What can be learned from useful models?
Matthias Adam

Since most scientific research and development aims primarily and directly at solutions to problems of practical importance, it seems safe to assume that in most cases, scientific modelling first of all serves practical rather than epistemic purposes. Due to the interdependence of scientific understanding and technological capacities, the consequences of the dominance of practical aims for the prevalent practices of modelling are not straightforward. I will therefore address the questions what of scientific importance can be learned from modelling that primarily aims to be useful, and what are the conditions for the fruitful combination of the practical and epistemic aims of modelling. To this purpose, I present findings from the study of a representative sample of drug development projects. It is found that a type of models that can be called ‘interaction models’ typically plays a crucial role in drug development. Interaction models capture chemical and spatial properties of drug candidates and of their molecular targets and directly guide the search for therapeutically valuable substances. While the interaction modelling enclosed in the development projects varies widely both in specificity and novelty, it turns out to be useful and of epistemic value if it combines in a peculiar way the hypothetical use of existing mechanistic knowledge with developmental risk taking.

Tracking Irrational Sets
Tom Addis, Jan Townsend Addis, Dave Billinge, David Gooding, and Bart-Floris Visscher

We argue from the Church-Turing thesis (Kleene 1967) that a program can be considered as equivalent to a formal language similar to predicate calculus where predicates can be considered as functions. We can relate such a calculus to Wittgenstein’s first major work, the Tractatus, and use the Tractatus and its relationship to the world as a model of the formal classical definition of a computer program. However, Wittgenstein found flaws in his initial great work and he explored these flaws in a new Thesis described in his second great work; the Philosophical Investigations. The question we address is “can computer science make the same leap?” We are proposing that because of the essential flaw identified by Wittgenstein, computers will never have the possibility of natural communication with people unless they become part of human society. The essential difference between formal models and human communication is that formal models are based upon rational sets whereas people are not so restricted. However, formal models are central to our means of using hypotheses through deduction to make predictions about the world. These formal models are required to continually be updated in response to peoples’ changes in their way of seeing the world. We propose that one mechanism used to keep track of these changes is the Peircean abductive loop.

Is there a logic of discovery?
Atocha Aliseda

In this talk, I will provide a critical analysis on the controversial enterprise of ‘logics of discovery’. I start by analyzing the twofold division between the contexts of discovery and justification, showing that it may be not only be further divided, but also its boundaries may not be so sharply distinguished. I then provide a brief history (from antiquity to the XIXth century), divided into three periods in time, each of which is characterized by an epistemological stance (infallibilism or fallibilism) and by the types of logic worked out (generational, justificatory inductive logics, non-generational and self-corrective logics). I then motivate the reformulation of this question into three of them, its purpose, pursuit and achievement, for in general there is a clear gap between the search and the findings in the question of a logic of discovery.

Moreover, I confront two foremost views on the logic of discovery, namely those of Karl Popper and Herbert Simon, and show that despite appearances, their approaches are close together in several respects. I claim that both accounts fall under the study of discovery --when a broad view is endorsed-- and the convergence of these two approaches is found in that neither Simon's view really accounts for the epistemics of creativity at large, nor Popper neglects its study entirely.

Finally, I advance the claim that logic should have a place in the methodology of science, on a pair with historical and computational stances, something that naturally gives place to logical approaches to the logic of discovery, to be cherish in a normative account of the methodology of science.

This talk shows that interest on the topic of the logics of discovery goes back to antiquity and spans over our present days, as it pervades several disciplines, namely Philosophy of Science, Cognitive Science and Artificial Intelligence. The moral of this talk is that the search of a logic of discovery is not a trivial question, in fact is not even a single question, for the words ‘logic’ and ‘discovery’ may be interpreted in several many ways.
A multiagent approach to modelling complex phenomena
Francesco Amigoni, and Viola Schiaffonati

Designing models of complex phenomena is a difficult task that can be tackled by composing a number of partial models to produce a global model of the phenomena. We propose to embed the partial models in software agents and to implement their composition as a cooperative negotiation between the agents. The resulting multiagent system provides a decentralized global model of a phenomenon. We applied this approach in modelling two complex physiological processes: the glucose-insulin metabolism and the heart-rate regulatory system. Beyond the effectiveness demonstrated in these two applications, the idea of structuring sets of models to give reason of complex phenomena is in accordance with current tendencies in epistemology, where it is evident an increasing use of models implemented in software agents for scientific explanation and for simulation purposes. Therefore, our approach to modelling complex phenomena has not only a practical, but also a theoretical significance: agents embedding models are a technology suitable both to representing and to investigating reality.

Abductive Reasoning, Interpretation and Collaborative Processes
Claudia Arrighi & Roberta Ferrario

In this paper we want to examine how the mutual understanding of speakers is reached during a conversation through collaborative processes, and what role is played by abductive inference (in the Peircean sense) in these processes. We do this by bringing together contributions coming from a variety of disciplines, as logic, philosophy of language and psychology. A paper by Davidson (1999) claims that the fact that two or more speakers know the words and the rules of a certain language is not enough in order for them to understand each other. What is required is a specific extra-linguistic competence: the capability of building plausible theories on the intentions of the other participants to the conversation. In other words, during a conversation, each participant forms some hypotheses aimed at giving a correct interpretation of the utterances. These hypotheses allow a sort of “contextualized” interpretation, which makes possible for the speakers to correctly react to unconventional or non codified uses of the language and, at the same time, enables a creative use of language, as in metaphors and malapropisms. This mechanism can be seen as the formation of temporary hypotheses, tested and modified thorough the whole conversation, and it is this aspect that Wirth, in his paper, connects with Peirce’s abduction inference.

Exploiting the Integration of ST-logic and MMASS Models for Pervasive Computing Applications
S. Bandini, S. Manzoni, F. Sartori, and G. Vizzari

The research contexts on which this work focuses on are Intelligent Monitoring Systems (IMS) and Pervasive Computing. A pervasive computing system is characterized by three main features: it is a distributed system, in which some devices that are part of the system are mobile and some are embedded in the environment. In particular, the aim of this work is to propose a framework for the development of IMSs for Pervasive Computing scenario through the integration of two formal and computational models (i.e. the Multilayered Multi Agent Situated System (MMASS) and Spatial-Temporal logic (ST-logic). The resulting agent-based architecture for the development of pervasive IMSs is made of four levels: observation (the state of a monitored field is periodically captured by a specific set of sensors); interpretation (where values detected by sensors are interpreted by dedicated devices); correlation (interpreted data are correlated, in order to identify possible mistakes and avoid the generation of wrong decisions); actuation (specific actions are taken in order to solve possible anomalous or dangerous situations resulted from the correlation of data). The work here presented is part of another project devoted to the design, development and deployment of complex monitoring and control systems based on the correlation of heterogeneous data acquired by different types of sensors through the exploitation of knowledge-based approaches. The framework resulting from the integration of MMASS and ST-logic will be applied within this project to industrial plant monitoring and control. ST-logic will be reference model to allow local interpretations collected by the sensor network while MMASS approach will be adopted in order to model this network as a system of interacting agents that collaborate to fulfill the common goal of monitoring and control the plant.

Using Abduction for Diagramming Group Motions
Bonny Banerjee

Many events, in domains such as military and meteorology, are characterized by a large number of individual moving elements, either in pursuit of an organized activity (as in military operations) in groups at different levels of abstraction,
or subject to underlying physical forces (as in weather phenomena) that group elements with similar motion.

Visualizing and reasoning about happenings in such domains are often facilitated by abstracting the mass of data into diagrams of group motions, and overlaying them on diagrams that abstract static features, like terrain, into regions and curves. Constructing such diagrams of motions at multiple levels of abstraction calls for generating multiple hierarchical grouping hypotheses at each sampled time instant, then choosing the best grouping hypothesis consistent across time instants, and hence following the groups to produce spatial representations of the spatiotemporal motions. Different spatial representations of motions might be useful for different purposes. For example, the well-known Minard's Map of Napoleon's Army is an excellent representation of the tremendous losses Napoleon faced during his Russian Campaign of 1812. Again, representing the same campaign with lines depicting motions of groups might be useful for understanding the maneuver intended by Napoleon’s Army. In this paper, we present an algorithm for constructing diagrams of group motions to be used for visualization by a human user or for reasoning by a problem solver for understanding high-level phenomena. We use a multi-layered abductive inference approach in which hypotheses largely flow upwards from raw data to a diagram, but there is also a top-down control that asks lower levels to supply alternatives if the original hypotheses are not deemed sufficiently coherent. We demonstrate our results deploying the proposed algorithm and discuss several issues related to construction of such diagrams, from data over a few days of a large number of military units engaged in exercises at the National Technical Center, California, USA.

A Diagrammatic Proof Search Procedure
as Part of a Formal Approach to Problem Solving
Diderik Batens

The aim of this paper is to describe a goal-directed and diagrammatic method for proof search. The paper is directed to devising a method that provides insight, rather than to its computational efficiency. The method (as well as one of the logics obtained by it) is particularly interesting in the context of formal problem solving. A typical property is that it consists of attempts to justify so-called bottom boxes by means of premise elements (diagrammatic elements that are obtained from the premises) and logical elements (diagrammatic elements that logically analyse the main goal as well as intermediate goals). Premises are not preprocessed, whence most premises lead to a variety of premise elements. The method is simple and insightful in three respects: (i) diagrams are constructed by drawing the goal node and superimposing the top node of a new diagrammatic element on an unjustified bottom box (a box in which no arrow arrives and that is not a premise box) of an element that already occurs in the diagram; (ii) the diagrammatic elements are built up from binary and ternary relations that connect nodes (comprising one or two boxes) to boxes (entities containing a single formula); (iii) the diagrammatic elements are obtained in view of existing bottom boxes by a unified (Smullyan-like) approach. At the propositional level, the method is an algorithm for (classical) derivability (but leaves certain choices to the user) it may be extended to the predicative level where it provides a criterion for derivability and non-derivability. The method is demonstrably more efficient than tableau methods in that it is strictly goal-directed. It also has certain advantages over prooflike (linear) methods and certain other goal-directed methods. (i) All insights provided by linear methods are easily carried over to the diagrammatic method. (ii) The diagrammatic method keeps insights related to elements, to partial paths and to paths separated, which is especially interesting for reusing elements and partial paths. (iii) It provides local as well as global insights on the derivability and non-derivability of certain formulas. Among the local insights are those related to the formulas justifiable from a premise on certain conditions; among the global ones are those related to the set of formulas that have to be justified in order for a (partial) path to be successful. (iv) It provides insights in the transformations that may be applied to elements and partial paths. (v) It has the unexpected advantage to simplify metatheoretic proofs. The method will be carefully described and its different advantages will be illustrated. The discussion will include ways to improve the efficiency of the method in view of insights provided by it.

Problem-solving in new product development: the role of abduction and virtual simulation
Markus C. Becker, and Francesco Zirpoli

Viewing new product development as a problem-solving activity, the focus in the article is on abduction as a problem-solving strategy. We identify the advantages of problem-solving by way of abduction, as compared to induction and deduction, present a rationale of how to decide between the different problem-solving strategies, and finally, draw on a case study of a main European car manufacturer to analyze how problem-solving by abduction is implemented in practice.
Seeking Allies: Modelling how listeners choose their musical friends  
Dave Billinge, Tom Addis, and Fei Wang

In this paper we describe in some detail a formal computer model of inferential discourse based on a belief system. The key issue is that a logical model in a computer, based on rational sets, can usefully model a human situation based on irrational sets. The background of this work is explained elsewhere, as is the issue of rational and irrational sets (Billinge and Addis 2004), (Stepney et al 2004). The model is based on the Belief System (Addis and Gooding 1999) and it provides a mechanism of choosing queries based on a range of belief. We explain how it provides a way to update the belief based on query results, thus modelling others’ experience by inference. We also demonstrate that for the same internal experience, different models can be built for different actors. The model is limited as to queries used, but it does provide a basis for the process of query and inference to be carried out.

We use the initial decisions made by the participants during their evaluation of the music heard in experimental sessions to initiate the model. We then compare the predicted order of ally choice made by each agent in the model as assessed from the agent’s perception of others, as drawn from a simulated conversation, with the actual outcomes of the sessions. We plan to modify the model to show from recorded conversations of the participants in our experimental sessions how the patterns of questioning compare with that generated by the model. The model has \( n \) actors and \( m \) aesthetic objects. The \( m \) objects in our experiments are pieces of classical orchestral music to which our actor/participants have a response. Actors have a response-scale for each piece of music representing their own subjective impression. Further, an actor has a separate scale of belief for the response to each piece of music for each other actor as derived from a conversation. In the model the actors can ask questions in turn and can only ask one question per turn. Only the actor asking the question can update his scales of belief.

We make three assumptions: that each actor assumes that other actors initially have the same perceptions of the heard music and thus the same ratings; that each modelling actor tends to ask the other actor about the music of which he, the questioner, has the most uncertain belief scale; and that the modeller can have no doubt of his own experience. In this way an actor tracks the subjective experience of others; an experience that may change over time. We also assume that, as supported by our observation of the experimental work with people, an actor will choose as an ally the fellow actor who is closest in \( m \) scale distance. The significance of this result is that it shows subjective experience can be inferred through conversations and we suggest that this may be a major purpose of discussions.

Finally we describe how we expect to adapt the model to fit in with observations to take into account other factors that decide group decisions. Our model should thus become more able to predict conversational behaviour and final group decisions from knowing individuals’ perceptions within this scenario.

Marrying Hempel and Cartwright: From Lies to Laws  
Rens Bod

It is well known that real-world phenomena and systems cannot be formally deduced from laws but that their derivations involve various nondeductive elements such as intermediate phenomenological models, empirical corrections and coefficients. While nondeductive knowledge makes trouble for the deductive-nomological model of explanation (Hempel 1965), we will argue that such knowledge can be aptly integrated by an exemplar-based model of explanation. This model, which is termed “EBE” (Bod 2004), embodies Kuhn’s idea that “Scientists solve puzzles by modeling them on previous puzzle-solutions” (Kuhn 1970: 187). EBE represents explanations as derivation trees that describe each step -- be it deductive or nondeductive -- in linking laws to a description of a phenomenon. Explanations of new phenomena are constructed out of partial derivation trees of previous phenomena. As long as nondeductive knowledge can be stated in terms of mathematical equations it can be fit in a derivation tree, and be reused to solve new problems. We show how EBE integrates theoretical and phenomenological models in fluid engineering, and argue that many empirical corrections and coefficients apply so widely among different systems that they are \textit{de facto} used as “laws”. We agree with Cartwright (1983, 1999) that “the laws of physics lie”, but we argue that they often lie so consistently that it is hard to draw a distinction between lies and laws.

Mechanistic models in the engineering sciences  
Mieke Boon

The use of science in technology is not well understood or even misrepresented in philosophy of science as well as in philosophy of technology. My paper will examine the role of science in engineering. This analysis will lead to the following conclusions. (1) In order to understand the role of science in technology ‘engineering sciences’ should be distinguished as a specific research practice with its own subject matter, cognitive aim and function, and epistemology
and methodology. In short, engineering sciences ‘mediate’ between science and technological design. (2) In existing philosophical analysis of the relation between science and technology a traditional image of science is implicitly assumed, which prevents recognizing the specific character of the engineering sciences qua science. (3) Due to this traditional view, philosophical accounts of the application of science in technology are caricatures and rather simplistic. (4) Recent developments in philosophy of science concerning the role of models in science as well as the renewed interest in the role of causes in scientific explanation are a suitable development for characterizing the engineering sciences. (5) Engineering sciences aim at the construction of models for technological phenomena. In a full description at least three types of models are combined. (6) From this perspective, the role of existing scientific knowledge in the construction of such models of technological phenomena can be clarified. Here I will focus on mechanistic models.

Probabilistic Graphical Models for the Diagnosis of Analog Electrical Circuits
Christian Borgelt, and Rudolf Kruse

We describe an algorithm to build a graphical model—more precisely: a join tree representation of a Markov network—for a steady state analog electrical circuit. This model can be used to do probabilistic diagnosis based on manufacturer supplied information about nominal values of electrical components and their tolerances as well as measurements made on the circuit. Faulty components can be identified by looking for high probabilities for values of characteristic magnitudes that deviate from the nominal values.

A Transconsistent Logic for Model-Based Reasoning
Joseph E. Brenner

Computational and dynamic approaches to cognitive science use fundamentally different models. The former applies algorithms of various kinds; the framework of the latter is that of dynamic systems theory and emergence. Advances in logic are usually associated with the former. Of the published contributions to the previous Conference on Model-Based Reasoning, held in Pavia in 2001, the volume of papers centered on philosophical, epistemological and cognitive questions is sub-titled “Science, Technology, Values”. The other major volume is sub-titled “Logical and Computational Aspects of Model-Based Reasoning”, and its papers are correspondingly oriented.

In the prefaces to both volumes, Magnani notes that many ways of performing reasoning cannot be described using notions derived from classical logic. This statement applies to the relevant issues in somewhat different ways. Ampliative extensions of adaptive logics are useful in certain cases of dynamic reasoning, while providing further scope for the computational approach. For some discussions of reasoning in science, however, even non-classical logics are not directly applicable or are excluded from consideration.

In the paper, we describe the “transconsistent” logical system developed by Stéphane Lupasco (1900 – 1988) and extended by Basarab Nicolescu (1940 – ). It suggests an alternative, dynamic framework for model-based reasoning in science, especially where creativity, values and non-sentential accounts of mental structure are involved. It may offer a new approach to some outstanding questions, such as the interface of models and reality. Its application requires a shift from focus on the axioms and formalism of classical and non-classical propositional or mathematical logic as the criteria of a valid logical system. The Lupasco approach, as a supplement to existing methods of inquiry, could provide insights for new notions of reasoning based on differences in the respective domains of application of the two forms of logic.

Towards Operational Abduction from a Cognitive Perspective
P.D. Bruza, R.J. Cole, D. Song, and Z. Abdul Bari

Diminishing awareness is a consequence of the information explosion: disciplines are becoming increasingly specialized; individuals and groups are becoming ever more insular. This presentation considers how awareness can be enhanced via operational abductive systems. Their goal is to generate and justify suggestions which can span disparate islands of knowledge. Knowledge representation is motivated from a cognitive perspective. Words and concepts are represented as vectors in a high dimensional semantic space automatically derived from a text corpus. Various mechanism will be presented for computing suggestions from semantic space: information flow, semantic similarity, pre-inductive generalization. Some thoughts and initial insights will be presented regarding a logic justification. The overall goal of this article is to introduce semantic space to model-based reasoning and abduction community and to illustrate its potential for principled, operational abduction by automatically replicating the Swanson Raynand – fish oil discovery in medical text.
Surviving Abduction
Walter Carnielli

Abduction or retroduction, as introduced by C.S. Peirce in the sense of looking for explanatory instances, can be seen as a kind of complement for argumentation. From this point of view, it suffers in principle from the triviality objection: any time a contradictory situation occurs, the system collapses and stops working. The traditional remedies for such collapsing are the expensive (indeed, NP-complete) mechanisms of consistency maintenance, or complicated theories of non-monotonic derivation that keep the system running at a higher cost. I intend to show that the robust logics of formal inconsistency, a particular category of paraconsistent logics which permit the internalization of the concepts of consistency and inconsistency inside the object language, provide simple yet powerful techniques for automatic abduction. Moreover, the whole procedure is capable of automatization by means of the tableau proof procedures available for such logics. Some motivating examples are discussed in detail.

The role of simulation models in visual cognition
Arturo Carsetti

As is well known, cognition is not only a self-organising process. It is also a co-operative and coupled process. If we consider the external environment as a complex, multiple and stratified Source which interacts with the nervous system, we can easily realise that the cognitive activities devoted to the “intelligent” search for the depth information living in the Source, may determine the same change of the complexity conditions according to which the Source progressively expresses its “wild” action. In this sense, simulation models are not neutral or purely speculative. The true cognition appears to be necessarily connected with successful forms of reading, those forms that permit a specific coherent unfolding of the deep information content of the Source. Therefore, the simulation models, if valid, materialise as “creative” channels, i.e., as autonomous functional systems, as the same roots of a new possible development of the entire system represented by mind and its Reality. As Kanizsa maintained, the world perceived at the visual level is constituted not by objects or static forms, but by processes appearing “imbued” with meaning. The line per se does not exist: only the line which enters, goes behind, divides, etc.: a line evolving according to a precise holistic context, in comparison with which function and meaning are indissolubly interlinked. The static line is in actual fact the result of a dynamic compensation of forces. Just as the meaning of words is connected with a universe of highly-dynamic functions and functional processes which operate syntheses, cancellations, integrations, etc. (a universe which can only be described in terms of symbolic dynamics), in the same way, at the level of vision we must continuously unravel and construct schemata, simulate and assimilate, make ourselves available for selection by the coordinated information penetrating from external reality, we have, in particular, to continuously adjust our action in accordance with the internal selection mechanisms through a precise “journey” into the regions of intensionality.

Defining knowledge: the Gettier problem and scientific reasoning
Luciano Celi

The aim of more cognitive theories is the explanation of conceptual change and acquisition. Particularly the Theory-Theory (TT) is more interesting for his capacity to create analogies between everyday and scientific reasoning: we often have theories (often wrong!) that try to explain how the world around us works.
A possible model for TT can be found in the analytical definition of knowledge, understood as true and justified belief, that is undistinguished in the case of everyday and scientific reasoning (or theories). However, this ‘historical’ definition of knowledge (to be found also in Plato) isn’t really applicable: in primis for the Gettier criticism. This criticism makes the definition unusable: for this reason, researchers try to find other solutions.
This situation is really similar to the scientist’s way of reasoning, which is often led by extra-scientific criteria to decide if a solution (/theory) is better than another.

Diagrams as Models:
An Architecture for Diagrammatic Representation and Reasoning
Balakrishnan Chandrasekaran

In a sense, all reasoning or problem-solving is model-based, since reasoning involves representations, and representations are models of the domain of discourse. AI and cognitive science by and large subscribe to the “Language of Thought” hypothesis, which treats thinking as taking place on a representational substrate made up expressions composed of symbolic predicates. Thus, in much AI work on problem solving as goal-directed reasoning, goals, knowledge, and problem states are all taken to be such representations, and information generation is modeled as application of inference rules on such representations. On the other hand, phenomenological accounts of our own
thought reveal that the cognitive state is multi-modal: while our linguistic component of our thought does have this characteristic, we also experience, as part of our cognitive state, perceptual images in different modalities. Diagrammatic representations are often a significant component of such cognitive states, especially during problem solving. During problem solving, in addition to traditional inference as application of rules on linguistic representations, we often apply – or think we apply – some kind of internal relational perception on diagrammatic images to generate information during problem solving. When diagrams are external, use of visual perception to obtain information from them as part of problem solving activity is common and uncontested. Diagrams are especially effective because some information that is entailed by given information is explicitly available – as emergent objects and emergent relations – for pickup by visual perception. While diagrams and other visual representations are ubiquitous as domain models, relatively little has been said about them as fundamental representational types in AI.

In this paper, I describe a bi-modal architecture for problem solving in which diagrams and predicate symbolic representations are co-equal representational modes. Problem solving proceeds opportunistically – whichever modality can solve a subgoal, perception on the diagrammatic component, or inference on the symbolic component, is allowed to make its contribution at each cycle. I describe an abstract data type called a diagram as a configuration of diagrammatic objects composed of instances of three types of objects, point, curve and region. A set of perceptual routines recognize emergent objects and evaluate a set of generic spatial relations between objects in a diagram; and a set of action routines create or modify the diagram in the service of problem solving goals. I describe the application of the architecture in the solution of problems involving information fusion.

While I think the work I describe is potentially quite useful as technology, I also discuss the implications of the work for cognitive architecture. I think cognitive architecture is fundamentally built on top of perceptual and kinesthetic representations, which play a deeper role in thinking than the traditional roles assigned to perception as getting information from the world, and to action as executing decisions. Internal images corresponding to perception and action participate in thinking, and the work I describe on diagrammatic representations suggests what a more fully developed multi-modal cognitive architecture would look like.

**Thought Experiments and Imagery in Expert Protocols**

**John J. Clement**

This paper focuses on case studies from think-aloud protocols with expert scientists solving explanation problems in which they appear to make predictions for novel systems they have never seen by “imagining what will happen” or “running” the system in their heads. This raises what I call the fundamental paradox of thought experiments, expressed as: “How can findings that carry conviction result from a new experiment conducted entirely within the head?” I refer to the category of untested thought experiments (in the broad sense) as the act of predicting the behavior of an untested, concrete, but absent system. In the cases studied here certain imagery-related observations such as spontaneous imagery reports and depictive hand motions co-occur with the prediction from a thought experiment. These co-occurrences can be explained via a hypothesized internal process of imagistic simulation, wherein one or more perceptual motor schemas generate dynamic imagery that depicts anticipations built into the schema. I expand this concept and use it to begin to address the fundamental paradox above.

Experts were also observed generating a special kind of thought experiment in a narrower sense that I call an evaluative Gedanken experiment: an untested thought experiment designed or selected by the subject to help evaluate a concept, model or theory. I believe both the broad and narrow categories of thought experiments as clarified here are useful, and both can be analyzed in think aloud protocols. The broad concept is appropriate for expressing the fundamental paradox. The narrower concept of an evaluative Gedanken experiment encompasses some famous thought experiments in the history of science, impressive in that they can even contribute to eliminating an established theory. Analyzing the nature of imagistic simulation can contribute to our understanding of how thought experiments work.

**An inductionless, default-based account of machine learning**

**Edoardo Datteri, Hykel Hosni, and Guglielmo Tamburrini**

It is often claimed that some mechanical learning systems perform epistemically justified inductive generalization and prediction. Moreover, models of sensorimotor coordination, including mechanical learning modules, actually succeed in replicating many aspects of adaptive behaviour that are typically explained by referring to inductive capabilities. Restricting ourselves to a representative class of learning machines, we argue that they fall short of bolstering the inductivist case in epistemology and the philosophy of science. Secondly we move on to consider a logical, induction-free, analysis of these learning procedures by means of a family of non-monotonic consequence re-lations. Our first example is drawn from behaviour-based robotics, and focuses on systems that learn from experience. We show how crucial assumptions about environmental features are embodied in the learning module of a repre-sentative behaviour-based architecture. Accordingly, the epistemic problem of induction is reformulated as the problem of whether these
background assumptions make it reasonable to believe the associated projections about behavioural rules and environmental properties. The same epistemic problem is more informatively addressed by reference to the symbolically richer, ID3-style machine learning algorithms. A sweeping problem in learning from examples – the overfitting of training data – jeopardizes the idea that epistemically justified inductive processes are at work there. Accordingly, we advance a different view of ID3-like projective behaviours, which brings to the fore the central role of deductive trial and error-elimination processes in autonomous learning mechanisms. Then, the opportunity of developing an induction-free logical analysis of this multifaceted reasoning process is considered by reflecting on some families of non-monotonic, albeit deductive, consequence relations. These enable one to frame mechanical projections of learning hypotheses from observed samples into more comprehensive inference processes enabling agents to retract falsified learning hypotheses and to modify underlying knowledge bases in suitable ways.

Model Validation, Evolutionary Systems and Semantics of Information
Gordana Dodig-Crnkovic, and Sandra Ijeoma Irobi

Computer science and engineering form the very heart of innovative technology and hence their landmark contributions cannot be overemphasized. Addition of new functionalities and maintenance of technological products such as complex critical systems are to a large extent dependent on model-based results and predictions, which thus assume a place of central importance.

The way the predictions of valid models yield information on which vital technological decisions could be based is a major issue of consideration in this paper. We explore the role played by information as defined by Floridi’s Theory of Strongly Semantic Information which basically consists of ‘content and truth’ and the prevailing concept of information as meaningful data from the model-based reasoning perspective of empirical sciences.

We argue that meaningful data does not necessarily have to be true to constitute information. Partially true information or even completely false information can lead to the ‘true’ outcome. Instead of insisting on the truth value of an empirical model, we choose to focus on the two basic concepts: correctness (validity) of the model and its appropriateness within a certain well-defined context. The meaning of the information content of the model is strongly contextual. We illustrate the chain of transformations of the encoded raw information from its basic form to its refining via feedback mechanisms of interactive models till the incorporation into knowledge represented by theories. A special chapter is devoted to the example of evolutionary systems and their modelling.

It is our conclusion that even though valid empirical models could in general only be ‘probable’ and not ‘true’, and therefore may not serve as sole decision-founding grounds for the target systems, they may produce adequate results and data on which very essential conclusions could be drawn. In that sense they can yield information vital for improving our knowledge about the actual empirical world that is also the precondition for the technological innovation.

There exist two models of organization of a scientific theory
Antonino Drago

Along two millennia Euclidean geometry played the role of the one model for a scientific theory. Actually it applied the Aristotelian model of the deductive science. A century ago Hilbert improved this model to an axiomatic organization. However, the subsequent Goedel theorem proved that any axiomatics results to be an incomplete one.

But some centuries before a different model than the "rational one" was verbally described by Leibniz, D'Alembert and Lazare Carnot ("empirical theory"), and recently in theoretical physics by both Poincaré and Einstein ("principle theory").

An inspection on past scientific theories shows that several founders organized their theories in a different way from the Aristotelian ideal: L. Carnot, Lavoisier, S. Carnot, Lobachevsky, Bolyai, Galois, Boole, Klein, Brouwer.

A comparative analysis of these theories suggests the following characterization of such an ideal. The theory puts an universal problem and then looks for a new scientific method capable to solve it. Then it develops this searching through some cycles of arguing; each cycle includes some double negated sentences, each one being not equivalent to its corresponding, positive sentence; hence, it belongs to a non-classical logic (e.g., intuitionistic logic). Eventually a completeness proof upon all cases at issue is obtained by means of an \textit{ad absurdum} proof, whose final sentence is the double negation of the thesis, \( \neg \neg T \). At this point, the author can think to have reached enough evidence for promoting the above conclusion to a positive statement by changing it into \( T \), that is for transgressing from the problem-based theory to an entirely deductive theory. This passage is almost the same as what Markoff claimed to be a principle.

In order to show in a detailed way the new model through an instantiation. The original Lobachevsky's theory of parallels (1840) is improved according to the characteristic features of the new model.
Since the resources in science are limited [1], it is necessary to optimize the research and reduce the respective costs and/or raise the outcome. Currently, research is mostly organized in research projects. A project is a set of actions with a concrete aim, a defined beginning and a defined end. Accordingly, a research project is intended to provide results within a limited period of time. In contrast to projects, a research program is a structure that provides a guideline for future research projects [2]. Such a guideline can be seen as a meta-model for research. It can have positive as well as negative influences on the outcome. Negative heuristics of a program comprise the condition that the underlying assumptions, the hard kernel, can neither be disapproved nor changed. The positive heuristics contains rough guidelines for the development of the research program. We will analyze the current viewpoint on research projects with an emphasis on studies, show lacks of the current viewpoint, and propose an extended research program.

Today, small teams of scientists erratically define single scientific studies, write a proposal, and send it to the refereeing board. In case of a funding, the study is carried out and the results are published. However, it would be more efficient to organize multiple research projects within a comprehensive program and thus optimize the application of the resources.

Therefore, a meta-model (paradigm) has to be established that comprises (a) the representation of the state-of-the-art decision knowledge, (b) the adding of new research questions, (c) the performing of trials to answer these questions, and (d) the revision of the current model.

It will be shown in detail how to structure studies within one research program in the future. Moreover, it will be discussed how to organize multiple studies within one research program.

Illustrations

Figure 1: Current procedure for the establishment of a study.

Figure 2: Extended and iterative approach for the definition of studies within an ongoing research program. Adding decision alternatives from real-life cases. Inactivate falsified decision alternatives in the decision tree.

**Analogical Reasoning with Sketches**

Kenneth D. Forbus

People often use sketches when reasoning through complex problems. This includes using analogies, involving both visual and conceptual knowledge, with prior sketches. This talk will describe a computational model we have developed for doing such reasoning, being explored through a new cognitive architecture, Companion Cognitive Systems.

**Abducting Abduction**

Is the methodology commonly used in abductive research disguising abduction for the inquirer?

M.Phil. Torgeir Knag Fylkesnes

The research into the rationality of abduction on the basis of examples (as related to deduction) throws “closed-box”-metaphysical shadows, where new information is derived from the same elements. It is therefore necessary to propose a distinction between “examples” and “cases”. Most research on abduction use examples as a mean to justify theories. An "example" is by definition connected to the theory that it denotes. An example exemplifies a thesis and acts therefore self-referring to the proposed theory. Examples work deductively within the frame of the theory and is generated on the basis of a theory. A “case”, on the other hand, “exists” with or without an explanatory thesis. As such, examples are exemplars of a theory, or “types” as Peirce may have put it, while cases, I hold, are related to the peircean method of experimenting.
Also, a “generated” example only reveals to us the *process* that the theory allows, while cases allow insight into processes that may contradict our theories. Cases are therefore important tools into creative processes where examples naturally come short.

Making use of examples, enable us to show how a theory works in a specific situation and in this way provide new areas of application. This is an important function as it reveals the areas that the theory acts upon (or not). Example-based inquiry resembles therefore deduction. Cases, on the other hand, are instances that are detached from the theory. First one describes the case, giving the case an independence from the theory, and then one tries to relate the theory to that case. In this way it exists independently of the analytical tools and works abductive. Following Peirce, one might say that case-based inquiry is experimental inquiry.

Example-based inquiry into abduction work evading. One inquires not into abduction, because the method is not abductive. Since there are elements in the abductive process that escapes formalisation, the inquiry of abduction must stem from the analyses of the entire process that leads to the formation of new hypotheses. Therefore, a general theory of abduction must be created on the grounds of a methodology that follows the principles of abduction.

**Modelling Scientific Experiments as Mediating Models**  
D. C. Gooding and T. R. Addis

We describe a model of experimentation conducted by agents who can interact, in order to illustrate an approach to discovery simulation. This aims to integrate formal and empirical approaches in order to include some of those features of science that philosophers, historians, and social and cognitive scientists identify as important for understanding the conduct of science. Our approach is to work from historical case studies of experimental scientists involved in the interpretation and development of novel, anomalous phenomena, using cognitive and ethnographic. These studies provide information about the structure of investigative processes and the types of information exchanged between observers. Empirical studies serve as sources for models which, when implemented and run as a computational model, simulate a network of interacting scientific agents. They also provide empirical benchmarks against which the behaviour of the simulation can be validated. In this paper we develop the argument that experiments can be considered as models of the particular aspects of reality they are designed to investigate, so in order to model experiments we need to identify and represent in our simulation, those features that all experiments have in common. These features can then be treated as parameters of a model of experiment, so that different types of experiment can be modelled by varying these parameters. Each particular experiment is treated as an instance of the model. We will describe the generalized model, how it represents different types of experiment, and provided examples of how each instantiation behaves under simulation.

**Technological Thinking and Moral Imagination**  
Michael Gorman

This talk will include two case studies of invention. The first focuses on a classic heroic individual inventor, Alexander Graham Bell, whose cognitive processes will be represented visually. Bell, of course, did not work in isolation, so the analysis will include his competition with another inventor, Elisha Gray. The second case involves an interdisciplinary design team that developed a new fabric which embodied environmental sustainability. Again, the invention path will be represented visually, and the role of moral imagination explained. The talk will include by briefly examining the frontier of work in scientific and technological thinking.

**Trading Zones, Moral Imagination and Socially Sensitive Computing**  
Michael Gorman

This paper will provide a framework for socially sensitive computing, based on trading zones and moral imagination. Frameworks differ from models in that the former provide an orientation, a way of organizing an approach to a new domain, whereas the latter provide a formal structure that is more useful later, after the boundaries of the domain are clearer and preliminary exploration has been completed. The trading zone metaphor has been applied to the development of particle accelerators, radar, MRI and the Mars Polar Lander (Baird & Cohen, 1999; Peter Galison, 1999; Lambert & Shaw, 2002). Communities separated by apparently incommensurable epistemological barriers can still trade by means of a reduced common language, or creole. This creole can involve both mutually agreed meanings for existing terms, and the development of new terms.
The emergence of symbolic algebra as a shift in predominant models
Albrecht Heeffer

Historians of science find it difficult to point to an exact period in which symbolic algebra came into existence. Partly because the historical process leading to this breakthrough in mathematics has been a complex and diffuse one, but it might also be the case that historians of mathematics, early twentieth century, have over emphasized the achievements in algebraic procedures and underestimated the conceptual changes leading to symbolic algebra. This is our attempt to provide a more precise setting for the historical context in which this decisive step to symbolic reasoning took place. For that purpose we will consider algebraic problem solving as model-based reasoning and symbolic representation as a model. This allows us characterize the emergence of symbolic algebra as a shift from a geometrical to a symbolic mode of representation. Symbolic representation, to which we are so accustomed, is so predominant in our mathematical reasoning that it becomes very difficult to look behind historical barriers. Babylonian algebra is an example where the geometrical model has long remained unrecognized. We analyzed about twenty algebraical manuscripts and books between 1460 and 1577 for methods and models in solving arithmetical problems leading to a set of simultaneous linear equations. We approached the original texts from the view point that the concept of an equation was not yet developed. In order to follow the problem-solving processes, we divided the original text in relevant fragments, accompanied by a meta-description in symbolic form. We considered mathematical objects to be present when: 1) they are consistently referred to within similar contexts, and 2) they are acted upon by mathematical operations. Our analysis of symbolic algebra as model-based reasoning allows us to point to 1539-1559 as the important shift in predominant models.

On Abductive Equivalence
Katsumi Inoue, and Chiaki Sakama

We consider the problem of identifying equivalence of two knowledge bases which are capable of abductive reasoning. Here, a knowledge base is written in abductive logic programming. In this work, we will give two definitions of abductive equivalence. The first one, explainable equivalence, requires that two abductive programs have the same explainability for any observation. Another one, explanatory equivalence, guarantees that any observation has exactly the same explanations in each abductive program under the common set of abducibles. Explanatory equivalence is a stronger notion than explainable equivalence, and in fact, the former implies the latter. We show that explanatory equivalence can easily be checked by means of the notion of strong equivalence, which has recently been recognized as an important concept in logic programming. We also discuss how the two notions of abductive equivalence can be applied to extended abduction, where abducibles can not only be added to a program but also be removed from the program to explain an observation. For this purpose, we need to extend the notion of strong equivalence by taking removals of rules into account. The new equivalence criterion called update equivalence is suitable to take program updates into account when two logic programs are compared.

Correctness criteria for models’ validation – a philosophical perspective
Irobi Ijeoma Sandra

Valid models are central to the existence of Computer science as in most other disciplines, but at what point can one say that a model is valid and hence correct?

A model is often taken to be an abstraction and simplification of reality (of the system being modelled) but reality (the nature of measured data, environmental and human factors) in itself, has a nature of abstract complexity, hence a ‘correct’ model could at best be judged as one which is ‘closest’ in representation to the real system, but the question is just exactly how close should ‘closest’ be to be correct?

In this paper, we shall examine some common and general correctness criteria for models validation and seek to relate them to various philosophical perspectives to see how much information the basis of acceptance of such valid models could give (content and truth).

We shall also strongly explore and consider the salient philosophical angle, which presents validation only as a method to improve the level of confidence in a model and not a demonstration of its ‘truth’ content. Models should not be used as a substitute or sole basis for critical thoughts, considerations or major decisions but should be viewed just as a tool for improving judgement and intuition.
The Role of Specific and Abstract Hypotheses in Anomaly Resolution
Andreas Keinath, and Josef F. Krems

The successful resolution of anomalous data is an important factor in many tasks, like scientific discovery or medical diagnosis. While there exist some studies on psychological responses to anomalous data little attention has been paid on the role of the initial and therefore by an anomaly contradicted hypothesis. However, some studies in the domain of medical diagnosis suggest that there is a difference between abstract (e.g. heart disease) and specific hypotheses (e.g. valvular defect) in anomaly resolution. Two experimental studies were designed to clarify if abstract hypotheses facilitate anomaly resolution and if there are differences in strategy selection. In our first experiment (N =30) we used predefined data-sets while in the second experiment (N = 30) participants were free in generating their own data after occurrence of the anomaly. Both experiments revealed consistent results. Tasks in which an anomaly contradicted an abstract hypothesis were solved more often and faster. Additionally, experiment two showed that participants in the abstract hypothesis condition needed less data to resolve the anomaly correctly. Our results are discussed within the Scientific Discovery as Dual Search (SDDS) framework of Dunbar & Klahr (1988). Our results support the interpretation that abstract hypotheses seem to trigger hypothesis space search while specific hypotheses trigger instance space search resulting for example in different solution times for abstract und specific hypothesis tasks. Although our main results fit into the SDDS framework further specifications are discussed in the light of hypothesis type (abstract vs. specific) and strategy selection.

Simulative modeling in physics and access to reality: The practice of modeling in contemporary condensed matter physics
Ismo T Koponen

The use of models and modeling has long traditions in physics and each year the leading journal series in physics publish hundreds of articles explicitly addressed to modeling. This activity reflects the immense importance of models in physicists' daily work. Examination of the situations where models are used in context of customary cases and problems, such as encountered in condensed matter physics, can contribute much to our understanding of simulative modeling.

In this study I take a closer look on the simulative modeling in contemporary condensed matter physics. The viewpoint chosen here is based on Giere's picture of models; clusters of models gradually building up more and more complete representations of reality. Special attention is devoted to notion of similarity. I argue that in simulative modeling in condensed matter physics the similarity is established mainly through the experimentally accessible processual similarities, which are established by "running the model" and by "running the experiment". In making the match between virtual reality of simulative modeling and real systems the matter of importance is to establish the "empirical adequacy" of the models (or clusters of models) used.

I discuss here the simulative modeling by using examples from surface growth phenomena. These examples help to contextualize the general notions; they also bring forward the important interplay between experimental imaging techniques and mathematical modeling. The proposed viewpoint helps to see, how microscopic reality is made accessible through the simulative modeling. The resulting picture, I believe, is close to views of physicists working in the field of condensed matter physics.

Theories looking for domains. Facts or fiction?
Structuralist Truth Approximation by Revision of the Domain of Intended Applications
Theo A. Kuipers

This paper starts with recapitulating the structuralist theory of truth approximation, as developed in ICR, and then elaborates a point that was put forward by Sjoerd Zwart earlier (1998/2001). In ICR (p. 207) I wrote, in concluding the second chapter (Ch. 8 of the book) on truth approximation:

"Finally, variable domains can also be taken into account, where the main changes concern extensions and restrictions. We will not study this issue, but see (Zwart 1998/2001, Ch. 2-4) for some illuminating elaborations in this connection, among other things, the way in which strengthening/weakening of a theory and extending/reducing its domain interact."
More specifically, in this paper I propose a coherent set of definitions of 'more truthlikeness', 'empirical progress' and 'truth approximation' due to a revision of the domain of intended applications. This set of definitions seems to be the natural counterpart of the basic definitions of similar notions in ICR as far as theory(-core) revision is concerned. The formal aspects of theory and domain revision strongly suggest an analogy between truth approximation and design research, in particular drug research. Whereas a new drug may be better for a certain disease than an old one, a certain drug may be better for another disease than the original target disease, a phenomenon which was nicely captured by the title of a study by Rein Vos (1991): "Drugs looking for diseases". Similarly, truth approximation may not only take the shape of theory revision but also of domain revision, naturally suggesting the phenomenon of "Theories looking for domains". However, whereas Vos documented his title with a number of examples, so far I did not find real-life empirical instantiations of the analogy, only, as such very interesting, non-empirical ones.

New Foundations for Geometry and Computation
Michael Leyton

In a series of books, I have developed new foundations to geometry that are directly opposed to the foundations to geometry that have existed from Euclid to modern physics, including Einstein. The central proposal of the new foundations is this: **Shape is the same thing as memory storage.** In other words, what we take to be memory storage is shape, and what we take to be shape is memory storage. This contrasts with the standard foundations for geometry that have existed for al-most three thousand years. In the standard foundations, a geometric object consists of those properties of a figure that do not change under a set of actions. These properties are called the **invariants** of the actions. Geometry began with the study of invariance, in the form of Euclid’s concern with **congruence**, which is really a concern with invariance (properties that do not change). And modern physics is based on invariance. For exam-ple, Einstein’s principle of relativity states that physics is the study of those properties that are invariant (unchanged) under transformations between observers (invariants of Lorentz transformations). Quantum mechanics studies the invariants of measurement operators (invariants of unitary transformations). Although much of modern geometry (e.g., the basis of relativity) is called "non-Euclidean", it is, in fact, based on Euclid’s fundamental concern with invariance.

However, my books have argued that the problem with invariants is that they are **memoryless**. That is, if a property is invariant (unchanged) under an action, then one cannot infer from the property that the action has taken place. Thus I argue: **Invariants cannot act as memory stores.** In fact, since standard geometry tries to maximize the discovery of invariants, it is essentially trying to maximize memorylessness. **Geometry, from Euclid to modern physics, including Einstein, maxi-mizes the erasure of memory storage.**

Scientific cognition as model-based reasoning
Ping Li and Dachao Li

A view of scientific cognition as model-based reasoning has increasingly occupied the literature for recent two decades, and the accounts of mental modeling have provided an elementary understanding of the cognitive basis of scientific reasoning. This presentation addresses the processes of problem solving via mental modeling occurring in the scientific mind, a kind of representational-computational apparatus and a construct useful to a cognitive theory of science, and some basic features of such kinds of processes called as 'model-based reasoning'. We use these features to characterize scientific practices in normal science and thus re-examine some important insights of philosophy of science. Our analysis of scientific cognition as MBR includes: (a) a distinction between the singular problem of mental models (MMs) -- a question of what is the nature of MMs and of why such mental representations can be called as 'models' -- and the plural one -- a question of the representational forms of models used in model based reasoning in favor of avoiding a potential conceptually confusion in current literature; (b) an emphasis on the role of working memory (WM) in mental modeling; and (c) an illustration of more real situations of reasoning based on multi-models with multi-forms of mental representations for scientific cognition.

Visualization and E-commerce: How Animation Increases Trust
Thessa Lindof, Dennis Dideriksen, Martin Weibel, Tina Hjorth-Jensen, and Dennis Ballin

In this article we investigate the effect of visualization in the perspective of giving rise to a higher sense of security in users of online stores. We had an initial hypothesis stating that with an increased use of graphical visualizations, it is possible to create a feeling of trust in some users, towards e-commerce. But first we had to identify the reason of the users’ lack of confidence in e-commerce.
Even though many e-commerce sites try to inform the users through various pages describing security issues like encryption and security seals, we found that a significant problem was that some users had next to no knowledge of online security. Through a quantitative questionnaire we found a direct connection between this low level of knowledge and the grading of the security level of a specific site. The lesser the knowledge of online security, the lower the level of the site’s security would be graded. Our aim was then to increase the knowledge of security, and with that, also the grading of the level of security. With an increasingly higher grading of this level, our hypothesis was that the confidence in e-commerce would also increase.

As hoped, the research actually showed that our specific group of users was more capable of understanding the complexity of online security, after they viewed our animations. This was partly demonstrated in the participants increased ability to discuss the effects of encryption and the possibility of hacker-attacks. However the higher understanding of security, didn’t seem to convey more need for shopping online. But another valuable effect, of the animation, was discovered. The animations resulted in a eagerness to discuss security aspects. The participants seemed to be more interested. This needs further research.

A Model-Based Approach to Robot Fault Diagnosis
Honghai Liu, and George M. Coghill

This paper presents a model-based approach to online robotic fault diagnosis: First Priority Diagnostic Engine (FPDE). The first principle of FPDE is that a robot is assumed to work well as long as its key variables meet task requirements, based on which it narrows faults down to different fault levels ad fault categories. FPDE consists of four modules: the bounds generator, interval filter, component-based fault reasoning (core of FPDE) and fault reaction. The bounds generator calculates bounds of robot parameters based on interval to denote corresponding faults. The core of FPDE carries out a two-stage diagnostic process: first it detects whether a robot is faulty by checking the relevant parameters of its end-effector, if a fault is detected it then narrows down the fault at component level. FPDE can identify single and multiple faults by the introduction of characteristic values. Fault reaction provides an interface to invoke emergency operation or tolerant control, even possibly system reconfiguration. The paper ends with a presentation of simulation results and discussion of a case study.

Algorithms for Computing Conflicts and Diagnosis
Shangmin Luan, Lorenzo Magnani, and Guozhong Dai

In this paper, algorithms for computing minimal conflicts are presented. The relationship between minimal conflicts and minimally inconsistent subsets is discussed firstly. Then an algorithm for computing all minimally inconsistent subsets, which is applied to generating all minimal conflicts, is introduced. Furthermore, an algorithm for computing all minimal conflicts using structured description is introduced, and its correctness is proved, and its time complexity is also shown. The algorithms for computing diagnosis are also introduced. At last, the algorithms are compared with related works. The algorithm using structured description terminates in polynomial time for some special system.

Mimetic Minds
The role of Cognitive Mediators and External Models
Lorenzo Magnani

The imitation game between man and machine, proposed by Turing in 1950, is a game between a discrete and a continuous system. In the framework of the recent studies about embodied and distributed models the machine Turing’s “discrete-state machine” can be seen as an external cognitive mediator that constitutively integrates human cognitive behaviour. Through the description of a subclass of the cognitive mediators I call “mimetic minds”, the presentation will deal with some of their cognitive and epistemological aspects and with the cognitive role played by the manipulations of the environment that includes them.

Simulation for the shift of paradigm
Stanislava Mildeová

First question that comes to our mind is how we usually think and why it brings such difficulties in conjunction with complex systems. To answer this question, we have to analyse our mental models.
It is obvious, that mental models as a representation of the world around are quite limited in comparison to its complexity. There still exists certain influence of conventionality and the current paradigm of perception of reality – mainly the linearization and tendency to omit feedbacks and delays. 

How can we reach required shift in thinking and the ongoing development of cognition? How can we understand important characteristics of the complex systems?

The objective of this paper is to indicate the possibility of overcoming the drawbacks given by the characteristics of people's mental models; the possibility, how can we use the knowledge gained from System dynamics for thinking development;

Here, the System dynamics is perceived as a methodology that allows simulation modelling that uses changes in time and the effect of feedback.

So described simulators were constructed according to principles of System dynamics. The author will summarize her own findings, how to conduct simulations on System dynamics models and how to represent the outputs in a form of a user-friendly interface, i.e. how to create simulators, in which the user can experiment with the model in a compressed time and space and enrich his or her own mental model of the problem situation.

It concentrates on models’ transformation on simulators, presents newly created simulator, discusses problems and communicates practical experience, that arose in the stage of creation of the user interface, it deals with the process of visualization during the interface design and its two aspects - content and form.

Simulators are shown as a tool that allows enhancing of our mental models and can help us with the desired shift in reasoning; as „learning labs”, allowing description of the complex system.

**Mediated processes of abductive search**
Sami Paavola, and Kai Hakkarainen

For Charles Peirce, one important basis for abductive inference was to explain how people have managed so quickly to find true and successful theories. According to Peirce, this could not have happened by chance because there would not have been enough time for that depending on trillions of hypotheses that could *in principal* be explanations for some specific phenomena. Peirce’s own explanation was to maintain that abductive reasoning has its basis on some sort of an instinct. Also other kinds of explanations can be offered for our abductive success. Various metalevel principles can guide the process of reasoning, like consilience and coherence. It can also be maintained that *strategic* rules of putting various moves of abductive reasoning together guide the abductive search. In this presentation we delineate still another kind of an explanation. Abductive inferences (when seen as a part of actual reasoning processes of inquirers) should be “embedded” to the more general interaction with surrounding material, social and cultural environment with historical time-span. This idea has its basis on Peter Skagestad’s interpretation of Peirce’s epistemology in general, according to which Peirce’s theory of signs should be read through an “augmentationist” framework, or as a form of evolutionary epistemology. As we see it, this goes nicely together with L. S. Vygotsky’s famous idea that human activity is always (culturally) *mediated* in nature. In short, we analyze those elements that guide and instigate abductive search for new hypotheses in actual, long-term processes of inquiry where such things as cultural and social practices and artifacts direct the search and interaction with the concrete objects of inquiry, besides purely inferential principles.

**The Pragmatic Logic of Ordered Representations**
Helmut Pape

The aim of this paper is to bring out the notion of formal order as an systematic, overall notion in Peirce’s pragmatism. This is done by showing that two on the first glance quite unrelated theories, the logic of abduction and the system of visual logic, the so-called existential graphs, have been constructed with the same ordertheoretic and semantic notion in mind, that has its roots in an analogy of how visual processes take place: The partial ordering of valid representations and logical formulas. Furthermore, I show that this idea is also a motivating force behind pragmatism’s logic of science. In this way, an aspect of the formal unity that motivates Peirce’s pragmatic philosophy is made explicit.

**Tacit Knowledge, Innovation and Institutional Complementarities**
Corrado Pasquali

An extensive empirical literature shows how a general trend can be observed in technological innovation which is characterized by an increasing degree of importance of non tangible capital accumulation. Substantial differences can be observed in the rate of factor input saving related to innovation.
The very existence of these differences is a strong argument against classical theories of the neutrality of technological innovation (i.e. Hicks, Salter, Harrod). At the same time, the pattern of non-neutrality in the direction of technical progress has undergone major changes in the last years.

The very role of knowledge in productive processes and its institutional definition has changed in the direction of an ever increasing degree of appropriability and codification which is rather independent from its embeddedness in physical objects. This is well witnessed by a deep restructuring process of institutional settings and property regimes regulating the use and exchange of knowledge as a productive factor.

In my paper I will try and set forth a tentative anlysis of the interplay between the use of knowledge in production and the institutional settings and complementarities which regulate it. In particular, I will focus on the relation between non neutrality, reduction of the tacit dimension of knowledge and property rights regimes.

Environmental Mental Models: Applying Repertory Grids to Cognitive Geoscience and Risk Perception Studies
Luca Pezzullo

This research is related to a new methodological approach in Mental Models and Risk-Perception studies in Cognitive Geosciences, based on a constructivist psychological tool (Repertory Grids). Cognitive Geosciences represent the most recent development of the Seventies’ “Perception Geography” research program; these disciplines aim to enhance methodological approaches and theoretical analysis of human-environmental interactions, focusing on Cognitive Science studies. A promising methodological approach in Cognitive Geoscience is the “Repertory Grid Technique” (a PCP tool developed by Kelly). A RepGrid requests the subject to "elicit" his own personal meanings and cognitions related to environmental objects and geographical structures. The elicited meanings, through a simple but well-structured evaluation phase, will be translated in a correlational matrix, and then analysed with factorial analysis, correspondance analysis and cluster analysis procedures. This knowledge elicitation procedure reveal the “subjective” geographical mental models held by people, and the specific ways they use to “make sense” of geographical and physical processes in their own natural environment. Knowing these previously "unexpected" correlations about environmental elements allows a deeper understanding of cognitive dimensions of geographical representations, and it’s really useful for disaster reduction planning. Repgrids, a mix between quantitative and qualitative techniques based on correlational psychometrics, could therefore be conceived as a cognitive approach in Geoscience studies. These tools have many interesting theoretical attributes, and powerful computational, methodological, features, therefore showing a good potential as an innovative Mental Models methodology in many “on-the-wild” settings. The present research tests the application of Repgrids to people living in a risk-prone area as the Venice Lagoon (recurrent floods, water pollution, high-risk chemical contamination from Porto Marghera Industrial Area, etc…). The first results show many counterintuitive, interesting, “anomalies” in the subjective mental models held by people about flood processes.

Qualitative Modeling for FMEA Automation: Open Problems and Research Challenges
Claudia Picardi, and Peter Struss

It has been said several times that "modeling is the bottleneck" in a widespread exploitation of qualitative model-based systems in real-world applications. On the one hand, the lack of a standardized framework for qualitative modeling makes it difficult for industrial users to cope with requirements models must fulfil in order to be usable and useful. On the other hand, technical problems still unsolved can prevent a human modeler from meeting those requirements, thus making the whole modeling process highly empirical and error-prone, without the guarantee of a satisfactory result.

This paper stems from the experience we had in bringing qualitative modeling towards industry within the AUTAS European Project.

The goal of the paper is first of all to unravel the main problems (both practical and theoretical) that hinder the diffusion of qualitative modelling into industry. Each of them can be ascribed to one or more of the requirements that qualitative models should meet in order to be successfully exploited. The second and more important goal is to highlight the research challenges whose investigation may lead to overcome existing obstacles, and clear out the road to a positive exploitation of qualitative model-based system in industrial applications.

In particular, we advocate the need for automated support to modeling activity, in the form of a software environment that helps the industrial user in building, debugging and testing qualitative models, automating when possible the production of qualitative models, easing the integration between automatically generated models and manually built ones, and supporting the aggregation of basic component models into complex systems.
As it is now, this is a rather ambitious goal. The paper will discuss existing research in this direction, as well as the open problems that must be faced and solved in order to make it a tangible opportunity.

**Gestalt effects in abductive and counterfactual inference**
Claudio Pizzi

Abductive and counterfactual inferences are here treated as paradigm cases of reasonable inference. Reasonable inference is seen in its turn as the most important kind of rational inference, being the one in which one or more natural laws connect essentially, in ways which may be highly complex, the supposition with the derived conclusion. In rational inference drawing a conclusion is seen as making a choice among a set of exclusive and disjoint statements which receive maximal probability from different subsets $K'$ of the set $K$ of background information elements. The selected conclusion $C$ is the one which follows from the most informative $K'$ compatible with the hypothesis $A$.

Goodman’s paradox shows that in inductive inference (the paradigm case of rational inference) the “natural” conclusion is actually the result of a selection among incompatible but legitimate conclusions, and is selected since it is the only one compatible with the so-called Principle of the Uniformity of Nature. The same mechanism may be seen to be at work, mutatis mutandis, in counterfactual and abductive reasoning, whose common features deserve attention also in view of the construction of a general theory of conditionals. It may happen, however, that two or more subsets $K'$ of $K$ compatible with the supposition $A$ have maximal information content and then that two or more statements appear to be candidates for a rational conclusion. In this inferential context a choice among the conclusions is impossible in principle and what can be done is to derive a conclusion in disjunctive form without selecting a determinate disjunct (see e.g., the “Bizet-Verdi” case in counterfactual reasoning). Such puzzling cases are qualified as inferential Gestalt effects. In defence of such a qualification, it may be shown that the description of visual Gestalt effects may be reconstructed in terms of the proposed schema.

**Abductive reasoning and linguistic meaning**
Pasi Pohjola

N. R. Hanson has argued that abductive reasoning relates strongly on the conceptual aspect of problem solving. In different kinds of intellectual enterprizes involving creation of new knowledge, language has an essential role. This conceptual aspect is here approached from a perspective of theory of linguistic meaning. The approach from theory of meaning intends to provide theoretical presuppositions for meaningful expressions and, thus, thoughts. It is argued that these presuppositions characterize the content of abductive reasoning. Language is essential for expressing and communicating knowledge, but it also plays role in how meaningful thoughts about the world are constructed. It is argued here that the propositional content of thoughts is related to language through logical and grammatical forms of language. If abductive reasoning is seen as reasoning bound by certain presuppositions (such as patterns or models), and the possible number of conclusions of reasoning is limited, these linguistic structures characterize the first criterion for possible meaningful hypothesis suggestions. The theory of meaning, especially provided by Jerrold Katz, has also another useful theoretical device for understanding abuction, in addition to the compositional sentence meaning described above. Especially in pragmatism the meanings of linguistic expressions are seen to be dependent of the context they are used. These contextual tokens of meanings provide contextual information of the possible uses and meanings of a linguistic expression. These two theoretical conceptions from the theory of meaning can provide more thorough understanding of the contents of abductive reasoning.

**The Role of Models in the Development of our Representations of Phenomena**
Demetris P. Portides

The Nuclear model research program is characterised by two distinct stages of development, each of which gave birth to models that represent the nuclear structure. Despite the fact that aspects of the models of the first stage are present in those of the second, the latter models are the result of a conceptual framework which is distinct from its predecessors. In moving from the first stage of development to the second quantum theory plays a minimal role. In fact, the evolutionary history of nuclear models demonstrates that scientific models possess a partial independence from theory, which is primarily based on the causal reasoning involved in their construction and the explanatory power they acquire because of the former. Through an analysis of the causal reasoning involved in the construction of the various nuclear models I explore the ways by which the two stages of the nuclear research program relate. In order to articulate an adequate logical analysis of the relation that accounts for the evolutionary history of the nuclear models, I argue, we must treat the models as partially independent from quantum theory. The approach suggested in this paper conflicts with the suggestion of the Semantic View that models of the theory represent their respective physical systems. I argue that scientific models acquire representational power because the assertions of the theory used in their construction are
supplemented or enriched with theory-independent causal reasoning. It is the causal reasoning involved in the construction that gives scientific models their explanatory power, without which they lack the capacity to represent actual physical systems.

**Tacit knowledge, implicit learning and scientific reasoning**  
Andrea Pozzali

The concept of tacit knowledge is widely used in sociology of science to refer to all those “knowledge or abilities that can be passed between scientists by personal contact but cannot be, or has not been, set out or passed on in formulae, diagrams, or verbal descriptions and instructions for action” (Collins, 2001b, 72; see also 2001a, 108). Several case studies have shown the role of tacit knowledge in many fields of science and technology, from laser-building (Collins, 1974) to the development of nuclear weapons (MacKenzie and Spinardi, 1995), from biological procedures (Cambrosio and Keating, 1988) to veterinary surgery (Pinch, Collins and Carbone, 1996).

So far, it seems that the literature on tacit knowledge in sociology of science has been affected by two kind of “biases”:

- the interest has been focused more on the result (tacit knowledge) than on the process (implicit learning). This sounds quite paradoxical, as Polanyi (1958; 1967), the first to introduce the term “tacit knowledge” into modern circulation, was more concerned himself with tacit knowing than with tacit knowledge. Moreover, implicit learning has been shown to be quite influential in many decision-making processes (Reber, 1993; Broadbent, Fitzgerald and Broadbent, 1986);
- “tacit knowledge” has been somehow reduced to implicit skills or know-how; other forms of tacit knowledge has been neglected.

By taking into consideration the role and relevance of implicit learning, it will be possible to develop a categorisation of tacit knowledge that allows to take in greater consideration all those forms of tacit knowledge that can not be equated with skills or other kinds of kinaesthetic abilities.

**Theoretical models in physics. Their role in the methodology of physics and their importance for the epistemological debate.**  
Andrés Rivadulla

Since the development of mathematical physics theoretical models have played an increasing role in the methodology of physics, and they have become indispensable for a better understanding of how theoretical physics deals with Nature. The fruitfulness of the use of models in physics is evident nowadays. There is no branch in theoretical physics where models are not used: From astrophysics and cosmology to microphysics. Models are not theories indeed -we might claim at most that they are theories restricted to a single phenomenon, or to a limited number of phenomena. Models make use of extant theories in order to do their job. Thus models in atomic and nuclear physics would be unthinkable without quantum mechanics, and so would cosmological models without relativity theory, or models in astrophysics without classical and quantum mechanics, electromagnetism and thermodynamics. Etc.

The common feature shared by all theoretical models is that they are intended to save the observed phenomena and to provide empirically testable predictions in their domains. They are not true or verisimilar representations of aspects of reality. This is precisely the point where I disagree with most philosophers of science. Neither verisimilitude (Karl Popper), nor isomorphism (Max Black, Bas Van Fraassen), analogy (Mary Hesse, Giovanni Boniolo), or similarity (Ronald Giere), are the possible relationships between models and the world. The reason basically is that the fundamental demand of any model is empirical success, and the inference from success to verisimilitude is not legitimate. Weaker demands like analogy or similarity are even less justified.

Models are merely instruments intended to deal scientifically with Nature. The fact that a model presumably refers to something out there in the world does not constitute any cogent reason for claiming that it represents it, because the only access we do have to the thing is mediated throughout the model itself. Thus the model cannot be at the same time judge and part of the ‘cognitive’ task.

In my paper I will resort to different examples of the history of physics that confirm my views on theoretical models. I maintain that here is no sense in the claim that models represent aspects of the world in a realist sense of the term representation. The use of theoretical models offers an excellent argument against realism in physics. And my paper will develop convincingly this argument.
A New Model Based Method for Mapping the ECAP Recording Results to Fitting Parameter of the Patients for Mimicking the Hearing In Cochlear Implant Systems
H. Sadjedi, S.A. Motamedi, and S.M.P. Firoozabadi

Cochlear implant systems are based on stimulation of the auditory nerve fibers by electrical current with implanted electrodes. In the clinical tests, based on stimulation by electrical current and recording the Evoked Compound Action Potential (ECAP) same as Neural Response Telemetry (NRT), electrical behavior and population distribution of the nerve fibers can be evaluated.

Stimulation parameter in mimicking the normal hearing can be determined by the results of these tests. Condition of these tests is different from the actual stimulation for hearing, both in amplitude and time sequence of the stimulation current pulses. Therefore, there are some problems in the mapping the test results to stimulation parameters.

In this paper we present a new model based method to estimate the electrical behavior of the fibers in normal use of the system for hearing, which has much more pulse rate than the test condition, we assumed a probabilistic function for recovery time of the fibers to map the test results to hearing condition parameters.

Simulation results show that the stimulation electrode array parameters can be determined more accurately by the presented modification qualitatively and quantitatively.

Disanalogies and the validity of animal models
Cameron Shelley

Animals are frequently used to model human conditions in biomedical research. Critics of this research have recently directed attention to the epistemological foundations of animal models on the grounds that if animal models are generally invalid epistemologically, then they are clearly unacceptable ethically. LaFollette and Shanks (1996) press an argument along these lines by noting the problem posed by disanalogies to animal models. For an animal to be a model of a human being, an analogy must exist between model and man. However, the argument goes, there are always relevant disanalogies between model and man, and since relevant disanalogies invalidate animal models, then animal modeling is generally invalid. The ethical unacceptability of animal modeling undeniably follows. I show that this argument is mistaken in two important respects. First, LaFollette and Shanks take analogy to be a matter of shared features or resemblance between model and target. This consideration, known as face validity in the biomedical literature, is of little consequence meaning that if the argument is accepted as is, then it is ineffectual. Second, the argument may be revised by taking analogy to be matter of shared functional relations between model and target. This consideration, known as construct validity, is crucial to the overall validity of an animal model. However, the concept of disanalogity that properly belongs to this version of the argument does not support LaFollette and Shanks’s conclusion. As described by Shelley (2002), a disanalogy is defeasible, that is, it may be undone in the light of contextual information. Thus, even if relevant disanalogies exist between an animal model and its human target, they do not necessarily invalidate the model. Thus, LaFollette and Shanks’s conclusion does not follow. I use the Porsolt forced-swim test, a mouse model of the action of anti-depressants in humans, to clarify the true nature of the problem posed by disanalogies for animal models in biomedical research.

Inventing electric potential
Melvin S. Steinberg

Investigations of charged conductors using electrometers led Volta and Cavendish in the 1770s to envision a compressible fluid model of charge in conductors. The causal agent of current propulsion was a pressure-like condition in the fluid, which Volta called “electric tension” and described as the fluid’s “effort to push itself out” of its conducting container. In this paper I discuss Volta’s use of analogy and imagery in model building, and compare similar model building by beginning students investigating circuits with light bulbs and capacitors in a newly developed electricity curriculum. I also describe Volta’s attempt to include electrostatic distant action in his model by borrowing imagery from thermal distant action, and show how this type of model building strategy has helped with designing the new curriculum to unify distant action with the compressible fluid model.

“Electric potential” was defined mathematically by Poisson in 1811, and by 1850 was understood to yield the same results as Volta’s “electric tension” in conducting matter while also accounting for electrostatic distant action in the exterior space where Volta’s original conception had nothing to say. But the greater generality that made electric potential a superior research tool also helped mathematical reasoning supplant intuitive foundations in instruction. I argue that science education lost something valuable when it failed to differentiate itself from the research agenda and retain Volta’s compressible fluid model as an intuitive foundation for understanding electric potential. As evidence, I discuss data from testing in 22 American high schools that show large conceptual and confidence gains from instruction
in the new curriculum compared with control groups. I suggest that the partial correspondence between the natural conceptual development of pioneering scientists and beginning students can help illuminate the scientists’ learning path.

**Embodied Anomaly Resolution in Molecular Genetics: A case study of RNAi**

John J. Sung

This paper approaches anomaly resolution in molecular genetics from a meaning construction perspective. The theory of meaning construction from cognitive linguistics (conceptual integration theory) is compared to concepts in philosophy of science, such as mental models, analogy, and mental simulation and is applied in reconstructing the conceptual development of anomaly resolution strategies in molecular genetics. Conceptual integration theory (CIT) attempts to explain how one constructs meaning from various stimuli, such as text and diagrams, through conceptual integration or blending. CIT provides a rich theoretical framework for reconstructing cognitive-historical development. The useful aspects of CIT demonstrated by applying it in reconstructing the cognitive development in anomaly resolution strategies in molecular genetics, specifically RNA interference, from textbooks and published papers. This paper argues: (1) cognitive linguistics and philosophy of science have similar goals and approaches, (2) these similar goals and approaches result in similarities between the concepts in the two fields (specifically between application of mental models and CIT), (3) the reconstruction of RNAi indicates that anomaly resolution strategies are embodied, i.e. relates to direct perceptions that are experienced in familiar frames (achieving human scale).

**Creating Theory**

The rationality of paradigmatic change in Kepler’s Astronomia Nova

Sigurd Tønnessen

One of the main focuses in the philosophy of science the recent years has been the process of discovering or creating new theories. I will demonstrate in a case study on Kepler’s work that the process of discovering, or developing, new concepts and hypotheses should be seen as a rational process. This rationality is most adequately elucidated when seen as a process of model based reasoning.

Kepler’s work has been a popular source for providing examples to philosophy of science. Yet I claim that several aspects of his reasoning has been overlooked or misinterpreted. A thorough and close reading of *Astronomia Nova* reveals arguments and investigations on several levels of representation. Kepler alternate between analyses of observation, geometrical representations of the planetary system, problems concerning measurement and representation of motion and probable causes for the motions. Although Kepler’s insistence on causes has been more acknowledged the recent years (Stephenson 1987, Voelkel 2001) than in earlier accounts (Koyré 1973), it is few (if any) that holds that his investigations on causal relations were indispensable in the process leading towards his two laws. The text has been perceived as a messy and unstructured conglomerate of more or less well founded speculations. What my reconstruction of Kepler’s reasoning demonstrates is a strong interdependence between the various representations and, moreover, that the primus motor for generation of new hypotheses is found in the relations and tensions between these representations. It will be shown that Kepler’s two laws; the area-law and the elliptic form of the path, resulted from the struggle to develop mathematical, kinematical and dynamical representations. The most important developments arose from Kepler’s strive to make the different levels of representations cohere. Kepler’s analyses on the adequacy of, and relation between, different representations and explanations are not possible to reconstruct as propositional arguments. I argue, nevertheless, that Kepler’s reasoning should be seen as rational and well founded. And, moreover, in my reconstruction it is not possible to differentiate between the context that enables Kepler to discover, or develop, hypotheses and the context wherein the hypotheses are justified.

**Cognitive Fictions**

Giovanni Tuzet

*Cognitive Fictions* represent non actually observable states of things inferred from actually observable ones. Examples of them are simulations and artificial representations of past or future events. This presentation won’t deal with the technical aspects of such devices; rather, with some logical and epistemological issues they raise.

In a possible classification of fictions, cognitive fictions are those approaching the most a representation of reality. On the one hand, they are fictions because they do not pretend to represent reality as it appears to us. On the other they have a cognitive value, since they are supposed to inform us of certain aspects of reality. They can consist in evidence-based artificial representations of past or future events. In the case of past events they are hypotheses (abductions). In the case of future events they are predictions (deductions). A simulation is an example of cognitive fiction. We can distinguish three kinds of simulations: (A) *Non-ampliative simulations*, that do not add any novel information to the amount at disposal before their realisation; (B) *Determinist*
Simulations, realised on the basis of deterministic laws; (C) Rule-based simulations, based on the rules of a game, or behavioural rules, or other rules governing a social interaction. Simulations of kind (A) are the less interesting. Simulations of kind (B) and (C) are informative but rule-based simulations do not give unique solutions to the problems specified (as determinist simulations do), since they elaborate different possible scenarios. The main issue becomes the evaluation of the different scenarios. So, which criteria determine the credibility and acceptability of a cognitive fiction? The criteria of coherence and inferability are considered.

In sum, devices like cognitive fictions can be of great importance for our cognitive tasks but must be used with due caution and many constraints must be put on their use.

**Disigning diagrams**

Barbara Tversky

Diagrams serve multiple purposes so that diagrams created for one may not be suitable for another. A frequent use is to convey clear instructions as to how to do something or how something works. I describe a research collaboration between cognitive science and graphics to design effective diagrams for routes and assembly. Participants with expertise produce diagrams and descriptions; analyses of the communalities reveals the mental representations to be conveyed and analyses of the diagrams reveals diagrammatic devices for conveying them. The resulting design principles are translated into computer algorithms for creating customized diagrams. Then the diagrams are tested by users. The design principles have general application to a broad range of situations where diagrams are useful.

**Using Wittgenstein’s Family Resemblance principle to learn Exemplars**

Sunil Vadera, Andres Rodriguea, Enrique Succar, and Jia Wu

The introduction of the notion of family resemblance represented a major shift in Wittgenstein’s thoughts on the meaning of words, moving away from a belief that words were well defined, to a view that words denoted less well-defined categories of meaning. Wittgenstein’s change of view is also part of a recent proposal by Addis et al. (2004), that argues for a paradigm shift away from systems that are based primarily on the use of rationale sets. This paper presents the use of the notion of family resemblance in the area of machine learning as an example of the benefits that can accrue from adopting the kind of paradigm shift proposed by Addis et al.(2004)

**The Complexity of Thinking System and the Supports of Model-based Reasoning**

Zhikang Wang

The scientists use the way of model-based reasoning to solve the problem of rationality about their scientific discovery or thinking creation. We should like to know how the tasks are solved. Three typical cases are examined: (1) the target model of radiation-biology, by which Lea and other bio-scientists succeed in explaining the mechanisms of radiogenic death. (2) the double helix model of DNA, by which Watson and Crick succeed in founding the theory of molecular biology. (3) the model of unfolded coefficient of \((a+b)^n\), by which Mendel succeed in establishing the second law of genetics. The result of examination indicates that in fact there are not only one but many supports in model-based reasoning. The supports come from different layers of human thinking system, concretely, from the layers of direct perception / indirect perception / rational faculty / world outlook / consciousness / subconscious / top-consciousness. Those supports support each other during the process of reasoning. The cognition is a system event. The scientific discovery or thinking creation cannot be accomplished by a single layer of thinking system with a single form of reasoning, because supports of reasoning in different layers are inter-independent, inter-contact, cooperate and influence each other. It is the important suggestion that a single form of reasoning cannot realize artificial intelligence.

**Epistemology of Design Decisions. Some preliminary notes**

Emil Weydert

Decision-making in the real world – for instance, picking up an appropriate de-sign model in system or software engineering – is often characterized, or should we say haunted, by incompleteness and uncertainty affecting each stage and every dimension of the decision process. In fact, this concerns not only the epistemic attitudes, i.e. the agent’s beliefs and their relative strength – whose recur-ring inadequacy is well-known – but also the motivational attitudes, the desires, preferences or cost functions – which are often more readily assumed to be given at decision time. The problem with the standard probabilistic/quantitative resp. logic-based/qualitative formal approaches dealing with these issues is that they require specific “well-defined problem descriptions” whose ingredients are hard to extract from the
heterogeneous and often incompletely processed informations and valuations available to the agent. As long as we have a human expert in the loop which uses his/her experience and methodological tools, and possibly some experimentation to build a task-specific decision model (family), these questions may of course appear to be less urgent – although an intersubjective understanding and control of these more tacit processes would certainly be desirable for philosophical and practical reasons. However, if we are going to construct intelligent agents meant to act autonomously in complex real-world situations, we also need a better formal account of these demanding preparatory steps, or perhaps even more generally, more appropriate approaches to the whole decision-theoretic planning process. Inspired by problems we encountered while investigating the semantics and pragmatics of design-level software complexity measures, in this note, we are going to pay particular attention to the choice of design models whose interpretations or implementations are intended to satisfy the evolving needs of users in different situations.

Advice on Abductive Logic
John Woods, and Dov Gabbay

Common to all abduction problems is a cognitive target that cannot be hit on the basis of what the abducer presently knows. Abductive hypotheses do not enhance a reasoner's knowledge. If they did, there would be no abduction problem to solve. Whereas deduction is truth-preserving and induction is likelihood-enhancing, abduction is ignorance-preserving. Accordingly, abduction problems are responses to, but not solutions of ignorance-problems. In making an abductive response, the abducer signal his readiness to down-grade, to substitute conjecture for knowledge. When his abductive hypothesis succeeds, a reasoner cannot be said to have attained his original target, but rather to have attained it presumptively. From the perspective of cognitive economics, the abducer shows himself to be a satisficer rather than a maximizer.

It is widely supposed that abduction is intrinsically explanationist in character. The plausibility of this claim is influenced by the latitude with we deploy the concept of explanation. But, even if explanation is given very wide scope, there are styles of abduction that are wholly devoid of explanatory force. An example is the regressive abduction of Russell and (independently) Goedel, in which a recondite principle of logic is justified by its role in a proof of a mathematical truism. So abduction cannot be considered explanationist as such. It is a fair question as to how much of abduction lies within the ambit of logic. There is a spectrum of views about logic. At one extreme is the opinion that almost nothing is logic, nothing, that is to say, beyond the first order predicate calculus. At the other end is a Cole Porter pluralism, in which "anything goes". But to the extent that they are allowed into the fold of true logic, the following would appear to have a substantial stake--although hardly an exclusive one--in the analysis of abduction: Goal directed logics, logics of non-monotonic reasoning, default logics, logics of defeasible reasoning, paraconsistent logics, and logics of plausibility, relevance and analogy. What is striking about abduction is not, as some purists aver, its resistance to logical analysis, but rather its call upon so rich a logical array.

Making Sense of Modeling in Science: Representation and Reasoning
Andrea I. Woody

Philosophical analysis of scientific theories traditionally concerns establishing the justificational status of propositions by assessing their connection to either relevant evidence or more fundamental theoretical suppositions. Yet typically these analyses are abstract in telling ways: we worry about neither the particular format of a given theoretical structure nor the precise manipulations, presumed in our assessments, required to connect theory to either world or other theory. Such "in principle" evaluations, admittedly invaluable for addressing certain issues regarding theory confirmation or reduction, bypass aspects of scientific theorizing essential to its reliable use in practice as a tool for further investigation of the world. In particular, the functions of theoretical models are rendered effectively invisible.

To the extent that models have been scrutinized, the primary issue to date has been how to make sense of the role of "false" models in science, asserting implicitly that it is their falsity that is noteworthy or in need of explanation. This essay aims to reorient such discussions by focusing self-consciously on representation. My aims are three-fold: to introduce a preliminary structure for representational analysis, to argue for the relevance of such analysis in theory justification broadly construed, and to display chemistry's particular virtues as a domain for investigation of these issues.

Drawing upon general philosophical analyses of representation and looking at contemporary theoretical model schemes in chemistry, especially diagrammatic and graphical schemes, I examine the ways in which particular representational choices facilitate or impede the reliability of reasoning typically required of these structures. In so doing, I contend that the "pragmatics" of scientific models are at least as deserving of philosophical attention as the "semantic" truth-talk that has dominated discussions to date. The epistemic status of scientific models, properly conceived, concerns their capacity to support ongoing investigation, something that clearly outstrips any narrow conception of the reasons we have to believe them true. Representational artifacts, much like pieces of laboratory equipment, are crucial tools for any ongoing scientific enterprise; as such, they must be well suited to both their presumed tasks and their typical users.
Consequently, the connection between representation and reasoning is critical for making sense of modeling in science. It is also necessary for any account of theory justification that aims to be genuinely normative.

Monotonicity Analysis for Constructing Qualitative Models  
Yuhong Yan, Daniel Lemire, and Martin Brooks

Qualitative models are more suitable than classical quantitative models in many tasks like Model-based Diagnosis (MBD), explaining system behavior, and designing novel devices from first principles. Monotonicity is an important feature to leverage when constructing qualitative models. Detecting monotone pieces robustly and efficiently from sensor or simulation data remains an open problem. This paper introduces an approach based on scale-dependent monotonicity: the notion that monotonicity can be defined relative to a scale. Real-valued functions defined on a finite set of reals, e.g., the sensor data the simulation results, can be partitioned into quasi-monotone segments, i.e., segments monotone with respect to nonzero scale. We can identify the extrema of the quasi-monotone segments. This paper then uses this method to abstract qualitative models from simulation models for the purpose of diagnosis. It shows that using monotone analysis, the abstracted qualitative model is not only sound, but also parsimonious because it generates few landmarks.

The Restudy of “Logic” and “Thinking”  
Qiming Yu

Human’s knowing of the world goes through the developing progress from nature? society? human itself (from physiology to psychology). Studies of thinking in cognitive psychology and artificial intelligence and thinking are ascendant and present many austere challenges to classical logic. What is required in rethinking of “logic” and “thinking”? The relationship between “logic” and “thinking” touches many subjects. Therefore it is very necessary to restudy them.

There has been the problem in the field of logic about the nature of the object and content of logic. The reason may lie in the difference between the broad sense and narrow sense of “logic”. The narrow sense just means deductive logic, mostly predicate logic and propositional logic. But from the perspective of historical development there are two kinds of logic: classical and modern. Besides deductive logic, the broad sense also includes inductive logic, analogical reasoning, abductive reasoning, etc., which have been the focus of much modern logic. Thus, as with other scientific developments in the modern world, the “science” of logic is developing at a rapid pace and the scope of logic should be greatly extended beyond the earlier conceptions and knowledge of logic.

If it is possible to break through traditional conceptions of reasoning, to create a kind of logic that can be seen to encompass non-linguistic and not strictly formal modes of reasoning, then not only the effective reasoning of abstract thinking is the contents of logic study but also effective visual reasoning could be brought into the scope of the scientific study of logic. In this way not only abstract concepts expressed in propositions could carry us through judgement and reasoning, so could visual representations. The reasoning processes of abstract thinking are based on concepts and resultant judgements, but the reasoning process of visual thinking are based on images and their association (imagination) and typification. The former deduces from one concept judgement to another. While the later infers from a one imagistic representation to another. The former is a linear, serial process; the later is often a non-linear, side-by-side process.