UNIVERSAL VS. PARTICULAR REASONING: A STUDY WITH NEUROIMAGING TECHNIQUES

V. Michele Abrusci, Claudia Casadio, Maria Teresa Medaglia

In this paper we explore the question of introducing interaction inside cognition as a general framework on the basis of which to develop an explanation of human reasoning allowing applications in the fields of neuroscience and brain knowledge. We analyze cognition as the complex human ability involving both mental and sensory-motor faculties connected to perception, memory, language, thinking and general intelligence. The theoretical framework of the proposed research is given by recent formulations of linear logic and ludics (Abrusci 2002, 2009, Casadio 2001), in which particular attention is paid to the intrinsic positive and negative polarity of logical operators (connectives and quantifiers). We show that this distinction has interesting applications to cognition, and particularly to the analysis of human reasoning. In the first part of the paper, the distinction between positive vs. negative operators is introduced and applied to the analysis of Aristotelian syllogism, the inferential deductive scheme particularly considered in the psychological studies of human reasoning and related experimental research in cognition and neuroscience (Casadio 2006). In the second part of the paper, an experimental research is presented applying the positive vs. negative alternation of operators to a contradictory reasoning task involving high-density electroencephalography (EEG) technique (Medaglia et al. 2009a, 2009b, 2010). This research is part of the national research project PRIN 2009, local unity of Chieti-Pescara, entitled: "Applications of Logic to the Study of Human Reasoning: Theoretical Models and Experimental Research with Brain Imaging Techniques".

ANOMALY ABDUCTION: THE PROCESS OF HYPOTHESES TESTING IN MEDICAL DIAGNOSIS

Atocha Aliseda

When a medical doctor is faced with her patient´s symptoms and signs, she has to resort –among other things-- to her existing knowledge of pathologies in order to choose the best fit as an explanation for her patient's condition. In this case we say she is performing a straightforward *novelty abduction*. If, on the other hand, a medical doctor is testing out a hypothesis as a diagnose for a certain illness, one which turns out to clash with existing medical knowledge or with the personal patient's clinical history, she may be facing what we have characterized as an *anomaly abduction*. The latter case however, faces two challenges: on the one hand, *anomaly abduction* has been characterized as a process by which it is the observation that clashes with a given theory and not so much as a hypotheses testing procedure. On the other hand, while there is plenty of formal work on novelty abduction, there is very little or nothing on *anomaly abduction*. In this talk we will propose ways to deal with anomaly abduction. Medical practice provides us with an excellent setting to highlight some of the challenges any analysis of abduction faces.

AUTONOMOUS MOBILE ROBOTS AS TECHNICAL ARTIFACTS: A DISCUSSION OF EXPERIMENTAL ISSUES

Francesco Amigoni and Viola Schiaffonati

The assessment of good experimental methodologies in autonomous mobile robotics can be inspired by some general experimental principles (comparison, reproducibility and repeatability, justification and generalization) holding in traditional scientific disciplines. However, experiments in engineering disciplines present peculiar features with respect to experiments in the sciences. We argue that these peculiarities arise from the fact that in engineering an experiment is performed to test an artifact, whereas in science an experiment is performed to understand a natural phenomenon. On the basis of the notion of technical artifact, as discussed in current

philosophy of technology, we analyze some peculiar aspects of experiments in engineering, taking autonomous mobile robotics as a case study.

MODEL-BASED REASONING IN MODEL CHECKING FOR THE EXAMINATION OF SOFTWARE SYSTEMS

Nicola Angius

Model checking, a prominent formal method developed in computer science to predict future behaviours of software systems, is here examined in the framework of the model-based reasoning paradigm. Preliminary, it is shown how both deductive and inductive reasoning are insufficient to determine whether a given piece of software satisfies the relevant properties it was designed for. Model checking enables one to examine computational systems by means of a transition system representing the target system and of an algorithm that searches throughout the model for desired/undesired behaviours, formalised using temporal logic formulas. Models developed in model checking are acknowledged as scientific models as conceived by the set-theoretic approach to models; the relationship between a transition system and the target system is examined in the light of the semantic approach to models and theories. The prominence of human agency in scientific modelling is brought to bear in the model-checking context in relation with the state space reduction techniques that simplify and readapt computational models with the aim of allowing the checking algorithm terminating in sufficient time and space resources. The epistemological question of how one learns about the target reactive system by means of formal models developed in model checking is examined in relation with the selective and manipulative characters of model-based reasoning. Models in model checking are opportunely modified to provide feasible solutions to the class of decision problems one is concerned with; hypotheses concerning potential executions of the examined program are selected by the checking algorithm that explores all paths implicitly contained in the representation of the target computational system. Finally, it is maintained that selected hypotheses of this kind assume the status of law-like statements holding according to the model and which need to be corroborated by observing actual software executions, usually by means of Software Testing techniques.

A CLASS OF LOGICAL MODELS FOR LEARNING PROCESSES AND PSYCHOLOGICAL CHANGE

Salvatore Roberto Arpaia

Abstract In the present talk I intend to discuss the validity of a model (or better, a *class* of models) of *learning* and *deuterolearning* processes in cognitive systems, constructed combining set-theoretical and proof-theoretical concepts. This class of models is based on ideas coming from different disciplines: 1) Gregory Bateson's systemic-relational theory of learning and change; 2) G¨odel's incompleteness theorem, and in particular one of foundational consequences of the Incompleteness theorems, so-called thesis of *incompletability of mathematics*; 3) The modelization of cognitive systems by means of deductive systems, where a deductive system is defined (in Hilbert, Gentzen or algebraic style) by axioms and rules of inference. This model allows to define in a precise way the distinction between almost three levels of learning process: (1) the level of *solving a single problem*, (2) the level *solving a class of problems* and (3) the level of the *creation of a new class of problems (and of related rules of solution)*. While the passage from (1) to (2) is generally continuous, the passage from (2) to (3) involves a discontinuity (e.g. change of character in a single person, or paradigmatic change in a scientific community). Definition will be given of a class of models in which a non-well-founded set or a paradoxical sentence are interpreted as undecidable statements of some deductive system, and the learning process, or the psychological-change process, is defined in term of a sequence of deductive systems, obtained by a process of generalization of the *consequence relations* of the systems involved.

COGNITION AND SEMIOTIC ARTIFACTS: SITUATEDNESS IN PEIRCEAN COGNITIVE SEMIOTICS

Pedro Atã and Joao Queiroz

According to Peirce's semiotic theory of mind, cognitive process fundamentally depend on sign process, in a sense that diverges radically from computationalism. For Peirce, thinking involves the process of sign action. Against any form of internalism, Peirce can be considered a precursor of situated mind and distributed cognition thesis. But differently from the anti-cartesianism defended by some embodied-situated cognitive science, which is predominantly anti-representationalist, as recently explored in a Merleau-Pontyan, Heidegerian, or a Gibsonian trend, for Peirce, mind is semiosis in a dialogical -- hence communicational -- materially embodied form, and cognition is the development of available semiotic material artifacts in which it is embodied as a power to produce interpretants. It takes the form of development of semiotic artifacts, such as writing tools, instruments of observation, notational systems, languages, and so forth. Our approach here centers on the consideration of relevant properties and aspects of Peirce's concept of mind as semiosis, with special attention to the material/formal/structural properties of signs. In our argumentation, Peirce's semiotic theory of mind is a branch with important implications and unprecedent consequences – it is at the same time situated, embodied, and representationalist, with focus on the properties of dependence of the material available in the semiotic environment. In a certain sense, it is closer to the ideas of wide computationalism, but does not restrict the inferences to transformation processes upon structured signs in a declarative symbolic systems. Our aim here is to examine the relationship between the notion of abductive inference and iconic semiotic artifacts in the context of his semiotic theory of mind. In order properly to develop our argument, we introduce: (i) the basic characteristics of abduction, (ii) the concept of semiosis and the morphological variety of semiotic processes, (iii) Peirce's notion of distributed cognition thesis. The reader should bear in mind that our argument borders on recent developments in situated cognition and extended mind approach.

MODELING DIGITAL ECOSYSTEMS AS SUPER-CONSTRUCTIONS AND THE ROLE OF CHANCE-SEEKING.

Emanuele Bardone

The notion of digital ecosystem has been recently adopted to describe models concerning the current stage of development of information and communication technologies. According to this approach, the information and communication technologies would not be just devices or tools helping us with a wide range of activities, but they would be better understood as forming digital ecosystems on their own, which are to be understood as self-organizing super-organisms. In my presentation I will argue against this idea by resorting to the theory of niche construction. Building on this theory, I will argue that digital ecosystems are not to be modeled as self-organizing super-organisms, but super-constructions in which human intentionality still plays a crucial role for their modeling and development. More specifically, I will show how a model of the development of digital ecosystems can only be partly described as self-emerging. And in doing so I will illustrate the role played by chance-seeking activities. In my view, chance-seeking activities conceptually bridge the gap between those properties of digital ecosystems which seem to work in a Darwinian way and those which are not.

ABDUCTION FOR RECONSTRUCTING PROTOLANGAGES

Cristina Barés-Gómez, Angel Nepomuceno-Fernández, Francisco J. Salguero-Lamillar

In this work abduction is taken as the main exponent of research in observational sciences, more specifically in certain linguistic investigations. We shall consider reasoning in relation with contexts and pay attention to a form of abduction that go beyond the context into which the scientific work is developing. So an inter-contextual chain of deductions can be part of abductive processes and the resulting hypothesis is still provisional. Then this will be used to explain ways of reconstructing proto-languages, where several disciplines play a cognitive role,

as archeology, history and linguistic, taking the case of reconstruction of the proto-Semitic with the unexpected fact of the discover of Ugarit and Ebla. This sample may shed light on the use of abduction to explain certain scientific practices.

ADAPTIVE DEONTIC REASONING

Mathieu Beirlaen

In view of its well-known shortcomings, Standard Deontic Logic (**SDL**) requires corrective and ampliative modifications. Corrective modifications weaken **SDL** by restricting some of its rules and/or axioms. Ampliative modifications strengthen **SDL** by enriching its language and/or by adding one or more axioms and/or rules. In spite of its problems, **SDL** remains intelligible as a standard of deduction for deontic logic. For corrective modifications, this means that they try to approximate ***SDL*** 'as much as possible'. For ampliative modifications, this means that they validate all SDL-inferences. We illustrate how corrective and ampliative modifications to **SDL** can be combined within the generic proof theory of the adaptive logics framework, and how the latter mirrors our everyday deontic reasoning by conditionally allowing for corrective and ampliative inference steps.

ENHANCING PROPOSITIONAL DYNAMIC LOGIC FOR STRUCTURED DATA

Mario R. F. Benevides, Paulo A. S. Veloso and Sheila R. M.Veloso

An extension of Propositional Dynamic Logic (PDL) is proposed for coping with mutable data structures, updates and parallelism. These situations appear often in Computing, when one deals with the dynamic changes occurring during the execution of a program. Propositional Dynamic Logic (PDL) is a modal logic for representing properties of sequential programs and reasoning about them. To each program Π one associates modalities $\langle\Pi\rangle$.The intended meaning of the formula $\langle\Pi\rangle\varphi$ is that some execution of program Π from the present state reaches some state satisfying the formula φ. The set of programs has an algebraic structure, so that one can express composition, non-deterministic choice and iteration of programs. PDL, though adequate for sequential programs, it is not quite so for other features such as parallelism and concurrency. In this paper, we will explore the use of algebraic features, such as fork algebra, to enhance the expressive power of PDL. Acknowledgements: Research partly sponsored by the Brazilian agencies CNPq and FAPERJ.

TWO KINDS OF EXPERIMENTS

Investigating the scientific framework between generative and demonstrative experiments

Tommaso Bertolotti

Current scientific practice is often identified with the experimental framework. Yet, what "experimenting" means could be less than perfectly clear. Going beyond the common sense conception of experiment, two broad categories of experiments can be tentatively identified: the generative experiment and the demonstrative experiment. While the former aims at generating new knowledge, new corroborations of hypotheses etc., the latter – which is actually the kind of experiment most laypeople came to terms with in their lives – is designed so that, by being successful, it reverberates knowledge on the experimenters/witnesses, thus instructing them, albeit the outcome was well known beforehand. The two kinds of experiment cannot be distinguished phenomenologically, therefore the existing distinction must rely on something else, namely the external framework (i.e. the cognitive niche) they are embedded into. The concept of "epistemic warfare", recently introduced by Magnani, can be of help in investigating this distinction in the experimental dimension, also to the scope of showing that it is not a sterile dichotomy but rather a theoretically fruitful continuum.

HOW THE TIGER BUSH GOT ITS STRIPES: 'HOW POSSIBLY' VS. 'HOW ACTUALLY' MODEL EXPLANATIONS

Alisa Bokulich

The use of idealized models in generating scientific explanations is pervasive in the sciences; however philosophers of science have only recently begun to try to reconcile this practice with traditional philosophical accounts of explanation (e.g., Bokulich 2008, 2011). An important distinction for any model-based account of scientific explanation is that between 'how-possibly' model explanations and 'how-actually' model explanations. There remains considerable controversy, however, concerning both how these categories are to be construed and whether how-possibly explanations are a distinctive kind of explanation that can be considered "complete" in themselves, or whether they are simply incomplete and/or poorly confirmed versions of how-actually explanations. In this paper, I articulate a way of understanding the distinction between 'how-possibly' and 'howactually' model explanations and shall argue that inadequate attention has been paid to the different sorts of contexts in which 'how-possibly' explanations can be deployed. I will develop and defend my account of 'how-possibly' model explanations through a close examination of current attempts to use idealized models to explain a phenomenon in ecology known as "tiger bush." Tiger bush is a striking, periodic banding of vegetation separated by barren gaps in remote, semi-arid regions. Tiger bush can occur for a wide variety of different kinds of plants and soils and does not depend on any local heterogeneities or variations in topography. An examination of the various ways in which idealized models are being deployed to explain how the tiger brush got its stripes yields further insight into what I shall argue is a more complicated relation between 'how-possibly' and 'how-actually' model explanations.

MODELING CAUSAL INTERACTIONS AND THE DOMAINS OF APPLICABILITY OF PHYSICAL DYNAMICS

Peter Bokulich

Nonreductive physicalists claim that causal models developed in the special sciences should be considered autonomous from microphysical dynamical models. I argue that while higher-level models do enjoy an important form of explanatory autonomy, the claim that they track *causal* features independent of physics is incompatible with a physicalist commitment to the causal closure of physics. The applicability of microphysical causal-dynamical models is justified by our knowledge of the domain of applicability of, e.g., quantum electrodynamics, and the fact that all special-science processes fall safely within this domain. I articulate a physicalist ontology of emergence that provides a framework for understanding how the causal commitments of special-science models fit with the requirement that all actual systems obey microphysical laws. On my account, the properties and causal connections appealed to in special-science models are properly seen as resulting from restrictions on the full microphysical states and dynamics. Special-science models do not represent *new* possibilities, instead they *rule out* a broad set of physically possible processes. Thus insofar as a model is supposed to capture the causal structure of an actual process or mechanism, that causal relations modeled cannot be autonomous from the actual physical dynamics at work. This presents us with a form of causal reduction that must be respected by any accurate model of causal interactions, but it does not imply that special-science models can be eliminated in favor of microphysical models for other explanatory purposes.

DISCOVERY OF ABSTRACT CONCEPTS BY A ROBOT

Ivan Bratko

This paper reviews experiments with an approach to discovery through robot's experimentation in its environment. In addition to discovering laws that enable predictions, we are particularly interested in the mechanisms that enable the discovery of *abstract* concepts that are not explicitly observable in the measured

data, such as the notions of a tool or stability. The approach is based on the use of Inductive Logic Programming. Examples of actually discovered abstract concepts in the experiments include the concepts of a movable object, an obstacle and a tool.

PARACONSISTENT DESCRIPTION LOGICS: THE FORMAL-CONSISTENCY VIEWPOINT

Juliana Bueno-Soler and Walter Carnielli

Description Logics (DLs) are an extensively used formalism for class-based modeling and knowledge representation that intend to express properties of structured inheritance network. These systems constitute variants of multimodal versions of the familiar normal modal logic K and can be also interpreted as fragments of first-order logic with interesting computational properties. DLs convey relevant logical formalism for ontologies and for the semantic web, much used in artificial intelligence. However, precisely because of its wide applicability, DLs may face serious difficulties in expressing knowledge bases (or ontologies) that contain contradictions. Considering that the capacity of reasoning under contradictions is a much needed feature in enhanced versions of DLs, we introduce the description logic CiALC based upon the Logics of Formal Inconsistency (LFIs), a class of powerful paraconsistent logics. CiALC is strong enough to encompass the ``classical" description logic ALC, so our proposal not simply repairs contradictory (or inconsistent) ontologies, but genuinely generalizes the notion of description logic by enhancing the underlying logic with a weaker negation and with a primitive notion of consistency independent from negation (that is, independent from any notion of contradiction). The new description logic CiALC based upon the logics of formal inconsistency is semantically characterized by quite philosophically acceptable semantics, thus representing a natural improvement in the notion of description logics.

ABDUCTION, COMPETING MODELS, AND THE VIRTUES OF HYPOTHESES

H.G. Callaway

Peirce claims (*Lectures on Pragmatism* [CP 1.196]) that “If you carefully consider the question of pragmatism you will see that it is nothing else than the question of the logic of abduction;” and further “no effect of pragmatism which is consequent upon its effect on abduction can go to show that pragmatism is anything more than a doctrine concerning the logic of abduction.” Plausibly, there is, at best, a quasi-logic of abduction, which properly issues in our best means for the methodological evaluation and ordering of (yet untested) hypotheses or theories. There is always a range of innovations that may be proposed, ranging from more conservative to less conservative, and it is important, in light of what Peirce has to say of the relation of abduction to pragmatism, that in ruling out “wild guessing,” attention be initially directed to more conservative proposals. Still conservativism, which we might understand in terms of Peircean continuity, is sometimes justly sacrificed for greater comprehension or overall simplicity of approach. This paper explores the relationships among Peircean abduction and pragmatism, the “theoretical virtues” approach to the evaluation of hypotheses, and contextual constraint on the scientific imagination.

ICONICITY AND ABDUCTION: USING CATEGORY THEORY TO MODEL SHAPES OF CREATIVE HYPOTHESIS-FORMATION IN PEIRCE’S EXISTENTIAL GRAPHS

Gianluca Caterina and Rocco Gangle

Iconic semiotics provides a useful conceptual framework for posing and resolving certain problems surrounding the formal modeling of abductive inference. To show how this is the case, we make use of the structural character of category theory, in which functors from one category to another may be more or less structure-

preserving, and which thus lends itself to diagrammatic, and hence iconic, expression. These features make category theory a natural instrument for analyzing iconicity, in particular the iconic character of Peirce's Existential Graphs. Peirce's graphs provide iconic and topological representations of logical relations at three levels: alpha, beta and gamma. For ease of exposition we focus on the alpha graphs, which model classical propositional logic. We take a category-theoretical approach to Peirce's graphs in order to address the specific problem of abductive inference therein. Our focus is primarily on how good – but not necessarily true – explanatory hypotheses may be generated with respect to new information in a propositional context. Category theory makes it possible to model iconic transformations among graphs in terms of functors between suitably-defined categories of graphs. We propose a generalization of this method into the richer arena of complete Heyting algebras. Our proposal shows how diagrammatic relations may be generated within the rich, highly-structured ambience of complete Heyting algebras (which Badiou in particular has placed at the basis of a highly general theory of ontology and phenomenology) and then imported along various degrees of freedom into the classical logical structures of the alpha graphs. Under certain constraints, such importation may be understood to model the creative but not irrational process of (good) hypothesis formation. We conclude by indicating how this model of abduction may prove useful in various contexts of implementation.

HOW AFFORDANCE CHANGE : BASED ON THE COINCIDENT MODEL OF TECHNOLOGICLE INNOVATION

Cao Dongming, Luo Lingling and Wang Jian

Affordance as a concept was proposed by Gibson thirty years ago and now this concept has already been extended to the man-machine design and widely used in the design of artificial things. The question we put forward is "how does affordance change during the technological innovation" ,so in this paper, we need to go back to the real technological innovation to pursue the trail of *affordance*, to find out where it comes from, and how it gets change during the process of technical innovation. Technological innovation is the a dynamic process. This process forms a chain and each link of this chain has an interaction between different subjects, If seen in this way, the chain is actually an *affordance chain. Due to the* critical criterion to the success of innovation is whether consumers (or users) accept the products or not, the *affordance chain* includes not only the interface between designers and machines, but also the interface between machines and the users(or consumers).In this way, *affordance* help to explain the entanglement between designers, users, and artifacts. Moreover, due to each technological innovation will experience not only a process of transverse developing but also a process of historical evolution, each innovation actually lies in a position of a Two-dimensional time coordinate. From the point of that view ,the affordance should also have some kind of evolutive accumulation.

TRUTH APPROXIMATION VIA ABDUCTIVE BELIEF CHANGE

Gustavo Cevolani

Abduction has been a hot topic in recent research both in Artificial Intelligence (AI) and in philosophy of science. In this paper, we explore the formal and conceptual relationships between abductive belief change, as studied by AI scholars like Pagnucco (1996) and Aliseda (2006)—see also Schurz (2011) for a philosopher's perspective—, and truth approximation, as analyzed within the "verisimilitudinarian" research program in philosophy of science (Oddie 2008). Abductive belief change studies how theory A should change in response to incoming evidence e when agent X, who accepts A, tries to find an explanation for e. The basic idea is that X will incorporate in A both evidence e and some abductive hypothesis h explaining e (called an *abducible* for e). When e is consistent with A, and h is an abducible for e, the resulting theory is called the abductive expansion of A by e, and is defined as $A \oplus e = \mathrm{Cn}(A \cup \{h\})$. Following Niiniluoto (2005, 2010) and others, we investigate whether abductive belief change can serve the purpose of truth approximation, i.e., under what conditions $A \oplus e$ is closer

to the truth than *A*. In particular, we define the notion of *verisimilitude-guided abductive expansion*—or *VS-guided abductive expansion* for short—according to which *X* will accept *e* only if an abducible *h* for *e* is available such that $A \oplus e$ is estimated as more verisimilar than *A* given the available evidence. In this sense, VS-guided abductive expansion defines a notion of belief change in the service of truth approximation. After exploring the logical and methodological features of this notion, we extend our analysis to the case of VS-guided abductive revision, where incoming evidence *e* is inconsistent with theory *A*. The result is a more realistic model of abductive reasoning, which is also more adequate for the analysis of actual scientific reasoning and inference (cf. Schurz 2011).

HOW FAR CAN WE GO WITH FUZZY LOGIC? PERSPECTIVES ON MODEL-BASED REASONING AND STOCHASTIC RESONANCE IN SCIENTIFIC MODELS

Silvia De Bianchi

The question of the need of approximate reasoning in the sciences can be ascribed to the more general framework of the suitable reasoning method enabling the application of mathematics to different branches of disciplines, in which vagueness or uncertainty play a decisive role. This contribution deals with the recent debate on the theory of explanation, by emphasizing the nature of mathematical models that cannot be used as if they were physical models, since they do not provide any causal explanation. I shall try to throw a fresh light on this debate, by reflecting upon fuzzy logic as a case study. Causal explanation cannot be ascribed to fuzzy logic despite the success of the latter in many applications in heuristic controls. Fuzzy logic appears to be similar to a mathematical model endowed of a fundamental regulative role, but that can be overcome by the development of new techniques and knowledge acquisition: its nature is provisional. After dealing with an Introduction, I shall review some fuzzy logic applications and investigate the ground of their reliability, in order to restrict their role in explanation. In section II I shall show strengthens and limitations of fuzzy logic, by analyzing the perspective of a model-based reasoning connected to stochastic resonance in scientific models and I relate the latter to physical and causal explanation. Conclusively, in section III, I shall analyze the manipulationist approach to intervention, and I shall conclude with possible perspectives that can be embraced for future studies.

LICENSE TO KILL. COGNITIVE MODELS, CATEGORIZATION AND MORAL JUDGMENT

Sara Dellantonio

In the contemporary debate on moral judgment we are often faced with discussions concerning the universality of principles such as the prohibition of murder, harming others, stealing, and even of cheating or lying (see e.g. Mikheil 2000; Dwyer 2006; Hauser 2006; Turiel 2002, Nichols 2004) Still, one of the main objections to such claims is that, even though most or even all social groups enforce these kinds of prohibitions, they also always allow exceptions, in the sense that each group decides who deserves moral consideration and who doesn't (see e.g.. Sripada, Stich 2006; Dwyer 2006). This work examines the question of moral consideration, starting from the assumption that moral status is not an all-or-nothing condition: how much and what of moral consideration is accorded an individual depends on how he/she is categorized, while the highest moral status is granted only to those that are categorized as *ideal persons*. For an explanation of how the categorization of persons works, Lakoff's semantic theory is applied according to which human knowledge is organized by means of structures called "idealized cognitive models", (Lakoff 1990, p. 68) or "frames" (Lakoff 2006, p. 10-14; Lakoff 2008, p. 250ff). As presented here, this idealized model characterizes a 'person' according to three main kinds of properties which, during the history of the western tradition, have been associated with the concept of person (see e.g. Sturma 2010): moral responsibility; rational and autonomous thinking; fulfillment of the duties and respect for the rights of others. Ideal persons exhibit all these properties in the highest degree. The thesis of this

work is that the more an individual is seen as distant from the ideal of a person, the less we respect his/her moral status. This research will show that on the basis of this conclusion it is possible to explain a large number of moral phenomena, specifically, cases in which people or groups agree to allow exceptions to their own moral principles and do not grant some individuals the rights that are otherwise considered to be universal and indisputable.

A MODEL-BASED REASONING EXTRACTED FROM THE DEVELOPMENTS OF SOME SCIENTIFIC THEORIES

Antonino Drago

Several scientific theories (chemistry, thermodynamics, non-Euclidean geometries, etc.) born by searching on basic problems; each theory suggested a new method capable to solve its problem. A comparative analysis of these theories showed a common model of arguing which is characterised by seven features: 1) The theory makes use of doubly negated statements which are not equivalent to the corresponding affirmative statements (DNSs), so that the mere sequence of these DNSs preserves the logical thread of author's presentation; this fact means that the author argues in intuitionist logic. 2) The DNSs may be grouped in units of arguing, each ending by an *ad absurdum* argument of the weak kind, i.e. concluding a DNS. 3) The last unit concludes a universal DNS about the solution of the original problem of the theory and all related problems. 4) The author, having achieved the maximum amount of evidence for extending his knowledge, changes the DNS in the corresponding affirmative predicate, which in the subsequent part of the theory plays the role of a new hypothesis for the usual deductive development. As an instance of the previous features, Lobachevsky's theory of the parallel lines is illustrated. 5) Every conclusion results to be formalised by a same logical predicate, which is the same even for the sentence: "Nothing without reason". 6) The change of the conclusive predicate is the same of Leibniz' principle of sufficient reason. 7) This change is enough for changing the logic in the classical one. A very general model for classical arguing, the square of opposition, was suggested by Aristotle; remarkably, the three different intuitionist translations of its four theses give uniquely determined intuitionist theses; only their predicates enjoys the conversion property in the quantifiers. Leibniz' principle represents the change of the main thesis A of this logical structure in the corresponding thesis of the classical square of opposition. The implications of this change of the kind of logic inside a theory, for an accurate definition of the induction process are drawn.

THE PROBLEM 'CAMERA' MODELING THE ACQUISITION, STRUCTURING, STORING, PROCESSING, PRESENTATION, AND REASONING OF PROBLEM-ORIENTED INFORMATION

Ekkehard Finkeissen

The discussions around problem-oriented knowledge have become complex and multilayer. The fundamental correlations between acquiring, structuring, storing, processing, presenting, and reasoning of problem-oriented information have to be comprehended before applying the schema to real-life situations. Therefore, a meta-model both comprehensible and still powerful has to be found. In this presentation the author proposes the analogy of a film camera: similar to camera recordings information around problems is supposed to represent aspects of reality: Each 'picture' representing excerpts of the subject area at a given point in time should be well adjusted with respect to viewpoint, details, focus, exposure time, and other characteristics. The sequence of 'pictures' from multiple perspectives is supposed to depict the development over time. Like photo and film technology is permanently extended with respect to resolution, sensitivity, contrast, problem-oriented knowledge management extend its problem categories to refine the resolution of the observed area of expertise. All of these aspects have to be considered while representing reality as a basis for sound decision-making and its anticipation, called 'planning'. Therefore, the proposed analogy will be used to explain fundamental properties of

problem-oriented communication and decision-making as well as the possibilities and limitations of respective computer support. Examples from medicine and law will be used to explain the underlying structures and processes.

MODELLING SYSTEMS IN TECHNOLOGY AS *INSTRUMENTAL SYSTEMS*

Maarten Franssen

In this talk I propose and discuss a new conceptualizaton of systems in technology, which allows for an adequate treatment of two key features of technological systems: their *hybridity* (they involve both physical, causal elements and intentional, action-related elements) and their *hierarchical stratification* (they can attain arbitrary levels of complexity in a systematic way through functional decomposition). These two features typically combine to result in layered systems in which many people participate in a variety of roles. Current approaches to modelling in engineering design are limited to a view of technological systems as physical systems, governed by causal links exclusively, and lack the resources to deal with the intentional aspects, which are crucial to an understanding how a technological system works, how it may fail, and how its functionality may be safeguarded. The central notion in the proposed conceptualization is that of an *instrumental system*. An instrumental system is a structured complex whose constituents are intentionally arranged in such a way as to transform a particular kind of input into a particular kind of output in a particular way. An instrumental system is defined as having three 'slots', receiving the three basic constituent parts of such a system, *user*, *instrument* and *object*, connected by relations that are partly intentional and partly causal. I show how this approach to modelling technological systems does justice to the fact that a technological situation involving multiple persons allows for multiple perspectives, corresponding to the simultaneous presence of multiple systems, and I show how it can enrich the analysis of the functionality of a system, and its possible modes of failure, by charting possible role conflicts, both within a system and between a system and its social environment.

PRESUMING A NEW PARTICLE OR REVISING AN EXISTING LAW? A CASE STUDY IN THE ABDUCTION OF DIFFERENT FORMAL KINDS OF HYPOTHESES IN PHYSICS

Tjerk Gauderis

One of the most interesting features of the process of (creative) abductive reasoning in physics is that a new puzzling phenomenon can trigger the formation of hypotheses of very different formal kinds. Certainly in the *context of discovery*, a scientist confronted with an anomalous experimental result has in principle no normative guidelines to help him decide whether he should explain this result by withdrawing or adapting an existing law, or whether he should presuppose the existence of a hitherto unobserved entity that explains the anomaly within the existing formal framework. When a new experimental anomaly in physics proves itself to be perseverant, even the greatest minds in the field can differ strongly in opinion about which kind of hypothesis will prove to be the answer to the puzzle. In the early 1930s, the physics community was mesmerized by a manifest anomaly: the energy of electrons emerging in beta-decay displayed a broad and even continuous spectrum, a contradiction with the new laws of quantum mechanics. This puzzle intrigued the most established and famous quantum scientists at that time such as Bohr, Heisenberg and Pauli, and invoked a lively debate over a period of the next three years. But the curious thing was that they all came up with different formal types of hypotheses. Bohr suggested that the law of energy conservation might not hold in the case of beta-decay; Heisenberg, trying to solve several problems about electrons in nuclei, thought about a second quantization of the space within the nucleus of an atom; and Pauli suggested in a famous letter the existence of a completely new elementary particle, which will be later known as the neutrino. The goal of this presentation is to examine how the choice between different formal kinds of hypotheses, which is an abductive inference in itself and mostly implicitly made, is

dependent on the previous experiences of the scientist and his specific perception of the problem. To that aim this concrete case study will be analyzed by means of modern logical and model-based analytical tools.

BOHR'S MODELLING OF THE ATOM: WAS HIS DEMARCHE INCONSISTENT?

Michel Ghins

Abstract: Standard quantum mechanics notwithstanding, Bohr's celebrated model of the hydrogen atom is still taught as a paradigmatic example of successful modelling in physics. The seminal articles published by Bohr in 1913-1914 do remain an inexhaustible source of inspiration for philosophers and historians of science alike who relish using them in a flexible way in order to support their cherished views on theory construction and heuristics. In deference to such a well-established tradition, I will have a close look at Bohr's original papers and propose a reconstruction of his demarche in the framework of the model-theoretic approach of theories. I will then argue that, contrary to widespread belief, Bohr's model is not inconsistent and that it can be interpreted to support the moderate and selective version of scientific realism that I favour.

CHAOS THEORY, FRACTAL MODELS OF REASONING AND NON-GENERIC UNIVERSALITY

Viorel Guliciuc

The human being is searching for order everywhere – from the minimal one to the absolute order. This search is based on and it is following the presupposition that there is order everywhere. This is why, based on the principles of the universal logic, it is somehow inevitable that we act to set up a chaos logic – or moreover a fractal logic (Zhi-Cheng Chen). From this perspective, all the forms of reasoning (including the probabilistic one) will be, in the end, fractal in character (David Atkinson). Yet, the models of the reasoning should not reduce the reasoning to the argumentation, but they should explain the generative forms of reasoning, too. When exploring the patterns of reasoning, we will find an outstanding variety, from the endless repetition of elements, to almost endless variation. These findings will finally send us to analyze that variety from a fractal perspective – as, after exploring the star-spiral-interpersonal-story-network or architectural reasoning, we will eventually reach the discussion on the "fractal reasoning" (Margaret A. Syverson). Here we will find a characteristic of fractal patterns that seems to be not enough analyzed: the fractals are regular but not predictable. This characteristic suggests we are building our scientific theories and philosophical world views by reducing the non-generic universality to only generic universality.

IDENTIFYING ADEQUATE MODELS IN PHYSICO-MATHEMATICS: DESCARTES' ANALYSIS OF THE RAINBOW

Albrecht Heeffer

The 'physico-mathematics' that emerged at the beginning of the seventeenth century entailed the quantitative analysis of the physical nature with optics, meteorology and hydrostatics as its main subjects. Rather than considering physico-mathematics as the mathematization of natural philosophy, John Schuster (2008) has characterized it as the physicalization of mathematics, in particular the mixed mathematics. Such transformation of mixed mathematics was a process in which physico-mathematics became liberated from Aristotelian constraints. Peter Dear (1995) has shown how this new approach to natural philosophy was strongly influenced by Jesuit writings and experimental practices. Representatives of the tradition, such as Mydorge, Descartes, Mersenne and Cassini were educated at Jesuit colleges while others, such as Fabri, Grimaldi and Scheiner were Jesuits themselves. In this paper we will look at the strategies in which models were selected from the mixed sciences, engineering and technology adequate for an analysis of the specific phenomena under investigation. We will discuss Descartes' analysis of the rainbow in the eight discourse of his *Meteorology* as an example of

carefully selected models for physico-mathematical reasoning. We will further demonstrate that these models were readily available from Jesuit education and literature.

ARGUMENT MAPPING AND KNOWLEDGE MANAGEMENT

Michael Hoffmann

The term “argument mapping” is used for the graphical representation of simple arguments, more complex argumentations for positions, claims, or recommendations, and debates on controversial issues. Usually argument mapping is done with software tools. The corresponding research field is known as Computer Supported Argument Visualization (CSAV). A central purpose of CSAV tools is to facilitate coping with complexity and ill-structured problems. Since an argument map is basically a diagram as defined by Charles Peirce, argument mapping can be conceived as a case of diagrammatic or model-based reasoning. For Peirce, the main function of diagrammatic reasoning is the creation of new knowledge. Constructing diagrams and experimenting with them is supposed to stimulate creativity. Stimulating creativity is also a main goal of argument mapping since the presentation of the inferential structures of one’s reasoning should foster meta-cognitive self-assessment of one's opinions and the reasons for holding them, and the discovery of deficiencies in one's knowledge and gaps in inferences. Weaknesses that are clearly visible in an external representation of one’s thinking motivate the search for remedies for these shortcomings. In my talk I propose a novel application of Computer Supported Argument Visualization: knowledge management. The management of knowledge is becoming increasingly important for large organizations that need to gather knowledge from many sources and apply it efficiently, or for libraries and other service providers that are facing the task to present huge amounts of knowledge to a large variety of clients with different needs, interests, and abilities. I will show how a particular CSAV tool, called AGORA-net, can be used to present knowledge, and I will outline a possible architecture of a search engine that would allow the retrieval of knowledge in user-specific forms. The most important feature of this novel, argument-based approach to knowledge management is that it starts from the philosophical notion of “knowledge” as “justified belief,” avoiding thus the usual conflation of “knowledge” with “information.”

GENERATION OF HYPOTHESES BY AMPLIATION OF DATA

Emiliano Ippoliti

The paper examines an aspect of ampliation of knowledge, namely the generation of hypotheses by ampliation of data. This issue is not effectively treatable from a logical viewpoint, as it is affected by the multiplicity (nay infinity) of hypotheses generated by data. This infinity is unavoidable, as a consequence of the underdetermination of data by hypotheses. The paper argues that the issue of the generation of hypotheses is, instead, treatable from a heuristic viewpoint. In particular, the paper argues that the relationship between data and hypotheses is a form of interaction: data affect hypotheses and vice versa. The processes of ampliation of data are crucial in the formation of hypotheses, as they narrow the infinity of paths leading to hypotheses that explain the data. They are essentially based on ampliative inferences, in particular analogies. Moreover the paper shows that an analysis of the processes of discovery also reveals something about the nature of mathematical objects, namely the irrelevance of the ontological issue and, in general, the irrelevance of the nature of mathematical entities for the ampliation of knowledge. The paper examines two case studies of generation of hypotheses by ampliation of data (and the integration employed in it), one negative and one positive. Both require a ‘leap in the dark’, and neither is safe beyond doubt. But the latter is based on plausible grounds, while the former is not. The negative example (a seemingly correct hypothesis that turns out to be a complete failure)

is the generation of the Black-Scholes-Merton equation, namely the hypothesis that the price of an option over time is given by the PDE $\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial t} - rV = 0$.

The positive example is the generation of the Feynman Path Integral, namely the hypothesis that paths followed by electrons are all possible (infinite) paths, not just the classical ones. This hypothesis is expressed by the functional integral $K(a,b) = \int_a^b e^{(i/h)S[a,b]} Dx(t)$.

ABDUCTION AND MODEL BASED REASONING IN PLATO

Priyedarshi Jetli

Plato's dialogues display abundant abduction including analogical reasoning and model based reasoning. Plato's compact reasoning provides paradigm examples of Magnani's 'abduction–deduction–induction cycle'. The Socratic *elenchus* is an abduction-deduction-induction cycle as displayed in the *Meno*. If the aim was just to get the answer Socrates would have made the boy use an argument such as: $2^2 = 4$; $\sqrt{4} = 2$; $\sqrt{8} = 2\sqrt{2}$. However, Plato uses geometrical models as the squares with side 2, 3 and 4 are drawn. In the *Republic* Socrates refutes Thrasymachus's definition of 'justice' as whatever is in the interest of the ruler by offering examples of arts like medicine, horse training and teaching where the doctor, horse trainer and teacher serve the interest of their respective subjects and not their own interest, analogously a ruler must serve the interest of his subjects and not his own interest. This is vintage analogical reasoning. The divided line and the allegory of the cave are paradigm models that show the ascendancy of knowledge from imagination to veridical perception to reason. The reasoning is minimally deductive but heavily abductive. This is prime model based reasoning. The two models are structurally isomorphic and loaded with abduction. The *Parmenides* provides a paradigm deductive inference in the form of constructive dilemma embedded inside a *reductio ad absurdum* argument. Parmenides poses an objection to Socrates' use of analogical reasoning, highlighting a methodological point that the analogy has to be appropriate, and the way to show that Socrates' analogy may not be appropriate is by posing another viable analogy. Two induction chains are used, one in each sub-argument of the dilemma of participation. The inductive chain then is part of establishing the deductively sound sub argument. Hence, we have the abduction–deduction–induction cycle.

DIAGRAMS AS MATERIAL ANCHORS FOR CONCEPTUAL MAPPINGS

Mikkel Willum Johansen

In this paper, I whish first of all to argue that a large class of mathematical diagrams are material anchors for conceptual mappings. Secondly, I wish to present qualitative data demonstrating precisely how professional mathematicians use diagrams in the production of new mathematical knowledge. As noticed by Hutchins (2005), conceptual structures are in some instances anchored in material representations. The physical representation is globally stable, but locally manipulable. This allows us to focus on the part of the structure manipulated on, and consequently, the use of material anchors allow us to work on more complex conceptual structures and perform more complex manipulations. Turning to mathematics, diagrams, in contrast to figures, do not have an apparent likeness to the objects, they represent. A diagrams can only be given meaning, if the mathematical content it represents, is conceptualized using a conceptual metaphor or a conceptual blend. A simple and instructive example is the Venn diagrams often used to represent set theoretical content in introductions to algebra. Here, using a conceptual metaphor, mathematical sets are conceptualized as bounded

regions in space, and the diagrams represent sets taken under this particular conceptualization. Venn diagrams furthermore are globally stable, but locally manipulable. They are in other words material anchors for a conceptual mapping. The classification of diagrams as material anchors for conceptual mappings gives a better understanding of the different roles played by figures and diagrams. In addition, it sheds light on the functional role played by conceptual mapping in both communication of mathematical results and in the production of new mathematical knowledge. Regarding the second of these, I will in my paper, present some of the results of a qualitative interview study to be conducted during the spring 2012. In the study, working mathematicians will be interviewed about their use of diagrams.

COMPUTER 3D-MODELING AND SCIENTIFIC REASONING

Natali Kareva

Computer visual modeling is now popular means of representation of the information is widely used in different spheres of life of the modern person. The 3D-model, created by means computer software, is capable to influence first of all on vision, hearing, senses which are most informative for the human perception of world around. Thanks to so powerful capabilities the computer visual modeling can simulate effect of presence of the person in the created with its help the virtual space. This feature is actively used for research purposes for evident and, therefore, the most user-friendly presentation of information. The principle of modeling as a method of scientific reasoning includes the deliberate restriction of number informative elements to the limit, to the minimum amount which is necessary to express the essence of the issue. Scientific model, therefore, aims to transfer a limited number of the most significant formal and intrinsic characteristics. Scientific reasoning, using possibilities of 3D computer modeling, can enhance its evidence by not at the aspiration for effect of presence in the virtual space but by strengthening formal and essential aspect instead material aspect.

REPRESENTATIONS AND COMPRESSIONS

Michael R. Lissack

Change results from cause, and cause is the subject of explanation. Two types of explanatory models are often evoked as the context underlying change. Models based on labels and categories we shall refer to as “representations.” More complex models involving stories, multiple algorithms, rules of thumb, questions, ambiguity we shall refer to as “compressions.” Both compressions and representations are reductions. But representations are far more reductive than compressions. Representations can be treated as a set of defined meanings – coherence with regard to a representation is the degree of fidelity between the item in question and the definition of the representation, of the label. By contrast, compressions contain enough degrees of freedom and ambiguity to allow us to make internal predictions so that we may determine our potential actions in the possibility space. Compressions are explanatory via mechanism. Representations are explanatory via category. This paper highlights the risk which occurs when we confuse the evocation of a representation (category inclusion) as the creation of a context of compression (description of mechanism). In the drive for efficiency such substitutions are all too often proclaimed – at our peril. Our "modern" world has found great efficiencies in the ascribed coherence of rules and algorithms. Efficiency has its place but it also has its price. Efficiency it seems can be the enemy of resilience. Category based explanations may be efficient but they are not resilient. Resilience requires: narratives not labels, mechanisms not categories, a focus on experience and not on labels and a need to be aware of when representations work and when they fail. We need to become aware of the complex role of both representations and compressions in defining the possibility space, in allowing for the overt recognition of affordances, and in challenging the experience of coherence as life itself unfolds

THE THEORY OF AFFORDANCE AND TECHNOLOGY EPISTEMOLOGY

Luo Lingling and Li Shuang

The theory of affordance is of great significance to technology epistemology and methodology. The relation of the theory of affordance and technology epistemology will be analyzed in terms of five aspects: Firstly, the affordance is, in general, closely related to human survival. That is, the affordance is concerned with survival directly as it can activate and generate corresponding behavior. The technology is regarded as the approaches to and means of human being for survive effectively. Thereby, the affordance inevitably offers an indissoluble bond with technology. Secondly, the theory of affordance provides a theoretical basis for the origin of the technological embodiment. The affordance is closely concerned with the behavior of organism by utilizing the information of the environment for survival. It will be helpful for giving account of how the original technical artifacts come into the world. Thirdly, the affordance is seen as relational, and it provides an ecological basis for the transition from the instinctive technology to intelligent technology. The survival of organism is in need of instinct, but human specifically has the intelligence that it can be regarded as superior to the other animals. Fourthly, human can make use of technology to transform the natural affordance into artificial affordance. The fear of survival is accompanied by the entire life of human being. Human being is the creature with the cognition of death. Fifthly, it is viewed as a breakthrough of technology phenomenology. This paper argues that the affordance used in a natural way is of embodiment. The embodied technology can be controlled by human being.

ON REPRESENTATION IN COMPUTATIONAL MODELING OF THE EMERGENCE OF COMMUNICATION

Angelo Loula and João Queiroz *(presented by Pedro Atã)*

Computational simulation has been consolidating as a general framework to model the emergence and evolution of animal communication systems (ACS), such as human language. This approach has been developing environments and creatures by means of which it is possible to simulate minimal constraints to observe the emergence and evolution of semiotic behavior. As a methodological principle, in great part of the computational approaches, the emergence of semiotic behavior is simulated in the absence of previous adaptation. Systems, or creatures, are capable of producing some form of communication in a scenario where communication, its components or structures, were not previously available. Here, we argue that there have been few systematic studies on the representation and the different modalities of representations involved in the emergence of communication by means of computer simulations. We argue that the absence of discussions is due to a lack of an appropriate theoretical framework that could not only offer means to analyze the emergent sign processes, but could also provide constraints in the process of setting up the experiments. According to our approach, Charles S. Peirce's semiotics can be such theoretical ground for building experiments and evaluating results on simulations of the emergence of communication. Peirce's semiotics is recognized as a strongly consistent theory, and has been brought forth by other researchers, though fragmentally or in an inconsistent form. We expect that Peirce description of sign processes can bring forth new perspectives in computational models of the emergence of communication.

THE NON-FICTIONAL NATURE OF SCIENTIFIC MODELS. MODEL-BASED SCIENCE AS EPISTEMIC WARFARE

Lorenzo Magnani

In the current epistemological debate scientific models are not only considered as useful devices for explaining facts or discovering new entities, laws, and theories, but also rubricated under various new labels: from the classical ones, as abstract entities and idealizations, to the more recent, as fictions, surrogates, credible worlds,

missing systems, make-believe, parables, functional, epistemic actions, revealing capacities. The paper discusses these approaches showing some of their epistemological inadequacies, also taking advantage of recent results in cognitive science. The main aim is to revise and criticize fictionalism, also reframing the received idea of abstractness and ideality of models with the help of recent results coming from the area of distributed cognition (common coding) and abductive cognition (manipulative). The article also illustrates how scientific modeling activity can be better described taking advantage of the concept of "epistemic warfare", which sees scientific enterprise as a complicated struggle for rational knowledge in which it is crucial to distinguish epistemic (for example scientific models) from non epistemic (for example fictions, falsities, propaganda) weapons. Finally I will illustrate that it is misleading to analyze models in science by adopting a confounding mixture of static and dynamic aspects of the scientific enterprise. Scientific models in a static perspective (for example when inserted in a textbook) certainly appear fictional to the epistemologist, but their fictional character disappears in case a dynamic perspective is adopted. A reference to the originative role of thought experiment in Galileo's discoveries and to usefulness of Feyerabend's counterinduction in criticizing the role of resemblance in model-based cognition is also provided, to further corroborate the thesis indicated by the article title.

MODEL-BASED REASONING IN THE MORAL DOMAIN: THE ROLE OF ABDUCTION, DEDUCTION, AND INDUCTION IN MORAL FUNCTIONING"

Gerhard Minnameier

Of course, cognitions are to be hot, especially in the moral domain. However, the overall and ubiquitous role of cognition across all processes or moral functioning have largely been underestimated. This is especially true for moral externalism and moral emotivism. But even in the internalist camp the simple claim prevails that moral judgement is motivating in itself, which seems to be only half of the story. What is claimed in the present paper is that the three Peircean inferences of abduction, deduction and induction guide the whole process of moral reasoning from the arousal of moral cognition until the eventual commitment to a certain kind of action. Much of what has been attributed to – more or less – spooky motivational powers is thus reanalysed in terms of an underlying logic. This yields a cognitive account of how moral principles as mental models for the analysis and solution of moral decision problems are activated, how they are used to derive action plans, and how these action plans are finally evaluated to determine whether one has to feel committed to them or not. What's more, the approach also allows us to explain why and how acquired moral principles are differentially activated depending on the concrete situation. This is a point in the abductive part of moral reasoning and its role in the flexible situation specific activation of cognitive structures.

ABDUCTIVE REASONING FROM THE AGENT'S POINT OF VIEW

Angel Nepomuceno-Fernández, Fernando Soler-Toscano, Fernando R. Velázquez-Quesada

Abductive reasoning is one of the most important reasoning processes, not only in philosophy-related areas like philosophy of science, but also in more practical settings like artificial intelligence. Recent proposals have explored approaches to abductive reasoning in a dynamic epistemic logic setting; the present work looks into that idea in further detail. First, we discuss what it means to have an abductive problem in terms of an agent's knowledge and beliefs, and then we explore the conditions a given formula should satisfy in order to be considered an abductive solution in this setting. With a collection of explanations in hand, we now discuss how can the agent choose 'the best' one and, once such explanation has been chosen, we finally propose a way to incorporate it to the agent's information.

UNDERSTANDING GALILEO'S DISCOVERY OF JUPITER'S MOONS THROUGH ABDUCTIVE INFERENCE STRATEGIES

Jun-Young Oh and YooShin Kim ·

The objective of this study is to understand the scientific inferences made during Galileo's discovery of the moons orbiting Jupiter, using an abductive inference strategies. The use of abductive reasoning is very important for both creative leaps and for scientific discovery during problem solving. Two research problems are presented: (1) we suggest the following scientific procedure involving abductive inference (2) we analyze "Galileo's discovery of the moons of Jupiter," historically considered evidence of the Heliocentric hypothesis, with our suggested inference procedure. This procedure will help us to understand the patterns of inference and to abductively generate and then test alternative hypotheses using the deduction-Induction method.

HOW TO LEARN ABDUCTION FROM ANIMALS?: FROM AVICENNA TO MAGNANI

Lecture in Honor of the 60th Birthday of Lorenzo Magnani, Chair of MBR012

Woosuk Park

Magnani's recent discussion of animal abduction sheds considerable light on both instinctual and inferential character of Peircean abduction. Inspired by this, I elsewhere noted some analogies and disanalogies between Avicenna's ideas on estimative faculty of animals and Peirce's and Magnani's views on animal abduction. Also, I confirmed the dividing role and function of the Beast-Machine controversy in the history of the study of animal cognition. In this paper, I propose to discuss rather extensively some of the most salient differences between Avicenna and Peirce-Magnani. Unlike estimation that only allows animals to sense what is insensible, i.e., intentions, abduction in both Peirce and Magnani is applicable to all perceptions. In order to appreciate the implications of such a contrast, I shall examine (1) whether the psychological aspect of abduction has been unduly ignored, (2) whether it is possible to develop abductive robots, and *eo ipso* (3) whether humans can learn ways of sharpening their abductive instincts.

ON CLASSIFYING ABDUCTION, SCIENCE, AND SIGN

Woosuk Park

We can witness the recent surge of interest in classifying different patterns or types of abduction. Many philosophers, including Thagard, Magnani, Gabbay and Woods, Schurz, and Hoffmann, have suggested their own classifications emphasizing different aspects of abduction. Such a development is remarkable, in view of the fact that until quite recently the focus of the research on Peircean abduction was to identify its logical form. Probably, it is Schurz (2008) that could be a nice point of departure for useful comparisons of all these classifications. For, he provides us with a rather extensive list of different patterns of abduction. In terms of the entity abduced, he distinguished between 15 patterns of abduction, grouped under 4 categories. Largely concurring with Schurz, Hoffmann further expands the list into a table by adding what he calls "meta-diagrammatic abduction". One common problem in Schurz's and Hoffmann's classifications of abduction must be their exclusive concern on "explanatory" abduction by denying or ignoring the existence of non-explanatory abduction. To say the least, such a procedure is controversial. For, non-explanatory abduction is what motivates Gabbay and Woods for distinguishing between AKM (Aliseda, Kuipers, Magnani) and GW (Gabbay, Woods) models of abduction. Based on the examination of these previous attempts, I shall fathom Peirce's mind as to the problem of classifying abduction. How would Peirce have classified abduction, if he intended to do so? I think that the unmistakable clue for this project of fathoming Peirce's mind as to the problem of classifying abduction

must be his lifelong interest in the classification of science. For, given the exhaustibility of all inferences by deduction, induction, and abduction, it seems natural to classify science in terms of the relative importance of each of these forms of inference in each individual science. I shall reconstruct conjecturally Peirce's implicit classification of abduction based on his ways of classifying these sciences. In the same vein, it might not be too farfetched to derive Peirce's classification of abduction from his classifications of signs. By probing question as to the relationships among the classification of abduction, the classification of science, and the classification of signs, I expect to deepen our understanding of the ultimate motivation of Peirce for these classifications as well how he would classify abduction.

TOWARDS A SIMULATION OF PEIRCE'S CYCLE OF ABDUCTIVE, DEDUCTIVE AND INDUCTIVE REASONING.

Pieter Pauwels, Ronald De Meyer, Jan Van Campenhout

The importance of abductive reasoning is increasing within diverse research domains. Especially in combination with deductive and inductive reasoning, as Peirce originally presented it, it appears to provide an answer to many issues in diverse domains involving idea generation, creativity, interpretation, surprise, etc. While keeping in mind the diverse issues related to design thinking and information system support, which is our main domain of research, we looked into the theory of Peirce and its diverse interpretations. Based on this research, we constructed our own interpretation of this theory. Central in this interpretation stands a cycle of abductive, deductive and inductive reasoning which is iterated continuously with the surrounding physical world as its subject. From this continuous iteration, experiential knowledge is built up. This kind of knowledge is considerably different from the more static knowledge typically embedded in currently available information systems. This paper documents a part of our efforts in simulating such a reasoning cycle using currently available technologies. These efforts have resulted in an environment in which a reasoning agent processes basic colour information and gradually builds up interpretations of such colours based on incoming information. At this stage of research, such colour information is considered representative for the kind of information typically available in our physical world. Diverse hypotheses and conclusions have been made from this experimental environment. For instance, we hypothesise that Peirce's reasoning cycle might be configured in reasoning levels, with each level handling information or patterns in different levels of invariance and meaning. We conclude that Peirce's approach could help in addressing some critical issues in diverse domains. However, important barriers prevent any important breakthrough in the near future.

MECHANISM AND PHENOMENON OF CONSCIOUSNESS REMARKS ON MODELS AND ANALOGIES IN DENNETT AND EDELMAN

Paolo Pecere

Since the XVIIth century, especially after the rise of Cartesian philosophy, the use of mechanistic models has dominated the study of the brain functions in Europe, while at the same time the ontological value of such models has been deeply contested, notably by Descartes himself. A widespread feature of contemporary philosophy (think of Dennett and Churchland) and neurosciences (think of Edelman and Damasio) lies precisely in the explicite rejection of Cartesian dualism. The precise heuristic and ontological value of mechanistic models, nevertheless, is highly controversial. I discuss this claim by comparing Dennett's and Edelman's different hypothetical theories about consciousness. In Dennett's theory presents a very complex «mechanistic» hypothesis, that draws inspiration from different disciplines, such as computer science, pragmatic linguistics and evolutionary theory. According to Dennett, consciousness (as the representation of *qualia*) has to be *explained away* and considered as a «virtual machine», a «software» installed on the parallel «hardware» of the brain, whose result is the single-channel reduction of subconscious, multi-track brain processes. The phenomenology

of consciousness is ultimately a domain of illusion with no ontological value. In Edelman's theory, on the contrary, different features of the brain involve a completely different value of phenomenology: the physical individuality of every single brain and the complexity of neural connection render any physical description of the brain «mechanism» practically impossible. Therefore, according to Edelman, evolution has produced a unique means of representing human experience in an economical and efficient way, that is consciousness (again, as the representation of *qualia*). Consciousness, therefore, serves as a model for mechanistic analogies that can never get to the latter's ultimate explanation. Indeed, the metaphorical language of common experience correcty reflects the complexity of the brain, contrary to the logical reduction of the mind process to computation in the past cognitive science. These conclusions share significant similarities in the European debate on phenomenology and neuroscience (for example in the seminal debate between Changeux and Ricoeur). In the different terminology of phenomenology, here, consciousness provides a «ontological» guiding tread for physical explanations of the brain processes.

INFORMATION INTEGRATION IN THE BRAIN: MODELING A PUTATIVE FUNCTION OF THE ASTROGLIAL NETWORK

Alfredo Pereira Jr.

In perceptual processes of human individuals and other species, signals carrying information about a stimulus are transmitted through multiple processing lines to populations of receptive neurons and thalamocortical circuits, leading to the formation of a spatial ensemble of local field potentials. This work addresses the problem of how the brain integrates the patterns embodied in local fields to (re)construct the stimulus in a conscious episode. Considering the strategic position of astrocytes, mediating somatic signals carried by blood flow and information carried by the neuronal network, as well as their intrinsic information processing capabilities, these cells are in an adequate condition to integrate spatially distributed information. The amplitude-modulated calcium waveform in astrocytes is a multiscale phenomenon, simultaneously operating on temporal scales of milliseconds and seconds, as well as in micro and macro spatial scales. Oscillatory synchrony, constructive wave interference and communication by means of ionic antennas are proposed to constitute a neuro-astroglial self-organizing mechanism of perceptual integration and feeling of the content of information.

COMPLEX NETWORKS OF MINDFUL ENTITIES

Luís Moniz Pereira

The mechanisms of emergence and evolution of cooperation — in populations of abstract individuals with diverse behavioural strategies in co-presence — have been undergoing mathematical study via Evolutionary Game Theory, inspired in part on Evolutionary Psychology. Their systematic study resorts as well to implementation and simulation techniques in parallel computers, thus enabling the study of aforesaid mechanisms under a variety of conditions, parameters, and alternative virtual games. The theoretical and experimental results have continually been surprising, rewarding, and promising. Recently, in our own work we have initiated the introduction, in such groups of individuals, of cognitive abilities inspired on techniques and theories of Artificial Intelligence, namely those pertaining to Intention Recognition, encompassing the modelling and implementation of a tolerance/intolerance to errors in others — whether deliberate or not — and tolerance/intolerance to possible communication noise. As a result, both the emergence and stability of cooperation, in said groups of distinct abstract individuals, become reinforced comparatively to the absence of such cognitive abilities. The present paper aims to sensitize the reader to these Evolutionary Game Theory based studies and issues, which are accruing in importance for the modelling of minds with machines. And to draw attention to our own newly published results, for the first time introducing the use Intention Recognition in this context, with impact on mutual tolerance.

COUNTERFACTUALS AND MODUS TOLLENS IN ABDUCTIVE ARGUMENTS

Claudio Pizzi

The paper starts from a neglected passage of a celebrated paper on counterfactuals in which Nelson Goodman asserts that every counterfactual may be converted into an equivalent trasposed factual conditional. The interest of Goodman's claim is twofold: (i) the factual conditionals which Goodman has in mind are conditionals which are “abductive”, in the sense that describe an inference from a fact to another which explains the first. (ii) in apparent conflict with the preceding remark, a well known feature of conditional reasoning is that contraposition is not a property which holds universally for counterfactuals. After giving a critical evaluation of an analysis of the problem performed by B. Skyrms in probabilistic terms, it is argued that the formula $((\neg A > \neg B) \wedge B) \supset (B > A)$ may be defended as a conditional thesis on the basis of plausible consequentialist assumptions. The final part of the paper contains, beyond a short reexamination of the taxonomy of conditionals, some reflections about the application of the mentioned thesis to standard procedures of abductive reasoning, which is here essentially intended as Inference to the Best Explanation.

IDEALIZATION AND SCIENTIFIC MODELS: REDUCING THE INFORMATION CONTENT

Demetris Portides

In this paper I focus on the character of idealization, particularly regarding its use in scientific models. More specifically, I try to analyze the ways idealization enters in scientific modeling from the perspective of the reasoning process involved. I argue that the core feature of the reasoning process behind scientific modelling is the systematic omission of information, which leads to reduction of information content in models. By relying on an analysis of the reasoning process as omission of information regarding the characteristics of target systems, three general ways by which information content is reduced are distinguished: idealization by undelimitation, idealization by isolation and idealization by decomposition. These three kinds of idealizations are explained and an attempt is made to demonstrate their usefulness in making sense of a variety of characteristics exhibited by models.

DO WE NEED INFERENCES FOR RECOGNITIONAL BELIEFS?

Athanasios Raftopoulos

In this paper, I examine the processes that occur in late vision, which is a stage of visual processing that succeeds early vision and starts about 120 ms after stimulus onset and which is conceptually modulated, and discuss whether late vision should be construed as a perceptual stage or as a thought-like discursive stage involving inferences. I argue that late vision, its (partly) conceptual nature notwithstanding, does not consist in pure thoughts, that is, propositional structures that are formed in the cognitive areas of the brain and participate in discursive reasoning and inferences. Although late vision implicates beliefs, either implicit or explicit, these beliefs are hybrid visual/conceptual constructs and not pure thoughts. As such, they do not stand in inferential relations with other propositional structures and the transformations that occur within late vision are not the results of discursive inferences but results of a dynamic sort of processing akin to that employed to describe the processes in dynamical neural networks. In other words, I am claiming that if there is any sort of reasoning in late vision, this is not reasoning carried out by logical manipulations of propositional structures. Instead, it is the sort of reasoning that befits neural networks in which inferences, or rather pattern matches, assume the form of model comparisons, where the models of the visual scene that the perceptual system construct are compared to the models of the world in the mind of the viewer. This comparison involves constructing and manipulating models rather than discursive reasoning that applies to propositional structures.

FROM INFORMAL THOUGHT EXPERIMENTS TO AGENT-BASED MODELS. A PROGRESSIVE ACCOUNT OF MODELING IN SOCIAL SCIENCES

Ruggero Rangoni

Many features of thought experiments are puzzling only if we assume that scientists are olympic rational agents, in which case thought experiments would be plain useless. On the other hand, regarding scientists as bounded rational individuals illuminates both the aim of thought experiments and what kind of knowledge we can attain through them. From a set of accepted assumptions, thought experiments allow to draw consequences which are far from being obvious. The price to pay is the possibility of fallacies, being the result of wrong assumptions or bad inference. Thought experiments are widely employed in the social sciences, as many experiments are not affordable or even impossible to realize. Informal thought experiments, which are typical of classical economics, involve vagueness in the inference from their premises. On the other hand, formalized theoretical models lack realism in their assumptions, such as modeling social actors as homogeneous, olympic rational agents. Agent-based models are a particular kind of thought experiments, which are especially useful when our intuition is dealing with complex subjects, such as the explanation of social phenomena. We will argue that, contrary to analytical models, agent-based models allow the interaction of bounded rational and heterogeneous agents. On the other hand, unlike informal thought experiments, the conclusion of a simulation is the result of a strictly deductive procedure. Hence, agent-based models improve the truthlikess of the assumptions of analytical models, while at the same time avoiding the vagueness of informal thought experiments.

ABDUCTION, UNPREDICTABILITY AND GARDEN OF EDEN

Chiaki Sakama and Katsumi Inoue

The notion of unpredictability has been a central theme in both natural and social sciences. To understand what is unpredictable, it is necessary to formulate the notion in contrast to predictability. In this paper, we first formulate unpredictability based on abduction. An abductive framework is defined as a pair <B, H> where B is background knowledge and H is a hypothesis space. Then, an event E is unpredictable under <B, H> if there is no hypothesis h in H such that E is a logical consequence of B and h. In propositional abductive theories, the complexity of deciding whether an event is unpredictable is at the second level of the polynomial hierarchy. Next, we apply the notion of unpredictability to the problem of identifying patterns having a specific feature in cellular automata (CA). In CA it is generally unforeseen whether a particular pattern is produced by given transition rules from the initial configuration. On the other hand, a configuration that cannot be reached by any initial configuration is called a Garden of Eden (GOE). One of the open questions is the existence of a GOE in an arbitrary grid size. From the viewpoint of abduction, a GOE is considered a configuration that is unpredictable by any predecessor under transition rules. We then characterize a GOE as an unpredictable event in an abductive framework. This characterization opens possibilities for finding a new GOE by abductive logic programming.

ROLE OF THEORETICAL MODELS FOR INFORMATION INTEGRATION IN THE SEARCH FOR SCIENTIFIC EXPLANATION OF CONSCIOUSNESS

Marcin J. Schroeder

Explanation of the phenomenon of human consciousness was always the highest goal of philosophy and of its offspring – science. Typically, at least from the times of Descartes, the problem of explanation is understood as a resolution of the problems of mind-body relationship. Traditional division of the attempts to resolve these problems (if they are not considered fallacious or impossible) is identifying as philosophical those which try to

explain how mind is reaching or creating material/physical reality, and as scientific those which try to explain how matter/physical-substratum is reaching or creating mind. In this paper, the attempt is made to show that the explanation requires an engagement of both perspectives. This dual-perspective approach necessitates a conceptual framework overreaching philosophical and scientific concepts, such as idea, perception, subject/object used in the former approach, and matter/energy, physical system, state in the latter. Such a framework has been developed in the author's concept of information and its integration, based on the categorical opposition of one and many. The main purpose of this paper is to demonstrate that the most promising, if not the only possible strategy in the explanation of consciousness is to utilize theoretical models of mechanisms responsible for consciousness in terms of information integration to guide searches for material models in terms of functional material units in the brain.

A HISTORICAL CASE STUDY OF A "NESTED ANALOGY" WITH MODELS OF THE SAME MATTER

Nora Alejandrina Schwartz

During scientific innovation episodes, models to reason about real world problems under investigation are usually created. In this paper I will present a case in the history of science in which the building of this sort of models constitutes a "nested analogy". Through the analysis of this case I intend to show that this type of structure may involve models of different order that have the same matter; or, at least, some "areas" of the same matter. I will deal with the development of Luigi Galvani´s research leading to the discovery of "animal electricity". Galvani builds "hybrid" models to understand the physiological role of electricity in animal models on which he works with the purpose of practicing electrical medicine on humans properly. Both models of first and second order have as matter a frog limb or a part of it. Galvani gives a neuroelectric explanation of the muscle movement, supported by his work on *animal models.* In *De viribus electricitatis in motu muscolari. Commentarius* from 1791, Luigi Galvani says that in the context of an electrical discharge experiment with a frog he faced an especific problem: *which is the source of the electrical current* in that case. In order to solve this problem thoroughly, Galvani builds a model which constitutes what Nersessian and Chandrasekharan call "nested analogy". Galvani seems to "design" on the limb of the prepared frog itself the shape of a Leyden Jar. Aiming to meet a relevant constraint from de Biology domain, this model is modified. So, he changes the former model and puts in its place another one: a single muscle fiber shaped like a little Leyden Jar.

MODELS AND IDEOLOGY IN DESIGN

Cameron Shelley

Research on model-based reasoning in technology tends to focus on the informational role of models. That is, is concentrates on the use of models as a source of information about how to solve a given design problem. However, besides their informational role, models can also serve an ideological role. That is, models can provide affirmation of the moral correctness of a design program. In this article, the role of models within three design programs is examined. These programs are Gothic Revivalism, Modernist architecture, and industrial design in the early 20th Century. In each case, the ideology of the program is sketched and the role of models within them is discussed. Through this exercise, we see that models for design are selected not only for their help in solving design problems but also for their service in reflecting and reinforcing the worldview of the designer.

LIVING IN THE MODEL. THE COGNITIVE ECOLOGY OF TIME - A COMPARATIVE STUDY

Chirs Sinha

with Wany Sampaio, Vera da Silva Sinha and Jörg Zinken

Time is at once familiar and mysterious, its status in the physical universe being uncertain and contested. Time seems to be fundamental to both biology and to the world of human experience. It seems certain that human beings in all cultures experience time, and have ways of linguistically referring to relations between events in time. It has been proposed by some cognitive scientists that there is a natural, transcultural conceptual domain of time. Cultural conceptions of time, however, vary considerably. I present some anthropological linguistic data from a study that my colleagues and I conducted in an indigenous Amazonian community (Sinha *et al.*, 2011). "Living in time", we contend, is to live in a model, and the conceptual domain of "time as such" is not a human cognitive universal. Concepts of time are cultural and historical constructions, constituted by schematic time interval systems, and embodied in language and culture dependent symbolic cognitive artefacts. Time is both artefactual model and cognitive niche (Clark, 2006; Magnani, 2009), made possible by the wider biocultural niche of language (Sinha, 2009).

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FULL BAYESIAN EPISTEMIC SIGNICANCE: FOCUS ON SURPRISE, MEASURE PROBABILITY

Julio Michael Stern, Carlos Alberto de Braganca Pereira

The Full Bayesian Signicance Test, or FBST, de_nes the e-value, ev(H), as a possibility measure that can be interpreted as the epistemic value of the hypoth- esis H given the statistical model's posterior probability distribution, $p(\theta)$. This article investigates the relation of this novel possibility measure to more traditional probability-possibility transformations. In particular, we show how and why the e-value focus on or conforms with $s(\theta) = p(\theta)=r(\theta)$, the model's surprise function relative to the reference density $r(\theta)$, while it keeps itself consistent with the model's posterior probability measure. This article also investigates traditional objections raised in the statistical literature against measures of statistical signicance engendered by probability-possibility transformations.

SCIENTIFIC REALISM, MATHEMATICAL PLATONISM, EVOLUTIONARY ADAPTATIONISM: THREE RELATED INFERENCES TO THE BEST EXPLANATION. SOME REMARKS FROM AN ANTIREALIST PERSPECTIVE.

Fabio Sterpetti

The aim of this paper is to show how Scientific Realism (SR), Mathematical Platonism (MP) and Evolutionary Adaptationism (EA) are related. I'll try to show how the main arguments for each of them are instantiations of Inference to the Best Explanation (IBE), and how their implicit assumptions are related, in order to underline that they have to face similar problems arising from the same realist view of knowledge they share, and to criticize it from an antirealist point of view inspired by Cellucci's work. So I hope to show that: 1) to support (or criticize) SR, MP or EA means to face both problems related to each of these positions *and* those related to the

relations existing between them; 2) to criticize (or to support) IBE means even to criticize (or to support) those positions. Finally, I'll try to show that the realist approach to IBE is untenable by adopting the point of view on abduction proposed in Cellucci 2011.

THE ARABIC SCRIPT, FROM VISUAL ANALOGY TO MODEL-BASED REASONING

Christian Tamas

For the Arabs in the beginning was the letter. The uttered one, the sound. And only afterwards the written word embodied and conditioned by the Qur'an. The phonetic and graphic shapes of the letters inspired a series of analogies which related to God as universal wholeness and script. Basing themselves on the close observation of the Qur'anic script as absolute matrix the Arab scholars began to model it constructing formal theories to describe and explain its meanings and their applicability in everyday life and developing a science named *tafsir* which tried to establish patterns in all the fields related to man's life and activity mainly on the basis of deduction and logical analogy. Thus, the Qur'anic written text and the geometrical forms derived from it served as diagrams hovering between theories and their models. They were very similar to the pictures of structures used many centuries afterwards by the non-Islamic model theorists who used them to think about the structures. If, when reasoning with diagrams, pictures or diagrams are seen more as a form of language rather than as a form of structure, for the Islamic theorists they were both, as language was besides its intrinsic quality a form of structure. As model-based reasoning plays an essential role in a deep understanding of any scientific topic, this was the essential strategy *avant la lettre* by which the Islamic theological and scientific schools "extended the experience reducing it to order" (Niels Bohr). Inquiry and application as basic practices of model-based reasoning crossed the border between accepted and verified observations and the models used in order to explain facts. Thus, the fact that both verified observations and the models used began and ended within a world and universe shaped and governed by the Qur'an has provided the Islamic culture its sufficiency until today.

FEAR-DRIVEN INFERENCE: MECHANISMS OF GUT OVERREACTION

Paul Thagard

Model-based reasoning requires not only inferences about what is happening in situations but also evaluations of the desirability of what is happening. Emotions are a key part of such assessments, but sometimes they can lead people astray, as in motivated inference when people believe what fits with their desires. In contrast, fear-driven inference generates beliefs that people do not want to be true. Although paradoxical, this kind of inference is common in many domains, including romantic relationships, health, parenting, politics, and economics. This article proposes that fear-driven inference results from gut overreactions, in which a feeling that something is wrong is erroneously taken as evidence that something really is wrong. We discuss psychological and neural mechanisms by which gut overreactions can lead to fear-driven inference, and show how a computer model of emotional coherence can explain both fear-driven and motivated inference.

MODELS, MAKE-BELIEVE AND THE INDIRECT FICTIONS VIEW

Adam Toon

In theoretical modelling scientists often make assumptions that are true of no actual, physical object. And yet they commonly talk as if there were such objects and as if they can find out about their properties. Theoretical modelling therefore poses ontological puzzles: how are we to make sense of the fact that a large part of scientific practice seems to involve talking and learning about things that do not exist? Many attempt to make sense of this by positing abstract or

fictional entities that satisfy scientists' modelling assumptions. According to these accounts, in modelling scientists represent the world *indirectly*, via abstract or fictional entities.

I will propose a *direct* view of theoretical modelling. According to this account, scientific models function as props in games of make-believe, like dolls or toy trucks. I will argue that this account allows us to solve the ontological problems posed by theoretical modelling. Rather than representing the world via abstract or fictional entities, scientists' assumptions and theoretical laws represent the world directly, by prescribing imaginings about it. I will suggest that this *make-believe view* has a number of advantages over the indirect fiction views offered by authors such as Peter Godfrey-Smith and Roman Frigg.

TOOLS OF THOUGHT

Barbara Tversky

When thoughts overwhelm the mind, the mind puts them into the world. Talk, gesture, diagram, and sketch help not only to augment memory and information processing but also to structure thought and promote inferences and discovery. Research from many domains will be presented that highlights the similarities, differences, and special characteristics of each of these tools of thought.

METAPHOR, ANALOGY, AND MODEL-BASED REASONING IN MATHEMATICAL PHYSICS

Ryan D. Tweney

The role of model-based reasoning in experimental and theoretical scientific thinking has been extensively studied. However, little work has been done on the role of mathematical representations in such thinking. I will describe how the nature of mathematical expressions in physics can be analyzed using an extension of the metaphoric analysis of mathematics. Lakoff and Núñez (2000) argued that embodied metaphors underlie basic mathematical ideas (e.g., the concept of "number" is based on the embodied operations of "collecting objects"), with more complex expressions developed via conceptual blends from simpler expressions (e.g., "addition" as "combining collections"). In physics, however, the need to represent physical processes and observed entities (including measurements) places different demands on the blending processes. In model-based reasoning, conceptual blends must often be based on immediately available embodiments as well as highly developed mathematical expressions. Thus, Faraday's representations of magnetic fields as "lines of force" were modeled by Maxwell as vectorial expressions, in a form similar to what later became known as Maxwell's Equations. In the talk, I will show how some aspects of Maxwell's Equations can be understood by unpacking the metaphoric underpinnings as physical representations. The implications for analogical and model-based reasoning accounts of scientific thinking and its pedagogy will be discussed.

THE ROLE OF MODELS IN MIND AND SCIENCE

Marion Vorms and David Lagnado

During the last few decades, models have become the centre of attention in both cognitive science and philosophy of science. In cognitive science, the claim that humans reason with mental models, rather than mentally manipulate linguistic symbols, is the majority view. Similarly, philosophers of science almost unanimously acknowledge that models have to be taken as a central unit of analysis. Moreover, some philosophers of science and cognitive scientists have suggested that the cognitive hypothesis of mental models is a promising way of accounting for the use of models in science. However, once the importance of models in cognition as well as in science has been acknowledged, much more needs to be said about how models enable

agents to make predictions, and to understand the world. In this paper, our goal (as a cognitive scientist, working on causal reasoning, and a philosopher of science, working on models and representations) is twofold. We would like to further develop the notion of mental models, *and* to explore the parallels between mental models as a concept in cognitive science, and models in science. While acknowledging that the parallel move towards models in cognitive science and in philosophy of science is in the right direction, we think that: *i.* the notion of mental models needs to be clarified in order to serve as a useful tool, *ii.* the relation between the hypothesis of mental models and the use of models in science is still to be clarified. First, we will briefly recall a few points about the mental model hypothesis, on the one hand, and the model-centred view of science, on the other hand. Then, we will present our parallel criticisms, and put forward our own proposals.

MODELING THE SOLIPSISTIC CONCEPTION OF SUBJECTIVE SIGNIFICANCE IN THE SEMIOTIC SPHERES OF HUMAN NATURE AND CULTURE

Zdzisław Wąsik

In this paper, a logical-philosophical approach to meaning-carriers or meaning-processes will be juxtaposed with the anthropological-biological conceptions of subjective significance uniting the semiotics of culture and nature. Special attention will be paid to communicational practices and patterns of meaning-creation and meaning-utilization in social interactions. The subject matter of the domain studied by human semiotics will be specified in terms of sign-and-meaning processing and sign-and-meaning interpreting activities of communicating selves who utilize the objects found in the ecological systems of their subjective universe as functional tools or valuable goods of culture. The roots of those subject-oriented conceptions of sign and meaning will be traced in instrumentalist and organicist functionalisms originating from the praxeological and axiological view of culture. Correspondingly, culture will be presented here as a set of praxeosemiotic and axiosemiotic regularities that occur between the meanings of functions or values and become realized in nonverbal and verbal products of the activity and attitudes of human beings which co-determine and condition the modes of their life and behavior. Exposed in such a human-centered theory of culture is the role of a subject who acts as a meaning-utilizer or meaning-evaluator, and who nominates and subsumes the objects of culture as signs of purposes or needs. In the semiotic activity of human beings, acting either as senders or receivers if messages, one can, therefore, distinguish two manifestation forms of meaning-nomination and meaning-subsumption, on the one hand, from the viewpoint of praxeology, and on the other, from the viewpoint of axiology. The praxeosemiotic nominations and subsumptions are connected with the ascription of functions to the objects hitherto being not useful for certain purposes. In turn, the axiosemiotic nominations and subsumptions result in the transfer of products and behavior of people to the realm of cultural objects, which are not necessarily connected with their usefulness.

MODELING MORAL COGNITION

J. Benjamin White

An adequate model of moral cognition must be equally able to represent the broad range of moral agency, from “monstrous” to “altruistic,” from antisocial to prosocial, from psychopath to hero of conscience, from individual to institutional. This paper details such a model. The ACTWith model of moral cognition is a bare-minimum implementation non-specific information-processing model inspired by hybrid models of human learning and proceeding from two key neurological insights, disgust and mirroring of expressed action and emotion. From a dynamic systems approach, it models not isolated agents, but situated agents, and is thus essentially a model of situated cognition representing a strong form of embodiment. Consistent with Lorenzo Magnani’s concept of the “moral mediator,” the ACTWith model was originally intended as a conceptual tool rendering solutions to the most difficult project in life – How to live a life worth living towards the realization of a world worth living in.

In this paper, its capacity as a moral mediator is illustrated in three forms. First, in providing an information-processing model of "conscientiousness." Second, in providing a model of psychopathy. Finally, in modeling the corporate "person."

MODELING NON-VIOLENT SOCIAL TRANSFORMATION – REVOLUTION BY DESIGN

J.Benjamin White

The philosophic vision at the core of Plato's *Republic* is that the structure of a society can be designed, and changes to existing structures realized, through model-based reasoning. By this reading of the Platonic project, the "City" is a product of determined changes to an existing institutional arrangement, and thus a just arrangement is potentially achieved through concerted exercise of reason towards an ideal end realized first as a model. In order to ensure what might be considered a "successful" popular revolution according to the Platonic vision - one resulting in a just social/political order both determined and achieved without the corruption of violence - powerful conceptual tools are required. This paper develops one such tool in the form of a modeling system representing social-political structures as information sharing networks of self-interested nodes, while at once representing social change as iterated transitions from one such structure to another. It potentially models transitions over multiple generations, facilitating the direct planning of slow, non-violent change. As such, this approach offers a system for the transparent conceptualization and evaluation of the endpoints of social movements unburdened by constraints typical of other guiding narrative forms.

HOW NOT TO FICTIONALIZE SCIENCE

John Woods

Characteristic of model based science is its attachment to idealizations and abstractions. Idealizations are expressed by statements known to be false. Abstractions are suppressors of what is known to be true. Idealizations over-represent empirical phenomena. Abstractions under-represent them. In a sense, idealization and abstractions are one another's duals. Either way, they are purposeful distortions of phenomenon on the ground. Sometimes phenomena on the ground approximate to what their idealizations say of them. Sometimes nothing in nature approaches them in any finite degree. So wide is this gulf between reality and idealization that Nancy Cartwright was moved to say of them that they are "pure fictions". Fictionalism in the philosophy of science endorses Cartwright's attribution, and occasions an obvious trio of questions. One is whether the fictionality of non-approximating idealizations is a load-bearing contribution to the semantics and epistemology of science. Another is, if load-bearing, do we know the satisfaction conditions for "is fictional" in virtue of which this is so? The third is whether those satisfaction conditions might profitably be sought in adaptations of what is currently known about the semantics and epistemology of literary fiction. In this talk I will present considerations which, we may come to think, offer to these questions scant promise of affirmative answers.

USING MATHEMATICAL EXPRESSIONS TO ANALYZE MODEL-BASED REASONING FOR EXPLORE CONCEPTUAL CHANGE IN PHYSICS

Wang Yihong

The paper use mathematical expressions in physics to analyze model-based reasoning. The first, this paper argues that causality principle in conceptual change may be represented as: if the weakness is being in science, then scientific theory will continuous change for modify those weaknesses when scientists who use a new theory to replace an old theory. For example, the role of mathematical expressions represents the motion of the bodies in classical mechanics. Second, mathematical expression is not independence, it can represent a continue process

of conceptual change in physics. Well-known Einstein used the theory of relativity to replace Newton's absolute space-time theory. This illustrate may clarify causality in conceptual change, and may explain a new theory to replace an old theory depend upon 'weakness' of science found by scientist. Finally, causality in conceptual change can be hold by scientists to push forward the development of science. For these reasons, mathematical expressions in physics may explore model-based reasoning in conceptual change, which is the best interpretation in one of many ways for analyzing cognitive science.