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Niklas Pramling

# Minding metaphors

## Using figurative language in learning to represent

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GÖTEBORG STUDIES IN EDUCATIONAL SCIENCES 238

Institutionen för pedagogik och didaktik

# Minding metaphors

## Using figurative language in learning to represent

av

Niklas Pramling

AKADEMISK AVHANDLING

som med tillstånd av utbildningsvetenskapliga fakulteten vid
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# Abstract

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The purpose of this thesis is to contribute to our understanding of the role of metaphor in learning and scientific reasoning. Metaphor is assumed to be fundamental for our learning and knowing. This issue is studied both on the level of scientific knowledge formation and on the level of individual reasoning and learning. The first part of the thesis consists of a general background of the issue, and of theoretical and methodological considerations. The second part of the thesis consists of four separate studies. The first study concerns the introduction, uptake, moulding, and use of one of the most famous metaphors in modern psychological theory, the metaphor of 'chunk.' By analysing scholarly articles on memory in leading psychological research journals, it was found that chunk was either taken as a static (reified) entity, or as a dynamic process (as chunking). It is argued that two different views of human abilities and capacities follow from this, one describing humans as severely limited in capacity and another describing humans as practically infinitely capable of expanding their knowledge and abilities. The second study shifts attention to scientific popularizations by analysing how the concept of 'DNA' is described and explained in two popular science magazines. It is found that anthropomorphic metaphors are functional in narrating scientific knowledge. From these metaphors, a view of humans as governed by infinitely small, but infinitely powerful, agents follows. The importance of distinguishing the representation from what is being referred to is emphasised. In the analysed material, however, these different 'levels' of description are often conflated, in which case a category mistake is made. The third study analyses the metaphors used in constituting a scientific theory and the subsequent difficulties that these metaphors may pose for learning and reasoning of students. The example studied is Darwin's theory of the evolution of species by means of natural selection. Anthropomorphic and teleological metaphors abound. It is concluded that the apparent simplicity of the theory (through its familiar metaphors) may in itself, in part, account for the empirically well-supported difficulty for learners. The fourth study, finally, re-analyses clinical interviews in the work of Jean Piaget. More specifically, the topic of analysis is how children qualify their answers. It is found that reasoning by 'as if' or by analogy are frequent. By analysing the children's answers in communicative rather than cognitive terms, a markedly different picture of the children's abilities and competences emerges. In learning to represent, the importance of simultaneously keeping a meta-perspective in mind is emphasised. Keeping the metaphorical quality of representations alive, finally, is hypothesised as one way of learning and knowing 'mindfully,' i.e., in learning to be open to learn anew.

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Göteborg, February 2006

Niklas Pramling

# Part One:
# Minding Metaphors

# Introduction

Every society has an interest in seeing its accumulated knowledge preserved for future generations. These products of learning, represented in artefacts such as language, technologies, tools, and the management of these, are fundamentally what our cultural development consists of, when viewed in a sociocultural perspective on learning and development (Nelson, 1996). For a complex society with increasing repertoires of various forms of knowledge that the child cannot discover and learn for herself, this also means that pedagogical practices must be available and institutionalized (Säljö, 2005). In response to this development, education enters our history. In order to study and clarify, for example, difficulties in learning something particular, questions such as the following are addressed: How has this knowledge been formed and developed? How is it taught and passed on in society? Which assumptions and perspectives are 'built into' or 'inscribed' into this knowledge? These are questions having to do with the sociogenesis of knowledge, to use sociocultural parlance (Säljö, 2000, 2005). A related question concerns the 'migration' of knowledge, concepts, perspectives, i.e., how something is taken from one domain of knowledge, or one practice, to another, and introduced and taken up/transformed there. Since every phenomenon may be described in a variety of different ways, learning how to pay attention to and discern what is pivotal for a certain practice is of great importance. Thus, questions regarding how phenomena are constituted in learning situations will be of interest to study from such a perspective.

The art of knowing, as Bruner argues, may be seen as consisting of 'expanding' our in one sense very limited capacity (see also, Miller, 1956; Study I in this thesis).

> We honor that capacity by learning the methods of compacting vast ranges of experience in economical symbols–concepts, language, metaphor, myth, formulae. The price of failing at this art is either to be trapped in a confined world of experience or to be the victim of an overload of information. What a society does for its members, what they could surely not achieve on their own in a lifetime, is to equip them with ready means for entering a world of enormous potential complexity. It does all this by providing the means of simplification–most notably, a language and an ordering point of view to go with the language. (Bruner, 1979, p. 6f.)

Thus, how complexity is reduced, and how phenomena are constituted, and what is 'opened up,' alternatively 'closed' for seeing and knowing, are important questions for work on learning. It will be emphasised in the present thesis (see especially Study IV) that metaphors (and to reason in an 'as if' manner) is one of the ways in which we do this. By means of metaphors, the learner extends her abilities. Also, I argue that 'metaphor' can be seen as an abstraction of a fundamental principle for how we adapt or make functional our language to new situations and experiences. The learner needs to be able to adjust her language to make sense of novel experiences. This presumes some flexibility in thinking. Perhaps this is accentuated today, in a 'complex world' with diverse forms of knowledge domains the individual can encounter (in, for example, but not exclusive to, formalized schooling). For research, different metaphors and their use may, among other things, yield different images of human abilities and capacities. The metaphors used in scientific work may also in concrete ways lead the research endeavour by providing the terms in which something is being studied, and what kinds of questions are asked (see, Study I in the present thesis).

Throughout intellectual history, at least since Aristotle (384-322 BC), metaphor has been a topic of interest for philosophers, rhetoricians, literary critics, linguists, psychologists, and others (Kövecses, 2002). Prominent scholars, who have written on or studied metaphor, include John Locke, Giambattista Vico, Friedrich Nietzsche, Ernst Cassirer, I. A. Richards, Benjamin Lee Whorf, Mary Hesse, Max Black, Nelson Goodman, Paul Ricoeur, Susan Sontag, Richard Rorty, and Evelyn Fox Keller, to name but a few. However, today, and especially since 1980, a renewed interest in metaphor can be noted. The prime focus here is on questions of how people make sense of the world around them (Franke, 2000). "The reason" for this renaissance for metaphor in research, Kövecses (2002, pp. x-xi) argues, is a realization "that metaphor plays a role in human thought, understanding, and reasoning and, beyond that, in the creation of our social, cultural, and psychological reality. Trying to understand metaphor, then, means attempting to understand a vital part of who we are and what kind of world we live in." This also makes metaphor interesting to study from the point of view of learning, which will be done in the present thesis.

In a sociocultural perspective, as well as in others, metaphor is not a specific kind of language for specific kinds of uses. Instead, metaphor is seen as a pervasive quality of our language, it is part of what we may alternatively term 'the constitutive function of language.' Language is not seen as simply corresponding to something, but as constituting what is spoken about as a certain kind of 'thing' in certain terms rather than others (Barclay, 1997; Säljö, 2000). Our knowledge is fundamentally discursive (consisting of similes and distinctions). Obviously, in order to speak about something we have to constitute or represent it in language. The form our representation takes and how this representation relates to what is being referred to will be important questions for anyone with an interest in learning and understanding.

In a general sense, discursive forms of knowledge can be seen as metaphorical (or analogical) in nature. Leary (1990, p. 2) illustrates this premise with the following example:

> If I am confronted with a word that I do not understand, I will either ask someone what it means or look it up in a dictionary. In either case, I will keep asking and searching until the word is defined in terms of other words that are better known to me. This simple example can serve as a paradigm for the many ways in which we confront and come to understand 'reality.'

However, with the establishment of certain ways of speaking about specific phenomena, i.e., with the conventionalization or institutionalization of ways of speaking, metaphors tend to become literalized (i.e., lose their status *as* metaphors for the users).[1] Another way of stating this is to say that certain versions of the world tend to be 'naturalized' over time. In fact, this is, in part, how scientific concepts are established. These conventionalized metaphors (as concepts or categories) then become the resources whereby institutions 'think,' to use Douglas' (1986) metaphor. This process not only means that words lose their metaphorical status (they are perceived as literal), but also that how a certain term (metaphor) should be understood in the specific practice is explicitly defined. In fact, learning how the metaphor is to be taken (and even if it should be understood *as* a metaphor or not) is a central difficulty for learners entering such a practice, e.g., in science education (see, Study III in the present thesis). However, conventionalized metaphors need not be any less 'leading' or 'forceful' in our reasoning. In fact, the opposite may be true, since we think *with* them but not *of* them after they have been literalized. That the categories of 'metaphorical' and 'literal,' respectively, in the view adopted in the present thesis, become a difference in degree rather than kind is also in my view what makes it important to have a socio-historical perspective when studying metaphor.

The question of the role, if any, of metaphor in science is a controversial and historically highly contested one (see, e.g., Hesse, 1966; Leatherdale, 1974; Smith, 1990). Assuming that for scientific knowledge metaphor is in a sense a necessity does not make it any less interesting to study how metaphor is employed, and what it may imply for knowledge formation and learning, which is the overall interest of the present thesis.

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[1] But there are also metaphors in a culture that become conventionalized *as* metaphors. For example, there exist symbolic lexicons in which prevalent cultural metaphors can be looked up to see how they have been used in a culture, in myths, poems, literature, art.

As a meta-comment, it may be noted that studying metaphor is in itself by necessity a metaphorical activity, i.e., it requires the use of metaphors. This can easily be seen throughout the present work. Thus, this thesis is in this sense 'self-illustratory' of one of its premises, and can be read as an illustration of the ubiquity of metaphor in knowing. And even the term 'metaphor' is a metaphor, as clarified through etymology: Of Greek origin, to "transfer, carry over," from *meta*, over, across, and *phérein*, to carry (CDE, 2000, p. 656). In more general terms, to narrate something requires that what is told is partly 'anchored' in what the reader or learner already knows or presumes. Hence, using the familiar to explain the novel is not only a feature of the composition of our language, it is also a communicative adjustment.

## Marking out metaphor in discourse

Using metaphors and metaphoric in my view does not imply that the speaker herself considers her way of speaking metaphorical. Whether she does so or not is in itself interesting and, as I will argue in this thesis, a critical issue for her learning and knowing. However, a speaker can make clear to her interlocutor that she intends her utterance to be metaphorical.

There are a number of different ways in which speakers can mark out that they speak non-literally. Goatly (1997) makes an extensive inventory of what he calls 'the signalling of metaphor.' The following are but a few examples: 'in a way,' 'kind of,' 'like,' 'as if,' 'so to speak,' '   ' (single quotation marks),[2] '(!),' 'as it were' (Goatly, 1997).

The most explicit way of signalling a non-literal use of language would be to say or write 'metaphorically speaking.' However, it is interesting and rather peculiar that the opposite of 'metaphorical,' i.e., 'literal,' may also be used in signalling a metaphorical use of words. "The paradox of why *literally* and other intensifiers" such as 'actually,' 'really,' 'quite,' and 'indeed,' "should be used to mark metaphor can perhaps best be explained by drawing parallels with the modality of possibility," Goatly (1997, p. 173) writes, and elaborates:

> The strongest truth claim one can make is one with no intensification of certainty on this modal scale: *he must be home by now*, despite the high level of probability of *must*, is less certain than *he is home by now*, as though the modal is a doubtful speaker's attempt at self-reassurance. Similarly *literally* implies the need for intensification of the truth claim. (loc. cit.; italics in original)

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[2] Putting a word within single quotation marks may alternatively be a way of marking out that the word is spoken *about* rather than *with* in a sentence. However, as also Goatly (1997) points out, both uses of inverted commas may be used at the same time, to mark out that a certain metaphor is used in a text referred to.

I will refer to cases like the above examples as 'meta-communicative markers' (Goatly, 1997, himself uses 'signalling' or 'markers'). However, in my understanding these markers communicate how one communicates and how utterances are to be 'taken' (Olson, 1994), and therefore warrant the label 'meta-communicate markers.'

In my view, marking out a non-literal use of language by the speaker shows a 'relational sensitivity' to what needs to be pointed out for the communicative partner, i.e., realizing what cannot be presumed that the interlocutor knows or understands. In this way, using and clarifying the status of a language that is non-literal is not only an adjustment of language but also has a communicative function (see also Study IV of this thesis).

## Guidance for readers

This thesis consists of two parts. The remainder of the first part is structured in the following manner. First, a theoretical framework for, and background to, the thesis will be presented. I will attempt to present a theoretical view of (a) the intellectual development of humans as driven by her tools, and argue (b) that her most important tool is language, and (c) that what expands our language is a principle or process which we can label 'metaphor,' and finally, (d) that we adjust our language and knowledge to ever new situations through metaphorical reasoning. That is, the view adopted here sees metaphor as a means through which our language – and hence our knowledge – develops. In addition, I will try to point out what kinds of questions become of some interest to study if such a theoretical framework is adopted. After this, follows a chapter on theoretical and conceptual considerations. Here, different theories of metaphor are presented and critically evaluated. Then, some central and closely related concepts (analogy, simile, metonymy, etc.) are distinguished and stipulatively defined. Writings and research on metaphor in science and in science education will then be exemplified and discussed. The following chapter begins with a treatment of methodological considerations, including identification and analysis of metaphor. The first part of the thesis ends with a summary of the four studies and a discussion of the further implications of the main findings.

The second part of the thesis consists of the four studies:

I. Possibilities as Limitations: A Study of the Scientific Uptake and Moulding of G. A. Miller's Metaphor of Chunk

II. Scientific Knowledge, Popularization, and the use of Metaphors: Modern Genetics in Popular Science Magazines

III. Re-figuring Evolution: Metaphors in the Formation and Learning of Scientific Knowledge

IV. 'The Clouds are Alive because they Fly in the Air as if they were Birds': A Re-analysis of what Children Say and Mean in Clinical Interviews in the Work of Jean Piaget

The focus of this thesis will be on scientific reasoning, both on a knowledge formation level (i.e., research), and on a level of learning of individuals. The theme for the thesis is metaphor (as a constitutive force) in scientific reasoning. From this general issue (as analysed by four studies), three sub-themes emerge: (1) A process of reification in metaphor, (2) A process of animating or anthropomorphizing (i.e., components are ascribed, given, intentional agentive abilities), and (3) A recurrent 'jump' between different levels of analysis/description. It will also be argued that the metaphors used or, rather, how they are used (introduced, taken up, and moulded), yield different images of human capacities and abilities. What is at stake here, if anticipating what will later be argued, are questions of what we know, how we know, what we may be able to do and not do – i.e., in our understanding, conceptualization, of ourselves as humans and learners. This may have implications for teaching practices and research on human learning and development. Finally, the importance of meta-cognition in keeping the metaphorical character of certain representations alive is discussed as potentially facilitating 'mindful' learning (Langer, 1989, 1997), i.e., learning to be able to learn anew.

One premise of this thesis is that there is a point in (a) studying different knowledge 'contents' and areas of inquiry in the respective studies, and (b) doing this on two 'levels' of learning, individual and collective (scientific). The reason for this is that it is not the different knowledge contents in the respective studies that are of prime interest. Instead, these knowledge contents are studied as examples of more general principles concerning the use of metaphor in trying to handle what is in some sense unclear. The thesis ends with an appendix containing the Swedish empirical examples analysed in Study II and III, respectively.

At this point, it may be asked whether learning is only achieved with the aid of metaphor. The answer to this question has to be no. There are many instances of learning that do not appear to involve metaphorical language or aspects of reasoning, to give but a few examples: manual trial and error, rote learning, non-discursive forms of knowing. And even in situations where reasoning, understanding, and learning could be analysed in terms of metaphor, there may be many other, more fruitful, i.e., more clarifying, approaches to apply. It is not my intention to suggest that metaphor is a panacea for the study of learning and development. But it is this perspective that I will employ in the present thesis. It does not exclude the importance of other approaches.

### *A brief note on the literature used*

A substantial part of the most interesting writings on metaphor throughout history has been written by philosophers. Hence, there will be some emphasis on such texts in the references. However, it is important, in fact fundamental, for understanding the present work, to realize that these texts are interesting as foundations, sources, or 'backgrounds' for researching questions about learning and thinking. These issues are the focus of the present thesis.

# A sociocultural perspective on learning and development

From a sociocultural perspective (Säljö, 2000, 2005; Wertsch, 1985, 2002) on learning and development, the concept of 'mediation' (Vygotsky, 1934/1986) is a central one. The idea is that we do not have direct access to the world as such but we relate to it as it is re-presented by means of different kinds of 'tools.' At least this is the case for the individual after having acquired a language (Ghassemzadeh, 2005). By far the most important mediational tool is our language (Nelson, 1996; Vygotsky, 1934/1986). Mediational tools may be psychological (discursive) or physical. However, this distinction may not always be clear-cut. "Indeed," writes Säljö (1997, p. 6), "cultural development, i.e., learning at the level of collectives, is largely a matter of transforming ideas and concepts into material artifacts." Two such examples, as I understand it, of direct relevance to the present work, would be a dictionary (illustrating and storing how we collectively have evolved our sense of our world) and a textbook (on scientific theories). The theory also argues that tools not only mediate one's understanding (and perception) of the world but also the relation between the individual and the collective culture (since tools have their genesis and are reproduced in communication between people). This also implies that the individual's thinking is not and cannot be an entirely private matter (Bruner, 1990). In Vygotsky's terms:

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, *between* people (*interpsychological*), and then *inside* the child (*intrapsychological*). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. (Vygotsky, 1978, p. 57; italics in original)

From their initial external or inter-relational existence between people, the mediational means or psychological tools are subsequently 'turned in' "'on themselves', that is, they become a means of controlling one's own mental process" (Ghassemzadeh, 2005, p. 285; cf. Karpov & Haywood, 1998). This suggests that the psychological tools (such as, and especially, language) can fill important meta-functions in the individual's thinking (and behaviour). For example, I will later argue for the importance of learning to deal with the indirect or mediational way in which our language represents the world. Hence, the importance of meta-communicative awareness.

According to developmental psychologist Katherine Nelson (1996), the development of humans as humans is fundamentally achieved by means of the development of humanly invented representational systems (or tools). This goes for the phylogenetic level as well as for the ontogenetic level of development. However, I will mainly be concerned with the latter. Thus, according to the argument, humans develop their thinking by inventing, appropriating, and using different representations. By far the most important representational system is our language, and "it is," in Nelson's (1996, p. 87) words, "human language and its potential for different ways of formulating thought that has driven and continues to drive human cognitive development on both the evolutionary and the individual scale." Language is understood as a collective tool allowing us to do things and serving various social purposes, such as organizing or coordinating social action. Language makes it possible, for example, to share and compare experiences (thus enriching the individual's knowledge), to open up for knowledge potentials that are not available without it, to invent new knowledge, and to provide information of present conditions and anticipating future conditions. Language further makes it possible for us to share knowledge over time and over individuals, from generation to generation. It 'opens up' for cumulating human experiences and knowledge (which are potentials for development of cognition as well as for science), and functions as a means of externalizing and storing memories.

"The human brain," Nelson argues, "is notably immature at birth in comparison with other primates, and it remains extraordinarily plastic and subject to quite radical reorganization in response to trauma or experiential deprivation (and presumably enrichment) for several years and, to some extent, even throughout life" (Nelson, 1996, p. 34). This plasticity of our brain also means that there can be no simple 'linearity' or simple 'expression' in development, but that our development becomes critically dependent, or contingent, on the experiences that we are allowed to make. Humans are socially dependent and mouldable.

The human mind is dependent on mediation from birth through the learning of representations and cultural categories implicit in practices and artefacts in the child's world. But in a more specific sense, the mind of the infant is inaccessible for representations of other minds until language as a representational system of exchange becomes available. "In this latter sense, language is the medium through which the mind becomes culturally mediated" (Nelson, 1996, p. 119). Ontogenetically, this drastic change in cognitive development – when culture 'takes over the human mind'– occurs with the emergence of language when the child is 2 to 6 years old. In terms of Nelson's (1996, p. 325) metaphor: "It is during these years that biology 'hands over' development to the social world."

Olson (1994, p. xiii) argues that “we live not in the world so much as in the world as it is represented to us.” Our knowledge in terms of which we perceive and act in the world is to a large extent representational. And, as Olson (1994, p. 29) continues, “we do our sciences by exploring alternative models or representations of things – a form of activity which presupposes a radical discontinuity between a thing and a representation of a thing.” Olson derives this mode of representing in science to the impact of literacy, and argues that this is a boundary “between the representation and what is represented or, more precisely, between metonymy and metaphor. In metonymy a *part* stands for the whole; the symbol is a part of the thing symbolized; in metaphor it merely stands for something” (ibid., p. 32f.; italics in original). This latter form of relation between a representation and what is referred to is, in Olson’s (1994) view, characteristic of literate thinking and, in extension, of scientific thinking.

In a sociocultural perspective, development becomes a question of appropriating (Wertsch, 2002) a variety of representational means. A representation may be anything that is used in referring to anything else (Wells, 2000). In this general sense, it lies close to a definition of metaphor. However, in the case of metaphor, this ‘something else’ has to be something that it cannot literally be. The view taken here is that in certain ways of representing the world, we use and reason in terms of metaphors and metaphoric. In this thesis I will focus on the metaphorical quality of certain forms of representations, for example, in making sense of and reasoning about (in popularizing) scientific knowledge, but also in the formation of such knowledge.

The relevance of this reasoning for the present thesis is primarily that it frames the interest and relevance of what is to be studied (metaphor as a quality inherent in the arguably most important representational system or tool whereby we make sense, learn and develop). It is further argued that in language, one of our primary means of ‘transcending’ our present language is by means of metaphor. Through metaphor new ways of speaking emerge and language develops. Hence, metaphor is, I argue, the means through which we develop our most important tool, our language. It is also by using language metaphorically that we are able to adapt our language to new situations and experiences. And this is one important aspect of what it may mean to learn.

For research on learning, a “fundamental issue” within a sociocultural perspective “becomes one of understanding how individuals are able to identify the situationally appropriate referential meaning of a concept or, alternatively, what it takes to use a concept in a relevant manner within a particular discursive practice” (Säljö, 1997, p. 10). Hence, appropriating (Wertsch, 2002) discursive tools is not simply a matter of 'taking these in,' as a traditional metaphoric has it. Of critical importance is to learn how these tools relate to what they refer to. For example, whether a representation should be understood as literally true or as metaphorically put – and if so, then how, in what sense could what is being referred to be spoken about and understood in these terms. Later on in this thesis, I will argue for, and study empirically, the importance of paying attention to meta-communicative markers as critical elements when learning conceptually demanding knowledge.

## Language as constitutive

The metaphor used for language in a sociocultural perspective is 'tools.' Vygotsky (1934/1986, 1978), writing on the metaphor of 'psychological (or intellectual) tools,' argues that one thing that tools do for us, so to speak, is to direct our awareness/perception (to something, and, thus, simultaneously by necessity, away from something else). Vygotsky (1978, p. 32) argues that with the advent of language, "The child begins to perceive the world not only through his eyes but also through his speech. As a result, the immediacy of 'natural' perception is supplanted by a complex mediated process; as such, speech becomes an essential part of the child's cognitive development." He concludes, on the basis of studies he briefly reviews, that these suggest that after acquiring a language "human perception" comes to consist "of categorized rather than isolated perceptions" (p. 33). And categories, I will further argue, could be seen as a form of conventionalized or institutionalized metaphors.[3] Consider the following research as an illustration of these claims.

Luria (1976, p. 12) and co-workers set out at the early 1930s in remote regions of the Soviet Union to analyse "the sociohistorical shaping of mental processes." These regions were being radically restructured, with a new economic system, new activities, schools being opened, and so on. A critical difference between the participant groups was between those having been exposed to schooling (who were literate), and those who had not (and who were 'illiterate'). Here, I will only relate to the study of perception of geometrical figures.

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[3] Psychological discourse provides many examples of terms coming into scientific theorizing as highly metaphorical, i.e., signalling a new use of old words, which are then defined and elaborated into categories or concepts, and as such cease to be perceived as metaphorical by professionals. This, in my view, illustrates how our language migrates and through this, how our knowing changes, develops over time, as it were. Some rather obvious examples that can be found in the glossary of practically any contemporary introduction to psychology (e.g., Atkinson, Atkinson, Smith, Bem & Nolen-Hoeksema, 1996) include: regression, depression, development, introspection, visual field, top-down processes, threshold, tabula rasa, theory (going back to Greek for 'look at' from 'spectator,' CDE, 2000, p. 1132), scapegoat, repression, projection, fuzzy concept, key-word method, obsession (from obsess, from Latin "besiege, occupy; literally, sit opposite to," CDE, 2000, p. 719), and pop-out effect. A quick overview suggests that they could be grouped into those focusing(!) on physical action or on visualization.

The participants were asked to name a set of geometrical figures, presented by the experimenter, and to classify similar figures into separate groups. The figures differed in a variety of ways: being complete or incomplete; 'light' (outlined) or 'dark' (solid) in colour; and formed by lines or by discrete elements, such as points, crosses, etc. (see, Luria, 1976, p. 33, for illustrations).

It was found that

> Only the most culturally advanced group of subjects–the teachers' school students–named geometrical figures by categorical names (circles, triangles, squares, and so forth). These subjects also designated figures made up of discrete elements as circles, triangles, and squares, and incomplete figures as "something like a circle," or "something like a triangle." (p. 32)

In contrast to this, the group of unschooled, illiterate participants

> assigned no categorical (geometrical) designation to any of the figures presented. They designated all figures with the names of objects. Thus, they would call a circle a plate, sieve, bucket, watch, or moon; a triangle, a *tumar* (an Uzbek amulet); and a square, a mirror, door, house, or apricot drying-board. They treated a triangle made up of crosses as crosswork embroidery, a basket, or stars; they judged a triangle made up of little half-circles to be a gold tumar, fingernails, lettering, and so forth. They never called an incomplete circle a circle but almost always a bracelet or earring, while they perceived an incomplete triangle as a tumar or stirrup. Thus this group's evaluation of abstract geometrical figures was decidedly concrete and object-oriented, and this tendency clearly predominated over abstract geometrical shape perception. (p. 32f.)

Thus, how we name 'things' in fundamental ways is related to the experiences we have been allowed to make. The unschooled participants spoke in terms of familiar objects and practices (cf. Säljö, 1997). These examples also illustrate how we perceive the unfamiliar in terms of something more familiar, in other words, through metaphorical extensions.

An additional note that I would like to add is that the two quotes above also illustrate how a description can never be neutral (Bruner, 1986). We have to describe or name what is being studied *as* something, speak of it in certain terms (e.g., as a 'bracelet,' 'circle,' etc.). Every description has to be in terms of something partially different; phenomena do not come pre-labelled by nature (only by culture-historical convention or institutionalization). And to become culturally competent (to be able to handle different forms of representations) is a question of learning to describe, speak about, phenomena in certain terms rather than others. Learning the language (discourse) of a science is a case in point.

Metaphors are thus important to consider because they function in making certain things, phenomena, processes, aspects, as Shotter (1993, p. 38) puts it "'rationally-*in*visible' to us" (italics in original). This means that through the 'directive function' of terms, there are "things which our ways of perceiving, acting, talking, and evaluating *fail* to make visibly-rational to us, and thus amenable to rational discourse and debate" (loc. cit.).

Viewed in this manner, metaphors sometimes become 'problem-setting stories,' i.e., descriptions of "what is wrong and what needs fixing" (Schön, 1993, p. 138; Reddy, 1993). Phrased differently, metaphor can be seen as setting the frame for how the phenomenon should (logically) be studied. According to this view, the function and importance of metaphor in scientific knowledge formation is not just at the beginning (as innovation), but as setting the frame for the following work and, perhaps even in the end, what the results may be, what can be known rationally within the established framework (see, Study I in the present thesis for an empirical elaboration of this reasoning).

According to Leary (1990, p. 14), already John Locke (1632-1704) made the point that "terms referring originally to sensible objects and actions have often come to stand for processes that are not accessible to sensory experience." He illustrated this claim through examples of such psychological concepts as 'imagination,' 'comprehension,' 'conception,' "each of which had originally signified physical states and processes" (Leary, 1990, p. 14). "In other words," Leary (pp. 14-15) continues,

> Locke recognized that our basic mentalistic concepts are metaphorical – transferred from the physical to the psychological realm in an attempt to express what our inner experience is *like*. But these metaphorical concepts are not simply *descriptive*; they have also been *transformative*: Their use has led to changes in human self-reference and hence to human self-consciousness. (italics in original)

New metaphors for our 'inner experience' change the way we think about ourselves and others. Consider, as additional cases in point, how such psychological concepts as 'emotion words,' including the very term 'emotion,' according to Edwards (1997, p. 182), show a "historical transformation, from overt social actions and public performances, to the inner life of the psyche." Even the very concept of 'consciousness' itself, without which it would not be possible for us to conceive of ourselves and account for human actions, is illustrative in this sense. In Shotter's explication, the word 'consciousness' stems etymologically from 'sci' which marks it out as a "knowledge word" (cf. 'science'), and 'con' which denotes "agents who act jointly" resulting in people acting "jointly knowing" (Shotter, 1993, p. 16; italics omitted). Hence, the history of the word 'consciousness' can be read as illustrating how (parts of) a word having a sense of 'doing' or some kind of activity is transformed into becoming a word for a mental phenomenon. The metaphors we use to make sense of our 'inner' life come from our 'outer' life and activities. (For an extensive discussion of 'how psychology found its language,' see Danziger, 1997.)

Metaphors derived from the culture, taken up in and defined by science, tend to come back to everyday life in a culture as 'labels' (categories) for construing people. "The intimate connection between culture and psychology that is so obvious *in* metaphor – and instrumentally accomplished, in part, *through* metaphor," Leary (1990, p. 53; italics in original) argues,

> – makes metaphor an extremely useful tool for the historian who wishes to study the impact of culture upon psychological theory and practice and the converse impact of psychology upon culture. The latter influence results from the energizing and popularizing that can begin within the domain of psychology, as, for instance, when Freud helped make awareness – or the supposition – of sexual motives, dream symbols, and various sorts of symptoms and defenses part of our cultural heritage. (ibid., p. 53f.)

## Learning metaphors

"As individuals we gain our command of metaphor just as we learn whatever else makes us distinctively human. It is all imparted to us from others, with and through the language we learn" (Richards, 1936, p. 90). Thus, in a general sense (i.e., of metaphor as an inherent quality of language), we learn a metaphoric when we learn a language. In a more specific sense (i.e., for learning metaphors *as* metaphors), play is likely to have a role in creating awareness in children of metaphor (though, needless to say, without knowing the term). In play, objects and people are transformed into something else (a table becomes a house, a little brother a dog, and so on). Something is spoken about as if it was – and within the activity of the play, becomes, or is transformed into, – something else. And further, as I will argue (see below, in the Discussion, p. 88ff.), narratives – learning to narrativize experiences – may be foundational in providing the learner with a fundamental kind of metaphors of our culture, i.e., anthropomorphic metaphors.

Rumelhart (1993, p. 72) claims that "both theoretical considerations of the language-acquisition process and empirical observations of the language of children suggest that far from being a special aspect of language, which perhaps develops only after children have full control of literal language, figurative language appears in children's speech from the very beginning." Instead, 'literalness' becomes the achievement with development, and, I would like to add, to learn to distinguish what is to be taken as metaphorical and literal, respectively. "Thus, the child's language-acquisition process should not be construed, as it often seems to be, as a process of first learning literal language and then, after that is thoroughly mastered, moving on into nonliteral language" (Rumelhart, 1993, p. 73).

In psychological research, the phenomenon of 'over-extension' of meaning or use of words in children's language acquisition has since long been observed (e.g., Sylva & Lunt, 1982). Children may infer the meaning of a word on the basis of a single (or a few) aspect(s) or perceptual properties, whereby the word becomes used for a wider category of phenomena than adult users would expect. Consider as illustrations, the following examples:

*Table 1.* Some examples of over-extension

| WORD | FIRST REFERENT | DOMAIN OF APPLICATION |
|---|---|---|
| ticktock | watch | clocks, all clocks and watches, gas meter, firehose wound on spool, bathscale with round dial |
| baw | ball | apples, grapes, eggs, squash, bell clapper, anything round |
| sch | sound of train | all moving machines |
| sizo | scissors | all metal objects |
| wau-wau | dog | all animals, toy dog, soft house slippers, picture of an old man dressed in furs |

(adapted from Clark and Clark, 1977, pp. 493-494).

Some of these examples, as Clark and Clark (1977) also point out, are based on 'shape' or 'form,' whereas some are based on 'sound,' and, in one case, as it appears, on 'texture.' Thus children pay attention to different aspects when over-extending words; Clark and Clark also give examples that seem to be based on 'movement' and 'size,' respectively. "Evidence from various lexical acquisition studies shows that while children tend to use static perceptual features as the bases of their lexical extensions," Winner (1988, pp. 70-71) writes, "they are capable of using nonsensory, functional features as well." There also exists the phenomenon of 'under-extension'; for example, a child may use the word 'car' initially only for cars that drive by on the street but not for cars that are parked or cars in pictures (Clark & Clark, 1977). Thus the question of the extension of the use of a word is a critical question in learning a language (and a question that is, so to speak, stretched to its limits in 'unconventional' metaphor).

However, Winner (1988, p. 91f.) argues that in her view it is important to "distinguish unintentional misuses (as children are working out the meanings of words) from metaphoric uses (deliberate misuses once the meaning of a word has been worked out)." This is, in her view, because

> there is an important difference between the communicative functions of overextensions and metaphors. [...] overextensions fill lexical gaps, and once the gap is filled by the appropriate word, the overextension drops out. Metaphoric misuses do not usually fill gaps. Instead, the child typically misnames an object despite the fact that he possesses the appropriate name for it. He does so to point out a resemblance that has struck him as noteworthy. To count an utterance as a metaphor, then, we must have evidence that the child knows the appropriate, literal name for the metaphorically named object. (Winner, 1988, p. 92)

Hence, in Winner's (1988) view, metaphors (or 'metaphoric misuses' as it were, implying a commonsense deviation view of metaphor) do not 'usually' fill gaps in discourse. But filling lexical gaps ('catachresis') is one function filled by metaphor not only for children but also for adults and scientists (some examples will be given later in this thesis). And for whom is there lexical gaps, the child or the analyst with access through lexicons to language at large? For Winner (1988), speaking metaphorically must be deliberate and the child must also know the literal term in advance. Why should this be so? As I will argue elsewhere in this thesis, metaphors tend to become literalized, and hence cease to be perceived as metaphors, over time and use for speakers. Whether a speaker sees her speech as metaphorical or not is in itself of importance in a learning perspective. As evident from the quote above, Winner (1988) also presumes that every metaphor can be replaced by a literal name, which obviously is not the case (consider 'oxymora' as explained below). In my view, over-extension can be seen as a case of how a learner applies something acquired to make sense of novel observations and experiences. This implies that speaking metaphorically may be seen as a special case of over-extension in discourse.

One way of phrasing the process of extending one's language is to say that initially what is familiar is used to include several experiences, but with additional learning an increasing ability to distinguish between what is in this manner categorized as in a sense 'the same' is achieved. This also includes learning what the literal use of the word is, how it could be used additionally, and how it cannot (conventionally) be used if the speaker wants to be understood by others.

Following Rumelhart (1993), this process can be seen as a fundamental metaphorical principle in how we extend our language/knowledge, whether as children learning a first language or, say, as students trying to learn the language of a science. Thus, once more what is a metaphor or not becomes a question of conventionality in a situation of use. Even children's language acquisition in this manner suggests metaphor as primary to literalness in our learning.

The process of 'over-extension' could thus in a general sense be seen as metaphorical, in that a term is used also to speak about other observations, phenomena, and experiences. However, in the more limited sense of metaphor (i.e., 'metaphor proper'), metaphor is more of a special case of this general process of language development.

This reasoning about how we extend our knowledge by metaphor is an issue that may be seen not only in children learning a language, but also in the reasoning of scientists and philosophers. Consider, as a brief illustration, the following:

> When Rutherford (following Nagaoka) conceived of the atom as a miniature solar system–electrons circling the nucleus as planets circle the sun–some philosophers suggested that electrons might really be planets with mountains, oceans and even living creatures. Perhaps these in turn consisted of atoms on a vastly smaller scale, which in their turn might be planetary systems, *ad indefinitum*. (Hanson, 1958/1981, p. 129)

This may be read as an illustration of the difficulty of discerning the limits of a metaphor, i.e., the question of how far a certain metaphor could be extended. In what sense, or to what extent, something is as something else, in terms of which it is conceived, is always a potential difficulty when one tries to understand something. What follows logically, as distinct from empirically, from the metaphor?

In this section, I have tried briefly to discuss two issues: (1) a view of metaphor as an inherent quality of our language, according to which children learn the metaphoricalness simply by acquiring a language in the sense of learning how to mean; (2) that children learning a language also come to learn that some ways of speaking (in certain situations and practices) should be taken *as* metaphors.

## Language as metaphorical and/or literal

Every argument for something, as Michael Billig (1996) has argued, is by necessity at the same time – explicitly or implicitly – an argument against something else. It is in relation to this 'something else,' within what Billig calls a 'tradition of argumentation,' that what is argued makes sense. In the present case, arguing for metaphoric as a property of our language reconnects to and presents an alternative to a view of the characteristics of our language and the way it works in our attempts at making sense of ourselves and our world in terms of ‘literalness’ and ‘correspondence.’ For this reason, I will briefly comment on this tradition and the distinction between ‘literal’ and ‘metaphorical’ (see also below on theories of metaphor, where this distinction is referred to in different ways).

The argument in this section will focus on scientific language. In a traditional view, scientific language is seen as characterized by precision, an absence of ambiguity, and as standing in a simple, clear correspondence to reality, which, in turn, is seen as something independent of language (Keller, 2002). The assumption is often that language is literal (Gibbs, 1994). Not only is literalness seen as a possibility but it is also seen as the primary form of language (ibid.). The word meaning is seen as purely corresponding to what is referred to. Ever since the beginning of ‘modern science,’ in the seventeenth century, this is the tradition of viewing language and its relation to reality (Olson, 1994). “Literal language is commonly seen as the language of science precisely because it presumably matches or reflects objective reality,” Gibbs (1994, p. 169) argues. The assumption of the literalness of language implies that language is ‘transparent.’ Hence, language is, in this view, not seen as perspectivizing phenomena. The notion of literal language is, according to Rommetveit (1988), a myth. But, as he points out, myths “are not only ‘stories told’ but also ‘realities lived’” (p. 15). However, such a view of language tends to remain presumed or implicit, unverbalized in research (Gibbs, 1994). The role of language in science is, accordingly in such a view solely to denote or label things, i.e., work by simple correspondence. It follows from this that metaphor by logical necessity becomes a ‘deviation,’ something ‘misleading,’ or ‘incorrect’ that is to be avoided at all cost if, as in science, striving to speak correctly (Keller, 2002). Smith (1990, p. 239) concludes this tradition of argumentation by saying that: “The standard view has been that whatever real content a metaphorical assertion may have, the content can and should be reformulated in literal language.”

What critique has been raised against the theory of language as literal? One line of reasoning is to point to the fact that those who propose such a possibility, themselves by their way of reasoning, contradict themselves. They are unable to present a theory of language devoid of metaphors, without themselves using metaphors (for such analyses, see, e.g., de Man, 1979, on Locke; also, Smith, 1990, on logical positivism philosophy and behaviorist psychology). Such texts build upon some fundamental metaphors (beginning, of course, with ‘literal’ itself). Thus, such claims disclaim the theory while arguing for it. Hence, no further critique is necessary.

A second possibility would be to see what would follow if such a view of language was in fact true. If language functioned in such a way (i.e., by 'pointing to,' 'depicting,' or 'matching' what is spoken about), then language would be totally 'locked' to a specific situation and its specific objects. That would require that we would all have to have had the exact same experiences, for us to understand each other (cf. Rommetveit, 1988). And since we do not have that, our language cannot work in such a way. And abstractions would further be impossible to speak about, since they by definition lack physical objectiveness. It is because human language is not locked to, or dependent in meaning on, specific objects, situations and experiences, that our language is so important for our knowing and learning. Language needs to have a 'looser connection,' or be more 'indirect' in relation to anything specific. We can mediate knowledge, insights (codified in language, if you will) to others who have not 'directly' experienced the same, in different places, in different times, over generations, and thus ensure continuity and cumulativeness in the knowing of humankind. It is our great fortune that our language is not 'literal,' or relates to the world as an 'exact correspondence.' A brief note, to conclude this part of the reasoning: Regarding abstractions, to speak is to generalise (i.e., to abstract). The question or problem is how to make descriptions more specific. The paradox is that we specify by adding, increasing, the amount of categories, thus as our description increases in abstraction (in one sense, i.e., by adding more abstract terms), we get more concrete.

In opposition to the above line of reasoning (of language as foundationally literal), I will argue that the point of departure should not be in a literal language but in a language as inherently metaphorical and only by convention (or through institutionalization) literal (cf. Nietzsche, 1873/1999). And instead of a metaphor for communication as 'conduit,' we may conceive of this in terms of a 'tool makers' metaphor, as suggested by Reddy (1993). Language is then seen as resources for actions, means by which we do things. One of the most important things we do with language, in ordinary life as well as in science, is to represent the world. It is with this activity that the present thesis is concerned. Research questions emerging from this perspective are for example: What is the nature or characteristic of these tools, how do they come about (i.e., where do they come from, how do they migrate, and how are they moulded or transformed), how do they work, what do they make possible for us to do, and what kind of view of or knowledge of phenomena are 'inscribed' in them, and what may this mean for our learning and knowing?

From the perspective of the present thesis (see also, Barclay, 1997; Goatly, 1997; Leary, 1990), our language evolves on principles of metaphorical extensions of words to cover new experiences and phenomena, and by recombining (parts of) old words in new ways. In these senses our language at large can be seen as inherently metaphorical. Eventually, by becoming simply the conventional way to say it, or through definition and critical evaluation (in an institution such as science) what was initially metaphorical will have become literalized. The term has then acquired a 'new identity' and will cease to be perceived as metaphorical for speakers. Hence, according to this perspective, literalness is an evolved 'achievement' not an original point of departure. Metaphor in this view becomes the means through which we adjust and develop our primary tool for knowing, our language. This line of reasoning also points to the fact that a novice may have difficulties in understanding how an utterance is intended to be 'taken' (Olson, 1994), in a familiar sense or in a new sense.

Consider, in addition, as also Richards (1936, pp. 118-119) has noted, that a "word may be *simultaneously* both literal and metaphoric," and "may serve to focus into one meaning many different meanings" (italics in original). For example, in certain kinds of jokes, the 'twist' or amusing point lies specifically in the play between two senses (literal and metaphorical) of a word in the utterance. Also, what for one person is a metaphorical sense may by another person be taken literally, or conversely.

An illustration of how a learner may understand an utterance as metaphorical, although it was not intended to be so by the teacher, is given by Lakoff and Johnson (1980). An exchange student at Berkeley commented on the metaphor that he kept hearing, 'the solution of my problems.' However, for the teacher this was not intended as a metaphor. But the student understood 'solution' in the sense of a chemical process. Hence, he understood this expression as "a large volume of liquid, bubbling and smoking, containing all of your problems, either dissolved or in the form of precipitates, with catalysts constantly dissolving some problems (for the time being) and precipitating out others" (Lakoff & Johnson, 1980, p. 143). Lakoff and Johnson interpret this metaphor in the following way:

> It gives us a view of problems as things that never disappear utterly and that cannot be solved once and for all. All of your problems are always present, only they may be dissolved and in solution, or they may be in solid form. The best you can hope for is to find a catalyst that will make one problem dissolve without making another one precipitate out. And since you do not have complete control

> over what goes into the solution, you are constantly finding old and new problems precipitating out and present problems dissolving, partly because of your efforts and partly despite anything you do. (p. 143f.)

In Lakoff and Johnson's interpretation, the "CHEMICAL metaphor says that problems are not the kind of things that can be made to disappear forever" (p. 144). The reappearance of a problem becomes a natural occurrence rather than a failure of one's approach to the problem. This example is presented by Lakoff and Johnson "as a clear case of the power of metaphor to create a reality rather than simply to give us a way of conceptualizing a preexisting reality" (loc. cit.):

> What the CHEMICAL metaphor reveals is that our current way of dealing with problems is another kind of metaphorical activity. At present most of us deal with problems according to what we might call the PUZZLE metaphor, in which problems are PUZZLES for which, typically, there is a correct solution–and, once solved, they are solved forever. The PROBLEMS ARE PUZZLES metaphor characterizes our present reality. A shift to the CHEMICAL metaphor would characterize a new reality. (p. 144f.)

In contrast to Lakoff and Johnson's reading of this incident, for me, this example illustrates how the issue of whether something said should be understood as a metaphor or not (and if so, as what kind of metaphor), at times, can be difficult for learners. How to take an expression is always an issue that may come up in communicative situations. We do not understand passively in the same way as a traditional conduit metaphor for communication and understanding would have us believe (Reddy, 1993). This thus also illustrates that how to take an expression (including whether to understand it as a metaphor or not, and if so, how) is clearly a knowledge question, of being familiar with how one means in a certain practice. For a teacher, this points to the importance of trying to make explicit how knowledge claims should be understood in the present context. One way of providing cues for the learners is by using meta-communicative markers (see above). For analyses of how this is done in different learning situations, see Studies II, III, and IV in the present thesis.

One implication, finally, of this view of metaphorical and literal, respectively, as points on a socio-historical continuum, is that what is a metaphor and what is not is not a logical question but an empirical one (i.e., a question of how words are used and in particular, how something is 'taken' by someone – the participant, the analyst on the basis of, for example, etymology). Phrased differently, the distinction between metaphorical and literal language is one of degree, not of kind. This is also a reason for treating metaphor as an empirical and learning issue in the present thesis, not solely as a philosophical matter.

# Understandings of metaphor and related concepts

This chapter consists of two parts. Firstly, theories and views of metaphor from Aristotle to the present are reviewed. Secondly, the relevant concepts (metaphor, analogy, metonymy, simile, and model) are distinguished and stipulatively defined. These concepts are often employed interchangeably, or for explaining each other. Hence, how I see the relations and distinctions between these concepts, within the present work, should be clarified.

'Metaphor' as a term exists in opposition to the term 'literal.' However, the nature of the relation between the two terms is understood in different ways in different theoretical accounts. Compare, for example, the view of Cameron (2003) and Goatly (1997), which also the present thesis connects to, with the common sense view (i.e., the 'comparison' and 'substitution' views). In the first case, the distinction between the two terms is seen as a temporary point on a socio-historical continuum. In the second case, metaphor is a deviation replacing the correct literal word for some decorative or poetic reason.

## Theories of metaphor

Historically, there have been shifting views on metaphor stemming back to the works of Aristotle in the fourth century BC. After reviewing Aristotle on metaphor, more recent proposals of how to understand the nature and functioning of metaphor will be attended to. By reviewing contrasting elaborations of metaphor, the reasons for the choice of theory of metaphor employed in the present thesis is simultaneously clarified.

### *Aristotle on metaphor*

There is no single work by Aristotle entirely devoted to the issue of metaphor, but the matter is repeatedly treated in his work on poetics and rhetoric, respectively. The instances where metaphor is treated in these two works will briefly be reviewed here [4] as a background to later developments of work on metaphor.

In *Poetics*, Aristotle (version, 1999, 1457b, p. 105) writes: "A metaphor is the application of a word that belongs to another thing: either from genus to species, species to genus, species to species, or by analogy." This is explicated as follows:

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[4] The extensive number of footnotes to Aristotle (by the translator), citing sources of quotes (from Homer and others) have been excluded by me from the quotes that follow.

> By "from genus to species" I mean, e.g., "my ship stands here": mooring is a kind of standing. Species to genus: "ten thousand noble deeds has Odysseus accomplished"; ten thousand is many, and the poet has used it here instead of "many." Species to species: e.g. "drawing off the life with bronze," and "cutting with slender-edged bronze"; here he has used "drawing off" for "cutting" and *vice versa*, as both are kinds of removing. I call "by analogy" cases where *b* is to *a* as *d* is to *c*: one will then speak of *d* instead of *b*, or *b* instead of *d*. Sometimes people add that to which the replaced term is related. I mean, e.g., the wine bowl is to Dionysus as the shield to Ares: so one will call the wine bowl "Dionysus' shield," and the shield "Ares' wine bowl." Or old age is to life as evening to day: so one will call evening "the day's old age," or, like Empedocles, call old age "the evening of life" or "life's sunset." In some cases of analogy no current term exists, but the same form of expression will still be used. For instance, to release seed is to "sow," while the sun's release of fire lacks a name; but the latter stands to the sun as does sowing to the seed, hence the phrase "sowing his divine fire." This type of metaphor can further be used by predicating the borrowed term while denying one of its attributes: suppose one were to call the shield not "Ares' wine bowl" but "a wineless wine bowl." (1457b, pp. 105-107)

Several things can be noted: (a) metaphor is seen as the employment of a single word (rather than, for example, as interaction between words), (b) metaphor is presented in terms of a sort of replacing of one word with another, (c) however, Aristotle also notes the use of metaphor for what is usually termed 'catachresis,' and (d) the definition of metaphor is wide, encompassing metonymy and analogy.

Aristotle continues that "a capacity for metaphor" is "the greatest asset," and that: "This alone cannot be acquired from another, and is a sign of natural gifts: because to use metaphor well is to discern similarities" (1459a, p. 115). Thus, here, metaphor (or at least the mastering of it) appears as something 'extra-ordinary.'

In the *Rhetoric*, Aristotle (version 2000, 1406b, pp. 365-367) writes that

> metaphors also are inappropriate, some because they are ridiculous–for the comic poets also employ them–others because they are too dignified and somewhat tragic; and if they are farfetched, they are obscure, as when Gorgias says: "Affairs pale and bloodless"; "you have sown shame and reaped misfortune"; for this is too much like poetry. And as Alcidamas calls philosophy "a bulwark of the laws," and the *Odyssey* "a beautiful mirror of human life," and "introducing no such plaything in poetry." All these expressions fail to produce persuasion, for the reasons stated.

Metaphor is presented here as a means for 'persuasion.' The concept of 'simile' is later introduced in his reasoning and he writes that the

> simile also is a metaphor; for there is very little difference. When the poet says of Achilles, he rushed on like a lion, it is a simile; if he says, "a lion, he rushed on," it is a metaphor; for because both are courageous, he transfers the sense and calls Achilles a lion. The simile is also useful in prose, but should be less frequently

> used, for there is something poetical about it. Similes must be used like metaphors, which only differ in the manner stated. (1406b, p. 367)

Hence, a 'simile' is also a 'metaphor'; further illustrating that for Aristotle, metaphor is the more general term, than it came to be understood through the centuries.

In an interesting passage of his reasoning, Aristotle writes on 'learning' in relation to 'metaphor':

> Easy learning is naturally pleasant to all, and words mean something, so that all words which make us learn something are most pleasant. Now we do not know the meaning of strange words, and proper terms we know already. It is metaphor, therefore, that above all produces this effect; for when Homer calls old age stubble, he teaches and informs us through the genus; for both have lost their bloom. The similes of the poets also have the same effect; wherefore, if they are well constructed, an impression of smartness is produced. For the simile, as we have said, is a metaphor differing only by the addition of a word, wherefore it is less pleasant because it is longer; it does not say that this *is* that, so that the mind does not even examine this. Of necessity, therefore, all style and enthymemes that give us rapid information are smart. This is the reason why superficial enthymemes, meaning those that are obvious to all and need no mental effort, and those which, when stated, are not understood, are not popular, but only those which are understood the moment they are stated, or those of which the meaning, although not clear at first, comes a little later; for from the latter a kind of knowledge results, from the former neither the one nor the other. (1410b, pp. 395-397)

By speaking of something in terms of something else, the mind is, so to speak, put to work. 'Simile' is, once again, subsumed under the more general term 'metaphor.'

"We have said that smart sayings are derived from proportional metaphor and expressions which set things before the eyes," Aristotle (1411b, p. 405) writes. "I mean that things are set before the eyes by words that signify actuality" (loc. cit.).

> And as Homer often, by making use of metaphor, speaks of inanimate things as if they were animate; and it is to creating actuality in all such cases that his popularity is due, as in the following examples: Again the ruthless stone rolled down to the plain. The arrow flew. [The arrow] eager to fly [towards the crowd]. [The spears] were buried in the ground, longing to take their fill of flesh. The spear-point sped eagerly through his breast. For in all these examples there is appearance of actuality, since the objects are represented as animate: "the shameless stone," "the eager spear-point," and the rest express actuality. Homer has attached these attributes by the employment of the proportional metaphor; for as the stone is to Sisyphus, so is the shameless one to the one who is shamelessly treated. In his popular similes also he proceeds in the same manner with inanimate things […] for he gives movement and life to all, and actuality is movement. (1411b-1412a, p. 407)

That Homer writes of 'inanimate things as if they were animate' is said to account for his 'popularity' (which is a point that is of interest when read in light of the second study in the present work, below).

That metaphor introduces an element of the unexpected is focused on when Aristotle returns to 'learning':

> Most smart sayings are derived from metaphor, and also from misleading the hearer beforehand. For it becomes more evident to him that he has learnt something, when the conclusion turns out contrary to his expectation, and the mind seems to say, "How true it is! but I missed it." (1412a, p. 409)

To conclude this brief review of Aristotle on metaphor (for a more elaborate discussion, see, e.g., Mahon, 1999), it can be seen that, there are tensions in Aristotle's treatment of metaphor: on the one hand, metaphor is the replacement of a word by a different word, but on the other hand, metaphor is used when there is no other word ('catachresis,' though Aristotle does not use this term at that point). Metaphor is used in rhetoric and poetry, but it is also a means for learning something new. For Aristotle, metaphor is a wide term, encompassing such terms as simile, analogy, proverbs, hyperboles, metonymy. The complexity of his view on metaphor opens up for different uptakes and mouldings in work that was to come. Some important views and theories will be reviewed, with a focus on more recent times (twentieth century).

The treatment of metaphor in Aristotle may strike the reader as somewhat extensive. However, this is motivated, I argue, as an historical background to the present work in showing how I reconnect to (a) an 'original' – in the sense that it is with Aristotle that, as far as we know, metaphor as a topic for intellectual concern begins – understanding of metaphor as a pervasive and very general form of discourse (encompassing simile, analogy, metonymy, as also I will do in this thesis), and (b) I want to show how my interest in metaphor and issues such as learning, knowing, and understanding has a historical 'resonance ground' in Aristotle. In the intermediate time between Aristotle and today, both these points were to a large extent lost from view. Why this was so is intimately connected with the historical fate of rhetoric as an intellectual tradition (see, Billig, 1996, for this history).

### *Substitution and Comparison views*

Commonsense notions of metaphor (see, e.g., in lexicons) have been formulated as the Substitution and Comparison view of metaphor, respectively. These two theories or views are similar enough for the present purpose to be treated as closely related.

According to the Substitution view, metaphor is a 'renaming' of what is spoken about by something else. An expression, or a word, is thought to replace, substitute for, another. The metaphor may be substituted back to its literal equivalent, without any loss of meaning. In this view, metaphor is of restricted application and can be dispensed with, since it is merely something decorative, ornamental. "The problem with the substitution interpretation" of metaphor, it may – if focusing on scientific reasoning – be said, as Draaisma (2000, p. 11) puts it, "is that many metaphors, particularly in science, owe their existence precisely to the fact that they express what cannot be said literally – either not yet or in principle." Hence, not only is the role often filled by metaphor in bridging lexical gaps (i.e., catachresis, see below) not possible to make sense of within this theoretical frame, nor can the transformation of terms from metaphoric to literal (and, sometimes, back) be explained.

The Comparison view may be seen as a variant of the substitution view. Here metaphor is seen as a reduced simile. According to this view, the reader must retrieve the similarity (i.e., clarify what is compared to what) between the two terms of the metaphor. As in the substitution view, "it is assumed that the similarity between the two terms can be articulated in a literal description," writes Draaisma (2000, p. 12), but asks: What are the literal equivalents to, e.g., 'search process' in memory, or the memory process labelled as 'storing'? Thus, the comparison view faces the same problem as the substitution view does. However, these two views of metaphor may work well for many obvious or idealized cases of metaphor, i.e., these views may be adequate for more specific forms, cases, of metaphor, but do not hold for metaphor generally.

Also, in these traditional views of metaphor, the problem of how to identify an utterance as metaphorical is seldom made explicit. This is probably due to the fact that only so-called metaphor proper (i.e., obvious, unconventional metaphor) is used in exemplifying.

In the Comparison and the Substitution view so-called 'oxymora' (Gibbs, 1993; Miller, 1993) become problems that cannot be solved within these frameworks for understanding metaphor. An oxymoron is a contradiction in terms, for example, a 'speaking silence' or 'literally speaking.' If presuming that a metaphor is a deviation that can be replaced by a literal equivalent without any change in or loss of meaning (as the two latter theories do), then an expression like 'speaking silence' is incomprehensible, for how do you say that literally?

In contrast, for a sociocultural perspective on metaphor, if I briefly foreshadow what will be explained below, oxymora pose no problem. Rather, an oxymoron can in such a framework be seen as a clear case of how we combine parts of or whole words that do not belong together in making sense of experiences and observations that we lack a language for. In a sociocultural perspective it is not presumed that a metaphor always can be replaced by a corresponding literal expression. This latter reasoning, of course, also goes for the case of 'catachresis.' In fact, oxymoron could be seen as a kind of catachresis.

### *Interaction theory*

The Interaction theory has its origin in the work of Richards (1936), whom I have already referred to. He argues that metaphor is "the omnipresent principle" of language, and "its constitutive form" (p. 90). He defines metaphor in the following manner: "In the simplest formulation, when we use a metaphor we have two thoughts of different things active together and supported by a single word, or phrase, whose meaning is a resultant of their interaction" (p. 93). The traditional view of metaphor is too limited in Richards' view:

> And thereby it made metaphor seem to be a verbal matter, a shifting and displacement of words, whereas fundamentally it is a borrowing between and intercourse of *thoughts*, a transaction between contexts. *Thought* is metaphoric, and proceeds by comparison, and the metaphors of language derive therefrom. (p. 94; italics in original)

Thus, metaphor in this view becomes a matter of thinking, and only secondarily a matter of language. Metaphor is, Richards continues, 'nothing special' but rather ordinary: "We must translate more of our skill into discussable science. Reflect better upon what we do already so cleverly" (p. 94).

Besides paving the way for a new and more dynamic understanding of metaphor, Richards (1936) introduced a terminology for analysing metaphor. He labels the two terms for distinguishing between 'the two ideas of a metaphor,' 'tenor' and 'vehicle,' respectively. These terms, and with the addition of 'ground' (see below), are still used occasionally today (sometimes with 'tenor' being replaced by 'topic').[5]

What is resulting from the co-presence of vehicle and tenor, Richards argues, is a meaning "which is not attainable without their interaction" (p. 100). Metaphoric interactions need "not work through *resemblances* between tenor and vehicle" (p. 107; italics in original), i.e., a metaphor in this view does not presume 'resemblances' between characteristics existing beforehand, but may actually create a new seeing, work generatively. However, if this in fact is so or not needs, I think, be clarified in each individual case (if this is the point) by further analysis. Thus, according to this view, a metaphor may generate new meaning by changing the relation between the two 'things.'

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[5] To briefly illustrate these terms with an example: "Life is a box of chocolates; you never know what you're going to get" (Goatly, 1997, p. 9; italics omitted). In this case, 'life' is the 'topic,' 'a box of chocolates' is the 'vehicle,' and 'you never know what you're going to get' is the 'ground.' However, it is important to realize that an idealized example like this one differs from metaphor in more general use. In the terms used in this example, it may be noted that very often the difficulty in how to understand the metaphor is that the 'ground' is not made explicit, i.e., something is *like* or *as* something, but in what respects? Without such specification, the possibilities and difficulties involved in how to understand the metaphor may be considerable.

Richards also briefly considers the term 'ground' for denoting "the common characteristics" (p. 117) between the tenor and the vehicle, but says that one seldom finds such a ground: "A metaphor may work admirably without our being able with any confidence to say how it works or what is the ground of the shift" (p. 117) in meaning. Richards illustrates this with the example of calling someone a 'duck':

> We do not call someone a duck to imply that she has a bill and paddles or is good to eat. The ground of the shift is much more recondite. The *Oxford Dictionary* hints at it by defining a 'duck' in this use as 'a charming or delightful object.' An extremely simplified account of the ground here would make it something like this: that some feeling, of 'tender and amused regard,' say, that it is possible to have towards ducks is being felt towards a person. (p. 117f.)

In the example given, the relation between tenor and vehicle seems to lie in the eyes of the beholder, as it were, not in any inherent properties of the two entities. That we cannot always see how a metaphor works, Richards argues, does not mean that it does not work.

According to this theory, by linking Topic and Vehicle, new meaning is generated, which is further claimed not to be reduced to pre-existing similarities (in contrast to the views above). However, the terms Topic, Vehicle, and Ground will not be used in my analyses. This is because (a) these terms were developed on the basis of, and are primarily useful for, analysing idealized (so-called, proper) forms of metaphor, not metaphors as variously used and formed in empirical discourse, and (b) since the topic or vehicle could be seen as established beforehand. For example, in Study II, 'DNA' is the topic, and the question is which vehicles are used for explaining this topic. Alternatively, in Study I, the vehicle, if using this term, is 'chunk,' whereas the question is what the topic of this term is.

Black (1962) later tried to develop the interaction theory. He, among other terms, uses the concepts 'frame' and 'focus.' In introducing the interaction view of metaphor, he writes that: "The new context (the 'frame' of the metaphor, in my terminology) imposes extension of meaning upon the focal word" (p. 39). According to Black, a metaphor works by means of a 'system of associated commonplaces,' i.e., by what is evoked or implied by the relating of the focus and frame, as some kind of more or less culturally shared assumptions or ideas (common knowledge) about the phenomenon in question (i.e., the 'focus' of the metaphor). The example Black uses is 'man is a wolf,' with the 'system of associated commonplaces' reading something like: 'fierce,' 'carnivorous,' 'hungry,' 'scavenger,' 'alarming,' but not, for example, 'vegetarian' (pp. 39-42). "The wolf-metaphor suppresses some details, emphasizes others–in short, *organizes* our view of man" (p. 41; italics in original). According to the view of the interaction theory, not only is man seen as more wolf-like through this metaphor, but wolf is seen as more man-like (anthropomorphic).

Black (1962) proposed that the reader bring with her to metaphor interpretation a 'system of associated commonplaces,' or in a later phrasing, an 'implicative complex' (Black, 1993). "These two complexes," Cameron (2003, p. 17) explains, "interact through mental processes of selection, mapping and organization, to produce a new understanding that cannot be paraphrased with literal equivalents," without any loss of meaning. Thus, in this theory, metaphor has a cognitive role, not just a linguistic one. In the literature of interaction theory, the focus tends to be on "novel and strongly active metaphors" (loc. cit.), hence metaphor is still treated as something 'special' (despite Richards' reasoning above). "The key development offered by the Interaction theory was the notion that Topic and Vehicle are systems of ideas, knowledge and beliefs that interact," thus it is not "just names or features of concepts that are simply 'transferred'" (ibid., p. 18). For example, as Draaisma (2000, p. 12) argues, "the exchange of associations between computer and memory has not only made the memory more technical, but has made the computer more psychological" (see also, Study I in the present thesis).

According to the substitution and the comparison view of metaphor (as seen above), metaphors can be literally paraphrased without any loss of meaning. Only the style of an utterance is thought to change.

> But "interaction-metaphors" are not expendable. Their mode of operation requires the reader to use a system of implications (a system of "commonplaces"–or a special system established for the purpose in hand) as a means for selecting, emphasizing, and organizing relations in a different field. This use of a "subsidiary subject" to foster insight into a "principal subject" is a distinctive intellectual operation (though one familiar enough through our experiences of learning anything whatever), demanding simultaneous awareness of both subjects but not reducible to any comparison between the two. (Black, 1962, p. 46)

Thus, according to Black's interaction view of metaphor, to literally paraphrase a metaphor means some "loss in cognitive content" (p. 46). Black does not deny cases of metaphor where such paraphrasing may be possible. However, with the kinds of metaphors that he says are of importance for philosophy (which is Black's theme), this is important to keep in mind.

With interaction theory, metaphor became a more dynamic phenomenon than in previous static views of 'replacement.' The transformation of metaphor from a linguistic to a primarily mental or cognitive phenomenon also makes this theory a bridge to the next theory of metaphor that was to appear.

*Cognitive linguistic theory*

In 1980, with the seminal work of Lakoff and Johnson's *Metaphors We Live By*, a new theory of metaphor was presented. I will follow Kövecses (2002) and others in speaking of this theory in terms of the 'cognitive linguistic theory of metaphor.' Lakoff and Johnson argued that metaphor is pervasive in our lives, not only in language but also in thought and action. Our ordinary concepts are said to structure our perceptions, our actions, and how we relate to others and ourselves. Metaphor is said to be pivotal to what we see as real. However, we tend not to be aware of the metaphorical nature of our conceptual systems. Lakoff and Johnson exemplify this with the metaphor ARGUMENT IS WAR (uppercase letters indicate 'conceptual metaphor' in their theory; see further below). They argue that we not only speak about arguments in this way, in terms of war, but also that this is how we do when we argue (i.e., we attack positions, we are planning and using strategies, abandon indefensible positions, take a new line of attack, change tactics, gaining or losing ground, defend ourselves, counterattack, win or lose, etc.) In this way, the metaphor ARGUMENT IS WAR is a metaphor we live by in our culture (hence the title of the book).

"The essence of metaphor," in Lakoff and Johnson's (1980, p. 5; italics omitted) definition, "is understanding and experiencing one kind of thing in terms of another." In the example just mentioned, 'argument' is partly structured, understood, performed, and spoken about in terms of 'war.'

A large part of our metaphors are 'orientational,' typically 'up-down,' 'front-back,' 'on-off,' 'depth-surface,' 'central-peripheral.' These kinds of metaphors, they argue, have their basis in our experiences, especially our bodily experiences. One of their examples is: CONSCIOUS IS UP, UNCONSCIOUS IS DOWN (e.g., 'Wake *up*,' or 'He *fell* asleep'), because humans sleep lying down but tend to be upright when awake; or HEALTH AND LIFE ARE UP, SICKNESS AND DEATH ARE DOWN (e.g., 'He's in *top* shape,' or 'He *fell* ill,' 'He *dropped* dead'), which is based on physical conditions forcing us to lie down, and dead as physically being down (in the ground).

This theory also offers an attempt at answering the question "Where does the ability to think metaphorically come from?" (Gibbs, 1994, p. 414). The suggestion given by the theory is that "Metaphorical thinking is not an innate property of the mind but arises from children's bodily experiences" (loc. cit.). One example presented as illustrative of this claim is the following:

> With continued growth, infants are eventually able to stand erect. As babies first stand, they experience both success (standing/walking) and failure (stumbling/falling). Once infants begin to stand, they have a means of control over their own behavior, an opportunity to imitate and master the behavior of adults. This is the foundation for the basic metaphorical concepts UNSTEADINESS IS NEAR FAILURE (*He stumbled through his oral exams*, *The government is tottering*) and FALLING IS FAILURE (*His jokes fell flat*, *The scheme fell through*, *The government has fallen*). To be erect and straight represents moral qualities of straightforwardness, uprightness, and respectability. Stooping and bent body positions are associated with debasement and failure (*They hung their heads in shame*, *Her spirits drooped*, *They were weighed down with grief*). To be crooked is to be dishonest (*That man is a crook*). (Gibbs, 1994, p. 415; italics in original)

"In general," Gibbs (loc. cit.) concludes, "young children's early physical, sensorimotor experiences form the basis for more complex thoughts that are constituted by metaphor." Early bodily experiences such as being up and down, being given food, and so on, are proposed as origins of the metaphors of our language.

Commenting on a quote from Gibbs (1994, p. 17) stating that "metaphorical understanding is grounded in nonmetaphorical preconceptual structures that arise from everyday bodily experience," Edwards (1997) argues that categories such as 'nutrient' (used as a foundation for speaking of 'love')[6] and 'heated fluid in a container' (as a metaphorical base for 'anger')[7] – two examples frequently used in this theory – are inserted by the analyst as objective categories in the world preceding description. As I understand it, the introduction of what is said to precede metaphor can be seen as an example of a more general scientific problem. In order to make sense of and communicate about what is 'pre-language' or 'non-language' we have to constitute it in language as such. However, the proposition given from cognitive linguistics theory about the origin of metaphor is a thought provoking idea. But the validity of the claim is not something I will attempt to evaluate or further comment on in this work.

In the cognitive theory (as with interaction theory), metaphor is seen as 'able' to create new understanding. An illustration of this principle is the reasoning of a student on 'the solution of my problems' (Lakoff & Johnson,

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[6] For example: 'He's drunk with love,' 'I am starving for your affection' (Gibbs, 1994).

[7] For example: 'He blew his top,' 'She is boiling with anger' (Gibbs, 1994).

1980), as related above (p. 33f.). Metaphors may be based on isolated similarities, Lakoff and Johnson reason, but more important, in their view, are the similarities that people create and experience when using metaphors.

Lakoff and Johnson's theory has had an enormous impact on metaphor research (for further treatment of the theory and subsequent work in its tradition, see, e.g., Kövecses, 2002). Metaphor in this theory is primarily a mode of thinking and only secondarily a linguistic phenomenon.

*Levels of metaphor, and some critical considerations*

In the 'cognitive linguistic view' of metaphor, two levels, as it were, in metaphor are employed. "We can state the nature of the relationship between the conceptual metaphors and the metaphorical linguistic expressions," Kövecses (2002, pp. 5-6) explains,

> in the following way: the linguistic expressions (i.e., ways of talking) make explicit, or are manifestations of, the conceptual metaphors (i.e., ways of thinking). To put the same thing differently, it is the metaphorical linguistic expressions that reveal the existence of the conceptual metaphors.

In this way, one level is said to show ('reveal' the existence of) another level. The linguistic expressions are further said to 'reflect' (Kövecses, 2002, p. 9) conceptual metaphor. That this way of reasoning is not merely a way of trying to communicate or making sense of the relation between thinking and speaking, but of making far more decisive knowledge claims, is seen later on. Kövecses (2002, p. 244) further, tellingly, writes that:

> Where do metaphors "reside" in the human organism? The most natural location for metaphors, and especially for simple, or primary, metaphors, is in the brain. Given a source and a target domain, if one domain is activated, other, metaphorically connected domains are also activated. This shows that metaphors not only have linguistic and psychological reality but are also real in our neuroanatomy.

But to be able to show some kind of statistical correlation between 'neuro-activity' and some metaphorical structure, and then draw the conclusion that this is what it (i.e., metaphor) is or where it is, means, from my point of view, conflating two totally different levels of description, and thus making a category mistake, in the parlance of philosopher Gilbert Ryle (1949/2000). Thus these, and similar, claims about metaphors as existing as such in the brain of the individual are seen as highly problematical within the theoretical framework of the present thesis.

Some additional critique may be raised against the cognitive linguistic theory of metaphor. Firstly, Lakoff and Johnson (1980) presented metaphor as primarily a cognitive phenomenon, and only secondarily a linguistic one.

However, in the following uptake in the tradition in recent years, it has gone so far that it has become 'necessary' or at least possible to point out the need for "Re-emphasising language in metaphor research" (Cameron, 1999a, p. 11; italics omitted), i.e., arguing about also considering language when studying metaphor. However, as also Cameron (1999a, p. 12) insists, nor can metaphor can be reduced to "*merely* a matter of language" (italics in original), since metaphor is about premises, knowledge traditions and practices, that remain largely implicit.

Secondly, there seems to be a kind of circularity of argument, through linguistic 'evidence' being used to derive 'cognitive structures' (conceptual metaphors), which are then confirmed or verified by linguistic evidence. Systematically grouping or categorizing a large number of individual expressions is for obvious reasons of great importance for scientific reasoning in general. However, to then 'forget' this act of categorizing as if the categorization already was 'there' (in the minds of people) beforehand, may be a rather problematic endeavour. It is important, I argue (see also, Cameron, 2003), to see these concepts as abstractions made by the analyst, not necessarily being underlying or preceding mental concepts actually existing as such in the brain of the individual. "Discursive thought creates more and more delicate means of encompassing and dealing with reality, and it is a logical error to confuse the means, the instrument, with what the instrument was created to deal with," Vaihinger (1924/2001, p. 69) argues. "Abstractions which we are compelled to regard as something real, are," he continues, "children of our imagination; and the cardinal error of all scholastic philosophy consisted in converting these fictions into independent entities" (p. 202). Such a fallacy is, of course, not found only in philosophy but also in other knowledge traditions.

"Undoubtedly," Goatly (1997) concludes, "our cognitive structure is determined by conventional metaphors, and evidence for this can be seen in the lexicon of English" (p. 79), and that "conventional metaphorical analogies structure the cognition of speakers of English as this is reflected in the lexicon" (p. 6). However, to see how different concepts are structured in a dictionary by different metaphors (fascinating as this is) is one thing, to draw the conclusion from this that this is in fact how individual thinkers think is, in my view, not reasonable.

Thirdly, Lakoff and Johnson launched the exciting idea of embodied experiences as generating metaphorical thinking. But despite this idea, studying as an empirical question how children and adults acquire and use metaphors through and in social practices is largely neglected in this research tradition, as also Cameron (2003) points out.

Fourthly, as is usually the case with also the previous views on metaphor, what is analysed and illustrated tends to be (idealized) examples 'made up' by the analyst, or definitions from dictionaries. Metaphor tends not to be studied as an empirical issue, as ways of acting in and with language to do things in different practices.

### *A sociocultural view on metaphor*

The framework of sociocultural theory for the present thesis has already been discussed in turns. Here, I will only briefly return to the question of metaphor within this perspective.

Within sociocultural theory there exists no theory of metaphor specifically. However, in theorizing about language and communication, a view of metaphor is implied. In the sociocultural perspective, language is conceived in dynamic terms, not as static labels for or picture of phenomena. In Vygotsky's (1934/1986) theorizing, the concept of 'mediation' is central. Our understanding of the world is not 'direct' but mediated or 'by way of' the categories of our language (see also, Vygotsky, 1978). This implies that language in a fundamental way perspectivizes what is being referred to. We speak of phenomena in terms of something partially different. There is, in Rommetveit's (1988, p. 17) words, a "perspectivity inherent in human cognition and communication." Language, in Vološinov's (1929/1986) pair of visual metaphors, not only 'reflects' but also 'refracts' reality. This idea is also closely related to the Wittgensteinian (1953) idea that humans 'see' something 'as' something. We do not simply see the world as such, but in certain terms rather than others. This 'seeing as' is, in my view, what makes visible the metaphorical quality of our language, and this implies that the tool mediates our understanding. However, this claim needs a qualification. For 'seeing as' to be seen as metaphorical requires, in my view, that which something is seen as is something that it cannot literally be.

In the case of learning scientific language, Vygotsky (1934/1986, p. 161) writes:

> The process of acquiring scientific concepts reaches far beyond the immediate experience of the child, using this experience in the same way as the semantics of the native language is used in learning a foreign language. In learning a new language, one does not return to the immediate world of objects and does not repeat past linguistic developments, but uses instead the native language as a mediator between the world of objects and the new language. Similarly, the

> acquisition of scientific concepts is carried out with the mediation provided by already acquired concepts.

Vygotsky argues that in learning scientific concepts, the learner uses her ordinary words. The language the learner already has is used in learning a new language. Phrased differently, the scientific concepts are learned through metaphorical relations, i.e., in terms of other terms. Obviously this is not in itself sufficient for appropriating a scientific discourse. Of critical importance is how the new terms or the new use of the same terms differ from the older familiar sense. Also scientific discourse is structured differently from ordinary discourse. Concepts are defined in terms of other concepts within a theoretical framework in a way that ordinary language is not (Lemke, 1990). As a meta-comment, Vygotsky's reasoning about learning scientific concepts builds upon an analogy to learning another (non-specialist) language. Hence, the reasoning is in this sense self-illustrative of its argumentative point.

Finally, where is metaphor, so to speak, located in a sociocultural perspective, on the scale/continuum or polarity between 'linguistics' (i.e., metaphor as a matter of mere language) and 'mental' (i.e., metaphor as a cognitive phenomenon behind, before, language, as it were)? In a sociocultural perspective, as I have already presented, metaphor is seen as a 'communicative' phenomenon (i.e., as a matter of how we do things in and with language in a wide sense, including gestures, etc.). And since also thinking, according to this view, is seen as 'internal' communication with oneself mediated by discursive tools (Vygotsky, 1934/1986), attempts are made to try to conceive of how we make sense without dividing mind and communication into dichotomous poles. Metaphor becomes a matter of use of tools (primarily verbal language), and therefore not only a matter of language per se, but also fundamentally of identifying and taking implications, premises for meaning (i.e., a question of learning how a word, etc., is used in a specific practice, for certain purposes).

Where metaphor is 'located' in a sociocultural perspective, as I understand it, can be further elaborated as follows. In some cases (as I will elaborate on below, see Method) metaphor is an analytical abstraction made by the analyst in order to organize and manage discursive data (see further below on this distinction, p. 80f.). In these cases, 'metaphor' is the analyst's term. In other cases, 'participants' actually use and themselves point to the fact that they use metaphors. But in other cases the metaphoric lies in the language used, in the ways of speaking that are more or less pervasive in a knowledge tradition or even in a culture.

*Summary*

To briefly recapitulate the different views on metaphor. According to traditional, commonsense, view of metaphor, it is (1) a linguistic phenomenon, (2) based on similarities between two given entities, (3) used deliberatively, typically for (a) rhetorical or (b) poetical purposes, (4) thus, not a necessary, but rather ornamental, different form of language from the ordinary, that is, strictly put, unnecessary. For the present concerns, it may be added that since in these views, metaphor is nothing but a word replacing a corresponding correct literal one, it should or could not have any place in scientific reasoning (i.e., in 'proper discourse'). With interaction theory, metaphor changed from being seen as a linguistic phenomenon to being seen as a primarily cognitive device, and metaphor was also transformed from a process of transfer to a process of transformation. However, metaphor still remained a special kind of expression, not a pervasive feature of our language (despite Richards', 1936, point).

These views were forcefully challenged by the work of Lakoff and Johnson (1980). In their 'cognitive linguistic view,' metaphor is (1) conceptual not linguistic in nature, (2) with the primary purpose of creating understanding, (3) not necessarily based on any previously existing similarities between separate entities, (4) an everyday phenomenon for people in general, and (5) inevitable, even fundamental, for human thinking and reasoning (see also, Kövecses, 2002).

With the sociocultural view of metaphor, there is an increase in emphasis on metaphor as a feature of (and as the constitutive form of) language, and as socio-historically contingent. The category of metaphor is seen as more dynamic in character. And the focus is shifted from idealized examples or dictionaries to language in use, when calling for empirical studies on, for example, the sociogenesis of scientific concepts and their educational explanation – which is the kinds of questions being pursued in the present work.

This latter view of metaphor (and its relation to literalness) makes it possible to account for the relation between ordinary language and scientific language, and how language 'migrates' between the two. To study metaphor as a socio-historical phenomenon further means that where, for example, scientific concepts come from, as well as the difficulties they may pose for a learner's reasoning and appropriation, can be analysed. Finally, this view of metaphor, as adopted in the present work, makes it possible to deal with metaphor as an empirical field for research.

## Conceptual distinctions

In this section, 'metaphor' as well as its closely related concepts of 'analogy,' 'simile,' 'model,' and 'metonymy' will be clarified. The reason for this is that these terms tend to be used in relation to each other, or sometimes interchangeably, in literature. A stipulative definition of metaphor will be given, 'freezing' the concept for the duration of the analyses. There are no prevailing agreements regarding definitions of these concepts (see, e.g., Leatherdale, 1974). At times they are (some or all of them) subsumed under one term, seen as synonymous, at other times they are (more or less clearly) distinguished from each other. At times they are used interchangeably, or written together (e.g., 'analogue model,' Black, 1962; 'metaphorical analogy,' Goatly, 1997; or 'material analogue-model,' Hesse, 1966). Whether to do so is, of course, a question of what one wishes to be able to say something about and on what level of abstraction/generality one wishes to reason. Not uncommonly, one (or more) of the terms may be used when explaining another. However, in this section, I will go through these concepts as I see them within the framework of the present work.

In a general sense, the following forms of discourse categories have a metaphorical aspect in the sense that they are means of making sense of the world in a 'by way of' manner, more or less non-literally. However, in a more specific sense, while they all share a discrepancy or incongruence in terms (i.e., speak of something in terms of, as if it were, something else), this relation is conceptualized as being of different kinds in the different concepts. In cases where it can help clarifying matters, the etymology of the terms will be briefly related.

### *Metaphor*

Metaphor is usually defined as 'to see something in terms of, or as, something else,' as already stated. Sometimes the seeing metaphor in this definition is replaced by 'talk,' 'think of,' 'conceive,' 'experience,' or 'understand.' The critical point, as I understand it, is that there is some kind of incongruence or discrepancy in terms that are nonetheless related in use. As seen, the definition of metaphor is rather general. Consequently, metaphor is used in this work as a generic term (encompassing at a general level also the terms below). Metaphor is not only used in the present case for so-called 'metaphor proper,' i.e., statements of the kind 'X is Y,' simply because this is an idealized form and not a way that people usually talk or texts tend to be written. To define the matter thus would mean to miss most of the phenomenon of interest for a work of the present kind. In regarding 'metaphor' in this double manner: in a broad as well as more particular way, I follow in a tradition with, among others, Leary (1990), Cameron (2003), and Knowles and Moon (2006).

### *Analogy*

Closely related to metaphor is the concept of 'analogy.' In its idealized form, an analogy is a statement between four terms of the kind: 'X1 is to X2 as Y1 is to Y2' (Miller, 1993). Hence, according to this definition, analogy is a more elaborate, systematised, and explicit discursive form than is metaphor. The term metaphor is more general and, in my view, therefore seems more appropriate a term for framing the interest of the present thesis than does the concept of 'analogy.'

Leatherdale (1974) claims that 'analogy' was originally a mathematical concept (as 'analogy of proportion'), meaning the same 'ratio' (e.g., A:B::C:D, where A, B, C, and D are mathematical entities, such as numbers). And it was not until later, with Aristotle, Leatherdale claims, that it came to denote simply resemblance of relations of any kind, and a relation of 'similarity' not 'identity.' This claim about the original sense of the term is confirmed by an etymological dictionary (CDE, 2000). It has even been argued that "this broadening of the concept of analogy is the key to the development of scientific thought in antiquity" (Leatherdale, 1974, p. 31).

### *Simile*

A 'simile' differs from a metaphor in that it makes the addressee aware of itself (so to speak), while the metaphor through its form 'hides itself' (Andersson & Furberg, 1992). That is, in its pure form, a simile states that 'X is like Y' (while the metaphor simply states that 'X is Y'). Thus the very nature of the relation is pointed out in simile, while it remains hidden in metaphor.

### *Model*

A 'model' is a rendering of something (a complicated abstract phenomenon) in a schematic form (often as a physical object), usually on a reduced or enlarged scale.

Keller (2002) makes an interesting point about 'modelling' in two scientific traditions: (developmental) biology and mathematical sciences (physics), respectively. She claims that the primary meaning of model in developmental biology is a 'model organism' (such as the fruit fly). And "unlike mechanical and mathematical models (and this may be the crucial point), model organisms are exemplars or *natural* models–not artifactually constructed but selected from nature's very own workshop" (p. 51; italics in original), as it were.

> Other differences are also worth noting. The primary criterion for the selection of a model organism is only rarely its simplicity–the principal criterion for a model in the physical sciences. Far more important is the experimental accessibility endowed by particular features (such as size, visibility, reproductive rate). Furthermore, its primary use is neither for the construction of a general theory nor as a guide to identifying the leading causal factors for a particular process. Model organisms represent in an entirely different sense of the word than do models in the physical sciences: they stand not for a class of phenomena but for a class of organisms. As such, they are more closely akin to political representatives, and, in fact, are employed in a similar fashion–as a way of inferring the properties (or behavior) of other organisms. It is for just this reason that biological modeling has sometimes been described as proceeding "by homology" rather than "by analogy." (p. 52)

Conversely, in the mathematical and physical sciences, Keller (2002, p. 97) argues, models "rely on imaginary constructions" that "make no pretense to literal truth." "One might even say that models in the physical sciences are fictions by definition," she continues; "they are analogical rather than literal, corresponding to an actually occurring phenomenon in some respects but not in others" (p. 97).

> Furthermore, the sense in which they may be seen to correspond may be quite abstract, involving no literal match at any point. But what may well be of greatest importance here is the fact that they are made up, based on imagination rather than observation. (p. 97)

These different understandings of 'model,' Keller (2002) concludes, also reflect the value placed in different scientific cultures on imagination and observation, respectively.

Thus, and to return from this excursion to the task of distinguishing and defining concepts, there is not one commonly agreed upon understanding, definition, of model in science. For reasons of simplicity and clarification, I will use the term 'model' in the sense of 'physical model' (e.g., the 'molecule-model' commonly used in science education, cf. p. 66) in this thesis.

### *Metonymy*

'Metonymy' is often clearly distinguished from 'metaphor' in the theoretical literature. For example, Gibbs (1999, p. 36) claims that:

> In metaphor, there are two conceptual domains, and one is understood in terms of another, usually very different, knowledge domain. Metonymy involves only one conceptual domain, in that the mapping or connection between two things is within the same domain.

However, the problem with this kind of distinction, as I see it, is the critical question of what are distinct 'knowledge domains.' How to categorize something as a specific, separate, domain of knowledge, is something that the analyst does on the basis of a certain interest, it need not be something that exists as some kind of 'natural kinds' that precede the act of categorizing. Thus, consequently, what is to be termed 'metonymy' and 'metaphor,' respectively, is not necessarily in advance self-evident – as it is presented in the theoretical treatments (see also, e.g., Kövecses, 2002) – but a choice the analyst makes in relation to what she is trying to account for.

The figurative kind of language referred to as 'metonymy' can take several different forms. Lakoff and Johnson (1980, pp. 38-39; all italics in original) list the following kinds: 'producer for product' (e.g., "I'll have a *Löwenbräu*"), 'object used for user' (e.g., "The *sax* has the flu today"), 'controller for controlled' (e.g., "*Napoleon* lost at Waterloo"), 'institution for people responsible' (e.g., "The *Army* wants to reinstitute the draft"), 'the place for the institution' (e.g., "*Paris* is introducing longer skirts this season"), and 'the place for the event' (e.g., "*Watergate* changed our politics"). However, the form of metonymy that may be the most well known or typical is 'the part for the whole' (e.g., "Get *your butt* over here!" [ibid., p. 38] or "I've got a new *set of wheels*" [said about a car]; ibid., p. 36). This latter form of metonymy is sometimes referred to as 'synecdoche' (ibid.). The relation between part and whole can be of two kinds: 'pars pro toto' (i.e., a part stands for the whole) or, conversely, 'totum pro parte' (i.e., the whole for a part). The two examples already given illustrate the first variant. An example of the latter alternative would be: 'Sweden won the gold in the Olympics,' where 'Sweden' as a whole stands for the athlete or athletes actually winning the medal(s).

The definition of metaphor above may not seem very specific to the reader. However, metaphor cannot simply be defined as propositions of the kind 'X is Y' (also, Cameron, 1999b). There are several reasons why such a definition is not fruitful for research. Some reasons for this claim are that language is not static, but constantly renegotiated, and that metaphor to great extent is about implications, what can be derived or what follows from what is explicitly said (Cameron, 2003). However, the main reason for such a definition to be insufficient, as I see it, is simply that people do not talk or write in explicit propositions in such an idealized manner as 'X is Y.' Thus such a definition would mean to miss much – in fact, most – of what is of interest for a study of, for example, the present kind. Instead, Cameron (1999b) suggests a view of metaphor in terms of the Wittgensteinian (1953, §§ 65-67) idea of categorizing by 'family resemblances.' I understand this as follows. Family resemblance is characterized by there not being any, for the 'family,' exclusive feature shared by all 'members' of the 'family'; in our case, all kinds of the general category of metaphor (including analogy, simile, etc.). These latter all share some kind of discrepancy or incongruence in terms. However, these relations are not 'the same' but of different kinds (e.g., opposition in irony, almost identity in simile, but not quite since only different 'things' can meaningfully be compared, made to seem similar), etc. Thus, not all metaphors in the present work will have the same form. But according to the criteria above, they can, nonetheless, be argued as being understood and analysed as metaphors.

Sometimes, either of the terms 'trope' and 'figurative language,' respectively, is used for what I speak of as metaphor (in the general, generic sense). However, looking at the explanations and etymology of these terms, it is seen that 'trope' is presented as: "figure of speech," of Greek origin, "turn, direction, turn or figure of speech" (CDE, 2000, p. 1170). Thus, this term has the view of a kind of 'deviation' inscribed in the very definition, which makes it inadequate as a term from the present perspective. And 'figurative,' from Latin "to shape or form" (CDE, 2000, p. 381), is an adjective, which makes it more difficult to use as a concept, since it always needs an addition. There may also be a pedagogical reason for using 'metaphor' rather than 'trope' or 'figurative language,' since the latter two are probably less familiar to a reader, and may thus cause additional difficulties in understanding.

# Metaphor in science and science education

The potentially relevant literature on metaphor is vast (see the volume edited by Ortony, 1993, and references therein). Texts on metaphor have been written over a period of almost 2,500 years (from Aristotle to this very day), in a variety of disciplines, knowledge traditions, and languages. Even with the present interest in metaphor in the work and teaching of science, the research literature is still unmanageable. However, I will here, without claiming to cover all this literature, illustrate and discuss some examples of what kind of points that have been made in the literature. Since there is no commonly agreed upon practice of how to define and distinguish metaphor from other concepts such as analogy and metonymy (see, Conceptual Distinctions, above, p. 50ff.), not all the examples discussed here will use 'metaphor' as a term. However, it is possible to treat the issues and examples discussed with this term as a generic category.

Instead of focusing on one topic as being treated in terms of metaphor in science and science education, respectively, an attempt has been made in this chapter to choose different illustrations. The point is to illustrate the workings of metaphor (analogy, model) in learning and knowledge formation, and it is this general line of reasoning that is the point, not (primarily) a specific metaphor in a specific topic.

## Roles played by metaphor in science

The issue of metaphor in science tends to be discussed in more personal recollections of researchers (e.g., Bradie, 1999; Bruner, 1979), rather than being systematically studied as a topic in its own right. Some claims that have been made about the roles played by metaphor in science will be briefly exemplified here. For some additional cases, see the individual studies in part two of this thesis.

### *...scientific creativity/innovation*

In his treatise on knowing with the 'left hand,' Bruner (1979) writes about the functionality of metaphor in the psychologist's work. The 'left hand' embraces what has been spoken about in terms of intuition, feeling for, impulse, suggestion, etc. Being a master narrator, Bruner's reasoning is worth reproducing rather extensively in his own words:

> One thing has become increasingly clear in pursuing the nature of knowing. It is that the conventional apparatus of the psychologist–both his instruments of investigation and the conceptual tools he uses in the interpretation of his data–leaves one approach unexplored. It is an approach whose medium of exchange

> seems to be the metaphor paid out by the left hand. It is a way that grows happy hunches and "lucky" guesses, that is stirred into connective activity [...] looking sidewise rather than directly. (Bruner, 1979, pp. 3-4)

The psychologist, Bruner argues, "is governed by the same constraints that shape the behavior of those whom he studies. He too searches widely and metaphorically for his hunches" (ibid., p. 4). Eventually, Bruner continues, the psychologist will have to

> tame the metaphors that have produced the hunches, tame them in the sense of shifting them from the left hand to the right hand by rendering them into notions that can be tested. It is my impression from observing myself and my colleagues that the forging of metaphoric hunch into testable hypothesis goes on all the time. And I am inclined to think that this process is the more evident in psychology where the theoretical apparatus is not so well developed that it lends itself readily to generating interesting hypotheses. (ibid., p. 4f.)

Of course, as Bruner points out, there is an economical gain in not reporting the whole process of how one came to think up the hypothesis. However, he argues, this at the same time suggests "that we may be concealing some of the most fruitful sources of our ideas from one another" (ibid., p. 5).

Bruner (1979) seems to imply that metaphor is important in knowledge formation, an importance that may be emphasised in the specific case of psychology, in generating hypotheses. However, I would in addition argue that metaphors do not cease to be of importance for knowledge formation with the advent of a hypothesis. Rather, as I have already argued, metaphor tends to be conceptualized as scientific work proceeds (see, Studies I and II in the present thesis). This means that speakers may have difficulty in perceiving the metaphoric nature of the conceptual tools they employ. This, in its turn, as I will argue at a later point in this thesis, has important implications for learners encountering scientific discourse.

In a later work, Bruner (1996, p. 124), in similar vein, argues that "scientists use all sorts of aids and intuitions and stories and metaphors to help them in the quest of getting their speculative model to fit 'nature' (or getting 'nature' to fit their model by redefining what counts as 'nature'). They will use any metaphor or any suggestive figure or fable or foible that may luckily come to hand." As an example, Bruner, stating personal communication as source, writes about how Niels Bohr came about "the idea of complementarity in physics–illustrated, for example, by the principle that you cannot specify both the position and the velocity of a particle simultaneously and therefore you cannot include both in the same set of equations" (loc. cit.):

> The general idea had first struck him as a moral dilemma. His son had stolen a trinket from the local notions shop, but some days later, stricken with guilt, he had confessed the theft to his father. As Bohr put it, although he was greatly touched by this moral act of contrition, he was also mindful of his son's wrongdoing: "But I was struck by the fact that I could not think of my son at the same moment both in the light of love and in the light of justice." This led him to think that certain states of mind were like the two aspects of one of those trick Gestalt figure-ground pictures where you can see either the duck or the rabbit, the vase or the profiles, but not both at the same time. And then some days later, as if the idea were blossoming, it occurred to him that you could not consider the position of a particle as stationary in a particular position and at the same time as moving with a velocity in no particular position at all. The mathematics was easy to fix. It was grasping the right narrative that took the hard work. (ibid., p. 124f.)

In this manner, knowledge of one domain may, by analogy or metaphor, be applied to an apparently disparate, different domain, to yield new insight, create new knowledge. In fact, the role most often ascribed to metaphor in science has been its role in discovery, in contributing to forming new hypotheses, Holyoak and Thagard (1995, p. 13) claim. They give, as an example, Friedrich Kekulé's theory of the molecular structure of benzene. He claimed, in Holyoak and Thagard's account, that "he was led to the hypothesis that the carbon atoms in benzene are arranged in a ring by a reverie in which he saw a snake biting its own tail." The visual image is thus claimed to have been functional in his creative thinking. Another famous example of analogy being functional in generating new scientific knowledge, is natural selection in terms of artificial selection of breeders in Darwin (for a more extensive treatment of this case, see Study III in the present thesis).

"The successful analogical act," Leatherdale (1974, p. 17) argues, "may be accomplished in a moment of insight, but its full implementation, elaboration and qualification may take one or several lifetimes, and is not restricted to the first discoverer." Thus, to work out the full implications (to specify the extension and limitation) of the analogy may preoccupy scientists for a long time, and may in a sense be one of the critical parts of the knowledge formatting process. In this sense, I argue that metaphors are not simply 'thrown away' when the theory they may have formed the basis of is formulated; but instead that they may at times be 'built into' or 'inscribed' in the theory (consider 'mind as computer' in cognitive psychology as a case in point). However, this is a historically much debated issue (Hesse, 1966). It is important to realize that some metaphors may be 'incidental' to a theory while others may be 'constitutive' (Boyd, 1993). Obviously, both stances could be argued by focusing on different metaphors. Metaphors do not fill just one function in scientific work.

The making of a new relation not only makes a new connection (between two static, fixed, entities), it also constitutes what is related in an, at least partial, new manner. This thus also makes understandable how we can create new knowledge and understanding despite using what we already know so.

*...filling gaps in discourse*

The concept 'catachresis' (Boyd, 1993) denotes how gaps are filled in discourse. Research is typically directed at the elucidation of phenomena that scientists do not have a clear understanding of, as Keller (2002) points out. In order to make sense of what is studied, scientists "need to invent words, expressions, forms of speech that can indicate or point to phenomena for which they have no literal descriptors" (Keller, 2002, p. 118). In these cases, using language figuratively, i.e., using metaphors, is the only possibility for the researchers.

In his description of where some scientific concepts come from, Sutton (1992, p. 14; bold and italics in original) writes about the term 'gas':

> All through the 1600s and 1700s the existence of a third state of matter [to solid and liquid] was being clarified. 'Air' was seen to be something rather than nothing, and people realised that there were different 'airs'. Gradually ways were devised to trap and collect them, and they were called elastic aeriform vapours for a long time. Jan Baptist van Helmont (1577-1644) had chosen the word **gas**, from the Greek word *chaos* (using the aspirated 'g' of his own language to stand for the chi of the Greek) for what he saw as the spirit or essence of things – chaotic in its wild tendency to escape, for example on heating.

In this manner, a way of viewing a phenomenon is 'built in' in the very term used to denote it.

Scientific concepts carry remnants of the origin and history of the words. In the words of Paul de Man (1979, p. 17): "tropes are not just travellers, they tend to be smugglers and probably smugglers of stolen goods at that." These other senses of words may once again be brought to the fore by learners when meeting the theories and concepts of science (if we here briefly foreshadow the topic of the second part of the present chapter). Admittedly, this risk may not be overwhelming in the specific case of 'gas,' as used today. (See further illustrations of this in Study III in the present work, where common senses of words may lead the reasoning astray, as it were.) Knowledge of the history of the words working as concepts in scientific theories may thus be valuable for a teacher in foreseeing difficulties of this kind, in order to try to prevent adrift in reasoning from occurring. But let me return to the issue of metaphor in science.

Baake (2003, pp. 96, 97) tells of Nobel Laureate physicist Murray Gell-Mann and others "on the search for quantum particles inside of an atom that appear and disappear in a matter of nano-seconds." The central term, "'quarks,'" Baake claims, "is adapted from the James Joyce novel, *Finnegans Wake*." This may, as in the case of the previous example, be seen as an illustration of how metaphor works in science by catachresis (Black, 1962; Boyd, 1993), i.e., by filling gaps in discourse. In order to speak of something that we lack a term for, we apply an old word, or form a new term on the basis of (parts of) other words. The world as studied by science does not come labelled in advance, the world does not speak for itself. Hence, the necessity of metaphor.

### *...for making predictions*

A key argument in Hesse (1966, p. 8), as I read her, is the following:

> When we take a collection of billiard balls in random motion as a model for a gas, we are not asserting that billiard balls are in all respects like gas particles, for billiard balls are red or white, and hard and shiny, and we are not intending to suggest that gas molecules have these properties. We are in fact saying that gas molecules are *analogous* to billiard balls, and the relation of analogy means that there are some properties of billiard balls which are not found in molecules. Let us call those properties we know belong to billiard balls and not to molecules the *negative analogy* of the model. Motion and impact, on the other hand, are just the properties of billiard balls that we do want to ascribe to molecules in our model, and these we can call the *positive analogy*. Now the important thing about this kind of model-thinking in science is that there will generally be some properties of the model about which we do not yet know whether they are positive or negative analogies; these are the interesting properties, because, as I shall argue, they allow us to make new predictions. Let us call this third set of properties the *neutral analogy*. (italics in original)

Thus, according to this argument, models are essential for a theory, in that they are by analogy what makes possible predictions (which could empirically be falsified or not falsified for the time being).

### *...for making sense of empirical observations and thinking through problems*

Ochs, Gonzales and Jacoby (1996, p. 333) studied physicists discussing and evaluating "experimental findings or theoretical calculations," trying "to arrive at a working consensus." A recurring observation was the use of what Ochs et al. (p. 339) term "an *indeterminate* referent":

> That is, the referent constructed in these utterances appears to be neither exclusively the physicist nor the object of inquiry but rather a blended identity that blurs the distinction between the two. Such utterances cannot, of course, be literally understood as indexing events in which physicists participate. Nevertheless, they appear to be completely unproblematic for the physicist interlocutors. Indeed, no one ever stops an interaction to ask, "What do you mean '*I'm* in the domain state'?" or "How could *you* possibly 'go below in temperature'?" Moreover, they are also ubiquitous in our data. (p. 339f.; italics in original)

Ochs et al. (p. 343) further state "that indeterminate constructions seem to be a referential resource especially suited to the activity of thinking through research problems together," and that this way of reasoning is without apparent difficulty carried out "by scientists in their everyday interpretive work" (p. 348): "Such a referential poetics allows interlocutors to symbolically participate in events from the perspective of entities in worlds no physicist could otherwise experience" (loc. cit.).

Ochs and colleagues also argue that "it appears that physicists come to their understandings and interpretations of physics partly through [...] sensori-motor and symbolic re-enactments of physical events and that the collaborative thinking-through process requires that this sensori-motor involvement be witnessed and evaluated by others present" (pp. 352-353). By gesturing and movements, the scientists make a problem visible for each other (and themselves) in collaboratively thinking it through. (For an early realization that we tend to metaphorize by gesturing in our communication, see, Whorf, 1956.)

Ochs et al. (1996, p. 358) conclude by saying that their "study has focused on a type of indeterminate utterance: one that combines a personal animate pronominal subject (e.g., 'I') with an inanimate physical event predicate (e.g., 'am in the domain state')." This "referential indeterminacy," they argue, "appears to be a valuable discursive and psychological resource as scientists work through their interpretations and come to consensus regarding research findings" (ibid., p. 359).

When trying to understand or explain something difficult, people tend to fall back on narrativizing, i.e., speaking in terms of someone doing something (anthropomorphizing phenomena). This is an issue I will come back to somewhat differently and elaborate several times in this work.

Closely related to the present category is that one function of metaphor in science may be as "a descriptive short-hand" (Hoffman, 1980, p. 399), i.e., serving the end of communicative economy.

*...organizing perception*

"It is important to realize," Leary (1990, p. 12; italics in original) argues, that the metaphors used in a knowledge tradition "have had historically significant *directive* functions: They have directed the gaze – not to mention the theoretical and practical activities – of researchers toward different aspects" of the phenomenon under study (cf. Muscari, 1988). Thus, according to this reasoning, metaphors have an organizing function for our perceptions and other actions.

Since metaphor has a 'directing' role in perception, it may lead one's research effort towards some aspects of a phenomenon and therefore, by necessity, at the same time lead away from other aspects of the phenomenon (cf. Hoffman, 1980). This is one of the reasons, I argue, why it is of importance to be aware of the metaphors used in research. In this sense, metaphors may decide, so to speak, what we can know within a particular framework. Metaphor may also be functional in design experiments, conducting them, and interpreting their outcomes (see Study I in this thesis).

Obviously, metaphor may serve several functions at once in science. Hence, the above categories of functions should not be read as mutually exclusive.

In his book on the discovery of geological time, the late professor of geology and zoology at Harvard, Stephen Jay Gould (1987) claims that certain metaphors filled decisive functions in generating that knowledge. The key to the 'finding' of geological time – or 'deep time' as the metaphor goes – lay in a dichotomy of metaphors expressing conflicting views on the nature of time (time as arrow and time as cycle, respectively). The interplay "of theory informed by metaphor and observation constrained by theory–marks any major movement in science" (ibid., p. 8), he claims. He further argues that "metaphors of time's arrow and time's cycle formed a focus for debate, and proved as fundamental to the formulation of deep time as any observation about the natural world" (ibid., p. 13).

Gould also makes an additional point of interest for the present thesis, the role of metaphors in coming to grips with or understanding phenomena in, so to speak, a deeper sense:

> An abstract, intellectual understanding of deep time comes easily enough–I know how many zeroes to place after the 10 when I mean billions. Getting it into the gut is quite another matter. Deep time is so alien that we can really only comprehend it as metaphor. And so we do in all our pedagogy. (Gould, 1987, p. 3)

This reasoning also points to the questions of what it means to understand something and what constitutes different kinds of understanding. However, these are not questions that I will elaborate on in this thesis. The use of metaphors in conceiving geological time will also be seen in Study III of the present thesis. As an illustration of the claim about the use of metaphor in education, Gould relates the following episode:

> A Swedish correspondent told me that she set her pet snail Björn (meaning bear) at the South Pole during the Cambrian period and permits him to advance slowly toward Malmö, thereby visualizing time as geography. (loc. cit.)

Thus, the point is that the movement of the snail is so slow that it is almost unnoticeable, yet it moves. This last example anticipates what I will review next, the use of metaphor in education, particularly science education. But first I will, in all brevity, draw some conclusions about what we know about the role of metaphor in scientific work, and point ahead to what I will attempt to contribute to this research. The evidence for the usefulness and pervasiveness of metaphors in science has often been rather anecdotal in nature. This calls for systematic studies of metaphors as topics in their own right rather than peripheral to something else. This is what I will set out to do in my empirical studies reported below. More studies of the kind provided by Ochs et al. (1996) are needed to clarify what kinds of metaphors are used in scientific work and what functions they may have in generating scientific knowledge. Additional studies are also called for that analyse the evolution of metaphors in knowledge formation and the work needed to try out and literalize or conceptualize initial metaphors. I will also try to make a contribution to this literature by analysing the metaphors used in bridging the domains of science and commonsense in popularizing scientific knowledge for a lay audience.

## Uses of metaphor in science education

Research on metaphor in educational science has primarily been of two kinds. The first body of literature consists of studies of metaphors *for* learning (e.g., Elmholdt, 2003; Mayer, 1996; Munby, 1986). For example, in an article about metaphors in our discourse on learning, Sfard (1998, p. 5) argues that there are two "metaphors that inform our thinking about learning." She calls these metaphors the acquisition metaphor (AM) and the participation metaphor (PM). The latter metaphor, which is also the more recent one in theorizing learning, offers, in Sfard's view, an alternative to AM's 'thing-like' notion of knowledge and learning. However, Sfard argues, for research, "some important things that can be done with the old metaphor cannot be achieved with the new one" (p. 9). What the acquisition metaphor makes possible to conceive of is what is traditionally termed transfer. This concept is, in its traditional sense, according to Sfard, "intractable" (loc. cit.) within the framework of the participation metaphor:

> Learning transfer means carrying knowledge across contextual boundaries; therefore, when one refuses to view knowledge as a stand-alone entity and rejects the idea of context as a clearly delineated "area," there is simply nothing to be carried over, and there are no definite boundaries to be crossed. (loc. cit.)

However, as also Sfard notes, a “satisfactory account of learning” needs to take account of “the actor’s previous experience” (p. 10). In a sense, this is what the present thesis is concerned with, by looking at how learners use what they know in trying to come to grips with novel or unfamiliar knowledge. In using her previous knowledge in a new situation, the learner cannot simply transfer literally what she knows. Rather, her knowledge and language will have to be adjusted to the new situation, not only in likeness but also, simultaneously, in difference. To mark out this difference in view, the term ‘transfer’ is not used in sociocultural theory. This is not to say that what learners bring to a task from what they previously have learned is not interesting in this perspective. Returning to Sfard’s reasoning, she makes the point that the two metaphors for learning offer something in addition to each other, and

> relinquishing either the AM or the PM may have grave consequences, whereas metaphorical pluralism embraces a promise of a better research and a more satisfactory practice. The basic tension between seemingly conflicting metaphors is our protection against theoretical excesses, and is a source of power. (loc. cit.)

Finally, Sfard claims that what is “true about educational practice also holds for theories of learning. It seems that the most powerful research is the one that stands on more than one metaphorical leg” (p. 11).

In my view, two points are worth adding to this reasoning. First, every metaphor is a ‘partial mapping’ of a phenomenon. For this reason, no single metaphor will do the job. Second, every metaphor, to be made sense of, needs another metaphor. For this reason, explanations will contain more than one metaphor.

However, interesting as these studies are, they are not in a more strict sense of relevance for the present thesis (in that they are about metaphors *for* learning, not metaphors *in* learning) and they will therefore not be further commented upon.

The second body of literature on metaphor and learning concerns the use of metaphor (primarily in terms of analogy) in science education. The nature of this latter body of research will be discussed by means of various examples. That the term that tends to be used in such work is ‘analogy’ need not concern us at this point; it falls under the general category of metaphor (as a generic term) as clarified in the section above on Conceptual Distinctions.

A topic in science education, well suited for a study of metaphor, is ‘the greenhouse effect,’ since this is not only highly abstract and complex, but obviously the very term itself is a metaphor. Koulaidis and Christidou (1999, p.

559) studied 40 primary school students' (11-12 years old) "conceptions concerning the greenhouse effect." The students were twice interviewed individually:

> The first interview served as an introduction to the discussion and aimed at setting the context. Children were presented with popularized, mass media type information about the greenhouse effect, as well as photos illustrating some major causes of global warming and were asked to state what they thought were the main messages or points of the material. The second interview was designed so as to: (a) encourage students to focus the discussion on specific scientific aspects of the greenhouse effect, by relating different concepts and explaining a variety of processes that they considered to be relevant to this phenomenon; and (b) give access to students' views by setting the conditions of a natural discussion. (p. 562)

This 'natural discussion' consisted of the student being presented with 19 cards, each with a term of relevance for the greenhouse effect. The students were asked to group the cards in 'causality' (i.e., 'X changes Y,' etc.).

The interviews were taped and subsequently transcribed. Each interview-test was then "condensed," i.e., "the students' original statements were isolated and grouped in terms of thematic coherence. In this way, each interview transcript provided a 'story' concerning the greenhouse effect" (p. 562). "Based on children's 'stories' we inferred a number of models of their thinking for the greenhouse effect" (p. 563), the researchers explain.

However, for the present purpose, the interesting sections of Koulaidis and Christidou's article, are the empirical examples given of the children's reasoning. For example:

> Carbon dioxide, together with methane are like a cover around the earth, a thin layer, that lets the sun's thermal rays to pass, but it doesn't let them go away. (student, cited in Koulaidis & Christidou, 1999, p. 564)

Here the metaphor of 'cover' is used, but marked out as not intended literally ('are like'). This reasoning also contains animation or anthropomorphizing, when speaking of how the 'cover' (i.e., carbon dioxide and methane) 'lets' (presuming intention) 'the sun's rays to pass.' The following example is also illustrative of this:

> I mean those rays that are allowed to pass. When a ray of the sun comes down to the earth and tries to get away, it can't go back because it touches the ozone and it falls back down to the earth. (student, cited in Koulaidis & Christidou, 1999, p. 566)

Terms like 'allow' and 'try' represent this abstract process as if it were the result of intentional acts (see also, Cameron, 2003, for similar findings). Through this way of speaking, what is to be explained is transformed into a communicative form that is easier to understand for the learner.

In my view, another clear illustration of the metaphors in learning is provided by a study by Roald and Mikalsen (2000, p. 337) on deaf children's conceptions of the Earth and the heavenly bodies. "As these natural phenomenaon [sic] are all spatial," they write, "conceptions about them must involve some visualization." And sign language being spatio-visual obviously makes this imperative; and further, many signs bear resemblance to what they represent. For example, the sign of 'Earth' consists of the two hands making a 'ball' movement in front of the body (also translatable into 'world'), alternatively, one hand circling a flat area in front of the body (also translatable into 'area,' 'land' or 'country').

One child is reported to have combined the signs for 'house' and 'everything' to denote 'the Earth.' This could be read as a small example of how people make sense of and communicate about phenomena in terms of something else, or how what one knows can be used in combination to extend what one can say or reason about.

At the end of their article, as suggestions for further investigation, the authors ask whether "the visual/spatial language of the deaf really have implications on how they are constructing their view of the world" (Roald & Mikalsen, 2000, p. 353). To answer this question, I would reply that not only deaf children, but other learners as well make sense of or speak about even phenomena or qualities that are abstract, and therefore invisible and a-spatial, in terms of spatial and visual metaphors. According to Lakoff and Johnson's (1980) theory, our conceptual systems are constructed on the basis of physical and/or social experiences, often in spatial terms. This is why, for example, they argue (as I have already reported), that 'consciousness is up' (e.g., 'wake *up*,' '*fall* asleep'; since we sleep lying down).

Another study of deaf children's ways of explaining and reasoning about scientific phenomena (Molander, Pedersen & Norell, 2001), in my view, provides some illustrative examples of how children communicate through metaphorical reasoning. One child (A) tries to explain to another child (B) what happens to an animal when it is dead (this is the same question as discussed below, in the Discussion, p. 90):

> A: .. It's always the same with atoms, I think [signs "seconds" as equivalent to atoms]. Always the same, and I think nothing happens to the atoms. If you think about an animal, and the animal consists of cells….
>
> B: Seconds? Are you signing seconds?

> A: Yes, I'm making this sign because I don't have any other sign for atom. (Molander, Pedersen & Norell, 2001, p. 205)

In Swedish sign language, there is no conventional sign for 'atom.' For this reason, the child (A) uses the sign for 'second' instead, since it is the sign for 'the smallest unit' (ibid.). This is in itself a fine illustration of a metaphorical relation whereby something for which the child does not have the language (sign) is communicated about through something else that is available. Even if this last example is somewhat exceptional, since there is no sign for the concept in question, as an explanation (i.e., how the task is solved, carried out) it is not, in my view, exceptional (cf. also on 'catachresis' and 'over-extension' above).

In another sequence reported in the same article, a child (E) is asked what the word 'atom' makes her think about:

> E: Atom, that's in the atomic bomb. That's what I think about, and then there is something in physics, something to do with atoms, too. Something red and white and black.. some sort of ball. (Molander, Pedersen & Norell, 2001, p. 206)

This excerpt, in addition to illustrating how the child understands atom in terms of something familiar and concrete (colour, ball, bomb), points to the problem of the relation of the representational system (or the mediational means) to what is being talked about. The learner is faced with the question of what to consider as relevant and not of the characteristics of the representation. For example, what is relevant at different levels of description (e.g., on the atomic level and at the level of a model, respectively).

When discussing the differences between hearing children and deaf children's introduction to science, Molander and colleagues (2001) write that in contrast to hearing children, who meet a popularized picture of science in different media, deaf children tend to meet science for the first time in school, and then from a scientifically more correct perspective. However, even if it may be so, the children, as can be seen in the excerpts above, still communicate about these phenomena in terms of something else.

Tamir and Zohar (1991, p. 57) looked at two forms of explanations in students' reasoning, 'teleology,' i.e., to refer "to cases in which ends are used as explanations for the way certain structures are built […], or for the manner certain functions are performed"; and 'anthropomorphism,' i.e., to refer "to the manner of attributing human reasoning to non-human beings." As an example of the latter, people may "think about adaptations of organisms in terms of mechanisms that direct their own behavior, such as desires, intentions, wishes, and aims. (e.g., 'Plants prefer wet soil' or 'the male peacock blows its tail open to impress and attract the female')" (p. 57f.).

While there is a risk of the learners confusing these forms of explanations with a cause-effect (causal-mechanistic) explanation, Tamir and Zohar (1991, p. 58) claim that "Scientists often use such formulations as short cuts in their communication among themselves." Thus, anthropomorphism and teleology may work and fulfil communicative and cognitive functions, and should not be taken lightly as misunderstandings or misconceptions. In fact, when interviewed, the students (high school students, aged 15 and 17) favoured the use of anthropomorphic terms. For example, they may say that "It is obvious that plants do not really try or wish; however, using such expressions makes it easier to understand," i.e., this way of speaking works in making something more comprehensible. And "We are big enough to know that the plant has no brain and hence no wishes; however, it is more convenient to communicate using these expressions" (p. 62), they explain.

However, a follow up study (Zohar & Ginossar, 1998, p. 688) reports, among other things, that when asked directly whether believing that plants "really wish, try, or strive," 29% of the students (aged 15 and 17) stated that they "believed that plants actually behave in this way" (see also, Helldén & Solomon, 2004). In my view, these findings illustrate that what for the analyst or teacher is metaphorical may be taken literally by the learner. How to understand the relation between a representation and what is referred to may be a real difficulty for the novice trying to appropriate, for example, a scientific vocabulary (see also, Keeping Action in and out of Mind, below). (For further illustrations of metaphorical reasoning in connection to a biological topic, see Study III of this thesis, and other studies reported therein.)

Adopting a Vygotskian 'socio-cognitive' perspective on learning science as moving from 'spontaneous concepts' to 'scientific concepts,' Cameron (2002) reports two studies on the use of metaphor. Reviewing research on children's understanding of metaphor, she points to three difficulties children face when trying to make sense of metaphor: (1) They may not recognise the metaphor as a metaphor. For this reason, understanding can be "assisted by more explicit marking of metaphor, as in similes" (p. 676). (2) The children may lack knowledge about the domain used as the point of departure for learning about another domain, in which case they will not benefit from the relation of the metaphor. (3) Even if children identify a metaphor as a metaphor, they may find it difficult to discern appropriate attributes and relationships between the two domains bridged by the metaphor.

The first empirical study carried out by Cameron consists of an analysis of two girls, 9 and 10 years old, respectively, jointly trying to make sense of two texts about the ozone layer. The girls' talk about the metaphor of 'blanket,' as used in the text, shows how it is recognized as metaphorical. The girls also contextualize 'blanket' in terms of 'bed' and 'protecting you from the cold.' In this sense, the ozone layer is made more concrete and related to a familiar experience.

However, as Cameron (2002, p. 681) argues, while "choosing the term '*blanket*', the writer" of the text "reinforces the protective function of the atmosphere," which was subsequently taken up by the girls, this "at the same time limits the type of explanatory help it provides." Even if we used all our knowledge about the domain of 'blankets,' Cameron argues, we would not be able to better understand through this metaphor "*how* the atmosphere protects the earth, since blankets protect by trapping a layer of air, whereas the atmosphere protects by reflecting certain wavelengths of light. In other words, the choice of '*blanket*' only allows the connection of attributes, not of relational properties" (loc. cit.; italics in original), i.e., it does not help to clarify how the two domains relate to each other. For this reason, the metaphor does not facilitate the girls' further learning about the ozone layer. The same conclusion goes for one of the girls' own metaphor for the atmosphere: 'a big ball of glass.' As a metaphor in this context, it is "powerless to explain relational properties," Cameron (p. 683) points out, "such as function or composition." This study is very interesting, in my view, if read in relation to the second empirical study reported by Cameron (2002).

The second study concerns how a teacher uses metaphors in classroom discourse. In the lesson analysed, the teacher tries to make the children (aged between 9 and 11 years) understand the formation of igneous rocks through volcanic activity. The teacher offers two metaphors for lava. The first is "it becomes like *sticky treacle*" (p. 685; italics in original). The addition of the adjective ('sticky') "narrows down which attributes" (loc. cit.) are to be considered relevant in this case. So also with the second metaphor that the teacher uses: "*runny butter*" (loc. cit.; italics in original). Besides delimiting the attributes to consider as relevant (through the adjective, and by explicitly stating that "there are two things it [i.e., butter being overheated in the microwave] does which are like volcanic rocks when they're being (heated?)"[loc. cit.]) the teacher in her talk also frequently marks out the metaphoricalness with the term 'like.'

The teacher marked out her metaphors, and made explicit in what sense what was being talked about was like something else the children were more familiar with. In contrast to this, in the first study, the two girls were left to their own devices in trying to work out the nature of the relation between the two domains connected through metaphor.

In Jakobson and Wickman (in press), the role of children's spontaneous metaphors in learning science was studied. The children who participated in the study were at elementary level (mainly 6-8 years old, i.e., Swedish grade 1 and 2). Audio recordings of pair work and small group discussions were collected. The children frequently made use of metaphors in these discussions. One function the metaphors filled for the children was as aids for making factual observations. For example, when learning about buds, a child used metaphors such as 'hair,' 'caterpillars,' and 'worms' (ibid.). The metaphor of 'hair,' Jakobson and Wickman (ibid.) explain, was used by the child "to describe the stigmas of the bud," hence "as a *factual descriptor* of the traits of the bud, saying something of their general appearance" (ibid., p. 8; italics in original). However, it is interesting to note, as Jakobson and Wickman point out, that also the metaphors used not only "helped the children in describing what they saw" but "also in making further observations in terms of the number and size of stigmas" (loc. cit.).

Jakobson and Wickman (ibid.) further show how the metaphors children used in addition to filling cognitive functions also were functional in their learning of the aesthetic dimensions and norms of science. However, while the children's spontaneous metaphors most often were meaningful tools in their meaning-making, the researchers note, "In exceptional cases metaphors could also be a hinder to children's communication and undertakings" (ibid., p. 9). This was the case when one child introduced a metaphor that did not seem to make sense or be familiar to the other child.

For science education, one implication of their analysis, Jakobson and Wickman (ibid., p. 15) argue, is that it is of importance that teachers "not be content with the tacit qualities expressed through the spontaneous metaphors that students use, but discuss what qualities that they intend and ask questions like 'What do you mean by that?'." As I understand it, this means making visible for the children themselves the terms they use and to make explicit the possibilities and limitations of a certain way of representing the phenomena, i.e., to engage the learners in metacognition (Pramling, 1996), a point that I will return to and emphasise in the Discussion (below, p. 94f.).

A body of research literature exists on the use of analogies in science education (e.g., Duit, 1991; Treagust, Harrison & Venville, 1996). “One problem” with many of these studies, in Pittman’s (1999, p. 2) view, “is that they” often tend to focus on the employment of “teacher-generated analogies.” “There are few studies of students spontaneously using analogies or students generating their own analogies” (loc. cit.), she claims. This latter proposal is more in line with my present thesis where I look at the metaphoric in and use of metaphors in learners’ discourse. Returning to Pittman’s (1999, p. 5) study, the purpose

> was to examine whether student-generated analogies could provide a better picture of student understanding about protein synthesis than traditional paper and pencil tasks such as the multiple choice test, and whether gender differences exist between the two types of assessment.

Seven and eight grade students ($n$ = 189) participated in the study. After two weeks of instruction about the topic (protein synthesis), the students were asked to create their own analogies. “The students were told to try to use verbs as opposed to nouns and adjectives to define their similarity (i.e., messenger RNA *delivers* a message, as opposed to messenger RNA looks like half of a ladder)” (ibid., p. 6; italics in original). “The use of verbs,” Pittman explains, “was an attempt to create a deeper understanding by forcing the student to look for relationships rather than surface features that a noun or adjective would provide” (loc. cit.). After having generated analogies, the students had to fill out a multiple-choice test. They were interviewed, and they were asked to write a narrative description as well as to illustrate the analogical relationships in a drawing.

In post tests one month later, it was found that the girls fared better than the boys on the multiple choice test while the boys succeeded better than the girls on the drawing test (ibid.). Hence, there did exist gender differences between the different types of assessment.

Interviewed about the topic or base used for their analogies, the students explained that they chose topics that they were well familiar with. These topics also differed between the girls and the boys. However, whereas all the students are said to have preferred learning science through analogies in this way compared to more traditional modes of instruction (lectures, labs), an interesting difference appeared between the girls and the boys. Student-generated analogies were preferred by 60 per cent of the boys, while 60 per cent of the girls preferred teacher-generated analogies. That the girls tended to prefer analogies provided by the teacher rather than their own analogies is explained by Pittman (1999, p. 17) as the girls not trusting their own abilities, an explanation she says is "congruent with their lack of self-esteem and their tendency to underestimate their performance in science."

The finding that the domain used in constructing their analogies was chosen by the students from what for them were familiar experiences also, in my view, points to an additional issue to keep in mind when one, as a teacher, uses analogies or metaphors in instruction. There is a risk that what is used as a familiar starting point when explaining something difficult will only be familiar to some of the students, for example, predominantly boys. In such a case, an additional difficulty will have been introduced for other students, for example, girls. In this way, using something familiar may actually risk increasing the difficulty in understanding for some students (see also Wee, 2005, below, for a discussion on using something allegedly familiar when explaining conceptually demanding knowledge).

Here, I will report two additional studies on the use of metaphor outside the domain of science education. However, I argue that these texts give relevant contributions that could also be applied to science education, by (a) clarifying some difficulties that students may have in understanding metaphors and some roles metaphors and other forms of 'vague language' (see below) may play in education (Littlemore, 2001), and (b) the issue of from where to begin to speak when explaining something conceptually demanding (Wee, 2005).

The use of metaphors by teachers and the difficulty this causes for students was studied by Littlemore (2001). She looked at university lectures at an International Development department at a British university. The students were Bangladeshi civil servants attending courses in Civil Service reform. The English proficiency of the students was high.

One difficulty in grasping a metaphor is to understand which aspect of the vehicle is being transferred to the topic. The ground for a metaphor is often culturally specific, Littlemore claims. Hence, a problem in understanding may arise if the learner transfers a different sense from the vehicle to the topic than the speaker intended. Littlemore gives the example of an overseas student who interpreted the expression 'parent company' as 'supplier' rather than – as intended by the lecturer – as 'controller':

> Both are connotations of the vehicle word 'parent', yet only one is used in this particular metaphor. It is not always easy to guess which meaning or connotation

> is intended. In this example, the student had no difficulties with the lexical aspects of the metaphor, but was confused by its discoursal and pragmatic features. (Littlemore, 2001, p. 334)

Metaphor can serve many functions in university lectures. Littlemore suggests the following:

(1) as an evaluative device – signalling the lecturer's take on the issue being spoken about.

(2) in labelling new concepts – i.e., the "process of transferring existing vocabulary to fill lexical gaps created by new semantic fields is usually metaphorical as it involves the ability to stretch the established boundaries of word meaning" (p. 335).

(3) in allowing the lecturer to be deliberately vague (cf. Channell, 1994) – the "speaker does not have to state exactly who, or what, he/she is talking about" (Littlemore, 2001, p. 336):

> metaphors are an aspect of vague language, which can be used to limit the amount of information given or to indicate that there is uncertainty about what one is saying. Many academic subject areas deal with controversial information. One might therefore expect lecturers to use metaphors for shielding purposes. (loc. cit.)

(4) providing a framework for and summarising ideas. If I give an example from another field: In psychology the metaphor of 'mind as a computer' provides a unitary framework for containing a variety of findings and claims.

(5) to entertain and help memorising.

In addition, Littlemore writes, it has "been suggested that metaphorical language encourages independent thinking" (loc. cit.). In my view, if this is the case, it is probably due to both the inherent vagueness of metaphor, and to the fact that a metaphor unites what does not conventionally belong together. The learner also often has to work out the meaning and implications of a metaphor for herself.

Littlemore's empirical study consists of two parts. In the first part, the students were asked to write down any difficult language encountered during the lectures. In addition, the researcher attended the lectures and wrote down potentially difficult expressions. A list comprising all the difficulties was drawn up. According to two independent native English speakers, of the 180 words and expressions on the list, 145 were clearly metaphorical. Hence, the first part of the study illustrated that a great deal of the difficulty encountered by the overseas students concerned metaphor.

The second part of the study was carried out in order to try to clarify the difficulties of the students in greater detail. Students were given a list of ten metaphorical expressions and were asked to explain what they thought these meant. In addition, the students were given three questions regarding what they thought was the opinion of the lecturer on the subject of discussion. These questions were closely related to metaphors used by the lecturer. As points of reference, the lecturers were also asked to complete this task. It was found that the understandings of the students differed markedly from those of the lecturers. For example, the metaphor 'have a new chapter added onto it' was interpreted by a participant in terms of 'continuity' rather than 'newness,' resulting in the conclusion contrary to what the lecturer had intended. Even if some of the 'misunderstandings' – from the lecturer's point of view – were of a factual nature, most concerned evaluation. This may have severe consequences for the students' learning and understanding. "Students who misinterpret the speaker's stance," Littlemore (2001, p. 342) argues, "are likely to miss the point of the lecture." In order to facilitate the students' understanding, Littlemore concludes, lecturers should increase redundancy in their lectures. That is, information of importance should be presented several times in different ways. In other words, as I understand it, there may be a point in using different metaphors for explaining the same thing.

A recurrent point made with reference to metaphor is the possibility of reconnecting to something familiar to the learner when explaining conceptually demanding knowledge (e.g., Cameron, 2003). The following study is interesting as contrast to this. Wee (2005) studied the use of 'constructed sources,' i.e., references to imaginary processes or phenomena. Analysing texts on neuroscience, artificial intelligence, and DNA copying, he shows that constructed sources – in these particular cases: fictional octopi practices, John Searle's 'Chinese room' (see, e.g., Edwards, 1997, for a discussion), and billions of typists in a row, respectively – are used in order to explicate and clarify complex concepts. The reason for making up a source instead of employing a familiar existing one, Wee (2005) argues, may be that no suitable source exists. Another reason, he points out, is that the learners' familiarity with a source may not always be an advantage. The learners may have a 'misconceived' notion of a source that is then transferred to the new knowledge that is to be acquired. Hence, Wee argues, a constructed source may have the advantage of allowing the teacher greater control over the point of departure in a learning situation. This reasoning points to a more general issue that is probably central in teaching at large, to make clear to learners what they should pay attention to, and how what is pointed out should be understood. That what the learner already knows or presumes need not always facilitate her further learning is also briefly discussed in Study III of the present thesis.

In an interesting article on 'figuring things out' in science, Sutton (1993, p. 1219) argues for a view of the distinction 'figurative' ('metaphorical') and 'literal' language, very much in line with the view advocated by the present work:

> New scientific insights are *redescriptions* of the phenomena being studied. They depend on language imported from some other area of use, in an attempt to figure out and reinterpret what is going on. They depend, that is, on metaphor. (italics in original)

As a side note, he also makes an interesting point regarding the historically (and still prevalent) depreciation of metaphor in scientific self-understanding:

> Scientific communities have usually been quick to try to fix new word meanings as they arise, and to define them clearly in the context of the new structure of thought around which consensus has been built. Further drift and change is therefore unwelcome, and this perhaps accounts for some of the hostility to figurative speech, the principal source of meaning change. (p. 1222)

However, Sutton's focus is on the practical implications of the proposed view of language (in contrast to a 'traditional' one) for the practice of science education in classrooms. He argues that it is important for the learners to understand the function of language in science not as simply labelling found facts, but as a 'medium for interpretation and persuasion.'

> We can show pupils that scientific ideas have been formulated by real people struggling for appropriate words. Analogies, similes, and metaphors were not extras for them, but a key part of their thought. With the help of such devices, scientists come to think, see, talk, and act in new ways. Pupils who appreciate the pattern can gain access to the same ways of thinking. (p. 1219)

Thus, to see how scientific knowledge has been converted into 'facts,' Sutton argues, may be helpful in trying to understand ('figuring out') scientific knowledge. The metaphors used throughout history to try to understand certain phenomena may, if made a topic in teaching, make visible to the students how scientific knowledge came to be formed in its current shape, i.e., how scientists thought to get there. Pointing to the employment of these metaphors could in addition, I argue, be a way of making visible to the learners how the same words come to take on a new meaning in science.

A final note that I think is of interest to the present thesis, even though not explicitly or directly being about metaphor in science education, will be briefly reviewed and commented upon here. Sutton (1992), reading Bruner (1986), argues as follows:

> Bruner points out that narrative prose exerts its effect by recruiting the reader's imagination and triggering presupposition about what may be coming next, or what underlies what has already been said. The reader's mind is working on what is *not* present on the page, as well as what is there. The lack of explicit spelling out of every aspect is the feature which makes it possible for the reader to enter into and engage with the story. It offers freedom to do that, whereas explicitness would reduce the freedom, and hence the degree of involvement with the text. Perhaps one reason why a factual account of a scientific topic in a textbook often fails to hold attention is that it does not leave enough doubt, or lead the reader to fill it out from his or her own thought. There are not enough cues to uncertain possibilities to keep the average reader thinking ahead. Of course scientific books make a virtue of spelling things out, and leaving no doubt. Here is one of several places where features appropriate to science itself are not so appropriate for education. (Sutton, 1992, p. 78f.; italics in original)

A good narrative may even in part be seen as characterized by how much it leaves unsaid. Working to large extent by implication is equally true of metaphors. However, the same does not hold for scientific knowledge, since one way of conceiving science is as an activity of making explicit, in terms of an 'explicit-making practice.' But this also means that metaphors may be useful as tools in science education for once again 'opening up' the certainties to how scientists thought in order to achieve a certain knowledge, how they came to make sense of this, and how meaning has been transformed and eventually locked into its current fixed form.

As seen in the examples above, learners tend to 'fall back' on something familiar when making sense of phenomena in science. A question of particular interest is whether the explanations provided by students actually reflect the way they understand (e.g., Zohar & Ginossar, 1998). Hence, phrased differently, are the metaphors used by learners 'merely a way of speaking' or do they mean what they say? Returning to this issue, I will propose that the analyst pay attention to what I have referred to as 'meta-communicative markers' (cf. Goatly, 1997) as a way for the speaker to distinguish between and clarify for the interlocutor what is said and what is meant.

# Empirical studies

This chapter begins with a clarification of methodological issues. How metaphors have been identified and interpreted in the materials studied will be explained. In the second part of this chapter, the four empirical studies will be summarised. When studying the role of metaphor in learning and knowledge formation, different empirical materials have been analysed. The materials studied consist of research literature, popular science magazines, group discussions, and individual interviews. Research is seen in this thesis as a collective learning, whereas in the cases of the students (Study III) and children (Study IV), learning is seen as being of a more individual kind.

## Method

In order to identify an expression as a metaphor, some kind of incongruence or discrepancy in terms has to be shown/argued. This could be done in quite a few different ways. For example. by pointing to the merging of different levels of description/analysis, different discourses, or different domains of knowledge.

So how is metaphor identified and analysed? Cameron (1999b) gives four ways of how, what she calls, 'domain incongruence,' and hence metaphor may be identified:

(1) on an etymological basis (metaphor as a matter of history)

(2) relative to norms in a speech community (metaphor as a matter of convention)

(3) relative to background knowledge (metaphor as a matter of experiences made)

(4) relative to what the individual actualizes on a particular occasion (metaphor as a matter of making explicit, *as* metaphor)

However, which of these criteria that will be used in an analysis is dependent on the nature of one's empirical material and the questions asked. This does not mean that not more than one of these criteria could be used in an analysis. Some criteria may be more helpful for analysing and presenting certain metaphors than other criteria. Indeed, these criteria are, or need not be, mutually exclusive.

In addition to these criteria, I would like to add two ways of not only identifying but also analysing metaphor. One way is to try to imagine (to think ahead, as it were) what an expression would mean if it were to be taken literally. If the result of such an 'intellectual experiment' is impossible or even absurd, then one has singled out the metaphor.

A second possibility would be by (a) paraphrasing the expression (a thesaurus may be a helpful resource for doing this); or (b) translating the expression (phrase, word) into a different language. What is then changed may be argued to be the metaphorical quality of the expression. By means of this translation, not only is the metaphor identified (as a metaphor) but it is also made apparent what kind of metaphor it is. To illustrate with a simple example, consider the following. Signalling danger in English may be done by calling out 'look out!' In Swedish, this call would be 'se upp!' [literally, 'look up!']. Thus, not only is the metaphoricalness of this expression made visible, but also more specifically that it is a visual and spatial metaphor (in both languages, but in two different 'directions' – thus also accounting for the difference in the metaphor in the corresponding expressions in the two languages).

But what is reasonable to require of such an analysis (in fact, more generally of any analysis) is more than simply identifying and analysing the metaphor. It is also important to be able to show that to study communication (an empirical material) in this manner adds something of relevance and interest for the study of the material at hand, the question pursued. And further, unless the question is which metaphors at large can be found in an empirical material, the phenomenon of interest needs to be further delimited. This is done in the studies in this thesis by focusing on a specific metaphor (as in the case of 'chunk,' Study I), or by analysing metaphors used for making sense of (describing, explaining) a specific phenomenon (as in the case of 'DNA,' Study II), or by focusing on metaphors that could be argued to be pivotal for a body of knowledge (as in the case of the 'theory of evolution,' Study III), or that serve (what can be seen as fulfilling) a specific function (as in the case of 'qualifying one's communication,' Study IV), respectively.

A brief note on etymology as one of the above-mentioned criteria for identifying metaphor might be appropriate here. The way I see it, the 'root meaning' that may be established by an etymological dictionary (as far as our etymological knowledge goes) is not the 'real,' 'true,' or 'proper' meaning of a word. Instead, I see such an explanation of words as a means whereby (invisible) conceptions 'inscribed' in language may be made visible to the analyst, thus as a way of identifying metaphor (and metaphorical transformations through time and languages). Etymology, as I see it, is 'pathways' tracing the 'migration' of words (and, hence, knowledge) through languages, knowledge domains, and practices. Or using a different metaphoric, an etymological dictionary could be seen as a kind of map of the conceptual development in how we have tried to make sense of our world at a collective level over generations.

Since there is an interest in the present thesis in how a metaphoric is conventionalized or institutionalized into perceived literalness (i.e., how a metaphoric is made invisible), there is an analytical point in interpreting texts anachronistically and in that sense disregarding the situation. This is a way of making visible what has been made invisible, i.e., being able to see the metaphoric that is used (or inscribed) but that the speakers themselves no longer see as metaphorical.

*Identifying metaphor in discourse*

A metaphor in my view means to speak of something in terms of something else that it cannot literally be, that the word does not literally apply to. Consider as an illustration the following four alternatives:

(1) The car is red.

(2) The car is tomato-coloured.

(3) The car is like a tomato.

(4) The car is a tomato.

The first case is not in my view metaphorical, since the car can in fact literally be red. The second and third examples are, in my view, in a sense metaphorical. However, more specifically they are 'similes,' and, at least in the third case, also marked out as a simile. Even if in the second case, the car may in fact have such a colour, the very term 'tomato-coloured' applied to something non-tomato is in a sense metaphorical. However, this example is not clear-cut either way. The fourth example, finally, is, as I see it, a metaphor, since the car cannot literally – as is claimed – be a tomato.

However, if returning to example one by way of etymology, things cease to be so clear-cut. According to the history of the word, 'car' stems from Latin 'carra,' which is the "plural of *carrus*, *carrum* two-wheeled vehicle for carrying loads, wagon […] cognate with Latin *currere* to run" (CDE, 2000, p. 143). "The word" car "was first applied to the automobile in 1896" (loc. cit.). Hence, 'car' is the plural of a wagon, i.e., a four-wheeled wagon. In this way, it can be seen how the word 'car' as it is literally applied today in English is founded through metaphorical over-extension of a previous use of the term. However, this historical dimension is lost to contemporary speakers, for which the word simply denotes what it literally is. In many instances, though, pointing out the historical metaphoricalness would be rather pointless. Unless one wishes to show for some analytical or educational purpose how also our literal language, if viewed as an historically evolved phenomenon, has a metaphorical quality or dimension (that could be hinted at in discourse). This also points to literalness as evolved and historically contingent, not as a distinctly different and more fundamental language than metaphor.

### *Whose metaphor?*

In this section, I will attempt to clarify what I consider to be metaphorical in this work, and also elaborate on the question of on whose terms the analysis is performed. I will argue that my analysis points to the need for making an additional distinction to the pair of 'analyst's' and 'participant's' categories as used in Conversation Analysis.

I will consider as metaphorical not only so-called 'metaphor proper,' for example, 'the mind is a computer,' but also a phrase or reasoning about 'natural selection' as (in this particular case, an anthropomorphic) metaphor. In the latter case, the metaphor is an analytical abstraction. In terms of the distinction in Conversation Analysis between the participant's and the analyst's categories (see the debate between Billig and Schegloff [1999] on, among other things, this distinction and analysing participants' talk 'in their own terms'), metaphor as used in the present work is mostly the analyst's category. However, at times, 'metaphor' is marked out by the participant. For example, as can be seen in Study III in the present thesis, Darwin sometimes uses the term metaphor. In other cases (see, e.g., Study IV in the present thesis) meta-communicative markers are taken by me as signalling a non-literal intention of an utterance, hence, as metaphorical. These markers, I will argue (see Discussion below, p. 95f.), in a learning perspective, signal a very important insight or condition in one's knowing and understanding.

'Metaphor' is, in this thesis, primarily the analyst's category. However, it is premised that whether 'metaphor' is also used as a term by, or marked out by, the learner or not points to an important distinction in the learners communicating their understanding. It is further premised that whether this is the case or not – i.e., whether they have this awareness of the non-literalness of their understanding may have important implications for their further learning (in keeping an open mind, if you will; see below on 'mindfulness,' p. 97ff.).

Marking out one's own discourse as metaphorical does not necessarily involve the use of the specific term 'metaphor' as I see it, but may also include other markers signalling a non-literal use of language. Hence, even if the term 'metaphor' often – though, as already noted, not always – is the analyst's category, a metaphorical use of language can still be communicated by the learners themselves. A point of the above reasoning is that it paves the way for an additional dimension or distinction between the learner's use of the metaphoric of our language though not marking these out as such, and that they (meta)communicate that they are keeping this issue in mind, respectively. Hence, not only may the participants communicate through the term 'metaphor' but often this feature of one's communication is marked out by more subtle means.

The possibility of seeing metaphor as marked out by the learners, even if they do not use the term, enables an important distinction to be made between learners who communicate that they are using language non-literally and those who do not do so. But without using the term 'metaphor,' this could not be seen through the distinction between participant's and analyst's categories, since it would then fall under the analyst's category. Hence, a very important analytical point is made visible which would not have been 'rationally visible' (Shotter, 1993) with the less elaborate distinction.

### *Ethical consideration*

In working with participants, the ethical guidelines of the Swedish Research Council for the Humanities-Social Science (Vetenskapsrådet, retrieved 22-03-2004) have been followed.

## Summary of the studies

The general interest of the four empirical studies is the role or workings of metaphor in learning and knowledge formation. The first study focuses on scientific work, analysing how a certain metaphor is introduced, taken up, and moulded in a research tradition. The second study is about the bridging function of popularizations in connecting scientific knowledge and individual lay learning. The third and fourth studies analyse metaphors as used by learners, in small groups and in individual interviews, respectively, when reasoning about scientific knowledge.

### *Study I: Possibilities as Limitations: A Study of the Scientific Uptake and Moulding of G. A. Miller's Metaphor of Chunk*

In this study, the question of how phenomena are constituted in science is addressed. Through the example of what can be argued to be a pivotal concept in cognitive psychology, the problem of how a metaphor is introduced, taken up, and moulded in research is analysed. The example chosen is the metaphor of chunk as introduced by George Miller (1956) in his seminal article "The Magical Number Seven, Plus or Minus Two." Firstly, Miller's (1956) article is analysed, showing that the metaphor of chunk was introduced in order to handle a well-known anomaly in psychology and, perhaps, in human knowing more in general. On the one hand, we as humans are severely limited in our capacity; on the other hand, we are practically infinitely extendible in our knowing. Secondly, the reception and transformation of the metaphor of chunk is analysed. The empirical material consists of articles on memory in the leading scholarly journals in psychology (at that time): *Journal of Experimental Psychology*, *Journal of Verbal Learning and Verbal Behavior*, *Psychological Review*, and *Cognitive Psychology*. How is the metaphor of chunk understood and put to work as an organizing principle in memory research? Phrased differently: What is the metaphor of chunk taken as a metaphor for? The result is twofold: (1) There is a tension in the literature regarding whether to place chunk in the material (the world) or in the activity of the learner; (2) There is a process of reification, whereby dynamic potentials are transformed into fixed entities. This means that the focus is shifted from the dynamic acts of expanding one's capacities through learning, to questions regarding bounded and limiting things or 'containers.' It is argued that the prevalent uptake and moulding of the metaphor yields a picture of humans as severely limited and fixed in ability, thereby ignoring the learning process whereby humans expand their knowing, abilities, which I argue, was what Miller (1956) tried to account for.

### *Study II: Scientific Knowledge, Popularization, and the Use of Metaphors: Modern Genetics in Popular Science Magazines*

For scientists, popularization of scientific knowledge is often a somewhat controversial issue. In rendering scientific knowledge intelligible for a lay audience, it has to be formulated and presented in a language form that does not presume familiarity with the knowledge domain of the discipline. At the same time, attempts are made to be true to that knowledge. In bridging the domains of the scientific discipline and the domain of the audience, i.e., between 'science' and 'popular' writing, metaphor becomes central. One way of conceiving of metaphor, is, as I have argued, to see it as a practice of speaking of something in terms of (as if it were) something else, thus merging differences. The example chosen for the study is the concept of DNA. The empirical material consists of 40 articles (spread over a period of ten years) in the two Swedish popular science magazines *Forskning och Framsteg* [Research and Progess] and *Illustrerad Vetenskap* [Illustrated Science]. The questions posed are: What metaphors are used? and What are they used for (or what do they do) in these texts? The results show a frequent use of anthropomorphic metaphors. Through the employment of these kinds of metaphors, DNA and genes are made into intentional agents that decide, choose, know, and remember. From these metaphors, a view of humans as governed by infinitely small but infinitely powerful agents emerges. In terms of a theatre metaphor (also used in the analysed texts), a human being becomes a kind of stage upon what one is is played out, staged. At times, the representation (the metaphor used) is not distinguished from what is being explained or described. In these cases, different 'levels' of description are conflated, whereby a category mistake is made. This points to the importance of meta-communicative awareness in the learner, since it is these markers that make it possible for the novice to distinguish between the representation and what is being represented. Finally, it is concluded that a consideration of levels in metaphor is critical for the potentials of a metaphor. It is also where the metaphors may be easily mistaken, in learning scientific knowledge.

### *Study III: Re-figuring Evolution: Metaphors in the Formation and Learning of Scientific Knowledge*

This study is about metaphors used in constituting a theory in science, and the difficulties these may pose in subsequent learning and reasoning. The case chosen, as an example, is the theory of evolution by means of natural selection. It is premised that this theory contains a set of central metaphors, and that how to understand these is a potential difficulty when trying to learn or reason about this theory. The analysis consists of two parts. In the first part, how metaphor plays a role in Darwin is illustrated by analysing examples taken from *On the Origin of Species* (Darwin, 1859). It is shown that Darwin uses a variety of metaphors when presenting his theory, and that he himself realizes the problematic nature of some of these metaphors in relation to the theory, as evident in him commenting on them. It may be objected that Darwin did not mean to speak in terms of, for example, anthropomorphism and teleology. However, it is precisely for this reason that this feature in how he explains evolution is interesting in a learning perspective. Through this way of speaking, there is a discrepancy in terms between how the theory is presented and what the theory in a strict sense claims(!). This discrepancy needs to be handled by the novice trying to learn and understand this knowledge. The learner needs to be able to distinguish between the representation and what is being referred to. In the second part, the reasoning of teacher students discussing some issues in relation to the theory of evolution that actualize metaphor is analysed. The results of this second part of the analysis show (a) a frequent use of anthropomorphic and teleological metaphors; (b) that the students using metaphors of 'steering' and progression for evolutionary change; and that they reason about geological time in terms of metaphors of spatiality and visuality; and (c) that the students, like Darwin, to some degree, see how they speak of (the theory of) evolution as problematic, as evidenced by explicit similes and other meta-communicative markers. It is argued that how a metaphor should be taken is a central issue in learning, for example, a scientific theory, and, that further, in the case of the theory of evolution, some of the metaphors constituting it pave the way for readings that are contrary to the theory itself, and that this 'misleading' may in part account for the reported difficulties in learning and understanding the theory. The apparent familiarity of the formulation of the theory may thus pose a difficulty when learning.

### *Study IV: 'The Clouds are Alive because they Fly in the Air as if they were Birds': A Re-analysis of what Children Say and Mean in Clinical Interviews in the Work of Jean Piaget*

Historically, in psychological research, the work of Jean Piaget has a standing like, probably, no other research. However, there exists an extensive body of literature questioning the conclusions that Piaget drew from his empirical findings. What is at stake in this debate is the question of children's abilities and competences. The fourth study in the present thesis aims at contributing to this research by taking a different route. The rich empirical excerpts of interviews with children in one of Piaget's most famous books, *The Child's Conception of the World*, are re-analysed. The focus of the analysis is on the qualifications that children give in their reasoning. It is found that the children recurringly qualify their replies by marking out their communication in terms of 'as if' or with similes. This analysis, considered in relation to Piaget's own analysis, yields a markedly different picture of the abilities and competences of the participant children. Instead of being taken as manifestations of conceptions held, the children are seen as meta-communicating something (marking out how they make sense), and showing an impressive communicative competence. Reasoning in terms of 'as if,' I have argued, can be seen as showing an important ability to meta-communicate (to communicate about how one communicates). Making sense of something unclear in terms of 'as if,' I further argue, can be seen as 'opening up' a 'space' for dialogue (or, in Vygotskian terms, a 'zone of proximal development'), 'within' which the learner and someone more knowledgeable can elaborate the relation between the two domains ('what is' and 'as if it were'), and, hence, make further learning possible.

# Discussion

When viewing metaphor as the way words are formed (in terms of parts of combinations of, or new uses of, other words), and as "a constitutive tool of language" (Barclay, 1997, p. 368), metaphors are ubiquitous. Eventually, a metaphor tends to be conventionalized, i.e., becomes simply 'the way to say it' in a practice or in a wider culture. It is then no longer understood as a metaphor, but as saying what it means in a more 'direct' sense. The metaphor has become 'literalized' (Knowles & Moon, 2006). It is also through such a process that the categories and concepts whereby institutions 'think' (Douglas, 1986) emerge. When 'institutionalized' (or 'literalized'), the semantic openness (Rommetveit, 1974) or polysemy of ordinary language is closed. The necessity of metaphor for literal language may already be seen in the fact that the very term 'literal' in itself is a metaphor (as is, of course, 'metaphor'), i.e., what is 'written' in a (word)book – a writing metaphor for language. "Inactive metaphors" – i.e., metaphors that no longer tend to be perceived as metaphors –, Goatly (1997, p. 41) argues, "become lexicalized, that is acquire a second conventional meaning and find their way into the dictionary." It is through this process that words come to mean what they mean according to the dictionary.

When a metaphor has been conventionalized and literalized, it loses its metaphorical qualities and status for speakers. The metaphor simply comes to say how *it is*. To give an example. Bowdle and Gentner (2005, p. 209; all italics in original) write about the "term *blockbuster* (as in *The movie* Star Wars *was a blockbuster*), which means 'anything that is highly effective or successful.'" This is the sense of the term 'blockbuster' in use today. However, most contemporary speakers are probably unaware of the fact that the word "originally referred to a very large bomb that could demolish an entire city block" (loc. cit.). To reinstate an explicit marker such as 'like' – "*The movie* Star Wars *was like a blockbuster*" (loc. cit.) – simply does not seem to make any sense anymore. For a speaker today, "the movie *Star Wars was* a blockbuster" (loc. cit.). It might even be somewhat of a prototypical example of what the word means. This also, I would claim, implies that what it means to think or understand by means of certain terms becomes different things over time as language evolves. Keeping the metaphorical quality in mind means, to borrow Richards' (1936) words, having two ideas present at the same time, one through which the other is thought about. When the metaphor has become literalized, the term is 'flat' ('steamrolled' by use), and thinking in terms of the word becomes a more 'single-minded' kind of activity. Or phrased differently, from being ‘two-dimensional,’ the word with familiarity becomes ‘one-dimensional.’ This is also a transformation from an ‘as if’ mode of thinking to a set understanding of how ‘it is’ in itself. In Langer’s (1997) terms (to be discussed and elaborated on below) this could be phrased as a change of mind or cognition from a ‘mindful’ to a ‘mindless’ state of mind or form of cognizing.

## Reification

A possible consequence of literalization of metaphor, Barclay (1997, p. 366) argues, is reification. Scientific (he speaks of psychological) concepts “are reified on the basis of their literal interpretation.” “As metaphors are taken as conventional truths, the literalization process reifies them into potentially inflexible constructs” (loc. cit.). This argument thus ‘opens up’ for the question of what the consequences of reification of metaphors in science may be.

One consequence of such a process, Säljö (2002, p. 401) argues, “is that we study objects instead of activities,” and that the problem with this is the tendency to view, for example, humans as static in character and thus to downplay or ignore potentials for change and development. The metaphors for human thinking as studied by Säljö (2002, p. 403) “have portrayed people as static and their capabilities as largely given by nature. In the context of education as a human activity, we urgently need a different set of metaphors that start from the dynamic and developing character of human beings.” This issue is clearly illustrated by the metaphor of ‘chunk’ as studied in Study I in the present thesis. Thus, how we constitute ourselves as humans in language, defines who we are and what we can (be) and not (our capacities and abilities). This may have consequences for educational practices. For example, if we take the limiting view of chunks (i.e., as container spaces within the larger container of mind), as something the learner has a certain and fixed amount or size of, then this might imply that measuring this ability could select those who would be best equipped or endowed for being educated, and, hence, who should be given access to education. If, instead, we take the dynamic view of chunking as how humans transcend their own limitations through learning, then the learner not mastering in advance what she is to learn could not be used in the distribution of educational opportunities. In a sense, this distinction could be seen as a miniature version of the general and more fundamental issue of whether education should be reproduction or human development (see, Bruner, 1996). How one understands the issue of chunk also suggests markedly different pedagogical practices. In the first case, information should correspond to how much the individual is capable of handling (i.e., what she has ‘room’ for) which should just be taken in and stored in the way it is; hence linear transmission of facts, as it were, seems to be the ideal pedagogical form. If, instead, we take the dynamic activity view, then teaching children and students different functional and powerful ways of constructing 'larger' meaningful chunks (e.g., categories, narratives, etc.) would constitute one of the most important lessons to learn in one's schooling.

For science, two additional problems stemming from reification may be (a) to over-generalize what may be historically contingent descriptions of human nature (as in the case of psychological concepts; consider as an example, Luria's [1976] critique of some claims made by Gestalt Psychology), and (b) to be 'mislead' by language (Wittgenstein, 1953, §§ 94, 356) into putting a lot of effort and resources into trying to answer what may be futile research questions, to pursue a red herring.[8] For example, searching for entities that our language practices have inscribed into the object(!) of study. One example was the attempt to localize 'chunk' as a container within a larger container (see Study I in the present thesis). Another example may be that not only are humans conceived in terms of computers but also computers are conceived in terms of human categories such as 'think' and 'understand,' as discussed by Edwards (1997). This could lead to asking misleading questions such as whether computers 'really understand' or are 'really intelligent' (see also, Bruner, 1990, for a critique). Using this example from cognitive science, Edwards (1997, p. 31) argues that the problem "is not that it pursues a metaphor, that it pursues a study of human nature as if we were digital computers, but that it tends to proceed as if that were not metaphorical, as if we were, actually, even self-evidently, information processing devices." This transformation of tentative propositions into reality claims is common, not least in regard to psychological phenomena (Soyland, 1994). In my view, the latter kinds of claims imply that a meta-perspective is lacking in order to distinguish the representational means from what is being represented. The antidote to such misplaced claims, I suggest, is to adopt a historical perspective.

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[8] A red herring, according to etymology, is "something used to draw attention away from the real issue, referring to a herring (reddened by the smoking process, before 1333) supposedly used by fugitives to put bloodhounds off their trail; apparently from a method of training hunting dogs to follow a scent by dragging a smoked herring along a trail" (CDE, 2000, p. 899). This explanation – given that it is true, and disregarding for the sake of argument the contested nature of what is 'the real issue' – also serves as an illustration of how something rather abstract (the term 'red herring' is frequently used in philosophical reasoning in disclaiming arguments), is formed in terms of a concrete action, practice, and has left a trace, if you will, of its socio-cultural history in the word.

"The first and major step on which the metaphorical structuring of abstractions depends," Goatly (1997, p. 46) states, "is reification." By concretizing abstractions as substances or objects and their qualities, abstractions are constituted as 'things' that can be 'created,' 'destroyed,' 'transformed,' 'transferred,' 'handled,' 'possessed,' 'have impact,' 'have location,' 'dimensions,' 'form,' and 'parts.' And, finally, 'made visually available for inspection' (imagination). Thus, abstract phenomena are transformed into something that is easier to 'grasp.' For example, mental phenomena are made perceptually available through metaphor (cf. the 'understanding is seeing' metaphor). Reification is a fundamental way by which we make abstractions cognizible.

How to handle abstractions is a question that has to be attended to when trying to learn the form of knowledge that is characteristic of scientific reasoning (and, more generally, of formal schooling). Scientific knowledge is one of the pillars on which discussions and debate on matters of importance for our society tend to stand. With the formation of scientific knowledge, ways of reasoning tend to be increasingly abstract, i.e., further disconnected or defamiliarized from concrete lived experiences. Thus, difficulties regarding how to make such reasoning understandable follow. One common way of making abstract knowledge graspable is by reification. This is not only a process that can be found in the reasoning of individuals trying to learn scientific knowledge, or in explanations in popular renderings (see Study II in this thesis), but also in scholarly work (see Study I in this thesis; Säljö, 2002; Soyland, 1994).

Another 'pattern' in the studied materials in the present thesis is 'animism' or, more specifically, 'anthropomorphic' metaphors.

## Animating/Anthropomorphizing

In a great many different situations, people tend to make sense of or explain inanimate phenomena or processes as animate ('animism'), or something nonhuman as (if it were) human ('anthropomorphism'). Such metaphors, Lakoff and Johnson (1980, p. 34) argue, "allow us to make sense of phenomena in the world in human terms–terms that we can understand on the basis of our own motivations, goals, actions, and characteristics," i.e., in terms of our own experiences (something that we are familiar with). For example, we may say that: 'we welcome an idea with open arms,' 'invite discussion,' 'a text can tell you something,' 'the situation demands' (cf. Goatly, 1997).

There is an interesting speculation to make in relation to this, by way of Pepper's (1942, p. 91) idea of what he terms 'world hypotheses,' as generated on the basis of common-sense 'root-metaphors':

> A man desiring to understand the world looks about for a clue to its comprehension. He pitches upon some area of common-sense fact and tries if he cannot understand other areas in terms of this one. This original area becomes then his basic analogy or root metaphor. He describes as best he can the characteristics of this area, or, if you will, discriminates its structure. A list of its structural characteristics becomes his basic concepts of explanation and description. We call them a set of categories. In terms of these categories he proceeds to study all other areas of fact whether uncriticized or previously criticized. He undertakes to interpret all facts in terms of these categories. As a result of the impact of these other facts upon his categories, he may qualify and readjust the categories, so that a set of categories commonly changes and develops.

My idea in relation to this is that 'intentional agency' ('anthropomorphizing' explanations) may be such a root metaphor. Since narration appears to be our primary mode of making sense of ourselves and our world (Nelson, 1989), and since narration fundamentally builds upon anthropomorphic terms, as I have argued elsewhere (and with Bruner, 1996), this may be our first root metaphor in terms of which we try to understand far beyond our first years of existence. The pervasiveness of anthropomorphic metaphors in human discourse may be 'founded' in experiences of participating in (and being told about) practices where people account for themselves and others in terms of 'aims,' 'intentions,' 'ideas,' etc., that are then overextended to also make sense of non-human phenomena.

An interesting finding in Ochs, Gonzales and Jacoby's (1996) study, was that the scientists reasoned as if they were sub-atomic particles (as already mentioned). This is very interesting considered in relation to what developmental psychologist Paul Harris reports on children's play. From about 2 years of age, Harris (2000, p. 30) claims, children engage in a new form of play. "Role play is striking because children temporarily immerse themselves in the part that they create. They frequently start to act on the world and to talk about it *as if they were* experiencing it from the point of view of the invented person or creature" (my emphasis). This appears to be a fundamental way of making sense of the world, as seen already in later infancy. Needless to say (as academic jargon goes), this is not to imply that the reasoning of scientists and children's play are the same thing, only that there is an interesting recurrence (or analogue), a way of making sense that even scientists tend to fall back on when confronted with something unknown or difficult to explain. This also implies that to speak of or reason in a mode of 'as if it were' (possible to see something, or act out, from someone's – or something's(!) – point of view) may be a pervasive feature of human sense-making activities. The importance of this 'thought figure' for cognitive development should not be underestimated. Role play (being characterised by animating) may be of developmental importance for social skills in the sense of showing insight regarding other people's mental states: e.g., other people's feelings and beliefs (Harris, 2000). To reason 'as if' is also a critical communicative competence, as argued in the discussion in Study IV in the present thesis.

## Conflations or jumps between different levels of description

A third recurring finding in the studies in the present thesis is, as previously stated, conflations or shiftings between different levels of description or analysis as if they were one and the same or at least were in a simple one-to-one relationship to each other. For example, it was seen that what goes for the level of human intentional agency was taken to also go for a molecular level of description (see Study II in this thesis).

An analogical finding has been reported in senior-level students' reasoning of ecological processes. The students in a randomized state selection of over 3,000 Swedish students in 9th grade were given the following task:

> Think of a wild animal in the forest. It consists of many atoms. The animal dies, and it starts to rot. What happen with the atoms when the animal rots, and in the end is not visible at all? Explain how you were thinking! (Andersson, Emanuelsson & Zetterqvist, 1993, p. 40; my translation)

The result showed that more than a quarter (26%) of the pupils answered that 'the atoms die, disappear, or rot away with the animal.' Thus, what goes for a macro level of description also goes for a micro level of description. However, the question for the children to answer is a tricky one in that the pupils can be seen as being led into a communicative context but are expected to answer in terms of some other context, as Säljö (1995; cf. Schoultz, Säljö & Wyndhamn, 2001) has argued. The pupil is then faced with the intricate problem of identifying the premises for what would be an appropriate, i.e., an expected, answer (and in which terms to speak).

Learning to distinguish between different levels of description is fundamental in learning the abstract forms of knowledge as typified by scientific knowledge. A second difficulty may thereafter be to learn to re-connect the different levels of description to each other, i.e., to know how, in what ways, they relate to each other (see also, Study III in the present thesis). It is important to realize that there is no simple one-to-one relation between different levels (as if it were only a question of magnitude, of more of the same), but that different levels are functional in accounting for, in a sense, different 'things.'

This points to an important cognitive socialization. In appropriating a conceptual system, it is critical to figure out how it is constituted in language, what features are central, and what in the representation is metaphorical. At the same time as a knowledge content is learned, the conditions in which we communicate about this 'content' need to be learned.

## Learning with metaphors and reducing and enhancing complexity

This thesis has been about the roles that metaphors play in learning and understanding, both on an individual level and, in the form of scientific knowledge formation, on a collective one. Metaphors serve a variety of functions in people's learning. When confronted with something unclear, the employment of metaphors may be one's only available means of making sense. A metaphor could be seen in terms of a pattern – in itself a small illustration that every metaphor needs another metaphor to be made sense of –, making something visible rather than something else (e.g., a human being as severely limited in capacity or infinitely expandable in ability, as seen in Study I). In terms of the metaphor, the phenomenon is constituted in a certain way, which has consequences for its employment in reasoning and learning. Another function of metaphor in people's sense-making activities is 'gap-closing' (e.g., by anthropomorphizing, as seen in Study II). The 'distance' between one's knowledge and language and what one is trying to learn about is 'closed' or 'bridged.' In this way metaphors also work for learners trying to make relevant their knowledge when attempting to learn something new. These are some of the ways in which metaphors are used in productive ways in learning.

However, metaphors may also lead one's reasoning astray. There seem to be consequences if the learner is guided by a certain metaphor. But in learning to speak in terms of a specific metaphor it is critical, I argue, to try to clarify and distinguish what follows empirically from what follows logically. Also, the use of familiar terms when learning about, or conceiving, something new or unclear, may make it difficult for the learner to see the difference between what is known and what she is to learn about (as briefly touched upon in Study III). One may easily be deceived into thinking that the words have their usual, ordinary, meanings. An assumption that one therefore already knows what is to be learned may be a large obstacle to one's learning.

By using metaphors when confronted with something unclear, people use something familiar (knowledge, language, experiences) in order to try to come to grips with, or communicate about, something new (e.g., by reasoning in an 'as if' manner, as seen in Study IV). By employing metaphor, complexities may be reduced (by being spoken about as if they were like something else and simpler) for the learner. But at the same time, the metaphors, for the analyst, 'open up' for increasing complexity by inserting or relating something else. In this way, a set of relationships is created that may need a great deal of effort to disentangle. Hence, in a way it could be said that humans reduce complexity by increasing complexity.

In order to be able to handle our environment, we have to reduce complexity. In one sense, a human being is very limited in her ability, in another sense humans are practically unlimited in their ability to transcend limitations through learning (Miller, 1956; Study I in the present thesis). By inventing and appropriating cultural tools (material, as well as intellectual and discursive, including metaphor), humans are able to both decrease the complexity of the environment, and, at the same time, or thereby, increase their ability.

## Keeping action in and out of mind

A recurrent tension made apparent within and in relating the four studies of this thesis is between speaking in terms of human activities or not. In the first study, it can be seen that already Miller's (1956) introduction of the metaphor of chunk contains this tension. On the one hand, chunk is something done by the learner (chunking, a term Miller himself, however, did not use). On the other hand, chunk is something that exists, in a sense, independent of human activities, for example as a word. In the uptake and use of the metaphor, chunk tended to be made into a concept of a 'thing.' The dynamics of the learner's activities when chunking to large extent disappeared from view.

In contrast to this, the second study illustrated how, when popularizing scientific findings to a lay audience, what was to be explained was anthropomorphized, i.e., transformed into a language of intentional agency. The third and fourth study gave additional examples of this tendency to speak of something non-human in terms of human intentional activities, but also described the ways that this way of speaking was qualified or meta-communicatively marked out for the communicative partner.

One of the characteristics of scientific discourse is that to large extent it builds upon other kinds of metaphors than 'activity' ones. In communicating with others (when, e.g., popularizing, see Study II) or with one another (see, e.g., Ochs et al., 1996), researchers often speak in activity terms (i.e., in anthropomorphic metaphors). But when explaining, for example, learning, human activities tend to be more or less absent from view (Säljö, 2002).

The difficulties, in these two opposing ways, of a language of action and scientific knowledge, also serve to illustrate how in a fundamental way a discourse not only makes 'visible' some things but also how it hides from view, i.e., consideration, other things. This is the question of what can be accounted for in different discourses. An educational implication of this line of reasoning is that to speak of something in some terms may be functional and forceful for some purposes, whereas learning about other aspects of the same thing could require other terms and other kinds of metaphors. This reasoning seems closely related to the empirical findings in Halldén (1998) about how students (in upper secondary school) handle the difficulties encountered in history class. When describing and explaining historical events, the students personalized these in somewhat different ways. The forms of personalization apparent in the reasoning of the students, Halldén (ibid.) argues, all seem to fall back on an explanation according to which "to explain a chain of events it is necessary to identify entities to which mental states can be attributed, i.e., human beings" (p. 138). Such a form of explanation is very different from the academic historian's use of structural conditions and other abstractions to account for history. As I understand it, the sense made by the students overlaps what I write about in this thesis in terms of 'anthropomorphism' (see also, Halldén, 1997).

The difficulties of avoiding anthropomorphizing or teleologizing when speaking of scientific knowledge can be seen as a consequence of the obvious realization that our language was not invented in order to be functional for science. Neither should these ways of reasoning be seen as simply inadequate. Metaphorical reasoning of the teleological and anthropomorphical kinds 'help' the students to speak about complex processes in a much simplified way, where only some aspects are discerned. The example of 'the giraffe got its long neck in order to reach the tree-tops' (to reconnect to the reasoning of students reported in Pedersen, 1992; see Study III in the present thesis) is not an example of a pointless reasoning. The utterance captures the ideas that species evolve and that some species become extinct. These realizations are highly relevant to a discussion about the theory of evolution. However, such a simplified reasoning at the same time 'hinders' the students from discussing what kinds of processes really constitute evolution. Hence, a metaphoric can facilitate some reasoning while hindering or making more difficult other reasoning. An important realization for the learner is that a terminology or a certain way of reasoning represents some aspects but fails to represent other aspects of what is referred to.

To say that 'the giraffe got its long neck in order to reach the tree-tops' may also be communicatively functional. Presuming that a correct scientific account is not what a person tries to give, it may actually be preferable to speak in such a teleological way. Not only is such an explanation easier to understand for non-specialists, it is also a much briefer account. Hence, the speaker arrives at what she wants to say faster and in a less circumlocutory manner. There may be a communicative economy in reasoning metaphorically. In more scientifically correct terms, the fact that 'the giraffe got its long neck in order to reach the tree-tops' would require a much more extensive narrative, systematically relating concepts such as: 'random,' 'mutations,' 'recombination,' 'intra-population variation,' 'inheritance,' 'reproductive success,' 'natural selection.' Hence, in many communicative situations and for different communicative purposes, scientifically inadequate ways of speaking also about knowledge from the domain of science may be preferable. It is thus important not to equate such a way of speaking with a mistaken understanding.

## The opening and closing of representations

In a society of the kind we live in today, there exists a large repertoire of representational tools in use in different activities. This means that socialization needs to be directed towards what Säljö (2005, p. 139) calls 'generative abilities' that the learner can apply in various situations. This points to the importance of developing different meta-abilities (Flavell, 1976; Pramling, 1996). Olson (2003, p. 139) introduces "the concept of *metacognition*" as "roughly, talking and thinking about one's own talking and thinking" (italics in original).[9] "Metacognition is not," in a sociocultural perspective, "cognition about mental processes or about introspection, but rather the concepts carried by a language for talking about how we think and why we believe" (ibid., p. 250). In a sociocultural perspective, it is the tool-dependent nature of human knowing (Säljö, 2005) that makes meta-cognition possible. The importance of such abilities is emphasised in much contemporary educational theorizing.

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[9] I will alternate between the terms 'meta-cognition' and 'meta-communication.' The first term is the most common in the research literature. The second term is more in line with the terminology of the sociocultural perspective employed in this thesis, since cognition is viewed as an internal form of communication (Vygotsky, 1934/1986).

> Modern pedagogy is moving increasingly to the view that the child should be aware of her own thought processes, and that it is crucial for the pedagogical theorist and teacher alike to help her to become more metacognitive–to be as aware of how she goes about her learning and thinking as she is about the subject matter she is studying. (Bruner, 1996, p. 64)

One such meta-knowledge that the present work has pointed to is to be able to distinguish the representation from what is being represented, and to communicate this to others. Using meta-communicative markers (cf. Goatly, 1997) in teaching especially abstract, 'inaccessible' knowledge, becomes important since it is these markers that allow the novice to distinguish the representation from what is referred to (see, Study II in this thesis).

However, to be able to make such a distinction between a representation and what is represented is not only a problem in one's initial learning of a knowledge domain. When the representational 'tool' (Vygotsky, 1934/1986) has been appropriated by the learner, it tends to be used unproblematicly or 'transparently' (or 'mindlessly' in Langer's [1997] sense, see below). The user then no longer 'sees' the tool as such. This could be seen as a process of transformation of one's knowing of what, for example, a term means (cf. Bowdle & Gentner, 2005). From a situation of initial uncertainty of in what sense (X) *is like*, or *might* be spoken about *as if* it were (Y) to a certainty in that this is what (X) *is*. Knowing by means of the tool becomes something else as its genesis and initial tentativeness are forgotten. The representation has been 'closed' or 'collapsed' for the speaker. From speaking of something in terms of something else, i.e., having two ideas active at once (Richards, 1936), this dynamic is 'flattened' or 'collapsed' through use as it becomes the conventional or institutional way of speaking. A new (second) sense of the term has then been 'singled' out. "What for the individual earlier was a gap between the tool and its use is now closed. We simply perceive that 'it is so one does'" (Säljö, 2005, p. 231; my translation), or in the present case with metaphors, 'this is simply how we say, or what it means.' This phase in the evolution of tools, Säljö (loc. cit.) continues, "is of educational interest, since it often is difficult to realize which naturalized tools one uses and which difficulties they present to an inexperienced user. It can be difficult to make oneself naïve and uninformed" (my translation). When a certain understanding has been achieved, it may be extremely difficult to 'unthink' (Olson, 1994) the representation, to see what someone unfamiliar with the representational tool may see 'the same' observation or phenomenon *as*, and also how to distinguish between the representation and what it refers to.

People in general, as well as specialists such as scientists, use metaphors daily (Gibbs, 1994; Lakoff & Johnson, 1980). However, it may not be until this is pointed out that speakers are made aware of this feature of language use. Being aware of this is important not least for teachers in order to prevent misunderstandings (for instance, taking utterances 'literally' when they are not intended to be), and in order to make explicit and visible to learners the discrepancy and (more or less) tentative relationship between a representation and what it is used to refer to.

As I have already argued, metaphor can be seen as a mechanism whereby we adjust our language and knowledge to new situations. This also suggests that a learner cannot simply 'take in' or 'take over' knowledge as something finished and fixed. Rather, knowledge has to be 'appropriated' (Wertsch, 2002), i.e., be recontextualized and made relevant by the learner. We do not simply reuse the tools of our language, we also transform them when using them to suit new experiences and needs (Säljö, 2005). The theoretical claim from a sociocultural perspective of human learning and development that the learner has to appropriate what is to be learned, I argue, is in a concrete manner made visible in the learner's employment of metaphorical reasoning when confronted with novel or conceptually demanding knowledge. That learners use metaphors in these cases, in my view, testifies to this very fact that a certain adjustment or moulding work is required by the learner.

On a more general note, trying to make sense of something unknown requires that we construe what we address in terms of something more well known, i.e., metaphorically. Eventually the phenomena/observations of interest will be conceptualised in a more formalistic (in science, typically, in mathematical) language. The metaphors used to begin to construe a phenomenon will eventually come to be locked into concepts, 'naturalized' in how they are understood. But the concepts may have to be 're-opened' in their metaphoricalness when teaching someone about scientific knowledge, since the novice lacks an adequate scientific language. What is to be taught therefore needs to be talked of in more familiar terms. This can, for example, be seen when a new concept is introduced into a science (cf. Study I in the present thesis), as well as when scientists popularise their work, when they write for the uninitiated, outside the intradisciplinary discourse community (Knudsen, 2003).

Cameron (2003, p. 260) concludes, on the basis of empirical work, that "students tend to use the same metaphors as their teachers." However, "While teachers may have a range of other ways of talking" about the topic to be learnt, "students are limited to those they encounter in discourse with other people," particularly the metaphors used by the teacher. Hence, "the cumulative effect of understanding through the metaphors of teachers and employing the metaphors in one's own discourse may have a strong impact on the construction of students' understandings" (ibid., p. 260f.) of a learning content. I would like to add that not only do the teachers, through the terms they use, set the frame for what the student can learn in the situation, but the importance of the students' understandings of the metaphors used by the teachers also points to the importance of developing a meta-communicative knowing (cf. above). This means learning to see the metaphors used *as* metaphors, and not as simply corresponding to or showing how something really is in itself. Such a meta-awareness may be the best antidote to rigid cognition – not 'thinking' in Dewey's (1910/1997) sense (see below) – according to which everything that exists is fixed, leaving no room for the possibility to think anew, to reconsider.

## The role of metaphor in mindful learning

The concept of 'mindfulness' stems from the work of psychologist Ellen Langer and colleagues. It is defined in contrast to the concept of 'mindlessness':

> A mindful approach to any activity has three characteristics: the continuous creation of new categories; openness to new information; and an implicit awareness of more than one perspective. Mindlessness, in contrast, is characterized by an entrapment in old categories; by automatic behavior that precludes attending to new signals; and by action that operates from a single perspective. (Langer, 1997, p. 4)

When being mindful, the learner is, among other things, alert to making distinctions and aware of more than one possibility of how to understand something. Being mindless, among other things, means to take information at face value (Langer, 1989), as simply stating how it (the world in itself) really is (Langer, 1997). I will argue that it is whether the learner considers the metaphoricalness of her way of representing or not that determines whether her approach will be mindful or mindless.

As I understand it, keeping the metaphoric nature of a representation alive is a way of being mindful in one's learning. To explicitly mark out such an awareness of the metaphoric, means to make clear that what one says is not to be understood as simply saying how it is but as tentatively or conditionally speaking of something novel, abstract, or conceptually demanding *as if* it were so. This also, by implication, in principle presumes an awareness of other possibilities of representing the phenomenon or experience. To mark out one's communication in this way means to distinguish what is being referred to from the terms by means of which it is being represented. Conversely, to take the metaphoric literally means to understand it as simply stating how it is, hence the representation and the thing referred are conflated or 'collapsed' into one and the same.

Even if creating a new category – i.e., a new set of distinctions – is a mindful activity, that category may then be used mindlessly, Langer and Piper (1987, p. 280) argue, and ask whether there is "a way to come to understand the world that does not simultaneously set the stage for limited use of that knowledge." Could mindful cognition be taught? In order to answer this question, Langer and Piper conducted a series of experiments. The subjects were introduced to objects either "conditionally (e.g., this *could be* an X) or unconditionally (e.g., this *is* an X)" (loc. cit.; italics in original). The objects were either unfamiliar or familiar. Then a need was introduced into the situation for which the objects were not explicitly suited but which they could be used to fulfil.

It was found that "Only those subjects in the conditional-unfamiliar group gave the creative response and met the need" (loc. cit.). Hence, these simple linguistic expressions seem to make a fundamental difference in encouraging or discouraging mindful cognition. Teaching conditionally, i.e., with explicit markers pointing out some kind of ambiguity or uncertainty, could be a way of fostering creative and flexible ways of thinking.

These findings also, I would like to add, testify to the 'awareness organizing' function of categories. When something is labelled as being of a certain sort, we perceive it in terms of this category and it may be very difficult for us to be able to see it as something else. The category 'locks' or 'freezes' the phenomenon in question. This 'limitation of information' might be a necessity for our knowledge accumulation but may also work as our 'intellectual tools' in 'locking' our thinking.

Starting from something familiar in order to grasp something else as yet unfamiliar, then in further learning it is important to learn to increasingly discriminate between the two parts of the metaphorical relation. This means understanding in what sense (Y) is not like (X) in terms of which it is spoken about. A fundamental realization is that for it to be meaningful to conceive of or communicate about (X) in terms of (Y), (X) and (Y) must be different 'things.' They cannot be 'the same' even though in trying to understand there might be a meaningful relation to be found between the two, potentially facilitating the understanding of one and/or the other. When a metaphor ceases to be perceived as metaphorical, there is a risk that it may be used 'mindlessly.' A 'mindful' use of a metaphor requires the metaphorical status of the term be kept alive.

This reasoning is in a sense similar to Dewey's (1910/1997) distinction between 'thinking' and 'knowing' (as briefly mentioned in Study IV in this thesis). "To say 'I think so,'" (Dewey, 1910/1997, p. 9) argues, "implies that I do not as yet *know* so" (italics in original). In his view, in all thinking there is an amount of uncertainty. In Dewey's notion of thinking there is a conscious consideration of how something (e.g., a term) 'stands for,' 'implies,' 'indicates,' or 'represents' something else. "[T]he origin of thinking," Dewey (1910/1997, p. 12) continues, "is some perplexity, confusion, or doubt." Thinking "affords the sole method of escape from purely impulsive or purely routine action" (p. 14) for the individual. Hence, in alternative terms, as I understand this, thinking is a cognitive activity that keeps the representation 'open,' counteracting the world as fixed in terms of the categories prevalent in the language of the culture. From a developmental perspective, thinking rather than knowing is preferable as a stance or outcome of learning. This also, in my view, testifies to the importance of uncertainty in learning (Langer, 1997).

Marking out the metaphorical quality or tentativeness of representations could, I argue, be a way of providing such learning opportunities. And, as seen in Study IV in the present thesis, even children, when confronted with conceptually demanding phenomena, can communicate that what they say should not be taken literally as reality claims. Maintaining this meta-awareness in learning becomes an important feature for teachers to make visible to learners. Communicating an awareness of the metaphorical nature of representations is one way of learning and knowing 'mindfully.' As I understand it, keeping the metaphoricalness of certain representations in mind is in the end a question of whether one's knowledge and language are learned in a way that makes them a hindrance in one's further learning or a resource for learning anew.

## Further research

Here, I will try to outline a few suggestions for further research on metaphor and learning. The first suggestion reconnects metaphor to 'mindfulness' and 'vague language.'

The concepts of 'mindful' and 'mindless' have been clarified above (see, p. 97) and will therefore not be repeated here. One reason for why we become mindless, Langer (1989) argues, has to do with our schooling. The focus of schooling, she argues, tends to be on goals (outcomes) rather than on processes whereby they are achieved. Phrased differently, the focus tends to be on 'what' questions rather than on 'how' questions. What Langer (1989) calls 'outcome education,' in her view, tends to represent facts in an unconditional form. Such an approach, she further argues, encourages a mindless mode of thinking. "If something is presented as an accepted truth, alternative ways of thinking do not even come up for consideration" (ibid., p. 35). Langer and her colleagues' work is based on extensive experimental work. However, they have not studied the extent of the use of conditionals or unconditional form in institutional learning discourse. This calls for empirical research in education from early years.

Another line of research that in my view could be of interest to connect to the above is studies of the pragmatics of language on 'vague language.' Channell (1994, p. 18) studied the use of what she calls 'vague additives' (i.e., adding vague words in discourse, such as 'around' five, 'something like,' 'about'), not vagueness by omitting to report information. Channell (1994) argues for a variety of different uses of vague language in discourse. For example, she points to referring vaguely to categories. Expressions like '… and things like that,' '… or something like that,' she argues, may function to suggest that a given item is a member of a category, i.e., an example of something more general. Using approximations may also be a means of focusing attention towards and away from something, respectively. Hence, approximations may be used for meta-communicating that this particular item is not something the learner should pay too much attention to as it may be peripheral to the gist of the argument. That vagueness could be used for meta-communicating that a general point is made, and hence that the utterance should not be taken precisely as it is presented (Channell, 1994), is also argued by Littlemore (2001) in research on discourse in higher education. Vague terms may work as part of a strategy in trying to prevent 'rote learning.'

From the learner's perspective, in contrast, using vague language may enable her to talk about something that she lacks knowledge about or the adequate vocabulary for. In scientific vocabulary, vague terms may also be used because there may as yet not exist a term for a phenomenon or observation. This 'gap-filling' function (or 'catachresis,' Boyd, 1993) is often filled by metaphor in discourse. In a more general sense, metaphor is a variant of vague language (Jucker, Smith & Lüdge, 2003; Littlemore, 2001) in that it is a form of discourse in which one thing is represented as if it were like another, but in what sense tends not to be clear. Metaphor, like other forms of vague language, presents the learner "not with something precise, but with a series of options" (Channell, 1994, p. 194). In line with Langer's (1989, 1997; Langer & Moldoveanu, 2000; Langer & Piper, 1987) research, such discourse could be premised to encourage a 'mindful' approach to learning and knowledge.

In her thorough exploration of vagueness in discourse, Channell (1994) makes two concluding points: (1) Vagueness may be a pervasive rather than occasional feature of communication; (2) Language users plainly have no particular difficulties with vague language. The first point, I argue, means that language users need to have been socialized into a way of communicating in which vague expressions make some kind of sense. How is this done? This calls for empirical research. The second point, in my view, makes it interesting to study in preschool, school, and higher education, how vague terms are used and communicated, for what purposes, and with what perceivable effects? Also, how frequent are vague expressions; does the frequency differ between, for example, preschool and school; and could the use of vague expressions differ?

The issue of vagueness in language has emerged as a topic for research in linguistics (Jucker, Smith & Lüdge, 2003). But the use of vague terms seems potentially to be of great importance for studying with an interest in learning. If, and in such case how, are vague terms used in early education (preschool and school)? What does vagueness, including metaphoric, and the uncertainty it presents imply for learning and understanding?

Two further questions requiring research, in my view, are the following. Gibbs (1994, p. 403) has argued that for an utterance to be metaphoric it must "indicate an intention" in the child "to violate established categories." But why should this necessarily be so? Instead, I propose that children's discourse be studied from the perspective of the analyst's understanding of what is non-literal. This could make visible a potential systematic in which kinds of utterances the child sees as metaphorical and which metaphorical utterances she uses without acknowledging them *as* metaphorical. This distinction within what, from the analyst's point of view, can be argued as a non-literal use of language is of interest from a perspective of learning and understanding. How children use what I have referred to in this thesis as 'meta-communicative markers' (cf. Goatly, 1997; Study IV in this thesis) is attended to in such analyses.

In line with recent suggestions (Cameron, 2003) that metaphors may fill a variety of functions in education, it is also in my view interesting to further investigate empirically what kinds of metaphors are used by pedagogues and teachers as well as by children and pupils, and what 'work these metaphors do' in diverse learning situations. Does the use (kind and function) of metaphors change between preschool and school, for example, and in school between different subjects? This could provide much additional knowledge of the roles, difficulties and possibilities of metaphors in education.

# References

Andersson, B., Emanuelsson, J., & Zetterqvist, A. (1993). *Nationell utvärdering – åk 9: Vad kan eleverna om ekologi och människokroppen?* [National evaluation – 9th grade: What do the pupils know about ecology and the human body?] (NA-spektrum, no. 6). Department of Education, Göteborg University, Sweden.

Andersson, J., & Furberg, M. (1992). *Språk och påverkan: Om argumentationens semantik* (8th rev. ed.) [Language and influence: On the semantics of argumentation]. Stockholm, Sweden: Thales.

Aristotle. (version, 1999). *Poetics* (S. Halliwell, Trans.). Cambridge, MA: Harvard University Press.

Aristotle. (version, 2000). *The "art" of rhetoric* (J. H. Freese, Trans.). Cambridge, MA: Harvard University Press.

Atkinson, R. L., Atkinson, R. C., Smith, E. E., Bem, D. J., & Nolen-Hoeksema, S. (1996). *Hilgard's introduction to psychology* (12th ed.). Fort Worth, TX: Harcourt Brace.

Baake, K. (2003). *Metaphor and knowledge: The challenges of writing science*. Albany, NY: State University of New York Press.

Barclay, M. W. (1997). The metaphoric foundation of literal language: Towards a theory of the reification and meaning of psychological constructs. *Theory & Psychology*, *7*(3), 355-372.

Billig, M. (1996). *Arguing and thinking: A rhetorical approach to social psychology* (2nd ed.). Cambridge, England: Cambridge University Press.

Billig, M., & Schegloff, E. A. (1999). Critical Discourse Analysis and Conversation Analysis: An exchange between Michael Billig and Emanuel A. Schegloff. *Discourse & Society*, *10*(4), 543-582.

Black, M. (1962). *Models and metaphors: Studies in language and philosophy*. Ithaca, NY: Cornell University Press.

Black, M. (1993). More about metaphor. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 19-41). New York: Cambridge University Press.

Bowdle, B. F., & Gentner, D. (2005). The career of metaphor. *Psychological Review*, *112*(1), 193-216.

Boyd, R. (1993). Metaphor and theory change: What is "metaphor" a metaphor for? In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 481-532). New York: Cambridge University Press.

Bradie, M. (1999). Science and metaphor. *Biology and Philosophy*, *14*(2), 159-166.

Bruner, J. S. (1979). *On knowing: Essays for the left hand* (exp. ed.). Cambridge, MA: Belknap Press.

Bruner, J. S. (1986). *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press.

Bruner, J. S. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.

Bruner, J. S. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.

Cameron, L. (1999a). Operationalising 'metaphor' for applied linguistic research. In L. Cameron & G. Low (Eds.), *Researching and applying metaphor* (pp. 3-28). Cambridge, England: Cambridge University Press.

Cameron, L. (1999b). Identifying and describing metaphor in spoken discourse data. In L. Cameron & G. Low (Eds.), *Researching and applying metaphor* (pp. 105-132). Cambridge, England: Cambridge University Press.

Cameron, L. (2002). Metaphors in the learning of science: A discourse focus. *British Educational Research Journal*, *28*(5), 673-688.

Cameron, L. (2003). *Metaphor in educational discourse*. London: Continuum.

CDE. (2000). *Chambers dictionary of etymology* (R. K. Barnhart, Ed.). Edinburgh, Scotland: Chambers Harrap.

Channell, J. (1994). *Vague language*. Oxford: Oxford University Press.

Clark, H. H., & Clark, E. V. (1977). *Psychology and language: An introduction to psycholinguistics*. New York: Harcourt Brace Jovanovich.

Danziger, K. (1997). *Naming the mind: How psychology found its language*. London: Sage.

Dewey, J. (1997). *How we think*. Mineola, NY: Dover. (Original work published 1910).

Douglas, M. (1986). *How institutions think*. Syracuse, NY: Syracuse University Press.

Draaisma, D. (2000). *Metaphors of memory: A history of ideas about the mind* (P. Vincent, Trans.). Cambridge, England: Cambridge University Press.

Duit, R. (1991). On the role of analogies and metaphors in learning science. *Science Education*, *75*(6), 649-672.

Edwards, D. (1997). *Discourse and cognition*. London: Sage.

Elmholdt, C. (2003). Metaphors for learning: Cognitive acquisition versus social participation. *Scandinavian Journal of Educational Research*, *47*(2), 115-131.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The nature of intelligence* (pp. 231-235). Hillsdale, NJ: Lawrence Erlbaum.

Franke, W. (2000). Metaphor and the making of sense: The contemporary metaphor renaissance. *Philosophy and Rhetoric*, *33*(2), 137-153.

Ghassemzadeh, H. (2005). Vygotsky's mediational psychology: A new conceptualization of culture, signification and metaphor. *Language Sciences*, *27*(3), 281-300.

Gibbs, R. W., Jr. (1993). Process and products in making sense of tropes. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 252-276). New York: Cambridge University Press.

Gibbs, R. W., Jr. (1994). *The poetics of mind: Figurative thought, language, and understanding*. New York: Cambridge University Press.

Gibbs, R. W., Jr. (1999). Researching metaphor. In L. Cameron & G. Low (Eds.), *Researching and applying metaphor* (pp. 29-47). Cambridge, England: Cambridge University Press.

Goatly, A. (1997). *The language of metaphors*. London: Routledge.

Gould, S. J. (1987). *Time's arrow, time's cycle: Myth and metaphor in the discovery of geological time*. Cambridge, MA: Harvard University Press.

Halldén, O. (1997). Conceptual change and the learning of history. *International Journal of Educational Research*, *27*(3), 201-210.

Halldén, O. (1998). Personalization in historical descriptions and explanations. *Learning and Instruction*, *8*(2), 131-139.

Hanson, N. R. (1981). *Patterns of discovery: An inquiry into the conceptual foundations of science*. New York: Cambridge University Press. (Original work published 1958).

Harris, P. L. (2000). *The work of the imagination*. Oxford: Blackwell.

Helldén, G. F., & Solomon, J. (2004). The persistence of personal and social themes in context: Long- and short-term studies of students' scientific ideas. *Science Education*, *88*(6), 885-900.

Hesse, M. B. (1966). *Models and analogies in science*. Notre Dame, IN: University of Notre Dame Press.

Hoffman, R. R. (1980). Metaphor in science. In R. P. Honeck & R. R. Hoffman (Eds.), *Cognition and figurative language* (pp. 393-423). Hillsdale, NJ: Lawrence Erlbaum.

Holyoak, K. J., & Thagard, P. (1995). *Mental leaps: Analogy in creative thought*. Cambridge, MA: MIT Press.

Jakobson, B., & Wickman, P.-O. (in press). Transformation through language use: Children's spontaneous metaphors in elementary school science. *Science & Education.*

Jucker, A. H., Smith, S. W., & Lüdge, T. (2003). Interactive aspects of vagueness in conversation. *Journal of Pragmatics*, *35*(12), 1737-1769.

Karpov, Y. V., & Haywood, H. C. (1998). Two ways to elaborate Vygotsky's concept of mediation. *American Psychologist*, *53*(1), 27-36.

Keller, E. F. (2002). *Making sense of life: Explaining biological development with models, metaphors, and machines*. Cambridge, MA: Harvard University Press.

Knowles, M., & Moon, R. (2006). *Introducing metaphor*. London: Routledge.

Knudsen, S. (2003). Scientific metaphors going public. *Journal of Pragmatics*, *35*(8), 1247-1263.

Koulaidis, V., & Christidou, V. (1999). Models of students' thinking concerning the greenhouse effect and teaching implications. *Science Education*, *83*(5), 559-576.

Kövecses, Z. (2002). *Metaphor: A practical introduction*. New York: Oxford University Press.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Langer, E. J. (1989). *Mindfulness*. Cambridge, MA: Perseus.

Langer, E. J. (1997). *The power of mindful learning*. Cambridge, MA: Da Capo.

Langer, E. J., & Moldoveanu, M. (2000). The construct of mindfulness. *Journal of Social Issues*, *56*(1), 1-9.

Langer, E. J., & Piper, A. I. (1987). The prevention of mindlessness. *Journal of Personality and Social Psychology*, *53*(2), 280-287.

Leary, D. E. (1990). Psyche's muse: The role of metaphor in the history of psychology. In D. E. Leary (Ed.), *Metaphors in the history of psychology* (pp. 1-78). New York: Cambridge University Press.

Leatherdale, W. H. (1974). *The role of analogy, model and metaphor in science.* Amsterdam, The Netherlands: North-Holland.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, NJ: Ablex.

Littlemore, J. (2001). The use of metaphor in university lectures and the problems that it causes for overseas students. *Teaching in Higher Education*, *6*(3), 333-349.

Luria, A. R. (1976). *Cognitive development: Its cultural and social foundations* (M. Lopez-Morillas & L. Solotaroff, Trans.). Cambridge, MA: Harvard University Press.

Mahon, J. E. (1999). Getting your sources right: What Aristotle didn't say. In L. Cameron & G. Low (Eds.), *Researching and applying metaphor* (pp. 69-80). Cambridge, England: Cambridge University Press.

de Man, P. (1979). The epistemology of metaphor. In S. Sacks (Ed.), *On metaphor* (pp. 11-28). Chicago, IL: University of Chicago Press.

Mayer, R. E. (1996). Learners as information processors: Legacies and limitations of educational psychology's second metaphor. *Educational Psychologist*, *31*(3/4), 151-161.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81-97.

Miller, G. A. (1993). Images and models, similes and metaphors. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 357-400). New York: Cambridge University Press.

Molander, B.-O., Pedersen, S., & Norell, K. (2001). Deaf pupils' reasoning about scientific phenomena: School science as a framework for understanding or as fragments of factual knowledge. *Journal of Deaf Studies and Deaf Education*, *6*(3), 200-211.

Munby, H. (1986). Metaphor in the thinking of teachers: An exploratory study. *Journal of Curriculum Studies*, *18*(2), 197-209.

Muscari, P. G. (1988). The metaphor in science and in the science classroom. *Science Education*, *72*(4), 423-431.

Nelson, K. (Ed.). (1989). *Narratives from the crib*. Cambridge, MA: Harvard University Press.

Nelson, K. (1996). *Language in cognitive development: The emergence of the mediated mind*. New York: Cambridge University Press.

Nietzsche, F. (1999). On truth and lying in a non-moral sense. In R. Geuss & R. Speirs (Eds.), *The birth of tragedy and other writings* (pp. 139-153, R. Speirs, Trans.). Cambridge, England: Cambridge University Press. (Original work written 1873).

Ochs, E., Gonzales, P., & Jacoby, S. (1996). "When I come down I'm in the domain state": Grammar and graphic representation in the interpretive activity of physicists. In E. Ochs, E. A. Schegloff & S. A. Thompson (Eds.), *Interaction and grammar* (pp. 328-369). Cambridge, England: Cambridge University Press.

Olson, D. R. (1994). *The world on paper: The conceptual and cognitive implications of writing and reading*. Cambridge, England: Cambridge University Press.

Olson, D. R. (2003). *Psychological theory and educational reform: How school remakes mind and society*. New York: Cambridge University Press.

Ortony, A. (Ed.). (1993). *Metaphor and thought* (2nd ed.). New York: Cambridge University Press.

Pedersen, S. (1992). *Om elevers förståelse av naturvetenskapliga förklaringar och biologiska sammanhang* [Students' understanding of scientific explanations in relation to biological contexts] (Studies in Education and Psychology, 31). Stockholm, Sweden: Almqvist & Wiksell.

Pepper, S. C. (1942). *World hypotheses: A study in evidence*. Berkeley, CA: University of California Press.

Pittman, K. M. (1999). Student-generated analogies: Another way of knowing? *Journal of Research in Science Teaching*, *36*(1), 1-22.

Pramling, I. (1996). Understanding and empowering the child as a learner. In D. R. Olson & N. Torrance (Eds.), *The handbook of education and human development: New models of learning, teaching and schooling* (pp. 565-592). Cambridge, MA: Blackwell.

Reddy, M. J. (1993). The conduit metaphor: A case of frame conflict in our language about language. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 164-201). New York: Cambridge University Press.

Richards, I. A. (1936). *The philosophy of rhetoric*. New York: Oxford University Press.

Roald, I., & Mikalsen, Ø. (2000). What are the Earth and the heavenly bodies like? A study of objectual conceptions among Norwegian deaf and hearing pupils. *International Journal of Science Education*, *22*(4), 337-355.

Rommetveit, R. (1974). *On message structure: A framework for the study of language and communication*. London: Wiley.

Rommetveit, R. (1988). On literacy and the myth of literal meaning. In R. Säljö (Ed.), *The written world: Studies in literate thought and action* (pp. 13-40). Berlin/Heidelberg: Springer.

Rumelhart, D. E. (1993). Some problems with the notion of literal meanings. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 71-82). New York: Cambridge University Press.

Ryle, G. (2000). *The concept of mind*. London: Penguin. (Original work published 1949).

Säljö, R. (1995). Begreppsbildning som pedagogisk drog [Concept formation as pedagogical drug]. *Utbildning & Demokrati*, *4*(1), 5-22.

Säljö, R. (1997). *Learning and discourse: A sociocultural perspective*. The Sixteenth Vernon-Wall Lecture. Berkshire, England: The Education Section of The British Psychological Society.

Säljö, R. (2000). *Lärande i praktiken: Ett sociokulturellt perspektiv* [Learning in practice: A sociocultural perspective]. Stockholm, Sweden: Prisma.

Säljö, R. (2002). My brain's running slow today – The preference for "things ontologies" in research and everyday discourse on human thinking. *Studies in Philosophy and Education*, *21*(4-5), 389-405.

Säljö, R. (2005). *Lärande och kulturella redskap: Om lärprocesser och det kollektiva minnet* [Learning and cultural tools: On processes of learning and the collective memory]. Stockholm, Sweden: Norstedts Akademiska.

Schön, D. A. (1993). Generative metaphor: A perspective on problem-setting in social policy. In A. Ortony (Ed.), *Metaphor and thought* (2nd ed., pp. 137-163). New York: Cambridge University Press.

Schoultz, J., Säljö, R., & Wyndhamn, J. (2001). Conceptual knowledge in talk and text: What does it take to understand a science question? *Instructional Science*, *29*(3), 213-236.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, *27*(2), 4-13.

Shotter, J. (1993). *Conversational realities: Constructing life through language*. London: Sage.

Smith, L. D. (1990). Metaphors of knowledge and behavior in the behaviorist tradition. In D. E. Leary (Ed.), *Metaphors in the history of psychology* (pp. 239-266). New York: Cambridge University Press.

Soyland, A. J. (1994). *Psychology as metaphor*. London: Sage.

Sutton, C. R. (1992). *Words, science and learning*. Buckingham, England: Open University Press.

Sutton, C. R. (1993). Figuring out a scientific understanding. *Journal of Research in Science Teaching*, *30*(10), 1215-1227.

Sylva, K., & Lunt, I. (1982). *Child development: A first course*. Oxford: Blackwell.

Tamir, P., & Zohar, A. (1991). Anthropomorphism and teleology in reasoning about biological phenomena. *Science Education*, *75*(1), 57-67.

Treagust, D. F., Harrison, A. G., & Venville, G. J. (1996). Using an analogical teaching approach to engender conceptual change. *International Journal of Science Education*, *18*(2), 213-229.

Vaihinger, H. (2001). *The philosophy of "as if": A system of the theoretical, practical, and religious fictions of mankind* (6th rev. ed., C. K. Ogden, Trans.). London: Routledge. (Original work published 1924).

Vetenskapsrådet. *Forskningsetiska principer inom humanistisk-samhällsvetenskaplig forskning* [Ethical guidelines of the Swedish Research Council for the Humanities-Social Science]. Retrieved 22-03-2004, from, http://www.vr.se.

Vološinov, V. N. (1986). *Marxism and the philosophy of language* (L. Matejka & I. R. Titunik, Trans.). Cambridge, MA: Harvard University Press. (Original work published 1929).

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner & E. Souberman, Eds.). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press. (Original work published 1934).

Wee, L. (2005). Constructing the source: Metaphor as a discourse strategy. *Discourse Studies*, *7*(3), 363-384.

Wells, G. (2000). From action to writing: Modes of representing and knowing. In J. W. Astington (Ed.), *Minds in the making: Essays in honor of David R. Olson* (pp. 115-140). Oxford: Blackwell.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind.* Cambridge, MA: Harvard University Press.

Wertsch, J. V. (2002). *Voices of collective remembering.* New York: Cambridge University Press.

Whorf, B. L. (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf* (J. B. Carroll, Ed.). Cambridge, MA: MIT Press.

Winner, E. (1988). *The point of words: Children's understanding of metaphor and irony.* Cambridge, MA: Harvard University Press.

Wittgenstein, L. (1953). *Philosophical investigations* (G. E. M. Anscombe, Trans.). Oxford: Blackwell.

Zohar, A., & Ginossar, S. (1998). Lifting the taboo regarding teleology and anthropomorphism in biology education–Heretical suggestions. *Science Education*, *82*(6), 679-697.

# Part Two:
# The Studies

This dissertation also includes four empirical studies. Since these are published elsewhere, they are for reason of copyright not included here. The following studies were part of this dissertation:

### Study I

Pramling, N. (2011). Possibilities as limitations: A study of the scientific uptake and moulding of G. A. Miller's metaphor of chunk. *Theory & Psychology*, *21*(3), 277–297.

### Study II

Pramling, N., & Säljö, R. (2007). Scientific knowledge, popularization, and the use of metaphors: Modern genetics in popular science magazines. *Scandinavian Journal of Educational Research*, *51*(3), 275–295.

### Study III

The manuscript for the third study was split into two separate studies before publication:

Pramling, N. (2009). The role of metaphor in Darwin and the implications for teaching evolution. *Science Education*, *93*(3), 535–-547.

Pramling, N., & Säljö, R. (2014). Reasoning about evolution: Metaphors in teacher students' rendering of Darwinian ideas. In T. Zittoun & A. Iannaccone (Ed.), *Activities of thinking in social spaces* (pp. 99–120). New York, NY: Nova Science.

### Study IV

Pramling, N. (2006). 'The clouds are alive because they fly in the air as if they were birds': A re-analysis of what children say and mean in clinical interviews in the work of Jean Piaget. *European Journal of Psychology of Education*, *21*(4), 453–-466.

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# Minding metaphors
## Using figurative language in learning to represent

Metaphors and metaphorical expressions play important roles in human language and learning. We understand and communicate about new observations and experiences in terms of what we already know and are familiar with. For instance, when something is abstract, as in the case of human thinking, we construe it in terms of something that is more tangible such as a ‘machine’ or a ‘computer’. Often metaphors are viewed as a problematic feature of our language that is a threat to clarity and exactness. However, today many scholars take the opposite view and try to understand the fundamental role that metaphors play for human communication and learning. In the present thesis, some features of the role of metaphors and metaphorical expressions for scientific understanding and for individual learning are studied. Analysing the functions of metaphors in texts and talk allows us to see how our language, and hence our knowledge at a collective level, have developed. In teaching and learning, the metaphoric elements of concepts may have to be ‘re-opened’ in order for concepts to be intelligible for novices in a field. But also scientists rely on metaphors, for instance when studying human memory and natural selection which are two of the areas explored in this study. How people understand and take into account the metaphoric qualities of expressions and concepts when understanding and using scientific concepts is also a sign of their meta-communicative awareness, i.e. to what extent they are aware of the fact that the concepts they use are not to be taken literally. These are the issues dealt with in this thesis. It is argued that keeping the metaphorical nature of many of our concepts and representations in mind is important for understanding how human knowledge relates to the world.

***Niklas Pramling*** works at the Department of Education, Göteborg University.

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