
Contraction
Dempster-Shafer
Additivity
Deductively-closed
Indifference
Dynamics
Conditionals
Preservation
Impossibility
Recovery
postulates
Ranking
Probabilism
Agnosticism
Belief
Probability
Lottery
Coherence
Error-minimisation
Rationality
Revision
Updating
Conditionalisation
Dutch
spheres
Books
Entrenchment
Ramsey
expansion
Expansion
AGM

50031 - Modeling Rational Belief

Jake Chandler
Institute of Philosophy, KU Leuven
Center for Mathematical Philosophy, University of Munich
✉ *jacob.chandler@hiw.kuleuven.be*

University of Bayreuth
Winter 2010-2011

Overview

This course offers an up-to-date introduction to the formal modeling of rational belief, which is a crucial concern in disciplines ranging from philosophy to AI, through economics and statistics. We will be focusing principally, but not exclusively, on the two most influential modeling frameworks: the Bayesian model of degrees of confidence, aka 'degrees of belief' (as reported in 'I am pretty sure that he needs help.') and the AGM-style model of unqualified beliefs, aka 'full beliefs' (as reported in 'He believes in fairies.'), evaluating their respective strong points and shortcomings and considering the nature of their relationship.

This course is on the rather more formal end of the spectrum. Students will be expected to have some background knowledge of elementary set theory, propositional logic, probability theory and decision theory. To get a feel for the level of technicality of the material covered, I recommend taking a look at the surveys by Weisberg and Arlo-Costa & Pedersen cited below (see sessions 2 and 9, respectively).

Admin

The course will consist of 14 weekly 2-hour discussion sessions, every Tuesday from 16:00 to 18:00, in S 74 (NW II). Attendance is compulsory. The working language of the seminar is English.

We shall be following a format already established in some of the modules at Bayreuth. Each session will be kickstarted by one or more beamer-based *student presentations*, based on a short essay (see below). Presentations will be expected to be 20 min long and will each be followed by a 10 min Q&A session. The essay on which the presentation is based is to be emailed to me by 09:00 on the morning of the day before the seminar and will be returned to the student, with marks and comments, at the end of the session.

The remainder of the session will be devoted to a *class discussion* of the topic. To help ensure that this is a productive exercise, you will be expected to have prepared a short list of issues that you think are worthy of general attention. Pertinent issues

include points of unclarity, perceived weaknesses in the arguments or suggestions for further work on the topic.

Method of assessment will vary according to the amount of credits taken. For all credit options:

> (i) Short essay of 2 000 ± 15% words + associated presentation (pass/fail).

In addition, for the *2 credit* option:

> (ii) (a) Short essay of 2 000 ± 15% words (pass/fail). Deadline for receipt, via email: 11 February 2011.

For the *6 credit* option:

> (ii) (b) Extended essay of 4 500 ± 15% words. Deadline for receipt, via email: 25 March 2011.

For the *8/10 credit* option:

> (ii) (c) Extended essay of 7 000 ± 15% words. Deadline for receipt, via email: 25 March 2011.

Regarding the short essay(s), you should be simply be aiming for a concise, well-structured critical overview of one of the session topics. Allocation of topics for item (i) above will be made during the first session. For the extended essay, you will be expected to provide something more substantial, going beyond a mere literature review. For this assignment, you may chose any topic connected with the course, subject to my approval. Note that I am happy to make suggestions if you are stuck. Please book an appointment with me, via email, for the first week following the Christmas break to discuss your proposed choice. You will then be granted two weeks after the meeting to mail me a 750 word provisional abstract.

Essays must be word-processed (no handwritten contributions please!), double-spaced and properly referenced. Note that the deadlines are firm and are renegociable only under exceptional circumstances.

Schedule & Reading

I will make available pdfs of various relevant articles. Please do not hesitate to contact me if you require even further reading. The schedule will be the following (compulsory reading is marked with a ⋆):

1. Introduction to the course

PART I: DEGREES OF CONFIDENCE

2. Some constraints on rational degrees of confidence We provide a broad brush overview of the range of rationality constraints, both synchronic and diachronic, that degrees of confidence have been said to be subject to.

Goosens, W. [1979]: 'Alternative Axiomatizations of Elementary Probability Theory', *Notre Dame J. of Formal Logic* XX(1), pp. 227-239.

⋆ Weisberg, J. [ms]: 'Varieties of Bayesianism', forthcoming in D. Gabbay, S. Hartmann & J. Woods (eds.) *Handbook of the History of Logic, vol. 10*. Sections 1.1, 1.2 (intro and 1.2.1), 3.1, 3.3, 3.4 & 3.7.

3. Justifying probabilism: Dutch Books Here we take a look at the best-known argument to the effect that degrees of confidence ought to obey the rules of the probability calculus ('probabilism'). The argument hinges on the observation that, given certain assumptions about the relation between degrees of confidence and betting behaviour, an agent liable to accept a set of bets that will guarantee her a sure loss if an only if she has non-probabilistic degrees of confidence.

⋆ Hajek, A. [forth.]: 'Dutch Book Arguments', in P. Anand, P. Pattanaik, and C. Puppe (eds.) *The Oxford Handbook of Corporate Social Responsibility*. Sections 1, 2, 3, 4 & 7.

Hajek, A. [2005]: 'Scotching Dutch Books?', *Philosophical Perspectives* 19, pp. 139-151.

Resnick, M. [1987]: *Choices: an introduction to decision theory*, Minneapolis: University of Minnesota Press. Ch. 3, section 3-3c 'Subjective views'.

Williamson, J. [1999]: 'Countable Additivity and Subjective Probability', *British Journal for the Philosophy of Science* 50, pp. 401-416.

4. Justifying probabilism: Error-Minimisation We discuss another argument for probabilism, which this time makes no reference to betting behaviour. Instead, probabilism is derived from the intuition that one's degree of confidence in a proposition is to be evaluated in terms of how closely it approximates the propostion's truth value. We focus here on a recent incarnation of the argument, due to Hannes Leitgeb and Richard Pettigrew.

Hajek, A. [2009]: 'Arguments for–or against–probabilism', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 229-251. Sections 1 & 5.

Joyce, J.M. [2009]: 'Accuracy and Coherence: Prospects for an Alethic Epistemology of Partial Belief', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 263-297.

⋆ Pettigrew, R. & H. Leitgeb [2010]: 'An Objective Justification of Bayesianism I: Measuring Inaccuracy', *Philosophy of Science* 77, pp. 201-235.

⋆ Pettigrew, R. & H. Leitgeb [2010]: 'An Objective Justification of Bayesianism II: The Consequences of Minimizing Inaccuracy', *Philosophy of Science* 77, pp. 236-272. Sections 1 to 6.1.

5. Agnosticism and the Principle of Indifference We turn to the controversial issue of modeling the degrees of confidence of a perfectly unopinionated agent. A number of well-known arguments suggest that probabilism, and in particular the view that degrees of confidence ought to obey a constraint known as 'additivity', stands in the way of achieving such a goal.

Haenni, R. [2009]: 'Non-Additive Degrees of Belief', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 121-159. Sections 1 & 2.

Kyburg, H. & C.M. Teng [2001]: *Uncertain Inference*, Cambridge: CUP. Ch. 5 section 5.4.

Norton, J. [2006]: 'Ignorance and indifference', *Philosophy of Science* 75, pp. 45-68.

Shackle, N. [2007]: 'Bertrand's Paradox and the Principle of Indifference', *Philosophy of Science* 74, pp. 150-175.

★ Weisberg, J. [ms]: 'Varieties of Bayesianism', forthcoming in D. Gabbay, S. Hartmann & J. Woods (eds.) *Handbook of the History of Logic, vol. 10*. Section 3.6

6. Justifying conditionalisation The view that updating ones degrees of confidence ought to be carried out by a procedure known as 'conditionalisation' has been supported by arguments somewhat similar to the ones adduced in favour of probabilism. We look at how Dutch book and error-minimisation considerations could be marshalled in favour of this other widely-endorsed constraint.

★ Hajek, A. [forth.]: 'Dutch Book Arguments', in P. Anand, P. Pattanaik, and C. Puppe (eds.) *The Oxford Handbook of Corporate Social Responsibility*. Section 5 (skip the stuff on DBA's for Reflection).

Pettigrew, R. & H. Leitgeb [2010]: 'An Objective Justification of Bayesianism II: The Consequences of Minimizing Inaccuracy', *Philosophy of Science* 77, pp. 236-272. Sections 6.2 and 7.

★ Skyrms, B. [1987]: 'Dynamic Coherence and Probability Kinematics', *Philosophy of Science* 54, pp. 1-20.

7. Justifying reflection We wind up our critical examination of rationality constraints on degrees of confidence with a discussion of van Fraassen's principle of Reflection. This principle, which has received a fair amount of attention in recent years, constrains the relation between our current confidence in a proposition and our expected future confidence in that proposition.

★ Briggs, R. [2009]: 'Distorted Reflection', *Philosophical Review* 118(1), pp. 59-86.

van Fraassen, B. [1984]: 'Belief and the Will', *Journal of Philosophy* 81, pp. 235-256.

van Fraassen, B. [1995]: 'Belief and the Problem of Ulysses and the Sirens', *Philosophical Studies* 77, pp. 7-37.

Weisberg, J. [2007]: 'Conditionalization, Reflection, and Self-Knowledge', *Philosophical Studies* 135, pp. 179-197.

8. Expanding the language: conditionals Up to this point, we have only considered agents whose degrees of confidence range over a very simple sentential 'language of thought'. Here we review the basics of a very lively debate over the prospects for expanding the language to include a conditional connective.

Lewis, D. [1976]: 'Probability of Conditionals and Conditional Probability', *The Philosophical Review* 85(3), pp. 297-315.

⋆ Hájek, A. & N. Hall [1994]: 'The hypothesis of Conditional Construal of Conditional Probability', in E. Eells & B. Skyrms (eds.) , 75-113.

Hájek, A. [forth.]: 'Triviality Pursuit', forthcoming in *Topoi*.

Part II: Full Belief

9. The AGM framework This session does for full belief what Session 2 did for degrees of confidence, introducing the standard view on the relevant synchronic and diachronic constraints, axiomatised by a famous set of principles known as the 'AGM postulates'. It also reviews various classic representation theorems connecting these postulates to various formal structures, such as so-called 'systems of spheres' and 'entrenchment models'.

⋆ Arlo-Costa, H. & Pedersen [forth.]: 'Belief Revision', forthcoming in L. Horsten & R. Pettigrew (eds.), *Continuum Companion to Philosophical Logic*, Continuum Press. Sections 1, 2 and 3, omitting section 3.3 (optional).

Gärdenfors, P. [2008]: *Knowledge in Flux*, London: College Publications. Ch. 2, sections 2.2-2.4., Ch. 3, omitting section 3.7, and Ch. 4, omitting section 4.10. Appendices A & B supplied for those who are interested.

Peppas [2008]: 'Belief Revision', in F. van Harmelen, V. Lifschitz & B. Porte (eds.) *Handbook of Knowledge Representation, Volume 3*, San Diego: Elsevier Science, pp. 317-359. Sections 8.1-8.3.5.

10. Expanding the language: conditionals The introduction of conditionals into the picture proves to be just as controversial in the domain of full beliefs as it was in the domain of degrees of confidence. We review a classical impossibility result, due to Gärdenfors, and some reactions thereto.

⋆ Gärdenfors, P. [1986]: 'Belief Revisions and the Ramsey Test for Conditionals', *The Philosophical Review* 95(1), pp. 81-93.

Rott, H. [1989]: Conditionals and Theory Change: Revisions, Expansions, and Additions, *Synthese* 81(1), pp. 91-113.

Lindström, S. & W. Rabinowicz [1998]: 'Conditionals and the Ramsey Test', in D. Gabbay & P. Smets (eds.), *Handbook of Defeasible Reasoning and Uncertainty Management Systems, Vol 3*.

11. Weakening the AGM postulates? As we saw in Part I, there is some concern as to whether the standard rationality constraints on degrees of confidence are somewhat overly restrictive. Similar worries turn out afflict the standard modeling framework for rational full belief. We take a look as some common complaints.

★ Arlo-Costa, H. & Pedersen [forth.]: 'Belief Revision', forthcoming in L. Horsten & R. Pettigrew (eds.), *Continuum Companion to Philosophical Logic*, Continuum Press. Sections 4 & 5.

Hansson, S.O. [1999]: 'Recovery and Epistemic Residue', *Journal of Logic, Language, and Information* 8(4), pp. 421-428.

Rott, H. [2004]: 'A Counterexample to Six Fundamental Principles of Belief Formation', *Synthese* 139(2), pp. 225-240.

12. Iterated change One noteworthy limitation of the AGM postulates is the lack of constraints that they impose on so-called 'iterated' changes in view: they tell us what ought to be the case after one change in view, but not after two. A set of supplementary postulates, due to Darwiche and Pearl, attempts to provide a corrective to this.

Darwiche, A. & Pearl, J. [1997]: 'On the Logic of Iterated Belief Revision', *Artificial Intelligence* 89, pp. 1-29.

Jin, Y. & M. Thielscher [2005]: 'Iterated Revision, Revised', *Proceedings of the 19th International Joint Conference in Artificial Intelligence*, pp. 478-483.

Nayak, A., M. Pagnucco, & P. Peppas [2003]: 'Dynamic Belief Revision Operators', *Artificial Intelligence* 146, pp. 193-228.

★ Peppas [2008]: 'Belief Revision', in F. van Harmelen, V. Lifschitz & B. Porte (eds.) *Handbook of Knowledge Representation, Volume 3*, San Diego: Elsevier Science, pp. 317-359. Intro of section 8.6 and section 8.6.2.

Stalnaker, R. [2009]: 'Iterated belief revision', *Erkenntnis* 70, pp. 189-209.

13. Ranking theory and cognate numerical frameworks In this session we take a look at a family of closely-related numerical frameworks for modeling the dynamics of full beliefs in rational agents. These kinds of models, which include Spohn's ranking theory and Dubois and Prade's possibility theory, are already fairly standard in artificial intelligence circles.

Dubois, D. & H. Prade [2009]: 'Accepted beliefs, revision and bipolarity in the possibilistic framework', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 161-184.

Huber, F. [2007]: 'The consistency argument for ranking functions', *Studia Logica* 86, pp. 299-329

⋆ Spohn, W. [2009]: 'A Survey of Ranking Theory', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 185-228. Omitting sections 2.4, 2.5 and 3.

Spohn, W. [1999]: 'Ranking Dunctions, AGM style', in B. Hansson, S. Halldén, N.-E. Sahlin & W. Rabinowicz (eds.) *Spinning Ideas: Electronic Essays Dedicated to Peter Gärdenfors on His Fiftieth Birthday*.

14. Degrees of confidence and full belief: some bridges We now find ourselves with two well-worked out models of two different aspects of our doxastic lives: a formal model of rational degrees of confidence and a formal model of rational full belief. The obvious question that springs to mind: Is there a connection to be drawn, and, if so, what is the nature of that connection? This turns out to be rather tricky to answer...

⋆ Chandler, J. [forth.]: 'The Lottery Paradox Generalised?', forthcoming in the *British Journal for the Philosophy of Science*.

⋆ Douven, I. & T. Williamson [2006]: 'Generalising the Lottery Paradox', *British Journal for the Philosophy of Science* 57(4): 755-779. Introduction and sections 1 & 2.

Smith, M. [forth.]: 'A Generalised Lottery Paradox for Infinite Probability Spaces', forthcoming in the *British Journal for the Philosophy of Science*.

Spohn, W. [2009]: 'A Survey of Ranking Theory', in F. Huber and C. Schmidt-Petri (eds.) *Degrees of Belief*, Synthese Library, volume 342, Springer, pp. 185-228. Section 3.