Workshop

Logic in the Wild

Book of abstracts

Date: 9-10 November 2017

Venue: Royal Academy of Dutch Language and Literature (KANTL)
Koningstraat 18 Ghent, Belgium

Organization:

Centre for Logic and Philosophy of Science
(Ghent University)

The Department of Logic and Cognitive Science
(Adam Mickiewicz University Poznań)

Chairs

Rafal Urbaniak (Ghent), Mariusz Urbański (Poznań), Erik Weber (Ghent)

Local Organizing Committee

Mathieu Beirlaen, Roxan Degeyter, Stef Frijters, Pawel Pawlowski, Erik Weber, Dietlinde Wouters

About the workshop

This workshop is organized within the series "Logic, Reasoning, and Rationality": http://www.lrr.ugent.be/

The series is supported by the Research Foundation Flanders (http://www.fwo.be/) through the scientific research network on Logical and Methodological Analysis of Scientific Reasoning Processes (LMASRP): http://www.lmasrp.ugent.be/

Research Foundation
Flanders
Opening new horizons

Abstracts

Invited speakers

Iris van Rooij
Radboud University

Cognition in the wild: logic and complexity

Models of cognition are often computationally intractable, meaning that they cannot reasonably scale from toy domains to real world situations. This holds true for all major formal approaches to modeling in cognitive science, be they based on logic, probability theory, neural networks or even heuristics. Many researchers see intractability as ''bad news" for competing theories without realizing that it applies to all major theories. Others view intractability as an artifact that can safely be ignored, either indefinitely or until solutions may be found in the future. I propose that cognitive science would benefit from letting go of either of these views, and instead recognize tractability as a fundamental constraint on cognition in the wild. In my talk I will explain how the tractability constraint can serve as a formal guide in theory development. I furthermore will illustrate how logic-based approaches may especially benefit from this approach as it may enlarge their recognized scope and relevance for cognitive science.

Relevant reading: van Rooij, I. (2015). How the curse of intractability can be cognitive science's blessing. In Noelle, D. C., Dale, R., Warlaumont, A. S., Yoshimi, J., Matlock, T., Jennings, C. D., and Maglio, P. P. (Eds.) (2015). In Proceedings of the 37th Annual Meeting of the Cognitive Science Society. Austin, TX: Cognitive Science Society.

Keith Stenning
University of Edinburgh

Memory is the organ of nonmonotonic reasoning

Nothing is wilder than the human mind? This talk will outline a program of research which uses Logic Programming (in a particular flavour) as a model of human semantic memory, in the service of nonmonotonic reasoning *to* an interpretation [2]. It will illustrate with some current, very psychological, modelling of decisions/judgements made during nonmonotonic reasoning [1], and then raise issues which will hopefully be of interest to a logical/philosophical audience. Applying LP to memory will serve as an example of a relation between logic and the mind, and hopefully motivate some researchers of a logical bent to collaborate with the kind of empirical work which needs to go on. There is a great danger, on both sides of the cognitive/logical fence, of underestimating the density of the problems which live down this crack. The psychologist who denies the relevance of logic's 'normative' systems is as numerous as the logician who thinks that his (usually but not always 'his') newly invented logic is straightforwardly a contribution to how human reasoning works.

References

[1] K. Stenning, L. Martignon, and A. Varga. Adaptive reasoning: integrating fast and frugal heuristics with a logic of interpretation. *Decision (submitted)*, 2017.

[2] Keith Stenning. *Human reasoning and cognitive science.* MIT Press, Cambridge, Mass, 2008.

Christian Strasser
Ruhr University Bochum

Reasoning by cases in the nonmonotonic wilderness
(joint work with Mathieu Beirlaen and Jesse Heyninck)

Reasoning by Cases (RbC) is an inference scheme especially apt for situations in which we deal with incomplete information. We may know that A or B is the case, but not which of the two. If now C follows from both A and from B, the inference to C is sanctioned by RbC. Similarly, defeasible reasoning helps us to efficiently deal with incomplete, uncertain and possibly inconsistent information. This makes it natural to integrate RbC in formal accounts of defeasible reasoning: in case we have defeasibly inferred that A or B holds, and C follows defeasibly from both A and B, the inference to C is defeasibly sanctioned by RbC. In this talk, some challenges for defeasible accounts of RbC will be discussed, shortcomings of approaches to RbC from the literature on non-monotonic logic will be highlighted, and, finally, a new account of a defeasible variant of RbC based on formal argumentation will be presented.

Contributed Talks

Stef Frijters, Frederik Van De Putte
Ghent University

Using specificity to deal with CTD-cases

When human beings are confronted with ethical or legal questions, they often derive the obligations applicable to the specific situation they are in from more abstract conditional obligations. In this talk we present a number of deontic logics that model the defeasible reasoning agents perform in these cases. These logics can handle the well-known problems posed by both specificity [3, pp. 63-64] and contrary-to-duty (CTD) cases [1]. To adequately treat CTD-cases, we follow a suggestion made by Carmo and Jones [1]. They propose a formal distinction between situations where it is "fixed" or "settled true" that a duty has been violated and cases where it is not.

To illustrate that taking this distinction into account is essential to derive the correct obligations, we present a paradigm CTD-case from the medical ethics manual of the World Medical Association (WMA) [4, p. 86, p. 97]. The premises of this example can be reconstructed as follows:

1. It ought to be that the leading surgeon does not use outdated operating techniques.
2. If the surgeon does not use outdated techniques, then he ought not to be reported to the hospital authorities by the anaesthetist for using outdated techniques.
3. If the surgeon does use outdated techniques, then he ought to be reported by the anaesthetist for using outdated techniques.
4. The surgeon does use outdated techniques.

There are two variants of this scenario. In the first variant, the surgeon is open to suggestions from the anaesthetist and willing to update his operating techniques. In this case we say that the fact that 'the surgeon uses outdated techniques' is not fixed. Consider also a second variant. Here the surgeon is unwilling to listen to any advice from the anaesthetist and will keep using outdated techniques. In this variant, we say that the fact that he uses outdated techniques is not only true, but also fixed. In the first variant, the anaesthetist ought not to be reported, whereas in the second variant he ought to be reported.

The logics we present have a few advantages over that of Carmo and Jones. Firstly, their logic, presented in [2], does not allow for specificity-cases. Aside from that our logics also have aggregation and inheritance of obligatory propositions. We achieve this by only allowing the derivation of actual obligations from conditional obligations when the most specific description of what is fixed in the situation is used.

References

[1] José M. C. L. M. Carmo and Andrew J. I. Jones. Deontic logic and contrary-to-duties. In Dov M. Gabay and Franz Guenther, editors, *Handbook of Philosophical Logic*, volume 8, pages 147–264. Kluwer Academic Publishers, 2nd edition, 2002.

[2] José M. C. L. M. Carmo and Andrew J. I. Jones. Completeness and decidability results for a logic of contrary-to-duty conditionals. *Journal of Logic and Computation*, 23(3):585, 2013.

[3] Christian Straßer. A deontic logic framework allowing for factual detachment. *Journal of Applied Logic*, 9:61–80, 2011.

[4] John Reynold Williams. *Medical Ethics Manual.* World Medical Association, 3rd edition, 2015.

Andrzej Gajda
Adam Mickiewicz University, Poznań

Abduction in connectionist inductive learning and logic programming system

The aim of this talk is to give an overview of a procedure for modeling abductive reasoning in a neural-symbolic system. Our system of choice, Connectionist Inductive Learning and Logic Programming System (CIL2P) [2], with some modifications, combines expressive power of Logic Programming and computational advantages of Artificial Neural Networks into effective procedure in which, unlike in previous research [4, 3], both abductive hypotheses and goals may take the form of Horn clauses, and backpropagation learning algorithm is used as a part of an abductive hypotheses generator. Thus this approach differs substantially from the one usually pursued within the framework of Abductive Logic Programming [5].

The presentation is divided into three parts. In the first part the problem of defining abductive goal in the form of a Horn clause is discussed, where the consequence relation is defined in terms of the immediate consequence operator [6]. This allows us to modify the translation algorithm proposed by Garcez et al. [2] in such a way, that the resulting neural network contains information form both: the logic program and the abductive goal. The definition of an abductive goal is constructed for definite and normal logic programs.

The algorithm, which translates a logic program and an abductive goal into a neural network, and which is based on the algorithm that Garcez proposed [2], is characterized in the second part of the presentation. The role of a couple of parameters (e.g. the number of additional neurons in the hidden layer) that influence the shape and functioning of the neural network, and therefore, how they affect abductive hypotheses generation is discussed here.

Finally, the crucial problem of finding an adequate learning set for a neural network is addressed along with possible solutions. Some examples of preliminary results of an implementation of the system are presented as well [1].

References

[1] Andrzej Gajda, Adam Kups, and Mariusz Urbański. A connectionist approach to abductive problems: employing a learning algorithm. In M. Paprzycki M. Ganzha, L. Maciaszek, editor, *Computer Science and Information Systems (FedCSIS), Proceedings of the 2016 Federated Conference on Computer Science and Information Systems*, volume 8, pages 353–362. IEEE, 2016.

[2] Artur S. d'Avila Garcez, Krysia Broda, and Dov M. Gabbay. *Neural-Symbolic Learning Systems: Foundations and Applications*. Springer-Verlag, London, 2002.

[3] Artur S. d'Avila Garcez, Dov M. Gabbay, Oliver Ray, and John Woods. Abductive reasoning in neural-symbolic systems. *Topoi: An International Review of Philosophy*, 26(1):37–49, 2007.

[4] Artur S. d'Avila Garcez, Alessandra Russo, Bashar Nuseibeh, and Jeff Kramer. Combining abductive reasoning and inductive learning to evolve requirements specifications. In *Software, IEE Proceedings*, volume 150, pages 25–38. IET, 2003.

[5] Antonis C. Kakas, Robert A. Kowalski, and Francesca Toni. Abductive logic programming. *Journal of logic and computation*, 2(6):719–770, 1992.

[6] Maarten H. Van Emden and Robert A. Kowalski. The semantics of predicate logic as a programming language. *Journal of the ACM (JACM)*, 23(4):733–742, 1976.

Jesse Heyninck, Christian Strasser
Ruhr University Bochum

Unrestricted rebuttal in structured argumentation

Structured argumentation is a family of formal approaches for the handling of defeasible, potentially inconsistent information. In order to do so, many models for structured argumentation distinguish between strict and defeasible inference rules. Defeasible rules guarantee the truth of their conclusion only provisionally: from the antecedents of the rules we can infer their conclusion unless and until we encounter feasible counterarguments. Strict rules, in contrast, are outside doubt: the truth of the antecedents is carried over to the conclusion. In structured argumentation, the concept of argumentative attack is used to give a formal explication of the fact that two arguments express conflicting information. When constructing arguments with defeasible rules, it seems sensible that whenever an argument a concludes the contrary of a defeasible argument b, a should be allowed to attack b. The attack form known as rebuttal does exactly this. One can either allow for unrestricted rebuttal or restrict the reach of a rebuttal. In a framework allowing for unrestricted rebuttals, such as ASPIC^- 0: [2], any defeasible argument can be rebutted. This contrasts sharply with more restricted notions of rebuttal to arguments only the last link of which is defeasible, as found e.g. in the ASPIC^+-framework [3]. In [2], it has been argued that, at least in a dialectical context, unrestricted rebut is more intuitive than restricted rebut. Recent empirical research [5] supports this claim.

To facilitate the study of such structured argumentation systems, [1] proposed several postulates the output of any sensible argumentation system should satisfy. For example, it seems reasonable to require that the output of an argumentation system is consistent. Likewise, the output of an argumentation system should be closed under strict rules.

Strict rules can be based on some kind of deductive system, like classical logic. When using sufficiently strong deductive systems such as classical logic, however, one needs to be wary of problems that are caused by rules such as *ex falso quodlibet*: this may cause two syntactically disjoint argumentation systems to interact in undesirable ways. The absence of such problems has been labelled Crash Resistance in [4]. A violation of crash resistance can render an argumentation system ineffective since given conflicting defeasible rules, the conflict can spread to unrelated, innocent bystanders and thus contaminate the whole output. This seems to defeat the purpose of structured argumentation frameworks, since it is meant to give us a sensible output *especially* in the case of conflicting but defeasible information.

In this paper we show that ASPIC^- , a system allowing for unrestricted rebuts, violates crash-resistance. We remedy this shortcoming by generalizing the attack rule of unrestricted rebut. Our resulting system $\text{ASPIC}^{\ominus}$ satisfies all the usual rationality postulates for prioritized rule bases while retaining the intuitiveness of unrestricted rebuttal.

References

[1] Martin Caminada and Leila Amgoud. On the evaluation of argumentation formalisms. *Artificial Intelligence*, 171(5):286–310, 2007.

[2] Martin Caminada, Sanjay Modgil, and Nils Oren. Preferences and unrestricted rebut. In *Computational Models of Argument (Proceedings of COMMA 14)*, pages 209–220. IOS Press, 2014.

[3] Henry Prakken. An abstract framework for argumentation with structured arguments. *Argument and Computation*, 1(2):93–124, 2011.

[4] Yining Wu. *Between Argument and Conclusion. Argument-based Approaches to Discussion, Inference and Uncertainty.* PhD thesis, Universite Du Luxembourg, 2012.

[5] Zhe Yu, Kang Xu, and Beishui Liao. An empirical comparison of argumentation formalisms.

Ottilia Kasbergen and Hanna Sofie van Lee
University of Copenhagen

Can we help the muddy children? The role of epistemic logic in understanding actual human reasoning

Using formal techniques to study knowledge and reasoning, one of the aims of epistemic logic is to capture human epistemic behavior. This approach has shown to cause a tension between the desire to equip agents with logical abilities and the desire to stay close to an everyday conception of knowledge. Human reasoning is not as consistent as the logic underlying the formal frameworks, creating a mismatch between the reasoning abilities of formal agents and those of the real agents they aim to model. This paper proposes a discussion starting from the following question: When trying to capture human epistemic behavior, what is the role of a formal system that deviates strongly from the reality of actual human agents?[1]

Two of the many directions in current research in epistemic logic are particularly related to the above described mismatch. The first approach introduces new frameworks that are closer to reality than the existing ones. For example, many solutions have been raised to the problem of logical omniscience [6]: e.g. awareness logic [2], the logic of justified belief change [1], or impossible world semantics [3]. In this approach, intuition, philosophical analysis and, more rarely, empirical data serve as guides to the re-definition of knowledge and inference. However, a persistent problem of these alternative frameworks is that human reasoning is highly complex and thus difficult to capture by means of a systematic logical framework. Whether the boundaries of logical frameworks can be stretched to overcome this structural problem remains to be an open question.

The second approach that relates to the discussed mismatch acknowledges the limitations of formal models of logic, but nevertheless applies them to phenomena of human knowledge and reasoning. As such, this research agenda complements empirical research by clarifying, verifying or exploring the phenomenon under study [5]. From this perspective, logical omniscience is the price paid for wanting to model logical abilities of the agent in a systematic way. A classical example that applies epistemic logic to a real world phenomenon is the solution to the muddy children puzzle (e.g. [7]), demonstrating that agents can acquire knowledge from statements of ignorance. This second approach thereby shows an interesting interplay between normative and descriptive aspects of epistemic logic.

Idealisations are inherent to formal modelling, and the perfect model does not exist. However, epistemic logical models should match reality well enough in order to say something meaningful about real agents. Are we on the right track by continously introducing new frameworks to grasp yet another aspect of actual human reasoning, or does the strenght of epistemic logic lie in its simple and idealised models? Does empirical data deserve a dominant place in the design of new frameworks? This paper governs a starting point for a discussion of the role of epistemic logic in understanding actual human reasoning and epistemic behaviour.

References

[1] Alexandru Baltag, Bryan Renne, and Sonja Smets. The logic of justified belief change, soft evidence and defeasible knowledge. In L. Ong and R. de Queiroz, editors, *Proceedings of the 19th Workshop on Logic, Language, Information and Computation*, volume 7456 of *Lecture Notes in Computer Science*, pages 168–190. Springer-Verlag Berlin Heidelberg, 2012.

[2] Ronald Fagin and Joseph Y. Halpern. Belief, awareness, and limited reasoning. *Artificial intelligence*, 34(1):39–76, 1987.

[1] The current paper is work in progress and based on the Master thesis of Ottilia Kasbergen, written under supervision of Sonja Smets and Martin Stokhof [4].

[3] Joseph Y. Halpern and Riccardo Pucella. Dealing with logical omniscience. In *Proceedings of the 11th conference on Theoretical aspects of rationality and knowledge*, pages 169–176. ACM, 2007.

[4] Ottilia Kasbergen. Abstractions and idealisations in epistemic logic. Master's thesis, ILLC, Universiteit van Amsterdam, 2017.

[5] Dominik Klein. *Social Interaction: a Formal Exploration*. PhD thesis, Tilburg University, 2015.

[6] Robert Stalnaker. The problem of logical omniscience, i. *Synthese*, 89(3):425–440, 1991.

[7] Hans van Ditmarsch and Barteld Kooi. Semantic Results for Ontic and Epistemic Change. In G. Bonanno, W. van der Hoek, and M. Wooldridge, editors, *Logic and the Foundations of Game and Decision Theory (LOFT 7)*, Texts in Logic and Games, Vol. 3, pages 87–117. Amsterdam University Press, 2008.

Paweł Łupkowski, Mariusz Urbański and Andrzej Wiśniewski
Adam Mickiewicz University, Poznań

Erotetic Reasoning Corpus: components, tags, annotation

The Erotetic Reasoning Corpus (ERC, [13]) is a data set for research on natural question processing. Intuitively, we are dealing with question processing in a situation when a question is not followed by an answer but with a new question or a strategy of reducing it into auxiliary questions. This phenomenon is studied within such theoretical frameworks as Inferential Erotetic Logic (IEL) [11, 12], [5]; inquisitive semantics [3]; or KoS [1], [6].

The corpus consists of the language data collected in the previous studies on the question processing phenomenon. These are: Erotetic Reasoning Test [9], QuestGen ([4], [8], [7]) and Mind Maze [10]. All the data is in Polish, however the tag-set used for the annotation allows for the data analysis for English-speaking researchers.

Tagging schema for the ERC has three layers: (1) *structural*—representing the structure of tasks used for ERC. Here we distinguish elements like: instructions, justifications, different types of questions and declaratives; (2) *pragmatic*—representing various events that may occur in the dialogue, like e.g. long pauses. It also contains tags that allow expression of certain events related to the types of tasks used (like e.g. when forbidden question is used); and (3) *inferential*—which allows for normative erotetic concepts to be identified.
The inferential layer plays an important role in ERC making our data set unique. The tags used here stem from the erotetic logic ideas and concepts. Our logical framework of choice here is IEL. This logic focuses on inferences whose premises and/or conclusion are questions (erotetic inferences). IEL offers some straightforward tools for modelling erotetic inferences. What is especially important from our perspective is that IEL not only gives semantical analysis of erotetic inferences but also proposes certain criteria of their validity (the most essential notion in our case is that of erotetic implication [12], falsificationist [2] and weak one [9]).

The whole ERC consists of 402 files (133.732 words) and it is available *via* its web-site[2] (along with the documentation and useful tools). The corpus is distributed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

In our talk we will present the theoretical background, linguistic data and tags used for the annotation process. We will focus especially on the unique inferential layer of annotation and describe how the tag-set stems from the IEL concepts and discuss its design and evaluation process. We will also present potential areas of use of ERC.

Acknowledgements The authors would like to thank the ERC project team members for their contribution. These are (in the alphabetical order): Wojciech Błądek, Andrzej Gajda, Agata Juska, Anna Kostrzewa, Bartosz Marciniak, Dominika Pankow, Katarzyna Paluszkiewicz, Oliwia Ignaszak, Joanna Urbańska, Natalia Żyluk.
This work was supported by funds of the National Science Centre, Poland (DEC-2013/10/E/HS1/00172 and DEC-2012/04/A/HS1/00715).

References

[1] Jonathan Ginzburg. *The Interactive Stance: Meaning for Conversation.* Oxford University Press, Oxford, 2012.

[2] Adam Grobler. Fifth part of the definition of knowledge. *Philosophica*, 86:33–50, 2012.

[3] Jeroen Groenendijk and Floris Roelofsen. Compliance. In Alain Lecomte and Samuel Tronçon, editors, *Ludics, Dialogue and Interaction*, pages 161–173. Springer-Verlag, Berlin Heidelberg, 2011.

[4] Paweł Łupkowski. Human computation—how people solve difficult AI problems (having fun doing it). *Homo Ludens*, 3(1):81–94, 2011.

[5] Paweł Łupkowski. *Logic of Questions in the Wild. Inferential Erotetic Logic in Information Seeking Dialogue Modelling.* College Publications, London, 2016.

[2] https://ercorpus.wordpress.com/.

[6] Paweł Łupkowski and Jonathan Ginzburg. Query responses. *Journal of Language Modelling*, 4(2):245–293, 2016.

[7] Paweł Łupkowski and Olivia Ignaszak. Inferential erotetic logic in modelling of cooperative problem solving involving questions in the QuestGen game. *Organon F*, 24(2):214–244, 2017.

[8] Paweł Łupkowski and Patrycja Wietrzycka. Gamification for Question Processing Research—the QuestGen Game. *Homo Ludens*, 7(1):161–171, 2015.

[9] Mariusz Urbański, Katarzyna Paluszkiewicz, and Joanna Urbańska. Erotetic Problem Solving: From Real Data to Formal Models. An Analysis of Solutions to Erotetic Reasoning Test Task. In Fabio Paglieri, editor, *The Psychology of Argument: Cognitive Approaches to Argumentation and Persuasion College Publications*. College Publications, London, 2016.

[10] Mariusz Urbański and Natalia Żyluk. Sets of situations, topics, and question relevance. Technical report, AMU Institute of Psychology, 2016.

[11] Andrzej Wiśniewski. *The Posing of Questions: Logical Foundations of Erotetic Inferences*. Kluwer AP, Dordrecht, Boston, London, 1995.

[12] Andrzej Wiśniewski. *Questions, Inferences and Scenarios*. College Publications, London, 2013.

[13] Paweł Łupkowski, Mariusz Urbański, Andrzej Wiśniewski, Katarzyna Paluszkiewicz, Oliwia Ignaszak, Natalia Żyluk, Joanna Urbańska, Andrzej Gajda, Bartosz Marciniak, Wojciech Błądek, Agata Juska, Anna Kostrzewa, and Dominika Pankow. Erotetic Reasoning Corpus architecture: components, tags, annotation. Technical report, Adam Mickiewicz University, Poznań, 2017. URL=https://ercorpus.wordpress.com/home/.

Maria Martinez
National Autonomous University of Mexico

Paraconsistent reasoning strategies and the epistemology of the inconsistency toleration

In his "The Founding of Logic" Corcoran introduces two distinct ways in which philosophers tend to understand logic: as *formal ontology* and as *formal epistemology.* On the one hand, philosophers who support the former standpoint tend to "emphasize the fact that formal ontology does not study reasoning *per se*. In fact, the formal onticists often think that the study of reasoning belongs to psychology and not to logic" [4, p. 19]. On the other hand, logic understood from an epistemological point of view is mainly focused on increasing our understanding of human reasoning through the analyses of certain inferential patterns that agents could actually employ (idem).

Nowadays, the role of contradictions in human reasoning is one of the few subjects that explicitly demand an analysis from a formal-epistemological point of view; especially in light of the assumption that the study of contradictory beliefs, and the different ways in which epistemic agents manage (and *resolve*) such contradictions, plays a fundamental role in elucidating the foundations of rationality [8].

Inconsistency toleration in science (henceforth, *ScIT*) is an epistemic and logical phenomenon that takes place once agents, who believe contradictions are malign, are able to identify a contradiction in their theories (or models or any relevant part of their reasoning) and still reason sensibly from them, this is, they are still able to distinguish between the products of their reasoning that are sensible given a particular context from those that are not. Due its epistemic nature, *ScIT* is expected to be considered as a serious candidate for a logical explanation —'logical' in the sense of formal epistemology.

As a matter of fact, logic has already played an important role in the reconstruction and understanding of different historical cases of *ScIT* (see [1, 2, 3, 6, 7, 9]). However, the majority of such resulting reconstructions has been used to elucidate inconsistent non-trivial reasoning exclusively for specific individuals; and when the explanations for these particular cases have been extended for a broader domain, important philosophical objections have been brought to the discussion. Philosophers and historians of science claimed that while doing so, logicians employ historical data only in order to support particular philosophical and logical theses, instead of trying to use such data as an orientation to build more accurate descriptions and explanations for the actual scientific phenomena [5, 10]. If they are right, logic has not been sufficiently useful for elucidating how agents deal with contradictions in science, and thus, has seldom saying something significantly valuable about rationality.

How can logic make things right —that is, how can logic help us to understand important inferential scientific practices— without losing a considerable amount of our historical reports of such practices? Here we will claim that by making use of paraconsistent reasoning strategies philosophers can obtain valuable understanding of some of the inferential practices involved in *ScIT* and at the same time, they can avoid the (strongest) historicist critiques about the misuse of historical data.

In order to so, we will proceed in five steps. First, we will argue that a formal reconstruction of a scientific episode of *ScIT* has the purpose increasing our understanding of both a particular case and the general phenomenon of inconsistency toleration. Second, we will stress that while the former purpose could be achieved taking into account particularities of each case, the latter need not pay attention to such specificities, it nonetheless has to take into account general elements involved in the most common practices of inconsistency toleration in science. Third, we will claim that scientific practices are often constrained by the way in which information is presented to scientists, and so, if logicians and philosophers of science could identify different ways in which contradictory information is first introduced to scientists, then they could foresee possible inferential maneuvers of inconsistency toleration for each type of scenario (or at least, recognize the implausible ones for each type of setup). Fourth, we will propose a taxonomy of (initial) states of inconsistent information in science. Finally, we will argue that such taxonomy could be captured by some of our best paraconsistent reasoning strategies, and while doing so, some of the most common practices of inconsistency toleration could be formally approached as well.

References

[1] Richard Benham, Chris Mortensen, and Graham Priest. Chunk and Permeate III: the Dirac delta function. *Synthese*, 191(13):3057–3062, 2014.

[2] Bryson Brown and Graham Priest. Chunk and Permeate, A Paraconsistent Inference Strategy. Part I: The Infinitesimal Calculus. *Journal of Philosophical Logic*, 33(4):379–388, 2004.

[3] Bryson Brown and Graham Priest. Chunk and Permeate II: Bohr's Hydrogen Atom. *European Journal for Philosophy of Science*, 5(1):1–18, 2015.

[4] John Corcoran. The Founding of Logic. *Ancient Philosophy*, 14(1):9–24, 1994.

[5] Kevin Davey. Can good science be logically inconsistent? *Synthese*, 191(13):3009–3026, 2014.

[6] Michèle Friend. *Pluralism in Mathematics: A New Position in Philosophy of Mathematics*. Number 32 in Logic, Epistemology, and the Unity of Science. Springer, 2014.

[7] Joke Meheus. How to reason sensibly yet naturally from inconsistencies. In Joke Meheus, editor, *Inconsistency in Science*, pages 1–70. Kluwer Academic Publishers, 2002.

[8] Carol Rovane. Rationality and Persons. In A.R. Mele and P. Rawling, editors, *The Oxford Handbook of Rationality*, pages 320–343. Oxford University Press, USA, 2004.

[9] D.J. Sweeney. Chunk and Permeate: The Infinitesimals of Isaac Newton. *History and Philosophy of Logic*, 35(1):1–23, 2014.

[10] Peter Vickers. *Understanding Inconsistent Science*. Oxford University Press, 2013.

Max Rapp, Grzegorz Lisowski
University of Amsterdam

Is the triviality of AGM a serious possibility?

The classical AGM-postulates of belief revision face problems when extended by some properties standardly assumed in static doxastic logic: when agents are introspective and there exists at least one “serious possibility" - an unbelieved proposition whose negation is not believed either - one can derive the “ Serious Possiblity Paradox" (SPP). Another problematic extension is the Ramsey-test for conditionals according to which a conditional is believed iff updating with the antecedent would lead to belief in the consequent. It can be shown that such a semantics of the conditional in the AGM-framework prohibits the agent from learning anything she does not already believe (T).

We investigate the connection between the Serious Possibility Paradox (SPP) and this Triviality result (T). In the setting of the Epistemic AGM semantic framework proposed by Baltag and Smets we show that T implies SPP but not vice versa. Namely a fix of T by restricting the Ramsey-test does not affect the derivation of SPP. This suggests by contraposition that there is a solution to SPP which can also fix T. Such a solution would have to be a *true* solution in that it needs to block not only the standard derivation of SPP but also all ways to recoup it.

One solution to SPP proposed by Duca and Leitgeb involves relativisation of belief operators to particular belief sets: instead of a single belief operator, there is one for every possible belief set. This is expressed syntactically by indexing belief operators. Thus belief update changes the belief operator and thereby precludes introspection across belief sets before and after updating. We submit that this approach is a true solution both for SPP and thereby also remedies T. In the context of a semantic, relativised AGM model we show that the standard derivation of T is blocked.

Our results indicate that the same defect - introspection across belief sets before and after updating - lies at the root of both SPP and T. This flaw is not easily apparent in syntactic AGM-models but exceedingly clear in semantic models. Thus ensuring that the syntactics adequately track the semantics is all that is needed to jointly satisfy full AGM, introspection and the Ramsey-test.

Anthia Solaki
University of Amsterdam

**Tracing the footprints to knowledge:
logical systems for resource-bounded reasoning**

Standard epistemic and doxastic logics have been widely criticized as they only account for reasoners with unlimited inferential power and neglect findings on the performance of real people in reasoning tasks ([3], [11]). The latter indicate that subjects are both fallible and *moderately* logically competent. Furthermore, boundedness of resources plays an important part in performance, despite being usually overlooked in formal logical modelling. Our goal is to fill in these gaps via the introduction of a non-standard logical framework, capable of explaining *how* knowledge (or belief) is attained. Inspired by attempts that view an agent's underlying reasoning as a concatenation of steps ([4], [9], [16]), we provide an elaborate and resource-sensitive unraveling of such processes, focusing on (a) the inference rules the agent applies, (b) their chronology, (c) the agent's increasing cognitive effort, (d) the external information integrated into the epistemic (or doxastic) state.

More specifically, the usual epistemic language is augmented by dynamic operators denoting applications of inference rules. Semantic interpretations are given with the help of enriched possible-worlds models. These also include impossible worlds (that may defy classical logic) and components responsible for each rule's cognitive cost and the agent's cognitive capacity with respect to certain resources (e.g. memory, time). Allowing impossible worlds to be epistemically accessible invalidates the closure principles constituting the *problem of logical omniscience* ([6], [7], [8]). Logical competence is, on the other hand, reflected in the dynamic truth clauses, which are given through a model update in the spirit of Dynamic Epistemic Logic ([13], [15]). In particular, an update triggered by a rule modifies epistemic accessibility and reduces the agent's capacity by the appropriate cognitive cost. Based on this, we provide theorems showing that consequences of one's knowledge cannot be automatically and effortlessly ascribed to her. However, they also ensure that if she successfully follows the right reasoning path, she can eventually *come to know* them. We additionally devise a quantitative extension of this system to attach resource-sensitive preconditions to reasoning steps. In this way, we explicitly elucidate how availability of resources determines the extent to which a reasoning process can evolve.

Next, we introduce actions of hard and soft incoming information, as for example in [2] and [12]. The constructions of our basic system are then adapted to build an (im)possible-worlds plausibility model, equipped with a function that assigns ordinals to worlds (similar to [1], [10], [14]). This can be suitably tailored to re-arrange – or even eliminate – worlds as a result of (i) applications of inference rules, (ii) public announcements, (iii) radical upgrades. This full framework can therefore express a plethora of attitudes found in [2] (knowledge, (conditional) belief, defeasible knowledge) and their changes, only now omniscience-free and keeping detailed track of reasoning processes. Finally, a reduction of our models to awareness-*like* structures, i.e. structures resembling those of [5], is available so that standard modal logic techniques can be exploited to obtain sound and complete axiomatizations.

References

[1] Guillaume Aucher. A combined system for update logic and belief revision. Master's thesis, University of Amsterdam, 2003.

[2] Alexandru Baltag and Sonja Smets. A qualitative theory of dynamic interactive belief revision. *Logic and the Foundations of Game and Decision Theory, Texts in Logic and Games*, (3):9–58, 2008.

[3] Kristien Dieussaert, Walter Schaeken, Walter Schroyens, and Gery D'Ydewalle. Strategies during complex conditional inferences. *Thinking & Reasoning*, 6(2):125–160, 2000.

[4] Ho Ngoc Duc. Reasoning about rational, but not logically omniscient, agents. *Journal of Logic and Computation*, 7(5):633, 1997.

[5] R. Fagin and J. Y. Halpern. Belief, awareness, and limited reasoning. *Artif. Intell.*, 34(1):39–76, December 1987.

[6] R. Fagin, J. Y. Halpern, Y. Moses, and Vardi M. Y. *Reasoning About Knowledge.* MIT press, 1995.

[7] Joseph Y. Halpern and Riccardo Pucella. Dealing with Logical Omniscience. *Artificial Intelligence*, 175(1):220–235, 2011.

[8] Jaakko Hintikka. Impossible possible worlds vindicated. *Journal of Philosophical Logic*, 4(4):475–484, 1975.

[9] Mattias Skipper Rasmussen and Jens Christian Bjerring. A dynamic solution to the problem of logical omniscience. *(forthcoming)*, 2015.

[10] Wolfgang Spohn. Ordinal conditional functions. a dynamic theory of epistemic states. In W. L. Harper and B. Skyrms, editors, *Causation in Decision, Belief Change, and Statistics, vol. II.* Kluwer Academic Publishers, 1988.

[11] Keith Stenning and Michiel van Lambalgen. *Human Reasoning and Cognitive Science.* Boston, USA: MIT Press, 2008.

[12] Johan van Benthem. Dynamic logic for belief revision. *Journal of Applied Non-Classical Logics*, 17(2):129–155, 2007.

[13] Johan van Benthem. *Logical Dynamics of Information and Interaction.* Cambridge University Press, 2011.

[14] Hans van Ditmarsch. Prolegomena to dynamic logic for belief revision. *Synthese*, 147(2):229–275, 2005.

[15] Hans van Ditmarsch, Wiebe van der Hoek, and Barteld Kooi. *Dynamic Epistemic Logic.* Springer Publishing Company, Incorporated, 1st edition, 2007.

[16] Fernando R. Velázquez-Quesada. *Small Steps in Dynamics of Information.* PhD thesis, Institute for Logic, Language and Computation (ILLC), Universiteit van Amsterdam (UvA), Amsterdam, The Netherlands, February 2011. ILLC Dissertation series DS-2011-02.

Bonan Zhao, Iris van de Pol, Jakub Szymanik
University of Amsterdam

Dynamic epistemic logic models for predicting the cognitive difficulty of the deductive mastermind game

We applied a combined method of logical and computational analyses to study the cognitive difficulty of the Deductive Mastermind (DMM) game. Deductive Mastermind (DMM) is an adapted version of the board game Mastermind. DMM has been implemented in an online educational game system, and more than 90,000 Dutch primary school students have used this system to practice their mathematical and logical skills. This system records players' speed and accuracy data in solving the game, and computes ratings for game items based on this data. These ratings serve as an empirical indicator of the cognitive difficulty of each DMM game item.

Gierasimczuk et al. (2013) have proposed an analytical tableaux model that converts each DMM game item into a set of Boolean formulae, and then builds a decision tree for each game item following the analytical tableaux method. The size of the decision tree serves as a proxy of working memory load for solving this game item. Linear regression analysis shows that the size of the decision trees predicts 66% of the ratings of the game items correctly. However, the tableaux model makes strong assumptions on the cognitive process of solving DMM game items, and researchers have discovered reasoning patterns reported by DMM players that are difficult for the tableaux model to represent.

In this paper, we developed a formalization of the DMM game, using dynamic epistemic logic (DEL). Our formalization makes fewer assumptions than the tableaux model, i.e., we do not claim the model to be a simulation of how players solve the game; instead, we focus on the information conveyed in each game item and model the cognitive task from Marr's computational level. We treat each possible answer of a game item as a possible world in the DEL model, and treat reasoning steps as event models. The DEL model always converges to the correct answer after a finite number of updates. This model provides a nice account for the reasoning patterns observed by researchers.

We investigated different measures of complexity of this DEL formalization, and linear regression analysis shows that measurements that consider certain feature, the feedback type, of the game predict 67% of the ratings of the game items correctly. In terms of prediction, our DEL model performs similarly well as the tableaux model. Combing the DEL and tableaux models leads to similar predictions of item ratings, and together with the fact that there is a high correlation between the tableaux and the DEL models, this shows that feedback type is a strong indicator of the cognitive difficulty of a DMM game item. This result also indicates that item ratings are not influenced by the choice of the logic used in developing a formal model of the game.

Natalia Żyluk, Dorota Żelechowska, Mariusz Urbański
Adam Mickiewicz University, Poznań

"Find Out": quantitative and qualitative analyses of solutions to an abductive task

The aim of our talk is to present preliminary results obtained in the research on abductive reasoning conducted using a new tool – "Find Out". "Find Out" is set up as a game that requires playing a role of an investigator seeking for an explanation of what has happened in the presented enigmatic story. The task consists of three time-limited stages that require forming and testing of hypotheses, as well as proposing final explanations in the form of the written report. Thanks to its design, "Find Out" enables to catch the abduction (understood as a form of reasoning by which an individual aims at making sense of surprising phenomena, filling the gaps in her or his beliefs) as a real-life and compound form of reasoning – consisting of both generation and evaluation of hypotheses. Moreover, the instrument makes it possible to assess abduction from both product and process perspective. In order to investigate possible internal variables of the tool, exploratory pilot research was carried out.

Pilot studies enabled us to formulate observations of both qualitative and quantitative character. First of all, a number of formulated explanations (at different stages of a problem-solving process), a number of questions generated to test hypotheses, the correctness of explanations, the way of testing hypotheses as well as strategy/style of solving the problem varied among participants. What is more, formed hypotheses and the final report differed in a number of aspects of the story used as a framework to formulate an explanation of what has happened ('the level of problem-space coverage' dimension). Another variation appeared as a consequence of the fact that the story included several aspects that were not specified enough. Those incomplete aspects (called 'the gaps') could be further elaborated and specified in order to formulate the subjectively satisfying explanation of what had happened in the story. Participants differed in the number of identified and filled 'gaps'. The number of alternative 'fillers' used to complete the gaps created a dimension called 'the breadth of an explanation' while the number of consecutive 'fillers' used to complete consecutive gaps we called 'the depth of explanation'. Our next step was to analyze the data qualitatively which led us to formulate complementing categories of 'gap fillers', e.g. instances, clarifications, details, quasi-fillers (too general to be sufficiently informative). Some fillers were future-oriented while other were past-oriented and aimed at determination of (internal or external) causes of what was known. It should be also emphasized that most fillers seemed to correspond with one of the "7 forensic questions": 'What has happened?', 'Who?', '(with) What?', 'Where?', 'When?', 'How?' and 'Why?'. Last but not least, differences among participants occurred in a manner of presenting content, which could be more paradigmatic (as pieces of information linked in cause-result order) or more narrative (as a story with beginning, expansion and ending, full of internal states of the subject or motives).

November 9, 2017	
9:00-9:30	**Registration**
9:30-10:30	**Keith Stenning** Memory is the organ of nonmonotonic reasoning
10:30-11:00	**Coffee break**
11:00-12:30	**Paweł Łupkowski, Mariusz Urbański and Andrzej Wiśniewski** Erotetic Reasoning Corpus: components, tags, annotation **Natalia Żyluk, Dorota Żelechowska and Mariusz Urbański** "Find Out": quantitative and qualitative analyses of solutions to an abductive task
12:30-13:30	**Lunch break**
13:30-15:00	**Andrzej Gajda** Abduction in connectionist inductive learning and logic programming system **Bonan Zhao, Iris Van De Pol and Jakub Szymanik** Dynamic epistemic logic models for predicting the cognitive difficulty of the deductive mastermind game
15:00-15:30	**Coffee break**
15:30-17:00	**Maria Martinez** Paraconsistent reasoning strategies and the epistemology of the inconsistency toleration **Anthia Solaki** Tracing the footprints to knowledge: logical systems for resource-bounded reasoning
19:00-	**Diner at Keizershof**

November 10, 2017	
10-00-11:00	**Christian Strasser** Reasoning by cases in the nonmonotonic wilderness
11:00-11:30	**Coffee break**
11:30-13:00	**Stef Frijters, Frederik Van De Putte** Using specificity to deal with CTD-cases **Jesse Heyninck, Christian Strasser** Unrestricted rebuttal in structured argumentation
13:00-14:00	**Lunch break**
14:00-15:30	**Max Rapp, Grzegorz Lisowski** Is the triviality of AGM a serious possibility? **Hanna van Lee, Ottilia Kasbergen** Can we help the muddy children? The role of epistemic logic in understanding actual human reasoning
15:30-16:00	**Coffee break**
16:00-17:00	**Iris van Rooij** Cognition in the wild: logic and complexity
17:30-	**Drinks at Dulle Griet**