FORMALITY AND REPRESENTATIONAL RELATIVISM: A CRITICAL PHILOSOPHICAL INVESTIGATION INTO KNOWLEDGE REPRESENTATION AS ONE TRANSFORMATION OF WESTERN PHILOSOPHY

Gerald Moshammer
Assumption University of Thailand

Abstract

This paper provides a philosophical discussion of Knowledge Representation [KR], which has become an influential interdisciplinary and technology friendly research field through Artificial Intelligence and Computer Science. While KR appears an increasingly fashionable and subsequently blurred term, it originally emerged out of genuine meta-theoretical considerations. Subsequently, the reconstruction of KR's formal, structural and functional foundations should call for further philosophical evaluation of KR's interdisciplinary and practical potential. The focus is put on KR's logical and semiotical roots, both methodologically and historically, whose exposure prove necessary for a proper understanding and possible criticism of KR's [technological] applicability. The stipulation of analytical symbol theory is new in this context, but nevertheless necessary, as only a more principal semiotic focus may allow an appropriate evaluation of symbolic intelligence, which has to be considered KR's essence.

INTRODUCTION

Knowledge Representation [KR] appears a genuine interdisciplinary research field with strong philosophical roots. Its openness for practical applications [such as Hotel Reservation Systems and Library Databases, cf. Sowa (2000), 513ff.] results from a methodological link to software engineering: an agenda to focus on the representation of knowledge from the perspective of technological implementation.

> "Computation supports the applications that distinguish knowledge representation from pure Philosophy" [Sowa (2000), Preface XII].

Another related technical term, "Cognitive Modeling"[1] [also called "Knowledge Engineering"], sharpens this characteristic.

> "The disposition, which separates the cognitive modeler from experimental psychologists, neuroscientists, and philosophers, is the belief that the best way to understand something is to try to build it. The goal of Cognitive Modeling is to understand the human mind to such a degree of precision that one could design a computer program that did the same thing. As a result, cognitive modelers tend to be computer scientists as well, and are generally well accepted into a larger computer science field of Artificial Intelligence, whose members share many of the same methods, if not the same values" [Gordon (2004), 1].

An underlying connection of Philosophy with Computer Science has thus become epistemologically crucial through Artificial Intelligence [AI], Cognitive Science and Cybernetics.[2] Moor (2002) gives an extensive coverage of "the intersection of Philosophy and computing" entitled "Cyberphilosophy". And there are even contemporary philosophers who are active participants in the modeling side of this new bond. Its most virulent philosophical manifestation can be found in Pollock (1995) with claims of the "first AI system capable of performing reasoning that philosophers would regard as epistemically sophisticated", called OSCAR [Pollock (1995), Preface XII]. The program of transforming Philosophy of Science into "Computational Philosophy" in Thagard (1993a) is another indicator for the aforementioned philosophical heresy. But KR does not just apply logical tools and computer languages; furthermore it colonizes the old philosophical branch of Ontology. Independent from specific platforms or implementation issues, computer oriented KR attempts here to work on a traditionally philosophical task [3] [cf. Simons (2004)]: the portrayal of the world's basic entities, their systematic specification and interrelation in terms of a commonsense metaphysics [4], i.e. from the perspective of how people think and talk about the world. Additionally, it should not be overlooked that KR is also concerned with the understanding of reasoning as a creative discovery process, especially with the emergence of new scientific hypotheses, explanations and theories. Generally, research into KR comes along with the discovery of knowledge acquisition techniques [cf. Gaines/Shaw (1995), Sowa (2000), 452-59]. The investigation into different forms of inference and categorization concentrates hereby on non-deductive procedures, which leads to a thematic overlapping with those philosophical streams that have criticized the narrow views of Logical Positivism dominant in the first half of the 20th century. In particular, since, as already mentioned, KR seeks distance to Philosophy via software implementation, its systematic preconsiderations tend to be methodologically closer related with more stringent philosophical theories. Semiotics is the most obvious candidate here, and it should be underlined in due course of this article that especially Nelson Goodman's Philosophy and Theory of Symbols [cf. Goodman (1976)], although hardly discussed in details by KR theorists, offers philosophical analysis and implicit criticism of fundamental KR issues. This is insofar remarkable as one main concern of Goodman's theory is Aesthetics and furthermore an interdisciplinary approach to education[5], which indicates the interdisciplinary relevance of the methodological principles involved.

A FRAMEWORK FOR THE DISCUSSION

KR functions mainly as metatheory and methodological foundation of a naturalistic and furthermore technological program with the outlook to answer traditionally philosophical questions of mind and knowledge by means of experimental research within the methodological scope of natural sciences.[6] Apparently, we face a kind of "naturalistic epistemology" here. But such a label provides more distortion than orientation. Obviously, the key concept of [mental] representation distinguishes the research programs under discussion fundamentally from any kind of Behaviorism. Furthermore, also the explanatory principles of Evolutionary Epistemology are considered insufficient and inappropriate [cf. Thagard (1993a), 101ff.]. But foremost, the central category of representation is philosophically disturbing. Philosophers such as Richard Rorty[7] have radically questioned a naive concept of representation, seeing in it a major paradigm which has mislead hundreds of years of Philosophy; and it should be noted that the so-called "linguistic turn" is meant to be explicitly included here, although language oriented Philosophy itself had intended to criticize and limit traditional Philosophy from a radical methodological point of view, namely the ontological analysis of language. While logico-linguistic Philosophy had often launched a rigorous anti-psychologism, nowadays, decades after cognition has become a multi- and interdisciplinary research field, the philosophical situation seems fuzzy insofar as the now so-coined "cognitive turn" [cf. Roy (2000)] allows again a speech of mental requisites, stored in the newly furnished mind's inner theater. Linguistics was the forerunner of this renaissance.

> "The basic idea is that knowledge of language involves a system of rules and representations, of mental computation, linked to the motor and perceptual apparatus; and that much of this system is fixed and invariant, just as the essential form and organization of the human body is fixed and invariant, determined by our biological endowment" [Chomsky/Putnam (1987), Para. 13].

The paradigm of computation merges so with the concept of representation to a technological picture of the mind, whose nature is supposed to provide the operating system for information processing. The following figure should allow a first orientation.

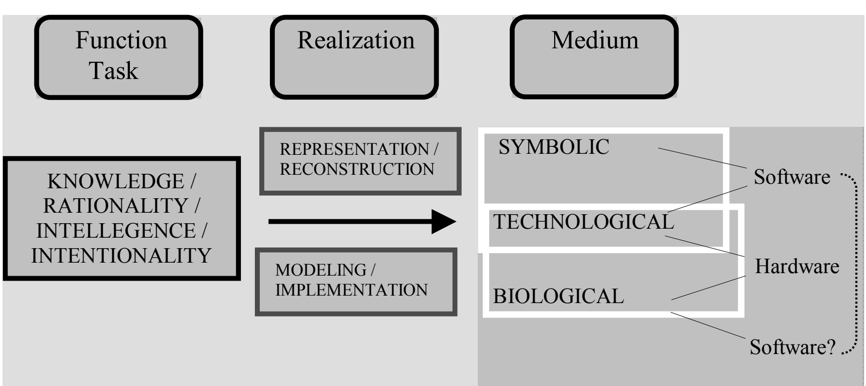

Figure 1

REDUCTIONISM AND REALIZATION

The technological analogy of the "mind as the software of the brain" [Block (1995)] is indeed one of the philosophically most controversial issues related to Cognitive Science. It is especially remarkable as it implies once more a radical program of reductionism, employing the computer analogy to suggest a [biological] hardware performing and materializing every aspect of mentality. The digital age rejuvenates so an old materialistic position by asking the central question involved in terms of equivalence: the man as machine and the machine as man? And as it always has been the case with reductionist explanations, philosophers seek reasons to let the reductionist's attempt appear principally impossible. Note that reductionists naturally have to say first what they attempt to reduce. Regarding Cognitive Science and AI it is exactly this heuristic characterization of mental features and abilities where philosophical argumentation against reductionism can gain ground. For example, Putnam (1975), Block (1978) and Searle (1984), have outlined now famous principal doubts that the cognitive modelers understand the key words in the discussion - intentionality, meaning and reference - properly. Jean Michel Roy summarizes one of the crucial problems as follows.

> "Accordingly, I tend to believe that one of the most important challenges facing the naturalization of intentionalism is not to do without the notion of representation, but to elaborate a non symbolic notion of mental representation" [Roy (2000), Section 4 Para. 3].

We face here the "symbol grounding problem" [Harnad (1990)] which opens a path to so-called "non-symbolic AI" with the emphasis on a more biologically oriented robotics. Contemporary research into "reinforcement learning" [cf. Sutton/Barto (1998)] and "intelligence without reason" [Brooks (1991)] takes a methodological approach which tries to get in distance to the sole influence of traditional Neumannian computer theory and its mathematical and logical models. This pre-logical and anti-computational "bottom up" method is significant as it transposes aspects of originally philosophical criticism of positivism and logocentrism, paradigmatically outlined by Philosophers such as Heidegger, Bergson and Merleau-Ponty, into an AI research issue. Furthermore, such a re-evaluation of AI with a focus on embodied machines and biological organisms enlightens the Cartesian dualistic nature of traditional AI which has appeared to replace Descartes' res cogitans simply by a mechanized manipulation of tokens. But still, since intentionality is aboutness, the concept of representation cannot be easily abandoned. The question regarding symbolic AI and Cognitive Science is then rather if and how their methodology can overcome the linguistic and semiotic turn. Indeed, a large portion of thoughts in traditional symbolic AI has to be considered a genuine logical, semiotic and methodological program [often then called "Knowledge Representation"] and the cognitive turn of symbolic AI does not substantially revolutionize the linguistic or semiotic turn at all, although Cognitive Science makes different theoretical claims [cf. Roy (2000)].

Figure 1 differentiates a symbolic, technological and biological level of mental manifestation. Ned Block (1995) outlines a hierarchy of such explanatory levels based on a criterion of generality and questions the possibility of an ultimate bottom.

> "This point is so simple, fundamental, and widely applicable, that it deserves a name; let's call it the Reductionist Cruncher. Just as the syntactic objects on paper can be described in molecular terms, for example as structures of carbon molecules, so the syntactic objects in our heads can be described in terms of the viewpoint of chemistry and physics. But a physico-chemical account of the syntactic objects in our head will be more general than the syntactic account in just the same way that the syntactic account is more general than the content account" [Block (1995), Section 3.3 Para. 6].

The main task for the reductionist is to show that a higher level can be framed in terms of lower levels. But again, what are the criteria of success here? How do we first specify the potential of a higher level and then upon what criteria can we judge that a lower level mirrors that potential? Of course, every level has to be framed in symbols, mostly verbally and mathematically, and will need interpretation in order to become a theory. Note that physical laws appear idealized in mathematical functions. We do need "bridge laws" [cf. Field (1980), 7-16] to relate constants to "real" things and to interpret variables, but it is the mathematical part that deals flexibly with quantities. Lower levels of explanation appear more general in a sense that basic entities are introduced in order to explain a wider range of phenomena in terms of them by means of functional interdependence. Lower levels systematize and integrate therefore to a higher degree; interrelating sciences depends on the possibility of ontological unity. But there lie some interesting structural discrepancies in explanatory hierarchies. Cases of non-isomorphism between terminologies at different levels have become a highly rated issue since Putman delivered his famous thought experiment of twin earths [cf. Putnam (1975)] which tried to challenge cognitive functionalism exactly through higher level differentiation at the content level, designed to be per definition inexpressible in terms of functionally understood mental states.[8] Nowadays, many-many mappings [cf. Endicott (1998)] and multi-realizibility [see Shapiro (2000) for a critical discussion] mark key issues in the debate and show the dominance of structural thinking when it comes to methodological heurism, analysis and criticism in the aforementioned debates.[9]

EXCURSION: SEMIOTIC CHANNELS

If we look at Figure 1 we find an example of Knowledge Representation. It offers not more than an unsystematic oversimplifying chart [which does not make it inappropriate for a first orientation] by using a simple representation modus which can be found in various types of media, especially academic textbooks, and a reader [or better viewer!] with a certain theoretical background might easily be able to understand aspects of its intention, to possibly criticize its general approach, to identify its shortcomings and eventual failures, but also to discover theoretically problematic relations and new tasks of inquiry. Given the background knowledge required, it will usually lead to a rather intuitive process of interpretation. And even if some reading instructions were added [e.g. as to the arrows and lines between certain categories, or regarding the different category frames], they would themselves be determined just to such an extent as they can be related to a certain representation type and insofar as they appear selected from a certain set of representational devices. For example, we might identify the last thought itself as a variation of Spinoza's "omnis determinatio ex negativo" respectively the structuralists' methodological principal of opposition, which could lead to certain paths of evaluation and criticism not immediately available to someone without background knowledge. Although KR does usually not deal with typologies of such general methodological principles, it is principally its stance to make background knowledge explicit for certain areas [stimulated exactly by the aforementioned goal of computational implementation] and to establish a meta-theory of logical constellations and symbolic devices. The methodological core point is here the examination of tools for detailed reconstruction, systematization and step-by-step reasoning for a representation of certain fields of knowledge, designed to possibly overcome or clarify any "jumping" intuition.

If we analyze Figure 1 as an example of symbolization, we recognize its use of different dash styles to outline some differences in categories and relations among them is purely random. Indeed, the relevant differences could be marked in many other ways [e. g. by means of colours] or we could easily just exchange dash styles without any loss of expression. There might be some psychological considerations governing such choices, but the basic semiotic task of differentiating does not depend on any material here. Now consider the following drawing as an attempt to sketch the anthropological difference between Chinese and Western medicine:

Figure 2

Apparently, the way of making the difference is relevant here: the dynamic lines shall symbolize energetic flow and the dotted lines fragmentation. Remember that linguists consider language to be arbitrary. Syntactically there is no difference between "syntax" and "syntax" and, from a semantically extensional view point we can refer to the same things with the English adjective "beautiful" as we do with the German "schön". In contrary, drawings like those in figure 2 depend essentially on their appearance. While their resizing or colouring would not spoil the message, a change of line style definitely would. Goodman (1976) has elaborated an analytical symbolic theory employing an integrated technical terminology for the analysis and description of such symbolic facts. He applies the method of abstraction to formulate syntactical and semantic criteria based on the logical concepts of equivalence and relation. Specific combinations of these criteria result in the general distinction between notational, verbal and pictorial symbolic systems [cf. Goodman (1976), 127-173]. Figure 3 illustrates the main idea of the aforementioned differentiation regarding symbolic systems and, moreover, gives a simple example of how a switch between semiotic channels, as I call it here, can be understood.

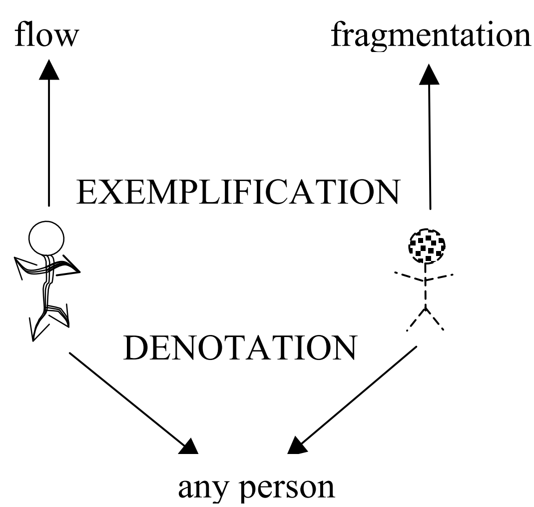

Figure 3

In Goodman's terminology [cf. Goodman (1976), 3-95 and 127-57 for details], the representations exemplify "flow" and "fragmentation", while they both denote a person. Unlike the different marks "a" and "a", which belong to the same character regardless their font style, the two marks in figure 3 make two different characters if they belong to certain pictorial scheme. It has to be emphasized, that no intrinsic property lets them function in that way. We could incorporate the same marks in a verbal scheme and thus make them syntactically equivalent. We just need to "see" them as members of the same equivalence class collecting marks like "person", "person" etc. Although such a mix of pictorial and phonological alphabets would be rather impractical, the following sentences could be syntactically equivalent in a non-standard scheme:

[1] Every struggles for life.

[2] Every  struggles for life.

[3] Every person struggles for life.

The second marks [as all others taking same positions in the aforementioned sentences] are fully interexchangable, since, if they function relative to a verbal syntactical scheme, they belong to one and the same character. The graphologist is apparently going the same path we have described in the opposite direction. He takes the handwriting of a person as a scheme whose pictorial properties are supposed to exemplify certain personal characteristics. Generally, a swift of [or oscillation between] semiotic channels constitutes a basic procedure in the arts and seems to be a radical move of symbolic intelligence, leading to possible epistemological innovation, transgression or even subversion. This is insofar remarkable in this context as research fields surrounding AI seem to be solely task oriented and tend to overlook even in their definitions of intelligence any kind of symbolic freedom, most generally, interpretative flexibility at the level of symbolic channels themselves.

ABSTRACTION AND FUNCTIONALISM

The differentiation between notational, verbal and pictorial syntactic schemes can be seen as a further reaching consequence of the well-known use/mention distinction. And the philosophically most striking manifestation of this distinction has been in Arithmetic. As there seems to be an obvious difference between numerals and numbers, e.g. "2" and 2, the almost unavoidable question is: What are these numbers? Or more specific: What kind of entities are they? Frege radically opposed the Psychologism of his time and located numbers in a "third realm" of [abstract] entities [cf. Frege (1884)]. According to Frege, numbers can neither be psychological entities like ideas nor the (physical) numerals themselves. Numbers and their properties [e.g. the property of the cardinal number one to remain identical when multiplied by itself] should be understood both transpsychological and transsemiotic. Their objectivity is so supposed to be predetermined. This kind of mathematical Platonism has been widely attacked in the 20th century by Nominalists [cf. Field (1980), Gosselin (1990) and Burgess/Rosen (1997)]. A comparison of abstract entities like numerals with terms referring to material objects, such as "house", enlightens the obvious difference. For instance, houses are not just fundamentally distinct from the term "house" but from "house-idea" as well, since - as simple as it is - we can perceive them. Material objects are open to ostensive definition, abstract ones are not. Of course, this is not more than common sense ontology; still, it is this difference which constitutes one aspect underlying endless philosophical comments about the ontological status of abstract entities. But in the kaleidoscope of 20th century Philosophy we can recognize certain attempts to overcome such ontological foundation problems by replacing them with more functional and constructive approaches. Indeed, Functionalism has been a key word in Cognitive Science as well, designed to replace strict Physicalism.

> "Functionalism has three distinct sources. First, Putnam and Fodor saw mental states in terms of an empirical computational theory of the mind. Second, Smart's "topic neutral" analyses led Armstrong and Lewis to a functionalist analysis of mental concepts. Third, Wittgenstein's idea of meaning as use led to a version of functionalism as a theory of meaning, further developed by Sellars and later Harman" [Bock (1996), Para. 2].

In a broader philosophical context, Ernst Cassirer's differentiation between substance and function [Cassirer (1994)] has to be added to this list. Remembered should be especially the German Philosopher and Mathematician Paul Lorenzen who developed a "constructive" approach to mathematics which explains Arithmetic in an operative way of building a numeral system and furthermore, explains basic logic operations in the form of dialogues where the two sides hold, challenge and defend certain assumptions [cf. Lorenzen (1974a), (1974b) and (1987)]. The foundation problem - ontological or axiomatic - is here supposed to be replaced by the questions how numbers and logical operators are introduced, learned and become elements of certain operational procedures. Functionalism and Operationalism explain equivalence as the potential of symbols to play an identical role and to allow specific moves whereas the tokens' intrinsic properties have no relevance and ontological considerations no priority.

LOGIC AND COMPUTATION: THE FORMAL PARADIGM

The recovery of a now naturalistic Psychologism and Rationalism in computational terms makes it worth to focus on the logical roots of computation, since Logic has widely been considered to provide a genuine example for a normative discipline, which causes a certain theoretical tension. At this point, Philosophy has to be recalled once more as methodologically a priori and self-reflexive [or, in the significant and specific sense of Kant, as transcendental]. This so described status of Philosophy happens namely to be purified in the Vienna Circle's radical and rigorous attempts to reduce Philosophy to logical syntax and of Wittgenstein's conclusive program to cut back the area of "Philosophy" to logical space and its possibilities in his Tractatus [Wittgenstein (1961)]. Such purification has its price: Philosophy now turns into a logico-linguistic theory of syntactical architecture. The a priori conception of Philosophy only survives in the normative determination of the combinatorial power of certain logical and axiomatic frameworks, i.e., the clear distinction between grammatical and ungrammatical expressions, and the classification of the former along the lines of metalogical concepts like analyticity, tautology, contradiction, etc. Kant's synthetic judgments a priori, the last genuine rationalistic heritage in modern epistemology, had vanished. But much more is involved here: Since there are different frameworks possible, "a priori" appears to be comprehensive solely relative to a systematic language. Wittgenstein and Carnap found in the new logic of Frege and Russell a powerful prototype, but already Carnap had to emphasize a transethical logical tolerance: "In Logic there are no morals"[10]. And Wittgenstein impressively refused the ultimo ratio of his own Tractatus by turning his attention to an unlimited space of ordinary language games [cf. Wittgenstein (1956)]. Also Tarski, who contributed extensively to the theory of deductive systems, sees logic as a matter of choice, foremost of the concept of inference itself [Tarski (1956), 409][11]. Nowadays, in times where there are much more logical systems than members in a comprehensive set of axioms, logic appears to be merely a flexible instrument and tool, sometimes even as - fruitfully - fuzzy. Thus, the originally narrow and most general field of formal logic enforces now a choice [cf. Lewis (1923)], depending on the Logician's goal oriented decision. With this signature it possibly becomes preferable to speak of norms, rules and axioms and leave the a priori to the historian of Philosophy. The old debates about a final justification of a definite starting point seem fruitless. But it should be kept in mind that Quine's famous attack of the analytic-synthetic distinction [Quine (1951)] was meant to abandon any conception of a "prima philosophia" but not construction and definition as necessary scientific tools. It is definitional transgression that performs the crucial step here. If we give up any a priori knowledge - innate, by intuition or through any necessary reasoning - how should we start a systematic construction of a certain framework? Or better: Which kind of criteria could justify the initial step? For example, ontological constructivism takes pure deductive logic as its role model and examines tools for a construction of different ontological systems. The first chapter of Goodman's seminal work "The Structure of Appearance" gets immediately involved with the question of how the accuracy [not adequacy!] of definitions could be tested and in an elaborated argument Goodman shows that solely a structural criteria[12] can provide necessary and sufficient conditions - recalling implicitly the Vienna Circle's discussions about "structural properties" [cf. Carnap

(1967a), para. 11-15, Schlick (1986), 190ff. and critically Waismann (1976), Chapter XII and XIII]. Together with its relatives, "syntax" and "structure", "formality" gets so the touch of (ontological) neutrality. Concerning Carnap's "The logical structure of the world", which applies the modern logic of relations to the construction of an ontological system, Michael Friedman emphasizes the search for "a peculiarly philosophical vantage point that is neutral with respect to all traditional metaphysical disputes" [Friedman (1987), 525]. The so emerged ontological neutrality becomes even more obvious with Nelson Goodman's further step in "The Structure of Appearance" [Goodman (1977)], where different ways of ontological constructions are investigated.

Quine's methodological emphasis of a "semantic ascent", outlined in the last paragraph of his famous *Word and Object* [Quine (1960)], cannot be overlooked here. Especially Quine's references to Carnap are interesting, as Quine builds his semantic ascent on the distinction between the formal and material mode of sentence construction. The main idea, similar to the switch from an object- to a metalanguage, the turn into the mode of speech about instead in a language, allows, through the medium of quotation, to get rid of ontological burden. It might be unknown, what entity "mile" refers to, but it is safe to state "'A mile' is true of the distance between the house and the main road", to expand Quine's example. Obviously, such a way out becomes especially urgent if we accept a theory of ontological commitment. "The more formality, the less ontological debate", seems to be the philosophical slogan. For the philosopher there is no vantage point outside the conceptual scheme, says Quine. But it is remarkable that semantic ascent should provide mediation between conceptual schemes.

> "The strategy is one of ascending to a common part of two fundamentally disparate conceptual schemes, the better to discuss the disparate foundations. No wonder it helps for Philosophy" [Quine (1960), 272].

It is this potential of mediation respectively clarification concerning different languages and theories[13], which seems to make the step to the formal mode philosophically relevant. Quine's methodological strategy has been criticized [cf. Willas (1983)], and indeed, the methodological emphasis of different linguistic levels seems at least misleading, as it suggests a higher level of also higher ontological "security". But linguistic clarification has no expressible starting point or halt. What remains is a position of semantic clarification as structural adaptation, to which I will come back at the end of this section.

The formal paradigm has had an enormous influence to Western thought in many areas [cf. Agazzi (1994)], but it has been the field of logic where "formality" found its purest expression. After the foundation crisis of mathematics at the beginning of the 20th century the answer to striking logical questions has been pushed back to a distinctive metalevel, which is concerned about the completeness, consistency and decidability of logical systems. This happened pretty early: Gödel's famous incompleteness proof [Gödel (1931)] came out just three decades after Russell confronted Frege's ambitious project of transforming Arithmetic into Logic with devastating antinomies [cf. Russell (1902)], and subsequently also Russell's and Whitehead's ingenious superstructure, Principia Mathematica [Russell/Whitehead (1925)], lost its universal explicitness: Since then, David Hilbert's ideal of a pure formalistic foundation of mathematics has had to be considered principally impossible. But Gödel's proof does not just awake us from the dream of comprehensive universal axiomatic systems; it furthermore exemplifies a procedure how to perform such a devastating proof. And since Gödel turned metamathematical proofs into algorithmic calculation, they could play a role model for the theory of computing, i.e., in mechanical procedures performing "intelligent" tasks. The famous Turing Machine, more an analogy than a machine actually, was the first famous computational output of the metalogical input. Logic as a formal system has so become the paradigm for intelligence and cognitive technology. Expanded to a panformalism and pancomputationalism, this reads like the following:

> "If any formal system can be explicitly mechanized as a Turing Machine, so can any actual machine nervous system, natural language, or mind in so far these are determinate structures. Number objects and formal languages [and their interpreters and interpretations] only reach stable specification within fully mechanized procedures…This suggests that the rest of our world and natural languages ….require understanding of the analogous sorts" [Leiber (1991), 57-8].

As far as formal systems determine rule governed actions - the formation and transformation of expression on the base of a stock of symbols - they allow technological implementation. Unsurprisingly, Gödel's metalogical results have been debated extensively within AI and Cognitive Science; they methodologically originate but also principally limit the computer analogy of the mind, giving again a certain support especially to the concept of intuition [cf. Sullins (1997)]. Mathematics appears a sophisticated exploration of structural possibilities which, regardless of its boundless inventions [or findings?], builds upon the basic operations of differentiation, abstraction and identification. As such, formal thinking is universally involved in any kind of intellectual activity. Of course, the mind is supposed to do more than moving tokens. Interpretation [inclusive translation], reference and intentionality are philosophical key issues. Naturally, the question "What is meaning?" cannot be answered formally. Like other sorts of general "What-questions", it might not be possible to answer it at all. Interestingly enough, specific semantic clarification is formal. In a large part of analytical Philosophy, from the analysis of ostensive definition[14] and its status to investigations into necessary and sufficient conditions for term definition, from the analysis of quotation, translation and interpretation to holistic theories of meaning, the core explications have always come along formal and structural lines. Especially comparative examples given for the inscrutability of reference, conceptual relativity and ontological indeterminism appear to be understandable just in case that they can generate functional mappings. Note that Wittgenstein's famous and highly controversial private language argument [cf. Wittgenstein (1978), Sections 244-71] heads into a direction where any reference to an individual inner sphere is absorbed by the force of public language, whose rules and grammar are supposed to solely determine the "meaning" of even psychological and mental predicates.

Formal sciences create semiotic possibilities and variability of expression, but not [empirical] knowledge. Experience results in a selection of certain semantic vehicles and their evaluation as "true" and "right". Without an understanding and interpretation of the symbols we use, if lacking the external source of experience, such a selection process would be boundless. Still, articulation and communication of knowledge, its interpretation, criticism and evaluation in two or more minds' communication depend on structural characteristics which could be paraphrased solely within formal semantics.[15] Indeed, it is important to realize that formal semantics builds a structure which can itself be seen as purely syntactic and does therefore not provide any intentionality respectively identification of entities.[16] In other words, the so-called interpretation of symbols, by means of a specific function that assigns values, results simply in new logical relations between these symbols. The interpretation of such relations as being semantic is a supposition not intrinsic to formal semantics. "Formal Semantics" appears an oxymoron and exemplifies so the ambivalent status of formal thought in meta-theorizing - especially if we evaluate such a pan-formalism as the strongest ground of mediation between different linguistic and semiotic expressions [foremost in terms of declarative speech].

As formal sciences define more and more methods and strategies of reasoning, the pressure of choice, and therefore of responsibility, has grown. Generally, if we understand how we are doing something, we can also do it differently. And that is the philosophically crucial point here. As machines should learn how to think, humans might ask: how should we [they] think?[17] The progress of disciplines like KR makes this question virulent at the methodological level. And regardless of our final stance, we should be committed to know what our possibilities are. Maybe that is a formal requirement for culture, for which scientific communities play a role model: not to be necessarily differentiated but to be differentiating to the highest possible degree.

POSTSCRIPT: NON-DEDUCTIVE KR TOOLS

Detailed and instrumental examination of rational tasks and the exploration of possible modes of their reconstruction make KR a genuine research program. Somehow untouched by principal and skeptical philosophical debates, there is a commitment to a more step-by-step experimental program which simply tries to go as far a possible in the analysis and [technological] mimicry of human capacities. In a certain sense KR can be understood to prolong the old tradition of a search for a proper "ars inveniendi", reflecting in many aspects the philosophical disputes concerning the status of an "ars demonstrandi" and a theory of categories paradigmatically outlined by Aristotle and Kant. But the influence of advanced Logic and Mathematics as well as computer technology - combined with a new methodological tolerance - certainly makes an enormous difference in theory building nowadays. In the context of this article the following characteristics of this development have to be underlined.

- The paradigm of deduction as the purest form of inference, still dominant in the first half of the 20th century, has not just been supplemented by intensive research into a theory of induction and probability, but furthermore a third concept, abduction[18], has drawn attention to theorists [cf. Wirth (1998)].
- The field of deductive logic itself has opened up a wide area of very heterogeneous formal systems, designed as logical tools with different sets of axioms and enriched with operators to allow for an analysis and [re-]construction of genuinely extralogical areas of human speech and thought.
- Non-monotonic formalisms, defeasible and prima facie reasoning have been addressed to give a more realistic picture of actual human rationality, allowing furthermore the speech of degrees of justification [cf. Pollock (1995)].
- Soft computing has become the key word for an approach in software design and controlling which allows tolerance for imprecision and uncertainty. The main techniques are here fuzzy logic, rough set theory, artificial neural networks and probabilistic reasoning.
- A re-discovery and development of conceptual logic has taken place after modern Predicate Logic since Frege had focused primarily on sentences and functions. Categorization[19], concept maps and conceptual hierarchies have become the subject of intensive investigation and appear often linked with methods in Computer Science such as frames, databases, ontologies and conceptual modeling tools [cf. Thagard (1993), 13-33, Sowa (2000), 51-205 and 408-452].
- Non-verbal symbolic systems, from diagrams to artistic notation, have been investigated in analytical and logical terms,

showing their epistemological value and relevance [cf. Goodman (1976)].[20]

Someone may miss Ethics in this list. It well could be included if we agree with an often forgotten implication of the Vienna Circle's scientific program. Referring to one of its members, Elisabeth Nemeth gives the following paraphrase of what science and its methodologies could teach us beyond science:

> "At this point we see more clearly why Frank believed that science…might even strengthen the belief in the validity of values. It can be experienced and habitualized as a form of social practice which enables us to reformulate not only theoretical but also moral claims in a changing world. And we can see what Philosophy of science could contribute to the public vision of what the pluridimensional cultural project is all about. It could intervene in the public discourse by demonstrating that the capacity for integrating new experiences into any social practice is determined at least by three factors: first by the willingness of the acting people to analyze the logical framework of their claims and to define the meaning of concepts by their "observable consequences"; second by the constructive power which is needed for the creation of a new, an enriched language, capable of describing "a new stock of facts"; third by the preparedness of people to "relativise" their own standpoint in order to contribute to the enrichment of our experience" [Nemeth (2003), last para.].

ENDNOTES

* Doctoral Degree in Philosophy from the University of Vienna. Master Degree in both Philosophy [University of Vienna] and Piano Pedagogy [Vienna University of Music and Performing Arts].

[1] Object modeling languages such as UML, Z and Alloy are, for instance, technologically motivated conceptual modeling tools whose expressive features and differences are also philosophically relevant [cf. Jackson (1999) for an illustrative introduction].

[2] KR has become a fashionable and fancy term which has lost power to describe any clearly defined and specifiable subject matter. While it happens to be applied in various academic disciplines, the discussion about its philosophical foundation has broadened to such an extent that it covers almost everything that has been a philosophical key issue. Paradigmatic publications such as Sowa (2000),

Thagard (1993a) and Pollock (1995) seem to result from ambitions almost comparable to traditional Systematic Philosophy and in clear distinction from spot analysis as it had been the favor of many 20th century analytical philosophers. At the other hand, "Knowledge Representation" is widely used in concrete scientific research and plays so a dominant role in reflections on research methodology as the representation modus naturally effects data interpretation. For example, Vamos (1995) discusses in a comparative article the so-called pattern method as to completely heterogeneous research fields: early brain development dysfunction, a sociological-legal project and a study of economic patterns. Moreover, management theories are highly concerned with knowledge creation, representation and transfer (cf. Boland 2001). This article concentrates solely on more logical, philosophical and semiotic aspects.

[3] The large-scale CYC project is the most outstanding example for the described ontological orientation in Computer Science [cf. http://www.opencyc.org].

[4] Strawson (1959) famously outlined a "descriptive metaphysics" [in opposition to a "revisionary metaphysics"] in a Kantian tradition which can be seen sharing some principal assumptions with domain and database oriented ontologies. Especially the opposition to logically and scientifically more sophisticated world views, accommodating neither common sense nor user friendly applications, let the aforementioned approaches appear related. Still, ontologies designed for information technology differ from Strawson's project fundamentally by their degree of systematization and specification.

[5]Nelson Goodman is well-known for his philosophical work, which is in larger parts abstract and technically demanding, while it is often overlooked that he founded the so-called Project Zero in 1967 as a Harvard University Graduate School of Education Research Associate. This project has been continued until today with the "mission to understand and enhance learning, thinking, and creativity in the arts, as well as humanistic and scientific disciplines, at the individual and institutional levels" [cf. http://www.pz.harvard.edu].

[6]The replacement of philosophical cosmology by [extraterrestrial] physics gives us an impressive example for such a transformation of a "philosophical" branch. But regarding this case we can question, if e.g. the Pre-Socratics really did Philosophy at all and not merely protoscience instead. Aristotle definitely was a universal scientist and an outstanding philosopher too, just to mention one example. On the other hand, also many great scientists have made paradigmatic philosophical contributions, notably in modern times, when Philosophy was already an isolated academic discipline. Thus, however we write intellectual history, an understanding of Philosophy as science in a primitive stage and therefore as something that has to grow up in order to become a real science seems rather ill-founded. Philosophical reasoning about new paradigms in science has often reflected back to the self-definition of Philosophy. And Philosophy questions even the most fundamental suppositions of extremely advanced sciences, as e.g. in

case of modern physics the ontological status of the whole mathematical apparatus employed, expressively numbers, classes and functions. The fact of being an integrated part of empirical or applied sciences should therefore not mislead an evaluation of modern research fields like KR.

[7]For a comprehensive overview of Rorty's standpoint see his two retrospective essays in Rorty (1992), 361-374.

[8]The observation of how his argument works is of interest independently from the question if we consider Putnam's "Externalism" a comprehensive philosophical standpoint.

[9]This is not new in Philosophy influenced by Logic and Mathematics. Carnap spoke of a "Spielraum" [combinatorial space] regarding the truth value distribution in sentential logic, and combinatorial logical possibilities always emerge when we reflect on cognitive principals and reconstruct them in a structured way. Indeed, combinatorial thinking and epistemological innovation are linked; in this context, especially Leibniz' treatment of an "ars inveniendi" within a broad "mathesis universalis" has to be recalled. For a radical structural Ontology see Dipert (1997).

[10]For a better understanding, here is the full passage: "In logic there are no morals. Everyone is at liberty to build up his own logic, i.e. his own form of language as he wishes." [Carnap (1937), 52]

[11]For a differentiated discussion of logical tolerance see Restall (2002), who refers to Tarski and especially Carnap to distinguish his own specific pluralism concerning the concept of logical consequence.

[12]A very interesting concrete manifestation of a methodological isomorphism similar to Goodman's structural and ontologically neutral criterion of definition can be found in Churchland (1998), 11f.

[13]It has to be remembered, that it was the "linguistic turn" which had led to the marketplace of semantics for a discussion of ontological issues. And in the pretty secure corner of extensionality the only issue to worry about is reference. Since this spot is mainly occupied by physicalists, materialists and/or nominalists, the theoretical challenges are easily identified: Besides terms that supposingly refer to abstract entities those with null-extension, especially fictious ones, appear puzzling. Over the last hundred years many strategies to deal with these theoretical difficulties have been applied. Paradigmatically, the main forerunners are here Frege's contexuality principle [cf. Frege (1884)] and Russell's famous theory of descriptions [Russell (1905)] using existential quantification to incorporate extensionally empty expressions into [false] sentences, while the relation of identity allows to safe singularity in definite cases. The problem of direct reference disappears as we solely have to determine truth values of whole sentences. Of course there is still the questions how to deal with verification, how to determine single propositions. After the logical positivists' attempt to root all our [scientific] knowledge in pure protocol language had failed, Holism has gone one step further and raised the problem of reference and verification to the level of whole different theories and languages. And once we reach this top level, the question is how the

speech about different conceptual schemes is comprehensive at all. Davidson rejects the idea of conceptual pluralism. He writes: "…we must say much the same thing about differences in conceptual scheme as we say about differences in belief: we improve the clarity and bit of declarations of difference, whether of scheme or opinion, by enlarging the basis of shared [translatable] language or of shared opinion. Indeed, no clear line between the cases can be made out" [Davidson (1973-74), 20]. Davidson's "shared language or opinion" seems again just comprehensive if we understand such a common pool as formal congruence, a kind of isomorphism at the end.

[14]Ostensive definition constitutes a philosophical challenge to any kind of pure structuralism. Indeed, many philosophers have emphasized its semiotic character and necessary mediation. Already Hegel gave in his famous "Phenomenology of Spirit" (1977) a lucid examination of "Sense Certainty". In the 20th century it was Wittgenstein who gave ostensive definition a linguistic turn in the opening passages of the so-called Blue Book [cf. Wittgenstein (1974)].

[15]If somebody - let's call him Mr. Hook - labels a whale "fish", you could say his general terms "fish" and "mammal" differ in meaning from the standard usage in Biology. But how could the difference be clarified and determined? Is Mr. Hook applying the simple universal sentence "Every animal of a certain shape and living in water is a fish" and still believes in a fundamental difference between fishes and mammals as to reproduction? Is he aware that whales have mammary glands with which they nourish their young? If so, why it this not reason enough for him to classify a whale as a mammal? How would Mr. Hook classify dolphins? Normally it would not be difficult to find out wherein the difference between Mr. Hook's and the Biologist's categorization lies. But the only path of investigation is the path of formal semantics, i.e. the identification to which entities a term is supposed to apply by testing how it is related to other terms considered relevant. The clarification process involves usually just a small part of concepts. For example, it might not refer to the fact that mammals and fishes show differences in the neuronal connectivity pattern of the olfactory bulb. A Biologist might try to clarify Mr. Hook's understanding just by pointing out that whales breathe air, are warm-blooded, breast-feed their young and have some hair, all characteristics typical for mammals in standard Biology. The closure and scope of conceptual [or belief] clarification and mutual adaptation in a dialogue of two or more minds depend finally on rather pragmatic reasons. But during the process of mutual understanding and clarification, regardless the actual point when we feel satisfied with the result, there is not more to do than exploring the relationships a term yields to others.

[16]As far as formal semantics is logical, the following characteristic of Logic has to be kept in mind "Logic does not deal with specific men or animals; it can apply to individuals if they are members of a class, but it can actually mention them only as members, not as individuals. We cannot say in logic , 'Reynard killed a lamb' meaning by 'Reynard' an individual known by personal acquaintance, we

can only say [x] : x is named Reynard and x killed a lamb. But this tells us only that at least one member of a class is named Reynard, and has killed a lamb. It still leaves us with 'at least one' not with 'this one'. The fact, that this fox killed a lamb, that this is Reynard, goes beyond the sphere of logic; it requires sense-experience, to furnish a specific individual to which one may point", Langer (1967), 113. Even if we added an identity clause here to secure singularity [[y]: if y is named Reynard and y killed a lamb then y = x] we still could just express "one and just one" and not "this one".

[17]The area of formal ontology is a good example for the elaboration of choices. A metatheory has been established that creates a comprehensive typology of various ontological constructions and principals [cf. Armstrong (1989) for an introduction]. The different formal ways of interpreting the relation between particulars and universals show in a paradigmatic way that at the level of common sense and ordinary language an ontological theory hardly can be finalized.

[18]The concept of "abduction" was introduced by Charles Sanders Peirce and it is remarkable that philosophers in the German-World find in it a link to thoughts related to German Idealism. For example, the Austrian philosopher Kurt Walter Zeidler compares in this respect Peirce with Hegel [cf. Zeidler (1990)].

[19]Categorization plays a central role in Nelson Goodman's Theory of Symbols and Epistemology, a theme which interestingly began with his famous "new riddle of induction" [cf. Goodman (1983)].

[20]Although there might be principal limits to the program of a naturalization and technological implementation of "human" intelligence and intentionality, a comprehensive reconstruction of how different intelligent tasks could be understood has definitely epistemological value and offers furthermore a useful repertoire of analyzing, organizing and creating knowledge. Moreover, achievements in KR could nota∃ly contribute helpful tools to enhance didactics and communication.

BIBLIOGRAPHY

[1] AGAZZI, E. (1994): *On Formalism*, in: Floistad, G., ed. (1994), Philosophical Problems Today. Dordrecht: Kluwer Academic.

[2] BLOCK, N. (1980): “Troubles with Functionalism”, in: Block, Ned, ed. (1980), *Readings in the Philosophy of Psychology*, Vol. 1, Harvard University Press.

[3] - (1995): The mind as the software of the brain. Retrieved May 15, 2006 from http://www.nyu.edu/gsas/dept/philo/faculty/block/papers/msb.html.

[4] - (1996): “What is Functionalism?” Retrieved May 15, 2006 from http://www.nyu.edu/gsas/dept/philo/faculty/block/papers/functionalism.pdf.

[5] BOLAND, R. J., Jr., et al. (2001): “Knowledge representations and knowledge transfer,” *The Academy of Management Journal*, Vol. 44/2, April, 393-

417.

[6] BROOKS, R. A. (1991): “Intelligence Without Reason”. Retrieved May 15, 2006 from http://people.csail.mit.edu/brooks/papers/AIM-1293.pdf.

[7] BURGESS, J. P./ROSEN, G. (1997): *A Subject With No Object*, Oxford University Press.

[8] CARNAP, R. (1967a): *The Logical Structure of the World - Pseudoproblems in Philosophy*. Berkeley, University of California.

[9] - (1967b): *The Logical Syntax of Language*, London: Routledge and Kegan Paul.

[10] CASSIRER, E. (1994: *Substanzbegriff und Funktionsbegriff*, Darmstadt: Wissenschaftliche Buchgemeinschaft.

[11] CHOMSKY, N./PUTNAM, L. R. (1987): *Language, Language Development and Reading*. Noam Chomsky interviewed by Lillian R. Putnam. Retrieved May 15, 2006 from http://www.chomsky.info/interviews/1987----.htm.

[12] CHURCHLAND. P. M. (1998): “Conceptual Similarity Across Sensory and Neural Diversity: the Fodor / Lepore Challenge Answered”, *The Journal of Philosophy* Vol: XCV/1, Jan 1998, 5-32.

[13] DAVIDSON, D. (1973-74), “On the Very Idea of a Conceptual Scheme”, *Proceedings of the American Philosophical Association* 47, 5-20.

[14] DIPERT, R. R. (1997): “The Mathematical Structure of the World: The World as Graph”, *The Journal of Philosophy* 114/7, 329-358.

[15] ENDICOTT, R. P., (1998): “Many-Many Mappings and World Structure”, *American Philosophical Quarterly* Vol.: 35/3, July, 267-280.

[16] FREGE, G. (1884): *Die Grundlagen der Arithmetik*, Koebner, Breslau: Koebner.

[17] FIELD, H. H., (1980): *Science Without Numbers*, Oxford: Basil Blackwell.

[18] FRIEDMAN, M. (1987): *Carnap’s Aufbau Reconsidered*, Nous 21, 521-545.

[19] GAINES, B. R./SAW, M. L. G. (1995): “Knowledge Acquisition and Representation Techniques in Scholarly Communication,” *The Journal of Computer Documentation* Vol. 19/2, 23-36.

[20] GÖDEL, K. (1931): Über formal unentscheidbare Sätze der principia mathematica und verwandter Systeme, Monatshefte für Mathematik und Physik, 38, 173 -198.

[21] GOODMAN, N. (1977): *The Structure of Appearance*, 3rd Ed., Boston: Reidel.

[22] - (1976): *Languages of Art: An Approach to a Theory of Symbols*, 2nd ed. Indianapolis: Hackett.

[23] - (1983): *Fact, Fiction, and Forecast*, 4th ed., Cambridge, MA: Harvard UP.

[24] GORDON, A. S. (2004): *Representation: An Analysis of Planning Knowledge*, Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2004.

[25] GOSSELIN, M. (1990): *Nominalism and Contemporary Nominalism: Ontological and Epistemological Implications of the Work of W.V.O. Quine and of N. Goodman*, Kluwer Academic: Dordrecht.

[26] HARNAD, St. (1990): "The Symbol Grounding Problem," *Physica* D 42: 335-346.

[27] HEGEL, G. W. F. (1977): *Phenomenology of Spirit*, translated by J. N. Findlay, Oxford University Press.

[28] JACKSON, D. (1999): "A Comparison of Object Modeling Notations: Alloy, UML and Z." Retrieved December 22, 2006 from http://people.csail.mit.edu/dnj/publications/alloy-comparison.pdf.

[29] LANGER, S. K. (1967): *An Introduction to Symbolic Logic*, 3rd ed., New York: Dover.

[30] LEWIS, Cl. I. (1923): "A Pragmatic Conception of the *a priori*," in: Kurtz, P. (1966), *American Philosophy in the Twentieth Century*. London: Macmillan, 388-396.

[31] LORENZEN Kurt (1974a): *Konstruktive Wissenschaftstheorie*, Frankfurt/M: Suhrkamp.

[32] - (1974b): *Methodisches Denken*, Frankfurt/M: Suhrkamp.

[33] - (1987): *Lehrbuch der Konstruktiven Wissenschaftstheorie*, Mannheim: BI-Wissenschaftsverlag.

[34] MOOR, J. H., BYNUM, T. W. (2002): "Introduction to Cyberphilosophy," *Metaphilosophy*, Vol. 33/1-2, Jan., 4-10.

[35] NEMETH, E. (2003): "Philosophy of Science and Democracy. Some Reflections on Philipp Frank's Relativity - a *Richer Truth*." [Published in: Heidelberger, Michael, Friedrich Stadler, eds., *Wissenschaftsphilosophie und Politik. Philosophy of Science and Politics*. (=Veröffentlichungen des Instituts Wiener Kreis, Vol.11) Wien New York: Springer 2003]. Retrieved May 13, 2006 from http://sammelpunkt.philo.at:8080/archive/00000993/

[36] POLLOCK, J. L. (1995): *Cognitive Carpentry: A Blueprint for How to Build a Person*, Cambridge: MIT Press.

[37] PUTNAM, H. (1975): "The Meaning of 'Meaning'," in: *Philosophical Papers, Vol. 2: Mind, Language and Reality*, Cambridge University Press.

[38] QUINE, W.V.O. (1951): "Two Dogmas of Empiricism," in Quine (1961), *From a Logical Point of View*, 2nd ed., rev., Cambridge, Mass.: Harvard University Press, 20-46.

[39] - (1960), *Word and Object*: Cambridge, Mass.: MIT Press.

[40] RESTALL, G. (2002): "Carnap's Tolerance, Meaning, and Logical Pluralism," *The Journal of Philosophy* Vol. XCIX/8, Aug., 426-443.

[41] RORTY, R. M., ed. (1992): *The Linguistic Turn: Essays in Philosophical Method*, Chicago: Univ. of Chicago Press.

[42] RUSSELL, Bertrand (1902): "Letter to Frege," in: Van Heijenoort, Jean (1967), *From Frege to Gödel*, Cambridge, Mass.: Harvard University Press, 124-125.

[43] - (1905): "On Denoting," in: Marsh, R.C., Ed. (1956), *Logic and Knowledge: Essays 1901-1950*, London: George Allen and Unwin, 41-56.

[44] RUSSELL, Bertrand/WHITEHEAD, A.N. (1925): *Principia Mathematica*, Cambridge: Cambridge University Press, 2nd ed., 1925.

[45] ROY, J.-M. (2000): "Cognitive Turn and Linguistic Turn," *Proceedings of Twentieth World Congress of Philosophy*, Philosophy Documentation Center. Retrieved May 13, 2006 from http://www.bu.edu/wcp/Papers/Cogn/CognRoy.htm6.

[46] SCHLICK, M. (1986): *Die Probleme der Philosophie in ihrem Zusammenhang*. Vorlesung aus dem Wintersemester 1933/34, Frankfurt/M: Suhrkamp.

[47] SEARLE, J. (1984): *Minds, Brains, and Science*, Cambridge: Harvard University Press.

[48] SHAPIRO, L. A. (2000): "Multiple Realizations," *The Journal of Philosophy* Vol: XCVII/12, Dec., 635-654.

[49] SIMONS, P. (2004): "Criticism, Renewal and Future of Metaphysics," *The Richmond Journal of Philosophy* 6, 6-13.

[50] SULLINS, J. P. (1997): "Gödel's Incompleteness Theorems and Artificial Life," *Society for Philosophy and Technology*. Number 3-4/2. Retrieved May 13, 2006 from http://scholar.lib.vt.edu/ejournals/SPT/v2n3n4/sullins.html.

[51] SUTTON, R. S./BARTO, A. G. (1998): *Reinforcement Learning: An Introduction*, Cambridge, MA: MIT Press.

[52] SOWA, J. F. (2000): *Knowledge Representation: Logical, Philosophical, and Computational Foundations*. Pacific Grove, CA: Brooks/Cole.

[53] STRAWSON, P. F. (1959): *Individuals*, London: Methuen.

[54] THAGARD, P. (1993a): *Computational Philosophy of Science*, Cambridge, MA: MIT Press.

[55] - (1993b): *Conceptual Revolutions*. Princeton, NJ: Princeton Univ. Press.

[56] TARSKI, A. (1983): "On the Concept of Logical Consequence," in: Woodger, J. H. tr., (1983), *Logic, Semantics, Metamathematics*, 2nd ed. Imprint: Indianapolis: Hackett, 1983.

[57] VAMOS, T. K. et al. (1995): "A Strategy of Knowledge Representation for Uncertain Problems: Experiments and Relations to Similar Concepts," *IEEE Transactions on Systems, Man, and Cybernetics (Part A)*, Vol. 25/10, Oct., 1371-1383.

[58] WAISMANN, F. (1976): *Logik, Sprache, Philosophie*, Stuttgart: Reclam.

[59] WILLAS, D. (1983): "Why Semantic Ascent Fails," *Metaphilosophy*, Vol. 14/3-4, Jul. /Oct., 276-290.

[60] WIRTH, U. (1998): "What is Abductive Inference?" (Published in: Bouissac P., Ed. (1998)., *Encyclopedia of Semiotics*, Oxford University Press). Retrieved May 13, 2006 from http://user.uni-frankfurt.de/~wirth/inferenc.htm.

[61] WITTGENSTEIN, L. (1974a): *Tractatus Logico-Philosophicus*, 2nd ed., London: Routledge.

[62] - (1974b): *The Blue and Brown Books*, 2nd ed., Oxford: Blackwell.

[63] - (1978): *Philosophical Investigations*, 3rd ed., Oxford: Blackwell.

[64] ZEIDLER, K. W. (1991): "Zeichen und Schluss: Peirce und Hegel" (Published in: Nagl L. et al., Ed. (1991), *Philosophie und Semiotik*, Vienna, 153-166). Retrieved May 16, 2006 from http://phaidon.philo.at/asp/puh.htm.