(More) Philosophical Problems in Belief Revision
Preliminary version

Eduardo Fermé *
University of Madeira and NOVA-LINCS
Portugal
ferme@uma.pt

Abstract

In 1985 Alchourrón, Gärdenfors and Makinson published *On the Logic of Theory Change: Partial Meet Contraction and Revision Functions*, the seminal paper of the logic of theory change (also called belief revision). In 2003, Hansson published *Ten Philosophical Problems in Belief Revision*, where he introduced open problems in belief revision theory, related to the representation of the belief state, different notions of degrees of belief, and the nature of change operations. In this paper, after more than fifteen years, we revisit some of the philosophical questions pointed out by Hansson and we introduce new challenging questions as well.

1 Introduction

The origin of the AGM theory was a confluence of two lines of research. For one side, Alchourrón and Makinson cooperated in studies of changes in legal codes, analysing the logical structure of the derogation procedure in

*Sven Ove Hansson is one of the people to whom I owe my academic career. He is my mentor. I feel very proud and happy to contribute in this tribute.
Part of the topics addressed in the present papers was the result of discussions and dialogues with Sven Ove Hansson during the elaboration of [FH11] and [FH18].

which a norm is removed from a legal corpus. They tried to find the general principles that any derogation process should satisfy, and defined a family of all the possible derogations [AM81]. The key idea was, given a code A, to create a partial order on the norms of A and induce an order on the set of parts of A. The maximal subsets of A that did not imply the norm to be removed were called *remainders*. Later they extended the horizon of the problem, arguing that the problem was not limited only to sets of norms. The set A might be an arbitrary set of formulae, and the problem was how to eliminate one of the formulae or one of the consequences of the set [AM82]. This procedure is called *contraction*. Two different ways to contract a theory by means of remainder sets were analyzed: *maxichoice* and *full meet*. On the other side, Peter Gärdenfors's early work was concerned with the connections between belief change and conditional sentences (if-sentences), looking for a model of explanations. Gärdenfors thought that explanations can be expressed as different types of conditional sentences. He was influenced by Levi and Harper [Lev77, Har77], and this led him to make a thorough study of epistemic conditionals [Gär78a]. Gärdenfors constructed a semantic account of epistemic conditionals that is based on belief states and belief changes [Gär78b]. He defined a set of postulates that change functions must satisfy [Gär82]. Gärdenfors's postulates were closely related to the ideas developed by Alchourrón and Makinson. With combined forces the three wrote a paper that provided a new, much more general and versatile formal framework for studies of belief/theory change, now known as the AGM model [AGM85].

AGM is considered the standard model of belief change and was the starting-point of a large and rapidly growing literature that employs formal models in the investigation of changes in belief states. These researches was mainly in the areas of Philosophy and Artificial Intelligence[CR11, FH18].

In [Han03], Sven Ove Hansson referred:

> "The theory is in a sense aesthetically closed. This aesthetic closure may be a major reason why several able researchers have, in private conversations, confided to me that they believe the subject may be more or less finished since there is nothing more important to add to it. **In my view, this is very far from the truth**."[1]

[1]Emphasis added.

In line with his view, Hansson introduced ten philosophical open problems in belief revision.
The present paper does not pretend to be a reply to Hansson's paper, but an analysis of (some) philosophical problems of belief revision after more than fifteen years. Some of the philosophical questions pointed out by Hansson are revisited, as well as new questions are introduced.

We assume in the rest of the paper that the reader is familiar with the AGM theory. For an introduction and overview see [Han99, FH18].

2 Belief change or logic of theory change?

We mentioned in the introduction that, in its origins, the AGM model was created as a model for theory change (Alchourrón and Makinson) and for rational belief change (Gärdenfors). If we consider real agents, even if we assume them rational, there is a crucial point of discussion that is that of using belief sets to represent the agent's belief state. The use of a logically closed belief set of sentences implies that all beliefs are treated as if they have independent status. Suppose that you believe that you have your keys in your pocket (p); it follows that you also believe that either you have your keys in your pocket or the archbishop of York is a quranist muslim ($p \vee q$). However, $p \vee q$ has no independent standing; it is in the belief set only because p is there. Therefore, if you give up your belief in p we should expect $p \vee q$ to be lost directly, without the need for any mechanism to deselect it. In the AGM framework, however, "merely derived" beliefs such as $p \vee q$ have the same status as independently justified beliefs such as p. Belief base models have largely been constructed in order to make this distinction (for an overview see [Han98, FH18, Ch. 6].
Furthermore, Isaac Levi has proposed that the belief set K should be interpreted as containing the statements that the agent is *committed to believing*, rather than those that she actually believes [Lev77, Lev91]. Such an interpretation may have other problems, but it defuses problems created by the high demands on inferential competence that seem to follow from logical closure.
The logical closure of belief sets is also problematic from another point of view. In a study of the philosophical foundations of AGM, Hans Rott pointed out that the theory is unrealistic in its assumption that epistemic agents are "[...] ideally competent regarding matters of logic". They should accept all the consequences of the beliefs they hold (that is, their set of beliefs should

be logically closed), and they should rigorously see to it that their beliefs are consistent" [Rot00].

Hansson argued that:

> "Formal models of belief revision, such as that used in AGM, have been obtained through [...] (1) idealizing-simplifying, i.e. they leave out many of the complexities of real life, and (2) idealizing-perfecting, i.e. they represent patterns that satisfy standards of rationality that are higher than those that actual (doxastic) agents usually live up to. In many cases, idealizing-perfecting also leads to idealizing-simplifying, so that the two forms of idealization may coincide. Nevertheless, they are conceptually distinct. In order to better understand the models we are working with, we need to distinguish between the two forms of idealization.
> The level of idealization-perfection is an important characteristic of a system of belief revision. Some researchers seem to conceive the ideal rational agents of belief change theory as having unlimited cognitive capacity. It is then fairly unproblematic to construct formal models in which these agents have to process infinite entities (such as infinite sets of sentences)."

Is AGM really a model for belief change, or, on the contrary, it is just for logical theories? Does the high level of idealization of AGM reduce its significance for belief change?

3 Types of changes

The AGM model recognizes three types of changes:

Expansion: This operation is in charge of incorporating sentences in the original set, without eliminating any sentence from it. It allows the passage from an epistemic state in which a belief is undetermined to another epistemic state in which the belief is accepted or rejected.

Contraction: This operation eliminates sentences from the original set without incorporating any new ones. It allows the passage from an epistemic state in which a belief is accepted or rejected to another epistemic state in which the belief is undetermined.

Revision: This operation incorporates a sentence in the original set, but it can eliminate some beliefs in order to preserve the consistency of the revised set. It allows the passage from an epistemic state in which a belief is accepted (rejected) to another state in which the belief is rejected (accepted).

In the literature, other kind of change operations are proposed. Among then we can mention[2]:

Forgetting: This operation eliminates certain elements from the language, without affecting the consequences that are inferable for the language elements that remain. In the same way as AGM contraction, it removes a belief p from a belief set. The main difference with AGM-contraction is that forgetting not only eliminates p as a consequence of the belief set, but also eliminates any appearance of p in the belief set (for instance $p \vee q$ can remain after an AGM contraction but not after a forgetting operation). For an overview see [EKI19].

Erradication: Eradication is a form of contraction that removes not only a sentence but also all of its non-tautological consequences from a belief set. It was defined by Hansson in [Han12]. It is different from contraction, since even if p is not in the belief set, erradication eliminates also the non-tautological consequences of p.

Update: This operator differs from AGM revision since whereas revision operators are suited to capture changes that reflect evolving knowledge about a static situation, update operators are intended to represent changes in beliefs that result from changes in the objects of belief [Win88, KM92]. We will discuss update operators on section 6.

Consolidation: If a belief base is inconsistent, then it can be made consistent by removing enough of its more dispensable elements. A plausible way to perform consolidation is to contract by falsum (contradiction).

Replacement: This operation replaces one sentence by another. Such an operator has two variables, in the outcome p is replaced by q. This

[2]We are referring only to changes in *one step belief change*. There are other changes for *iterated belief change* like improvement [KP08], raising/lowering [Can97], reconsideration[JS05], revision by comparison [FR04], etc., that we will not consider here.

operation can have outcomes that are not obtainable through AGM operators [Han09]. Replacing p by $\top$ is one possible way to implementing forgetting.

Reformulation: Reformulation is an internal operation of a belief base, where some explicit beliefs become implicit beliefs and vice-versa, while the resulting base is logically equivalent to the initial base i.e., $Rec(B_1) = B_2$, where $Cn(B_1) = Cn(B_2)$ but not necessarily $B_1 = B_2$ [FH20].

Is this battery of change operators enough to describe all kind of possible changes in the beliefs of a rational agent?

4 Credibility Limit and Trust

When a rational agent is confronted with new information, one possible attitude is to reject it. There are several possible reasons for this, but we can simplify it by giving to the new information the status of "non credible" (or non acceptable). We can explain that the reason to declare new information "non credible" is because it came *so far* from the limit of credibility (or limit of acceptance) of the agent. Formally spoken, we can define a function in the following way:

$$K \circ p = \begin{cases} K * p & \text{if } p \in \mathcal{C} \\ K & \text{otherwise} \end{cases}$$

where $*$ is an AGM revision function (that accepts the new information). Sentence p will be accepted in credibility-limited revision if and only if the input sentence p is credible, assuming $\mathcal{C}$ is the set of credible sentences. Several authors have proposed non-priorityzed revision functions (for an overview see [FH18, Ch.8]). However, the notion of credibility-limit appears informally discussed in [FH99b, p.404] and formally defined in [Mak97] (screened revision) and in an extensive and dense paper in [HFCF01]. In the later, the notion of credibility-limited revision was characterized in terms of possible worlds, epistemic entrenchment, and axiomatically characterized for different properties of the set $\mathcal{C}$. Later models of credibility-limited revision was extended to iteration [BFKP12] and belief bases [FMT03, GFR18]. However, the main characteristic of these works is that all of them were developed at

the formal level. All the papers lack of a philosophical discussion about what credibility-limited really means for rational agents.

The idea of credibility-limit is closely related to that of trust. In this case, the credibility is related to the source of the information and not to the information itself. There are several approaches about credibility of the sources in the belief change literature (e.g., [Boo06, Can98, DGB97, TGFS14]). This trust depends not only on the source, but also on the context of the information.

Which are the philosophical issues that must be addressed in credibility-limited belief change? How the trust on the source and the context of the information may influence it?

5 Irrelevance of syntax

In classical belief revision, irrelevance of syntax is characterized by the postulate "If $\vdash p \leftrightarrow q$, then $K?p = K?q$", where ? can be an expansion, a contraction, or a revision operation. In belief bases, there are two opposing trends in order to represent the beliefs of an epistemic agent. One approach, supported by Dalal [Dal88], is associated with a coherentist epistemic representation in which all elements of the belief set have equal status, and belief bases are a merely expressive resource. This interpretation requires that the outcome of a belief change operation is the same for different belief base representations of the same belief set. For instance, if $Cn(B1) = Cn(B2)$, then $Cn(B1?p) = Cn(B2?p)$.

In the other one (known as Hansson's approach), the formalism of belief bases is associated with an epistemic foundationalist view. This approach treats inclusion in the belief base as epistemically significant. The belief base contains those sentences that have an epistemic standing of their own. Suppose that the belief set contains the sentence s, "Shakespeare wrote Hamlet". Due to logical closure it then also contains the sentence $s \vee d$, "Either Shakespeare wrote Hamlet or Charles Dickens wrote Hamlet". The latter sentence is a "mere logical consequence" that should have no standing of its own [Han06]. In this approach, belief bases increase the expressive power of the belief representation, since two belief bases with the same logical closure can represent different ways to hold the same beliefs. Since the two belief bases $\{p, q\}$ and $\{p, p \leftrightarrow q\}$ have the same logical closure, they are "statically

equivalent", i.e., they generate the same belief set. However, they are not "dynamically equivalent" since they behave differently under operations of change; revision by $\neg p$ will presumably result in $\{\neg p, q\}$ and $\{\neg p, p \leftrightarrow q\}$, respectively, and therefore they generate different belief sets [Han92].

Hansson's approach is more expressive, nonetheless it still conserves the extensionality postulate: "If $\vdash p \leftrightarrow q$, then $B - p = B - q$". Even if this postulate is reasonable, when we deal with human agents, the fact that $\vdash p \leftrightarrow q$ is believes, it does not means that the agent will be consider p and q interchangeable. As an example, we can mentioned what in Psychology is knows as the *framing effect* [TK81]:

Example 1 [TK81] Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people and two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

Problem 1:

- If Program A is adopted, 200 people will be saved.
- If Program B is adopted, there is $\frac{1}{3}$ probability that 600 people will be saved, and $\frac{2}{3}$ probability that no people will be saved.

Problem 2:

- If Program C is adopted 400 people will die.
- If Program D is adopted there is $\frac{1}{3}$ probability that nobody will die, and $\frac{2}{3}$ probability that 600 people will die.

The question is the, which of the two programs would you favor?

In this experiment (that was followed in the literature by similar ones) 72% choose Program A and 20% Program B. Surprisingly, 22% choose Program C and 20% Program D. Even if the outcome of Program A and C are the same, the prospect of certainly saving 200 lives is more attractive than the certain death of 400 people.

A similar problem was pointed out in the use of "better than" and "worse than", which are not symmetrical [CS66, p.244] as we can see in the following example [Han05]:

Example 2 Consider a conductor who discusses the abilities of the two flutists of the orchestra conducts. If he says "the second flutist is better than the first flutist", he may still be very satisfied with both of them (but perhaps want them to change places). However, if he says "the second flutist is worse than the first flutist", then he probably indicates that he would prefer to have them both replaced.

How can we model a belief change approach that considers dependency of syntax (in the way of the framing problem) but conserving (as much as possible) the AGM aesthetic?

6 Belief Revision vs Update

In 1992, Katsuno and Mendelzon presented a type of operation of change that they called update [KM92]. Whereas revision operations are suited to capture changes that reflect evolving knowledge about a static situation, update operations are intended to represent changes in beliefs that result from changes in the objects of belief. The difference was pointed out for the first time by Keller and Winslett [KW85] (in the context of relational databases) and is captured in the following example [Win88]:

Example 3 Initially the agent knows that there is either a book on the table (p) or a magazine on the table (q), but not both.

Case 1: The agent is told that there is a book on the table. She concludes that there is no magazine on the table. This is revision.

Case 2: The agent is told that subsequently a book has been put on the table. In this case she should not conclude that there is no magazine on the table. This is update.

The difference between update and revision has important implications in real life contexts. For instance, assume that I give requirements for the construction of a computer system and when deployed, the system doesn't match with the requirements. It is important, in terms of responsibilities, to determine if the requirements were misunderstood or if the requirements actually change.

From the formal point of view there are important formal differences between KM-update and AGM-revision; in particular AGM postulate Vacuity (If $K \not\vdash \neg p$ then $K * p = Cn(K \cup \{p\})$) does not hold for KM-update, which,

instead satisfies Idempotence (If $K \vdash p$ then $K * p = K$). Idempotence is not free of controversies, and provoke that real examples of updates cannot be represented by KM-update as we can see in the following:

Example 4 Initially the agent knows that the wall of the room is white (p). The agent is told that subsequently that the wall of the room was repainted white (p) or grey (q) but not both.

It is reasonable that the agent now believes that the wall in the room is white or grey but not both. However, if we solve this problem using KM-update, the agent still believes that the wall in the room is white. [3]

The difference between revision and update is more evident in the possible worlds approach. Katsuno and Mendelzon proposed that when the world changes, the agent changes each of the worlds that (s)he considers to be possible in order to accommodate the input while changing as little else as possible. Katsuno and Mendelzon argued that "we think one of them is the real world, but we do not know which one. Now the real world has changed, we examine each of the old possible worlds and find the minimal way of changing each one of them so that it becomes a model of p".
However, this argument is not free of controversy. Lang [Lan07] shows the following (counter) example:

Example 5 My initial belief is that either Alice (a) is in the office or Bob (b) is in the office (but not both). Both tend to stay in the office when they are in. Now I see Bob going out of the office. What do I believe now?

Since there is at least one possible world μ that implies (a) and ($\neg b$), it is not possible to eliminate it in KM-update and, consequently, the agent cannot belief in ($\neg a$) after the update.

Another interesting point to be discussed is about how the agent recognize which kind of change must perform in front of new information:

Example 6 Assume that I believe that the walls of room A are white and that room A and B were painted using the same paint can. I enter in room A and discover that its walls are grey.

[3] Additional discussions and counterexamples of Idempotence can be found in [FH99a]. However Friedman and Harper focussed in the case of iterated changes, while here we are interested only in a single change.

In the above example if the agent makes a revision (i.e., the previous information about the color of the walls was wrong) it is perfectly reasonable to believe after the revision that the walls of room B are grey, but if (s)he makes an update (i.e., the wall was painted of grey) it is reasonable to still believe after the update that the walls of room B are white. The problem is that the agent must decide which kind of change must be applied.

Which conditions do we need to consider to construct a model that represents real world updates?

7 Acknowledgement

I would like to thank Maria Vanina Martinez for her valuable comments on earlier versions of this paper. I also thank the participants of the workshop *Philosophical Tools for Real-World Problems – Reflections on Sven Ove Hansson's Style of Philosophizing*, in particular Wlodek Rabinowicz for their contributions and comments to improve the paper. This paper is partially supported by FCT through projects UID/CEC/04516/2019 and PTDC/CCICOM/ 30990/2017.

References

[AGM85] Carlos Alchourrón, Peter Gärdenfors, and David Makinson. On the logic of theory change: Partial meet contraction and revision functions. *Journal of Symbolic Logic*, 50:510–530, 1985.

[AM81] Carlos Alchourrón and David Makinson. Hierarchies of regulations and their logic. In Risto Hilpinen, editor, *New Studies in Deontic Logic: Norms, Actions, and the Foundations of Ethics*, pages 125–148, 1981.

[AM82] Carlos Alchourrón and David Makinson. On the logic of theory change: Contraction functions and their associated revision functions. *Theoria*, 48:14–37, 1982.

[BFKP12] Richard Booth, Eduardo Fermé, Sébastien Konieczny, and Ramón Pino Pérez. Credibility-limited revision operators in propositional logic. In *Proceedings of the 13th International Conference*

on Principles of Knowledge Representation and Reasoning (KR 2012), pages 116–125, 2012.

[Boo06] Richard Booth. Social contraction and belief negotiation. *Information Fusion*, 7(1):19–34, 2006.

[Can97] John Cantwell. On the logic of small changes in hypertheories. *Theoria*, 63:54–89, 1997.

[Can98] John Cantwell. Resolving conflicting information. *Journal of Logic, Language and Information*, 7(2):191–220, 1998.

[CR11] Raúl Carnota and Ricardo Rodríguez. AGM theory and artificial intelligence. In Erik J. Olsson and Sebastian Enqvist, editors, *Belief Revision meets Philosophy of Science*, volume 21 of *Logic, Epistemology, and the Unity of Science*, pages 1–42. Springer Netherlands, 2011.

[CS66] Roderick M Chisholm and Ernest Sosa. On the logic of" intrinsically better". *American Philosophical Quarterly*, 3(3):244–249, 1966.

[Dal88] Mukesh Dalal. Investigations into a theory of knowledge base revision: Preliminary report. In *Seventh National Conference on Artificial Intelligence, (AAAI-88)*, pages 475–479, St. Paul, 1988.

[DGB97] Aldo Franco Dragoni, Paolo Giorgini, and Marco Baffetti. Distributed belief revision vs. belief revision in a multi-agent environment: First results of a simulation experiment. In *European Workshop on Modelling Autonomous Agents in a Multi-Agent World*, pages 45–62. Springer, 1997.

[EKI19] Thomas Eiter and Gabriele Kern-Isberner. A brief survey on forgetting from a knowledge representation and reasoning perspective. *KI-Künstliche Intelligenz*, 33(1):9–33, 2019.

[FH99a] Eduardo Fermé and Sven Ove Hansson. Selective revision. *Studia Logica*, 63:3:331–342, 1999.

[FH99b] Nir Friedman and Joseph Y. Halpern. Belief revision: A critique. *Journal of Logic, Language, and Information*, 8:401–420, 1999.

[FH11] Eduardo Fermé and Sven Ove Hansson. AGM 25 years: Twenty-five years of research in belief change. *Journal of Philosophical Logic*, 40:295–331, 2011.

[FH18] Eduardo Fermé and Sven Ove Hansson. *Belief Change: Introduction and Overview*. Springer Briefs in Computer Science Series. Springer, 2018.

[FH20] Eduardo Fermé and Andreas Herzig. Reformulation. Unpublished manuscript, 2020.

[FMT03] Eduardo Fermé, Juan Mikalef, and Jorge Taboada. Credibility-limited functions for belief bases. *Journal of Logic and Computation*, 13:1:99–110, 2003.

[FR04] Eduardo Fermé and Hans Rott. Revision by comparison. *Artificial Intelligence*, 157:5–47, 2004.

[Gär78a] Peter Gärdenfors. Conditionals and changes of belief. *Acta Philosophica Fennica*, 30:381–404, 1978.

[Gär78b] Peter Gärdenfors. Conditionals and changes of belief. *American Philosophical Quarterly*, 18(3):203–211, 1978.

[Gär82] Peter Gärdenfors. Rules for rational changes of belief. In Tom Pauli, editor, *Philosophical Essays Dedicated to Lennart Åqvist on his Fiftieth Birthday*, number 34 in Philosophical Studies, pages 88–101, 1982.

[GFR18] Marco Garapa, Eduardo Fermé, and Maurício DL Reis. Studies in credibility-limited base revision. In *Sixteenth International Conference on Principles of Knowledge Representation and Reasoning*, pages 240–247, 2018.

[Han92] Sven Ove Hansson. A dyadic representation of belief. In Peter Gärdenfors, editor, *Belief Revision*, number 29 in Cambridge Tracts in Theoretical Computer Science, pages 89–121. Cambridge University Press, 1992.

[Han98] Sven Ove Hansson. Revision of belief sets and belief bases. In *Belief change*, pages 17–75. Springer, 1998.

[Han99] Sven Ove Hansson. *A Textbook of Belief Dynamics. Theory Change and Database Updating.* Applied Logic Series. Kluwer Academic Publishers, Dordrecht, 1999.

[Han03] Sven Ove Hansson. Ten philosophical problems in belief revision. *Journal of Logic and Computation*, 13:37–49, 2003.

[Han05] Sven Ove Hansson. Decision theory. *A brief introduction. Department of Philosophy and the History of technology. Royal Institute of Technology. Stockholm*, 2005.

[Han06] Sven Ove Hansson. Logic of belief revision. In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. The Metaphysics Research Lab. Center for the Study of Language and Information. Stanford University, 2006. URL = http://plato.stanford.edu/entries/logic-belief-revision/.

[Han09] Sven Ove Hansson. Replacement: A Sheffer stroke for belief revision. *Journal of Philosophical Logic*, 38:127–149, 2009.

[Han12] Sven Ove Hansson. Eradication. *Journal of Applied Logic*, 10(1):75–84, 2012.

[Har77] William Harper. Rational conceptual change. In *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, Volume Two: Symposia and Invited Papers*, pages 462–494. The University of Chicago Press, 1977.

[HFCF01] Sven Ove Hansson, Eduardo Fermé, John Cantwell, and Marcelo Falappa. Credibility-limited revision. *Journal of Symbolic Logic*, 66(4):1581–1596, 2001.

[JS05] Frances L. Johnson and Stuart C. Shapiro. Improving recovery for belief bases. In Leora Morgenstern and Maurice Pagnucco, editors, *IJCAI-05 Workshop on Nonmonotonic Reasoning, Action, and Change (NRAC'05)*, pages 65–70, Edinburgh, 2005.

[KM92] Hirofumi Katsuno and Alberto Mendelzon. On the difference between updating a knowledge base and revising it. In Peter Gärdenfors, editor, *Belief Revision*, number 29 in Cambridge

Tracts in Theoretical Computer Science, pages 183–203. Cambridge University Press, 1992.

[KP08] Sebastien Konieczny and Ramón Pino Perez. Improvement operators. In *Proceedings of the 11th International Conference on Principles of Knowledge Representation and Reasoning (KR 2008)*, pages 177–186, 2008.

[KW85] Arthur M. Keller and Marianne Winslett. On the use of an extended relational model to handle changing incomplete information. *IEEE Transactions on Software Engineering*, 11(7):620–633, 1985.

[Lan07] Jérôme Lang. Belief update revisited. In *IJCAI 2007, Proceedings of the 20th International Joint Conference on Artificial Intelligence, Hyderabad, India, January 6-12, 2007*, pages 2517–2522, 2007.

[Lev77] Isaac Levi. Subjunctives, dispositions, and chances. *Synthèse*, 34:423–455, 1977.

[Lev91] Isaac Levi. *The fixation of belief and its undoing: changing beliefs through inquiry*. Cambridge University Press, Cambridge, 1991.

[Mak97] David Makinson. Screened revision. *Theoria*, 63:14–23, 1997.

[Rot00] Hans Rott. Two dogmas of belief revision. *Journal of Philosophy*, 97(9):503–522, 2000.

[TGFS14] Luciano H Tamargo, Alejandro J García, Marcelo A Falappa, and Guillermo R Simari. On the revision of informant credibility orders. *Artificial Intelligence*, 212:36–58, 2014.

[TK81] Amos Tversky and Daniel Kahneman. The framing of decisions and the psychology of choice. *Science*, 211(4481):453–458, 1981.

[Win88] Marianne Winslett. Reasoning about action using a possible models approach. In *Proceedings of the Seventh American Association for Artificial Intelligence Conference*, pages 89–93, 1988.