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Guest Editors' Introduction

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After preliminary foundational work of William Harper and Issac Levi, it was only 30 years ago when the formal study of *belief change* or, as it is alternatively called, *theory change* started. The seminal work was due to Carlos Alchourrón, Peter Gärdenfors and David Makinson, a trio of researchers that was soon widely referred to by the acronym "AGM". During the 1980s, AGM introduced a qualitative model of belief change that acknowledged three doxastic attitudes, namely, belief, disbelief and nonbelief. The problem of belief change is how these attitudes should rationally change in response to new information. Two kinds of operations were regarded as central: *Revision* is the transformation of beliefs that happens if some new piece of information is to be incorporated into the body of a reasoner's beliefs; especially relevant is the case in which the new information contradicts his or her beliefs. *Contraction* is what happens if some piece of information is to be discarded from the body of the reasoner's beliefs. It seems fair to say that the AGM model has been very well corroborated as a model for belief change in the case in which information comes or goes in a single package, both at a certain instant in time and over a stretch of time. The 25th anniversary of the central paper of AGM [1] on *partial meet contraction and revision* has recently been celebrated in a special

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issue of this journal (Number 2 of Volume 40, April 2011). We recommend the survey article by the guest editors Eduardo Fermé and Sven Ove Hansson for a detailed and up-to-date account of the history of the AGM programme [6].

It was soon noticed that the original AGM model is incomplete. One of its deficiencies is that information does not come in only once. What was needed was an extension or revision of the model that can deal with several items of information coming in simultaneously or one after the other. These cases characterize the problem of *multiple belief change* and *iterated belief change*, respectively. Both problems were dealt with from the beginning of the 1990s on, and as the present special issue shows, they indeed continue to present us with challenging questions and offer plenty of room for new ideas and discoveries. The problems of multiple and iterated belief change should, of course, not only be treated in isolation of each other. Delgrande and Yin [5], for instance, have recently presented their model of *parallel belief revision* which addresses the problems of multiple belief change within a framework of iterated belief change.

The present collection of papers arose out of a workshop "Information Processing, Rational Belief Change and Social Interaction" held at Schloss Dagstuhl on 23–27 August, 2009 (Dagstuhl Seminar 09351). We have divided the contributions into three parts. Four contributions are grouped under the heading "multiple belief change" (Part I), and five contributions under the heading "iterated belief change" (Part II). Especially in Part II, the papers do not only pick up the particular questions raised, but also extend and modify the framework of AGM. Part III deals with preference aggregation and consists of only one contribution.

The problem of multiple belief change was addressed head-on for the first time by Fuhrmann and Hansson [8]. They distinguished *package revision and contraction*, the operation of accepting or discarding *all elements* of a given set of propositions, from *choice revision and contraction*, the operation of accepting or discarding *at least one* of the elements of such a set. While it is not trivial to reduce any of these operations to revisions by singletons, three out of four are amenable to comparatively straightforward solutions, if the input sets are finite. It can be argued that package revision by a finite set of sentences is equal to the revision by the conjunction of its elements and that choice contraction by a finite set is equal to the contraction by its conjunction. Choice revision may perhaps be modelled by the revision by the disjunction, and if this does not succeed in the acceptance of any element, one may perhaps just pick one of the favoured elements randomly (where "favoured" means "consistent with the result of the revision by the disjunction").

In the first paper of Part I, Maurício Reis and Eduardo Fermé present a possible worlds semantics for partial meet contraction by a set of sentences, or *partial meet multiple contraction* (where Reis and Fermé mean *package contraction* here). In the second paper, Fermé and Reis investigate the logic of multiple contractions based on systems of spheres of possible worlds, and show that this class forms a subclass of the partial meet multiple contractions (the ones that are studied in the first paper). This approach generalizes the

well-known presentation of the original AGM model in terms of systems of spheres by Grove [9]. Following Zhang and Foo [15], Pavlos Peppas uses a slightly different sense of *set contraction*. In his paper, $K-\Gamma$ means the contraction of K that is necessary to make K consistent with the set Γ. Peppas focusses on the problem of infinitary sets Γ, and bases his considerations on a notion of comparative possibility, a generalization of the notion of epistemic entrenchment introduced by Gärdenfors and Makinson in 1988. The first three papers deal with the problem of belief contraction. The fourth and final paper of Part I by Marcelo Falappa, Gabriele Kern-Isberner, Maurício Reis and Guillermo Simari is about belief revision and belief merging. While *multiple belief revision* (more exactly, *multiple package revision*) is constrained by the condition that the new information be accepted, *merging* treats old beliefs and new information symmetrically, with the effect that the latter does not always get priority. In doing this, Falappa et al. use the method of taking maximal subsets of a belief set consistent with a given piece of information as well as the method of taking minimal subsets of a belief set inconsistent with a given piece of information (this method of "kernel revision" is based on foundational work by Hansson [11]).

The seminal paper addressing the problem of iterated belief change was Darwiche and Pearl [4]. In order to deal with iterated belief change, not only sets of beliefs, but full *belief states* must be taken as primitive. Belief states that were left implicit in the meta-theory of the AGM approach were made part and parcel of the logical modelling of belief dynamics in the 1990s. Belief change functions usually take belief states as arguments and give belief states as values. Often belief states have been (partially) represented as selection functions or preference relations, and belief change has consisted in the transformation of such structures. The problem of iterated belief change is addressed by the five papers in Part II of this issue. Raghav Ramachandran, Abhaya Nayak and Mehmet Orgun consider three different approaches to iterated contraction which they call *moderate*, *natural* and *lexicographic contraction*. The semantics they use for these operations are based on total preorders of possible worlds (which are essentially equivalent to Grovean systems of spheres) and degree of belief functions. The second paper in this part, by Sven Ove Hansson, presents operations of iterated contraction and revision that are based on *global selection mechanisms*, i.e., mechanisms that are applicable to any arbitrary belief set. Because they do not show any path-dependence, they are, in a sense, independent of the particular belief state the agent happens to be in. Hansson argues that such models are suitable if and only if the successive inputs are logically and epistemically independent of each other. The remaining three papers depart from the AGM model in one way or another. Rott's paper discusses *two-dimensional revision operations* in which inputs are pairs of sentences. Besides an input sentence, there is a reference sentence specifying the strength or the extent to which the input sentence is to be accepted. The first operations of this kind were *raising* and *lowering* by Cantwell [3] and *revision by comparison* introduced by Fermé and Rott [7]. These operations violate the Darwiche-Pearl postulates for iterated belief change. Rott offers an

alternative that satisfies these postulates. Bonanno introduces explicit *modal operators* for belief, information and time into the language of belief revision. On the semantic side, such operators are interpreted in terms of branching-time belief revision frames developed in Bonanno [2]. Bonanno explores the conditions under which these model are compatible with the notion of AGM belief revision, and discusses various principles of iterated belief revision. Emil Weydert's approach is based on *ranking measures*, functions that intuitively express quantitative magnitudes and formally generalize Spohn's [14] ranking functions. He presents a variety of principles and mechanisms for belief change that evaluate informational inputs, including graded or parameterized conditionals, as constraints to be satisfied by the posterior belief state and are faithful to the "minimal information paradigm" introduced in earlier work of Weydert's.

The paper by Herzberg and Eckert that forms Part III of this special issue deals with the aggregation of preferences. Preference aggregation is relevant to the problem of belief revision because, as we have seen before, it it quite common to identify belief states with doxastic preference relations or choice functions (cf. Grüne-Yanoff and Hansson [10], Lang and van der Torre [12]), and belief revision models crucially apply these structures in the process of resolving contradictions. As Herzberg and Eckert emphasize, Arrow-type preference aggregation is also relevant for the related field of judgment aggregation (cf. List and Puppe [13]). In the context of their model-theoretic approach, they provide a new proof of an impossibility result concerning free ultrafilters in infinite domains.

We received twelve submissions for this special issue, ten of which are published now. Almost every paper has been substantially revised in response to the comments made by our reviewers. Each paper submitted for this collection was reviewed by three referees. We would like to thank the reviewers for their excellent work.

We are grateful to the management and the staff of Schloss Dagstuhl for the excellent environment they have provided for the conference on which this special issue is based. We would also like to thank Hans van Ditmarsch and the other editors of the Journal of Philosophical Logic for their extraordinary encouragement and support for this project.

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