichts ist ohne Zeichen. Die Sprache der Natur: Unwiederbringlich?', in: H. Böhme, *Natur und Subjekt*, Suhrkamp, Frankfurt/M., pp. 38-66.
- Cacciari, C.: 1998, 'Why do we speak metaphorically? Reflections on the functions of metaphor in discourse and reasoning', in: A.N. Katz, C. Cacciari, R.W. Gibbs Jr. & M. Turner, *Figurative language and thought*, Oxford UP, New York, pp. 119-157.
- Campos, J. & Figueiredo, A.D. de: 2001, 'Searching the unsearchable: Inducing serendipitous insights', in: R. Weber & Ch. Gresse von Wangenheim (eds.), *Proceedings of the workshop program at the Fourth International Conference on Case-Based Reasoning, Harbor Center in Vancouver, British Columbia, Canada, 31 July 2001, Technical note AIC-01-003*, Navy Center for Applied Research in Artificial Intelligence, Washington, DC, pp. 159-164.
- Campos, J. & Figueiredo, A.D. de: 2002, 'Programming for serendipity', in: P. McBurney, Y. Ohsawa & S. Parsons (eds.), *Chance discovery: The discovery and management of chance events*, AAAI Press, Menlo Park, CA, pp. 48-60.
- Cassirer, E.: 1942, 'The influence of language upon the development of scientific thought', *The Journal of Philosophy*, **39** (12), 309-327.
- Corradi Fiumara, G.: 1995, *The metaphoric process: connections between language and life*, Routledge, London – New York.
- Daniel, H.-D.: 1993, *Guardians of science: fairness and reliability of peer review*, VCH, Weinheim et. al.
- Danneberg, L.; Graeser, A. & Petrus, K. (eds): 1995, *Metapher und Innovation: die Rolle der Metapher im Wandel von Sprache und Wissenschaft*, Haupt, Bern.
- Einstein, A.: 1917, *Über die spezielle und die allgemeine Relativitätstheorie, gemeinverständlich*, Vieweg, Braunschweig.
- Fauconnier, G.: 1997, *Mappings in thought and language*, Cambridge UP, Cambridge – New York.
- Fauconnier, G. & Turner, M.: 1998, 'Conceptual integration networks', *Cognitive Science*, **22** (2), 133-187.
- Fauconnier, G. & Turner, M.: 2001, 'Conceptual integration networks' [Expanded web version of Fauconnier & Turner 1998, 10 February 2001] <http://www.inform.umd.edu/EdRes/Colleges/ARHU/Depts/English/englfac/MTurner/cin.web/cin.html> (30/12/02).
- Figueiredo, A.D. de & Campos, J.: 2001, 'The serendipity equations' in: R. Weber & Ch. Gresse von Wangenheim (eds.), *Proceedings of the workshop program at the Fourth International Conference on Case-Based Reasoning, Harbor Center in Vancouver, British Columbia, Canada, 31 July 2001, Technical note AIC-01-003*, Navy Center for Applied Research in Artificial Intelligence, Washington, DC, pp. 121-124.
- Gentner, D.: 1982, 'Are scientific analogies metaphors?', in: D.S. Miall (ed.), *Metaphor: problems and perspectives*, Harvester, Brighton & Humanities Press, New Jersey, pp. 106-132.
- Gentner, D.; Bowdle, B.F.; Wolff, Ph. & Boronat, C.: 2001, 'Metaphor is like analogy', in: D. Gentner, K.J. Holyoak & B.N. Kokinoy (eds.), *The analogical mind: perspectives from cognitive science*, MIT Press, Cambridge, MA, pp. 199-253.
- Gentner, D. & Wolff, Ph.: 2000, 'Metaphor and knowledge change', in: E. Dietrich & A.B. Markman (eds.), *Cognitive dynamics: conceptual and representational change in humans and machines*, L. Erlbaum Associates, Mahwah, NJ, pp. 295-342.

- Gibbs, R.W.Jr: 1998, 'The fight over metaphor in thought and language', in: A.N. Katz, C. Cacciari, R.W. Gibbs Jr. & M. Turner, *Figurative language and thought*, Oxford UP, New York, pp. 88-118.
- Glicksohn, J. & Goodblatt, Ch.: 1993, 'Metaphor and Gestalt: interaction theory revisited', *Poetics Today*, 14, 83-97.
- Glucksberg, S. & McGlone, M.S.: 1999, 'When love is not a journey: What metaphors mean', *Journal of Pragmatics*, 31 (12), 1541-58.
- Glucksberg, S.; Manfredi, D.A. & McGlone, M.S.: 1997, 'Metaphor comprehension: How metaphors create new categories', in: T.B. Ward, S.M. Smith & J. Vaid (eds.): *Creative thought: an investigation of conceptual structures and processes*, American Psychological Association, Washington, DC, pp. 327-350.
- Gozzi, R.Jr.: 1999, 'The oxymetaphor – paradoxical superstar', *ETC: A Review of General Semantics*, 56 (2), 211-216.
- Grünfeld, J.: 2000, *Soft logic: the epistemic role of aesthetic criteria*, UP of America, Lanham, MD et al.
- Günther, A.: 1992, 'Der logische Status der Anführungszeichen', *Zeitschrift für Semiotik*, 14 (1-2), 123-140.
- Gusfield, J.: 1976, 'The literary rhetoric of science: comedy and pathos in drinking driver research', *American Sociological Review*, 41, 16-34.
- Hartmann, D. & Janich, P.: 1996, 'Methodischer Kulturalismus', in: D. Hartmann & P. Janich (eds.), *Methodischer Kulturalismus: Zwischen Naturalismus und Postmoderne*, Suhrkamp, Frankfurt/M., pp. 9-69.
- Hesse, M.B.: 1963, *Models and analogies in science*, Sheed & Ward, London.
- Hoffmann, R.: 1996, 'Just a little bit unnatural', *Art Journal*, 55 (1), 62-63.
- Hoffmann, R.; Minkin, V.I. & Carpenter, B.K.: 1997, 'Ockham's Razor and Chemistry', *Hyle*, 3, 3-28 [<http://www.hyle.org/journal/issues/3/hoffman.htm>].
- Hoffmann, R. & Torrence, V.: 1993, *Chemistry imagined: reflections on science*, Smithsonian, Washington DC.
- Hopper, P.J.: 1987, 'Emergent grammar', in: J. Aske, N. Beery, L. Michaelis & H. Filip (eds.), *Berkeley Linguistics Society, Proceedings of the 13th Annual Meeting*, Berkeley Linguistics Society, Berkeley, CA, pp. 139-157.
- Ickler, Th.: 1993, 'Zur Funktion der Metapher, besonders in Fachtexten', *Fachsprache*, 15 (3-4), 94-110.
- Jäkel, O.: 1999, 'Kant, Blumenberg, Weinrich: Some forgotten contributions to the cognitive theory of metaphor', in: R.W. Gibbs Jr. & G.J. Steen (eds.), *Metaphor in cognitive linguistics. Selected papers from the 5th International Cognitive Linguistics Conference, Amsterdam, 1997*, John Benjamins, Amsterdam – Philadelphia, pp. 9-27.
- Jäkel, O.: 2002, 'Hypotheses revisited: The cognitive theory of metaphor applied to religious texts', *metaphorik.de*, 2, 20-42 [<http://www.metaphorik.de/02/jaekel.pdf> (06/12/02)].
- Janich, P.: 1992, 'Chemie als Kulturleistung', in: J. Mittelstraß & G. Stock (eds.), *Chemie und Geisteswissenschaften: Versuch einer Annäherung*, Akademie-Verlag, Berlin, pp. 161-173.
- Kantorovich, A.: 1993, *Scientific discovery: logic and tinkering*, SUNY Press, Albany, NY.
- Kästner, E.: 1998, *Zeitgenossen, haufenweise. Gedichte*; ed. by H. Hartung, Hanser, München – Wien.
- Kleist, H.v.: 1990, 'Über die allmähliche Verfertigung der Gedanken beim Reden' [1805/06], in: K. Müller-Salget (ed.), *Sämtliche Werke und Briefe in vier Bänden, Bd. 3: Erzählungen, Anekdoten, Gedichte, Schriften*, Deutscher Klassiker Verlag, Frankfurt/M., pp. 534- 540.

- Kretzenbacher, H.L.: 1992, 'Zur Stilistik der Wissenschaftssprache im 18. Jahrhundert', in: Arbeitsgruppe Wissenschaftssprache (eds.), *Historische Wissenschaftssprachforschung. Zwei Referate eines Kolloquiums*, Akademie der Wissenschaften zu Berlin, Berlin, p. 41-60.
- Kretzenbacher, H.L.: 1994a, 'Bemerkungen eines Philologen zum Dialog zwischen Chemie und Geisteswissenschaften', in: E. Winter (ed.), *Selbstbilder und Fremdbilder der Chemie. Dokumentation eines Werkstattgesprächs, 15.-17. September 1993, Schloß Reisenburg, Günzburg*, Stifterverband für die Deutsche Wissenschaft, Essen, pp. 157-185.
- Kretzenbacher, H.L.: 1994b, '«Just give us the facts!» The connection between the narrative taboo, the ego taboo and the metaphor taboo in scientific style', *Lingua e stile*, 29 (1), 91-106.
- Kretzenbacher, H.L.: 1995, 'Wie durchsichtig ist die Sprache der Wissenschaften?', in: H.L. Kretzenbacher & H. Weinrich (eds.), *Linguistik der Wissenschaftssprache*, de Gruyter, Berlin – New York, pp. 15-39.
- Kretzenbacher, H.L.: 1996, 'Geschlossene Ketten und wirbelnde Schlangen – Die metaphorische Darstellung der Benzolformel', in: N. Psarros & P. Janich (eds.), *Die Sprache der Chemie. 2. Erlenmeyer-Kolloquium zur Philosophie der Chemie*, Königshausen & Neumann, Würzburg, pp. 187-196.
- Kretzenbacher, H.L.: 1997, 'Mind your metaphors! Historical and theoretical notes toward a constructivist theory of metaphor in scientific communication', in: A. Duszak (ed.), *Culture and styles of academic discourse*, Mouton de Gruyter, Berlin – New York, pp. 131-140.
- Kretzenbacher, H.L.: 1998a, 'Fachsprache als Wissenschaftssprache', in: L. Hoffmann, H. Kalverkämper & H.E. Wiegand (eds.): *Fachsprachen / Languages for Special Purposes. Ein internationales Handbuch zur Fachsprachenforschung und Terminologiewissenschaft / An International Handbook of Special Languages and Terminology Research*, vol. 1, de Gruyter, Berlin – New York, pp. 133-142.
- Kretzenbacher, H.L.: 1998b, 'Metaphern und ihr Kontext in der Wissenschaftssprache. Ein chemiegeschichtliches Beispiel', in: L. Danneberg & J. Niederhauser (eds.), *Darstellungsformen der Wissenschaften im Kontrast. Aspekte der Methodik, Theorie und Empirie*, G. Narr, Tübingen, pp. 277-297.
- Kretzenbacher, H.L.: 2002, 'Old Foes – New Friends? Terminology and Linguistics', paper given at AILA 2002, 13th World Congress of Applied Linguistics, 16 – 21 December 2002, Singapore (<http://www.aila2002.org/paper.htm>).
- Kretzenbacher, L.: 1970, 'Ikonotropie zu Kultbildern und Fresken in Südosteuropa', *Südost-Forschungen*, 29, 249-266.
- Kretzenbacher, L.: 1986, *Ethnologia Europaea: Studienwanderungen und Erlebnisse auf volkskundlicher Feldforschung im Alleingang*, R. Trofenik, München.
- Kretzenbacher, L.: 1989, 'Die »Himmelsleiter« zur Sozialismus-Sonne: Zur politisch-tendenziösen Umprägung einer frühmittelalterlichen Bild-Idee in Bulgarien', in: L. Kretzenbacher, *Volkskunde im Mehrvölkerraum: Ausgewählte Aufsätze zu Ethnologie und Kulturgeschichte in Mittel- und Südost-Europa*, R. Trofenik, München, pp. 329-349 (first published in 1981).
- Kretzenbacher, L.: 1991, 'Säkularisierte Ikonotropie zu religiösen Bildthemen Südost-Europas', *Südost-Forschungen*, 50, 215-234.
- Kretzenbacher, L.: 1994, *Nachtridentinisch untergegangene Bildthemen und Sonderkulte der 'Volksfrömmigkeit' in den Südost-Alpenländern*, Verlag der Bayerischen Akademie der Wissenschaften, München.
- Kretzenbacher, L.: 1999, 'Ein Neu-Versuch zum Bild-Gedanken »Schwieriger Weg nach oben«. Vom byzantinisch-geistlichen Bild der »Paradiesesleiter« des Johannes Klimakos († 649) zu »entgeistlichten« Ikonotropien', in: F. Grieshofer

- & M. Schindler (eds.), *Netzwerk Volkskunde: Ideen und Wege. Festgabe für K. Beil zum 70. Geburtstag*, Verein für Volkskunde, Wien, pp. 565-588.
- Lakoff, G.: 1993, 'The contemporary theory of metaphor', in: A. Ortony (ed.), *Metaphor and thought*, 2nd ed. Cambridge UP, Cambridge – New York, pp. 202-251.
- Laszlo, P.: 2000, 'Playing with molecular models' *Hyle*, 6 (1), 85-97.
(<http://www.hyle.org/journal/issues/6/laszlo.htm>).
- Lechleiter, H.: 2002, *Die Fachsprache der Chemie in Theorie, Praxis und Didaktik / Theory, practice and didactics of the Language for Special Purposes of chemistry*, PhD Thesis, Dublin City University.
- Lévi-Strauss, C.: 1962, *La Pensée sauvage*, Éd. Plon, Paris.
- Levrier, G.: 2000, 'The pathway between art and science – one painter's metaphorical journey', *Leonardo*, 33 (3), 191-196.
- Liebert, W.-A.: 1997 'Stop making sense! Metaphor and perspective in creative thinking sessions of scientists and scientific radio broadcasts', in: W.-A. Liebert, G. Redeker & L. Waugh (eds.), *Discourse and perspective in cognitive linguistics*, J. Benjamins, Amsterdam – Philadelphia, pp. 149-183.
- Lightman, A.P.: 1989, 'Magic on the mind: physicists' use of metaphor', *The American Scholar*, 58 (1), 97-101.
- Maasen, S. & Weingart, P.: 2000, *Metaphors and the dynamics of knowledge*, Routledge, London – New York.
- McGlone, M.S.: 2001, 'Concepts as metaphors', in: S. Glucksberg (ed.), *Understanding figurative language: from metaphors to idioms*, Oxford UP, Oxford – New York, pp. 90-115.
- Merrell, F.: (s. d.), 'Semiotics versus semiology: or, how can we get a handle on semiosis?' (<http://www.digitalpeirce.org/floyd/merrell.htm> [09/01/03]).
- Merton, R.K.: 1965, *On the shoulders of giants: a Shandean postscript*, Free Press, New York.
- Miller, A.I.: 2000, 'Metaphor and scientific creativity', in: F. Hallyn (ed.), *Metaphor and analogy in the sciences*, Kluwer, Dordrecht et al., pp. 147-164.
- Mistichelli, W. J.: 1994, 'Style and truth: reflections on the language of science', *Papers on Language & Literature*, 30 (3), 257-284.
- Mistichelli, W.J.: 1998, 'Can plants hear bassoons? Science and the sublime', *Papers on Language & Literature*, 34 (1), 19-56.
- Müller, W.: 1981, *Topik des Stilbegriffs. Zur Geschichte des Stilverständnisses von der Antike bis zur Gegenwart*, Wissenschaftliche Buchgesellschaft, Darmstadt.
- Neus, J.: 2002, *Aromatizität: Geschichte und mathematische Analyse eines fundamentalen chemischen Begriffs*, HYLE Publications, Karlsruhe.
- Nimis, S.: 1988, 'Aristotle's analogical metaphor', *Arethusa*, 21 (2), 215-226.
- Norris, C.: 1995, 'Metaphor, ontology, and scientific truth: Against some dogmas of the new anti-realism', *The Belgrade Circle Journal*, 3-4
(<http://www.usm.maine.edu/~bcj/issues/three/norris.html> [09/01/03]).
- Paek, S.: 1993, *Die sprachliche Form hypothetischen Denkens in der Wissenschaftssprache*, Iudicium, München.
- Paek, S.: 1999, 'Metaphern als Erkenntnismittel in der Wissenschaftssprache', *Koreanische Zeitschrift für Germanistik*, 72 (vol. 40.4), 244-262.
- Pereira, F.C. & Cardoso, A.: 2002, 'Conceptual blending and the quest for the holy creative process', in: *Proceedings of Creative Systems: Approaches to Creativity in AI and Cognitive Science. Workshop of ECAI'02*. Lyon 2002
(<http://eden.dei.uc.pt/~camara/files/QuestCRC.pdf> [30/12/02]).
- Psarros, N.: 1993, 'Chemische Theorien und Modelle: Abbilder der Natur oder Handlungsanweisungen?', *Wirtschaft & Wissenschaft*, 1 (3), 20-30.

- Psarros, N.: 1996a, 'Die Chemie als Gegenstand philosophischer Reflexion', in: N. Psarros, K. Ruthenberg & J. Schummer (eds.), *Philosophie der Chemie: Bestandsaufnahme und Ausblick*, Königshausen & Neumann, Würzburg, pp. 111-141.
- Psarros, N.: 1996b, 'Die chemische Reaktionsgleichung als Kalkül', in: N. Psarros & P. Janich (eds.), *Die Sprache der Chemie. 2. Erlenmeyer-Kolloquium zur Philosophie der Chemie*, Königshausen & Neumann, Würzburg, pp. 127-138.
- Ranke-Graves, R.v.: 1984, *Griechische Mythologie: Quellen und Deutung*, trans. by H. Seinfeld, Rowohlt, Reinbek.
- Rohrer, T.: 1997, 'Conceptual blending on the information highway: How metaphorical inferences work', in: W.-A. Liebert, G. Redeker & L. Waugh (eds.), *Discourse and perspective in cognitive linguistics*, J. Benjamins, Amsterdam – Philadelphia, pp. 185-204.
- Schäfer, S.: 1996, *Komik in Kultur und Kontext*, Iudicium, München.
- Schmidbauer, W.: 1969, *Methodische Probleme einer Psychologie des Mythos, aufgezeigt an der Ödipus-Sage*, E. Reinhardt, München.
- Schoenfeld, R.: 1989, *The chemist's English*. 3rd, rev. ed., VCH, Weinheim et al.
- Schwedt, G.: 1998, *Goethe als Chemiker*, Springer, Heidelberg.
- Spivey, N.N.: 1997, *The constructivist metaphor: reading, writing, and the making of meaning*, Academic Press, San Diego et al.
- Stammerjohann, H.: 2002, 'Eleganz: Eine Causerie zum 75. Geburtstag von Harald Weinrich' (http://www.daf.uni-muenchen.de/DAF/AKTUELL/stj_weinrich_geb.pdf [24/09/02]).
- Steinhart, E.Ch.: 2001, *The logic of metaphor: analogous parts of possible worlds*, Kluwer, Dordrecht et al.
- Stern, J.: 2001, 'Knowledge by metaphor', in: P.A. French & H.K. Wettstein (eds.): *Figurative language*, Blackwell, Boston – London, pp. 187-226.
- Thagard, P.: 2002, 'The passionate scientist: Emotion in scientific cognition', in: P. Carruthers, S.P. Stich & M. Siegal (eds.), *The cognitive basis of science*, Cambridge UP, New York, pp. 235-250.
- Tirrell, L.: 1991, 'Reductive and nonreductive simile theories of metaphor', *The Journal of Philosophy*, **88** (7), 337-358.
- Tsur, R.: 2000, 'Metaphor and figure-ground relationship: Comparisons from poetry, music, and the visual arts', *Psyart: Hyperlink Journal for the Psychological Study of the Arts*, (<http://www.clas.ufl.edu/ipasa/journal/articles/psyart2000/tsur03.htm> [05/01/03]).
- Turner, M. & Fauconnier, G.: 1999, 'A mechanism of creativity', *Poetics Today*, **20** (3), 397-418.
- Weinrich, H.: 1976, *Sprache in Texten*, Klett, Stuttgart.
- Weinrich, H.: 1989, 'Formen der Wissenschaftssprache', *Jahrbuch 1988 der Akademie der Wissenschaften zu Berlin*, pp. 119-158.
- Weinrich, H.: 1993, *Textgrammatik der deutschen Sprache*, Dudenverlag, Mannheim et al.
- Yang Yaokun, Cheng Liangdao: 2000, 'The rationality of scientific discovery: The aspect of the theory of creation', *Twentieth World Congress of Philosophy Boston, MA, 10-15 August 1998*, (<http://www.bu.edu/wcp/Papers/Scie/ScieYang.htm> [07/01/03]).
- Zangwill, N.: 1991, 'Metaphor and realism in aesthetics', *The Journal of Aesthetics and Art Criticism*, **49** (1), 57-62.

Heinz L. Kretzenbacher:

Department of German and Swedish Studies, The University of Melbourne, Victoria 3010, Australia; heinz@unimelb.edu.au