Introduction
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Source: *Synthese*, Vol. 146, No. 1/2, Non-Monotonic and Uncertain Reasoning in Cognition (Aug., 2005), pp. 1-5
Published by: Springer
Stable URL: https://www.jstor.org/stable/20118613
Accessed: 13-03-2019 16:25 UTC

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INTRODUCTION

This special issue contains a selection from the invited papers of the workshop 'Non-monotonic and Uncertain Reasoning in the Focus of Competing Paradigms of Cognition' which was organized by the guest-editors of this issue as a part of the special research programme F012, from 18–20 July 2002, at the University of Salzburg. We have to thank the FWF (Funds for Scientific Research) in Austria for giving us the financial support which has enabled this workshop, and the Faculty of Science at the University of Salzburg for offering us rooms and local facilities. The aim of this workshop was to bring together three scientific communities who traditionally work in a rather separated manner – *philosophers, artificial intelligence researchers*, and *cognitive psychologists*, who should present and exchange their findings on non-monotonic and uncertain reasoning in order to obtain a comprehensive *interdisciplinary perspective* on this topic. We hope that we have reached this aim, or at least, that we are on the right way. In any case, the lively discussion within the workshop and the general wish of the participants for a continuation has stimulated the genesis of this special issue of *Synthese*.

Non-monotonic reasoning, default reasoning, and uncertain reasoning are all labels for kinds of reasoning from partial and non-conclusive premise information to conclusions which are justified as long as *defeating* information is *absent*. Thus, adding new premise information may turn a valid argument into an invalid one: this is the kind of phenomenon called "non-monotonicity" which is excluded in deductive reasoning. Under different headings, research on non-monotonic reasoning has a long tradition in analytic philosophy. However, it was in the artificial intelligence research of the late 1970s that attempts to formalize non-monotonic reasoning have become a growing industry. Very recently, also cognitive psychologists have drawn their attention to this kind of reasoning, investigating to which extent human reasoning corresponds to the basic principles and technical details on non-monotonic reasoning as have been laid down by philosophers, logicians, and computer scientists.

The volume is divided into two parts. The first part, entitled 'From Philosophical Foundations to Cognitive experiments', starts with a

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paper by *Pelletier and Elio* which impressingly demonstrates the *range of applications* of non-monotonic reasoning: from philosophy of science to ethics, from generic and habitual knowledge to conditionals and counterfactuals, from probabilistic to causal reasoning, from prototypes and schemata in linguistics to implicatures and natural logic in pragmatics, and finally from diagnostic expert systems and knowledge representation in artificial intelligence to evolutionary psychology and neuronal networks. Yet, at the fundamental level, there is still no consensus about the *nature* of non-monotonic reasoning. According to Pelletier and Elio, there simply exists no *external standard* of the correctness of non-monotonic reasoning, contrary to the unanimously accepted external standard of deductive-monotonic reasoning given by strict truth-preservation. Therefore, psychological investigations of human reasoning from default rules become crucial. Pelletier and Elio report their experimental results on Lifschitz' benchmark problems. In particular, they observe that the recognition of the exceptional nature of an object with respect to one default rule increases the tendency of test persons to regard this object as exceptional also with respect to other default rules.

Schurz develops a uniform foundation of an important kind of non-monotonic reasoning – reasoning from normic laws of the form "As are normally Bs". According to his central thesis, normic laws are the phenomenological laws of *evolutionary systems*. Based on this thesis, he argues that evolutionary success implies the existence of an external standard of normic reasoning which consists in statistical reliability and low complexity. He goes on to argue that the well-known *system P* of non-monotonic reasoning satisfies this standard to a high degree. He finally reports basic results of his experimental study which document that intuitive human reasoning matches two basic reasoning patterns of non-monotonic reasoning, namely strict and weak specificity.

Benferhat, *Bonnefon* and *Neves* present a general logical foundation of non-monotonic reasoning which is based on *possibility theory* and which is focused on the system P and the stronger systems Z (or rational closure) and lexicographical closure. The authors report experimental findings which establish that test persons reason in accordance with all the basic rule of system P (LLE, RW, CUT, CM, OR and AND). Based on their second experimental study, the authors find that human default reasoning is more in accordance with lexicographical closure than with the system Z, because there is no clear indication that humans respect the rule RM of rational monotony.

In contrast to the previous experimental results, *Ford* reports a variety of careful experiments which demonstrate how difficult default reasoning can be for untrained human adults. In particular, her experimental results undermine the thesis that the pattern of *specificity* is really essential for human default reasoning. As an alternative, she proposes the following three heuristic factors, which, according to Ford, are central to intuitive default reasoning: recognition of the relevance of the fact that (i) if all Xs are Ys, then there might be Ys that are not Xs; (ii) if all of the Ys are Zs then any Xs that are Ys are also Zs; and (iii) if Xs are usually Ys then there are potentially many Ys that are not Xs.

Pfeifer and *Kleiter* have designed problem solving experiments in which they investigate to which degree human probability estimates correspond to the *probability propagation rules* which can be associated with the rules of system P. With respect to the rules AND, OR, LLE, they obtain the result that most of the test persons' estimates fall within the correct interval predicted by probability theory. Interestingly, however, being able to solve AND and LLE tasks has no effect on being more cautious in the famous LINDA task of Kahneman and Tversky.

Horsten concludes the first part of the volume with an investigation of *Gricean conversational implicatures* as being compared and contrasted to non-monotonic rules. He focuses on the implicature that if a speaker asserts a disjunction (A or B), then it is implicated that it is not the case that (A and B). He argues in favour of the thesis that is to be considered as a *rule of interpretation* rather than as a default rule in a non-monotonic system, and thus he formally reconstructs the implicature in an *algebraic* fashion rather than in proof-theoretic terms.

The second part of the volume, entitled 'From Formal Models to Neuronal Networks', starts with a contribution of *Adams*, the founder of *probability logic*, and in particular of the system P, which turned out to be a formal bridge between non-monotonic reasoning and probability theory. Adams presents a statistical proportionality analysis of *syllogistic reasoning* from premises which include non-strict generalizations of the sort "Most As are Bs". He establishes various preservation rules, specifying a lower bound of the proportion (or statistical probability) associated with the conclusion, in dependence of the proportion (or probability) associated with the premises. While some of the rules of syllogistics remain untouched, others change significantly.

In the next paper, *Gilio* develops a probabilistic logic based on de Finetti's concept of *coherence*. His probabilistic logic includes information about the propagation of *probability intervals*. He establishes a variety of theorems about generalized coherence and the satisfiability of families of conditionals, associated with lower probability bounds or with probability intervals, in terms of the existence of suitable probability assessments.

His final theorem explicates probabilistic entailment (g-coherent consequence) among conditionals in term of *conditional rankings* on the set of conditional probability assessments.

The contribution of *Lukasiewicz* is focused on probability logic, too. After pointing out some significant differences between probabilistic logic under coherence and model-based probabilistic logic, Lukasiewicz develops a new *probabilistic generalization* of Pearl's Z-entailment and of Lehman's lexicographical entailment. His notions of z-λ- and lex-λ-entailment are parameterized by a value $\lambda \in [0, 1]$ which describes the *strength of inheritance*. In the special cases of $\lambda = 0$ and $\lambda = 1$ Lukasiewicz' entailment reduces to z-entailment and lex-entailment, respectively.

Brewka describes a new development concerning *logic programs* under answer set semantics: logic programs which may contain an *ordered disjunction* in the heads of their rules. This new logic programming system is designed as a *qualitative* approach to *decision making*. The intuitive reasoning behind an ordered disjunction A $\times$ B is the following: if possible, A, but if A is not possible, then B. Brewka illustrates the application of logic programs containing ordered disjunction with several examples, among them Savage's famous rotten egg example. He arrives at several strategies for ordering answer sets which differ among each other with respect to their degree of cautiousness.

The two final papers relate non-monotonic reasoning to important topics of *natural science*. *Leitgeb* starts with a general conception of *interpreted discrete dynamical systems*: the states of such systems carry information given by the interpretation of a propositional language. Leitgeb proves that the non-monotonic reasoning system C is adequate for his new dynamical system semantics, and moreover, that the system CL is adequate for the subfamily of hierarchical discrete dynamical systems (both systems are subsystems of the system P). Leitgeb then elaborates four important examples of interpreted dynamical systems: two classes of *neural networks*; *logic programs*; and *evolutionary systems*.

In the final paper, *Werning* develops a qualitative logic of compositional feature representations in the human brain based on *oscillatory networks*. Oscillators that represent properties of one-and-the-same object oscillate *synchronically*, while oscillators representing features of different objects *desynchronize*. Based on these well-confirmed experimental results, Werning develops an oscillatory network semantics for a fragment of *first order logic*.

Due to necessary size limitations, all contributors had to cut down their papers to the "essentials". The only exception is the first contribution by *Pelletier and Elio* which serves as a kind of overview article. The reader who is interested in more information is encouraged to get in contact with the authors whose postal and electronic addresses are listed at the end of each contribution.

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