First publ. on: Oxford Bibliographies Online (http://www.oxfordbibliographiesonline.com/view/document/obo-9780195396577/obo-9780195396577-0024.xml), Zugriff am 7.7.2011

Confirmation

BY FRANZ HUBER

INTRODUCTION

The term "confirmation" is used in epistemology and the philosophy of science whenever observational data and evidence speak in favor of or support scientific theories and everyday hypotheses. Historically, confirmation has been closely related to the problem of induction, the question of what to believe regarding the future given knowledge that is restricted to the past and present. One relation between confirmation and induction is that the conclusion H of an inductively strong argument with premise E is confirmed by E. If inductive strength comes in degrees and the inductive strength of the argument with premise E and conclusion H is equal to r, then the degree of confirmation of H by E is likewise said to be equal to r.

GENERAL OVERVIEWS

Most overviews on confirmation are also overviews on probability theory and induction, and some the other way round. The reason is simply that Bayesian confirmation theory, by far the most prominent account of confirmation, is based on probability theory and that confirmation theory is a modern answer to the problem of induction. As is true for so many topics in philosophy, the first sources to consult are the relevant entries of the *Stanford Encyclopedia of Philosophy* (Hájek 2003, Hawthorne 2004, Joyce 2003), which are available online. Other useful sources that are available online are the relevant entries of the *Internet Encyclopedia of Philosophy* (diFate 2007, Huber 2007), and Fitelson 2006. A widely used introductory textbook is Skyrms 2000.

diFate, Victor. "Evidence." In *Internet Encyclopedia of Philosophy*. Edited by James Fieser and Bradley Dowden, 2007.

An excellent overview with a focus on epistemological questions that is available online.

Fitelson, Branden. "Inductive Logic." In *The Philosophy of Science: An Encyclopedia*. Edited by Jessica Pfeifer and Sahotra Sarkar, 384–394. New York: Routledge, 2006.

A historically informed and very accessible overview of confirmation and inductive logic.

Hájek, Alan. "Probability, Interpretations of." In *Stanford Encyclopedia of Philosophy*. Edited by Edward N. Zalta, 2003.

An excellent overview on interpretations of probability that is available online.

Hawthorne, John. "Inductive Logic." In *Stanford Encyclopedia of Philosophy*. Edited by Edward N. Zalta, 2004.

An excellent overview on inductive logic that is available online.

Huber, Franz. "Confirmation and Induction." In *Internet Encyclopedia of Philosophy*. Edited by James Fieser and Bradley Dowden, 2007.

An opinionated overview that is available online.

Joyce, James M. "Bayes's Theorem." In *Stanford Encyclopedia of Philosophy*. Edited by Edward N. Zalta, 2003.

An excellent overview on Thomas Bayes's theorem and its importance for Bayesian confirmation theory that is available online. Joyce favors a confirmation-theoretic pluralism according to which there are several legitimate measures of incremental confirmation: each of them measures an important evidential relationship, but the relationships they measure are importantly different.

Skyrms, Brian. *Choice and Chance: An Introduction to Inductive Logic*. 4th ed. Belmont, CA: Wadsworth Thomson Learning, 2000.

This is an elementary introduction by one of the leading figures in the field.

TEXTBOOKS

Most textbooks currently available share the feature that they all are biased in the sense that their authors not only review the existing literature but also defend particular views. In addition, with the exception of Earman 1992, there is no textbook that tries to cover more than one paradigm. Besides Bayesian confirmation theory (Fitelson 2001, Howson and Urbach 2006, Jeffrey 1983, Joyce 1999) and error statistics (Mayo 1996), both of which are probabilistic, there is the nonprobabilistic paradigm of formal learning theory (Kelly 1996). The latter has been inspired by work by Hilary Putnam (see Probabilistic Theories of Confirmation) and others and evaluates methods in terms of the reliability with which they find out the correct answer to a given question. The use of a method to answer a question is justified when the method reliably answers the question, if any method does. There are different senses of reliability corresponding to how hard a question is to answer, which provides a classification of all problems in terms of their complexity. It is fair to say that formal learning theory is not too popular among philosophers, and part of the explanation for this is that it requires a substantial background in mathematical logic.

Earman, John. *Bayes or Bust? A Critical Examination of Bayesian Confirmation Theory*. Cambridge, MA: MIT Press, 1992.

Earman's *Bayes or Bust?* is probably the first reference for anybody interested in Bayesian confirmation theory. The book can be used as textbook, though it quickly moves to fairly advanced and mathematically involved topics.

Fitelson, Branden. *Studies in Bayesian Confirmation Theory*. PhD diss., University of Wisconsin, 2001.

This is Fitelson's PhD thesis that should be replaced by his book *Confirmation Theory* (forthcoming).

Howson, Colin, and Peter Urbach. *Scientific Reasoning: The Bayesian Approach*. 3d ed. La Salle, IL: Open Court, 2006.

Howson and Urbach's *Scientific Reasoning* is an opinionated exposition of Bayesian philosophy of science at book length that belongs to the canon of the literature on Bayesian confirmation theory.

Jeffrey, Richard C. *The Logic of Decision*. 2d ed. Chicago: University of Chicago Press, 1983.

This book presents Jeffrey's evidential decision theory. While the topic of the book is not confirmation, it is closely related to it and too important for Bayesianism not to be mentioned here. Among others, Jeffrey formulates an update rule, now known as "Jeffrey conditionalization," that is applicable when the evidence received does not come in the form of a certainty or even a proposition.

Joyce, James M. *The Foundations of Causal Decision Theory*. Cambridge, UK: Cambridge University Press, 1999.

[DOI: 10.1017/CBO9780511498497]

Causal decision theory is the main alternative to Richard C. Jeffrey's evidential decision theory, and this book is the standard reference to the former. Joyce's book has been important for Bayesian confirmation theory because of the discussion of the problem of old evidence in chapter 6.

Kelly, Kevin T. *The Logic of Reliable Inquiry*. Oxford: Oxford University Press, 1996.

This is the standard reference to formal learning theory.

Mayo, Deborah G. *Error and the Growth of Experimental Knowledge*. Chicago: University of Chicago Press, 1996.

This is Mayo's book on her error-statistical philosophy of experiment.

ANTHOLOGIES

Most anthologies relevant to confirmation, especially Carnap and Jeffrey 1971, Hintikka and Suppes 1966, and Jeffrey 1980, are fairly old and do not represent the current state of the art. Earman 1983 and Stalker 1994 are thematically focused but contain papers by authors with different views and approaches. Two recent collections of papers (Fetzer and Eells 2010, Huber and Schmidt-Petri 2009) are indirectly devoted to confirmation.

Carnap, Rudolf, and Richard C. Jeffrey, eds. *Studies in Inductive Logic and Probability*. Vol. 1. Berkeley: University of California Press, 1971.

This is an anthology containing some of Rudolf Carnap's later works, including his "Inductive Logic and Rational Decisions."

Earman, John, ed. *Testing Scientific Theories*. Minnesota Studies in the Philosophy of Science 10. Minneapolis: University of Minnesota Press, 1983.

This collection of articles, many of them on Clark Glymour's *Theory and Evidence*, contains several important articles, among others Daniel Garber's "Old Evidence and Logical Omniscience in Bayesian Confirmation Theory."

Fetzer, James H., and Ellery Eells, eds. *The Place of Probability in Science: In Honor of Ellery Eells (1953–2006)*. Boston Studies in the Philosophy of Science 284. Dordrecht, The Netherlands: Springer, 2010.

This is an anthology containing, among others, Branden Fitelson and James Hawthorne's "How Bayesian Confirmation Theory Handles the Paradox of the Ravens."

Hintikka, Jaakko, and Patrick Suppes, eds. *Aspects of Inductive Logic*. Amsterdam: North-Holland, 1966.

This is a collection of articles on Rudolph Carnap's project of inductive logic that had been influential at the time of its appearance. It contains, among others, Jaakko Hintikka's "A Two-Dimensional Continuum of Inductive Methods," which presents a system of inductive logic in which universal generalizations can receive positive probability, something that was not possible in Carnap's early systems.

Huber, Franz, and Christoph Schmidt-Petri, eds. *Degrees of Belief*. Synthese Library 342. Dordrecht, The Netherlands: Springer, 2009.

[DOI: 10.1007/978-1-4020-9198-8]

This anthology on degrees of belief, which is available as a paperback, contains surveys on alternatives to probabilism such as Dempster-Shafer theory, possibility theory, and ranking theory as well as top-notch articles on probabilism, including a revised version of Joyce 1998 (cited under Modern Bayesian Confirmation Theory).

Jeffrey, Richard C., ed. *Studies in Inductive Logic and Probability*. Vol. 2. Berkeley:

University of California Press, 1980.

This is an anthology including David Lewis's "A Subjectivist's Guide to Objective Chance," in which he formulates the Principal Principle. The latter says that an ideally rational agent's initial credence in a proposition *A* given that the objective chance of *A* equals *x*, and no further information that is not inadmissible, should equal *x*. It is important for Bayesian confirmation theory, because it allows for the confirmation of statistical hypotheses.

Stalker, Douglas F., ed. *Grue! The New Riddle of Induction*. Chicago: Open Court, 1994.

This is a collection of articles on Nelson Goodman's new riddle of induction. It is representative up to the time of its appearance.

REFERENCE WORKS

This section lists and annotates the milestones in the literature on confirmation and induction in chronological order from David Hume's formulation of the problem of the justification of induction over Karl R. Popper's falsificationism, Carl Gustav Hempel's criteria of adequacy and the ravens paradox, Rudolph Carnap's syntactic approach to probability and induction, Nelson Goodman's "new riddle of induction" and the demise of the syntactic approach, Hans Reichenbach's pragmatic vindication of induction to Kevin T. Kelly's formal learning theory that is inspired by work by Hilary Putnam and, finally, modern Bayesian confirmation theory.

Early Works on Induction

While both Bacon 1901 (first published in 1620) and Mill 1973 (first published in 1843) belong to the classics of Western philosophy, it is Hume 2000 (first published in 1739) that forms the starting point of most work on induction and confirmation. Hume 2000 argues that it is impossible to justify induction. According to David Hume, such a justification consists in a deductively valid or an inductively strong argument to the effect that induction will lead from true premises to true conclusions. On the one hand there is no such argument that is deductively valid and whose premises are restricted to the past and present (and all premises we can know are restricted in this way). On the other hand every argument that is inductively strong will be inductively strong in the very sense at issue and thus begs the question.

Bacon, Francis. *The Works*. Vol. 4, *Novum Organon*. Edited by J. Spedding, R. L. Ellis, and D. D. Heath. London, 1901.

Bacon's *Novum Organon* is the first (modern) work on induction. His method focuses on exclusion or elimination and is sometimes seen as a forerunner of Karl R. Popper's falsificationism.

Hume, David. *A Treatise of Human Nature*. Edited by David Fate Norton and Mary J. Norton. Oxford: Oxford University Press, 2000.

In Book 1, Part 3, section 12 Hume gives the classic formulation of the problem of the justification of induction.

Mill, John Stuart. *System of Logic, Ratiocinative and Inductive: Being a Connected View of the Principles of Evidence and the Methods of Scientific Investigation*. Collected Works of John Stuart Mill 7–8. Edited by John M. Robson. Toronto: University of Toronto Press, 1973.

In Book 2, chapter 9 Mill presents his famous "Methods of Experimental Inference." These can be considered to form the first attempt at formulating a system of inductive logic.

Nonprobabilistic Theories of Confirmation

The Popper 1994 falsificationism has been popular among scientists but does not have many defenders in today's philosophy of science. It is slightly misleading to list Reichenbach 1938 among nonprobabilistic theories of confirmation, but Hans Reichenbach's work has led almost exclusively to non-Bayesian accounts of confirmation that do, however, take into account statistics. Carl Gustav Hempel's seminal papers on the logic of confirmation (Hempel 1945a and Hempel 1945b) are must-reads for anybody interested in confirmation. Hempel 1945a discusses the Nicod criterion of confirmation according to which universal generalizations of the form "all *F*s are *G*s" are supported by "instances" of the form "*a* is *F* and *G*." Hempel then presents the famous ravens paradox. By the Nicod criterion, a nonblack nonraven confirms the hypothesis that all nonblack things are nonravens. But that hypothesis is logically equivalent to the ravens hypothesis that all ravens are black. So a nonblack nonraven such as a white shoe can be used to confirm the ravens hypothesis. Hempel 1945b states the prediction criterion of confirmation (which Hempel rejects), the satisfaction criterion of confirmation (his official theory), and the following four conditions of adequacy on any relation of confirmation: the entailment condition, the consequence condition, the consistency condition, and the converse consequence condition. He shows these four conditions to entail that any two statements confirm each other. This leads him to reject the converse consequence condition. Glymour 1980 is a historically informed discussion of theory testing in the tradition of Hempel but with a novel twist to it known as "bootstrap confirmation."

Glymour, Clark. *Theory and Evidence*. Princeton, NJ: Princeton University Press, 1980.

Glymour's "bootstrap confirmation" incorporates the idea that, when a whole theory is tested, some parts can be used in testing other parts. The book also contains a chapter in which Glymour explains why he is not a Bayesian. The problem of old evidence raised there is one of the most discussed problems of Bayesian confirmation theory.

Hempel, Carl Gustav. "Studies in the Logic of Confirmation I." *Mind* 54 (1945a): 1–26. [DOI: 10.1093/mind/LIV.213.1]

This is the first part of Hempel's seminal paper on the logic of confirmation in which he discusses the Nicod criterion of confirmation and presents the famous ravens paradox.

Hempel, Carl Gustav. "Studies in the Logic of Confirmation II." *Mind* 54 (1945b): 97–121.

This is the second part of Hempel's seminal paper on the logic of confirmation in which he states the prediction criterion of confirmation, the satisfaction criterion of confirmation, and four famous conditions of adequacy on any relation of confirmation.

Popper, Karl R. *Logik der Forschung*. Tübingen, Germany: J. C. B. Mohr, 1994.

This book, which was first published in 1935, is Popper's best-known work in which he famously argues that many scientific hypotheses cannot be verified but can be falsified. Consequently science should put forth bold hypotheses, which are then severely tested. Hypotheses surviving many and severe tests are "corroborated." Hypotheses that are falsified should be put aside if there are alternative hypotheses that are not falsified.

Reichenbach, Hans. *Experience and Prediction: An Analysis of the Foundations and the Structure of Knowledge*. Chicago: University of Chicago Press, 1938.

[DOI: 10.1037/11656-000]

In this book Reichenbach states the "straight rule" according to which one should conjecture that the limiting relative frequency equals the observed relative frequency. Reichenbach justifies this rule by his "pragmatic vindication of induction": if any rule converges to the correct limiting relative frequency, then the straight rule does so as well.

Probabilistic Theories of Confirmation

Kolmogorov 1956 formulates the mathematics on which Bayesian confirmation theory is based. Rudolf Carnap is the most important figure in Bayesian confirmation theory. Carnap 1962 and Carnap 1952 are the book-length results of what are now considered to be failed attempts to define probability and confirmation in purely syntactic terms. Goodman 1983, Putnam 1963a, and Putnam 1963b are important because of their criticism of Carnap's project. Gaifman and Snir 1982 proves important mathematical results for modern Bayesian confirmation theory.

Carnap, Rudolf. *The Continuum of Inductive Methods*. Chicago: University of Chicago Press, 1952.

This is Carnap's continuation of his attempt to define, in purely syntactical terms, a logical measure of probability. His program is slightly less ambitious now in that he is content with providing criteria that determine a set of measures that are characterized by a parameter λ rather than a unique measure. λ is inversely proportional to the impact of evidence.

Carnap, Rudolf. *Logical Foundations of Probability*. 2d ed. Chicago: University of Chicago Press, 1962.

This is Carnap's *opus magnum* on probability and confirmation, which was first published in 1950. He attempts to provide a set of criteria that single out one probability measure as the unique logical measure of probability. Among others, Carnap introduces the important distinction between absolute confirmation (conditional probability) and incremental confirmation (increase in probability) and argues that Carl Gustav Hempel mixes them up when presenting his four conditions of adequacy.

Gaifman, Haim, and Marc Snir. "Probabilities over Rich Languages, Testing, and Randomness." *Journal of Symbolic Logic* 47 (1982): 495–548.

[DOI: 10.2307/2273587]

Gaifman and Snir's convergence theorems proved in this paper belong to the most important mathematical results that form the basis of modern Bayesian confirmation theory.

Goodman, Nelson. *Fact, Fiction, and Forecast*. 4th ed. Cambridge, MA: Harvard University Press, 1983.

Goodman's book, which was first published in 1954, marks the demise of Carl Gustav Hempel's and Rudolph Carnap's syntactic approach to confirmation. His famous new riddle of induction illustrates that no purely syntactic notion of confirmation can be adequate.

Kolmogorov, Andrej N. *Foundations of the Theory of Probability*. 2d ed. New York: Chelsea, 1956.

In this book, which was first published in 1933, Kolmogorov lays the axiomatic foundations for the modern theory of probability that underlies Bayesian confirmation theory.

Putnam, Hilary. "'Degree of Confirmation' and Inductive Logic." In *The Philosophy of Rudolf Carnap*. Edited by P. A. Schilpp, 761–783. La Salle, IL: Open Court, 1963a.

Putnam's critique of Carnap's inductive logic formulated in this paper inspired the development of formal learning theory.

Putnam, Hilary. *Probability and Confirmation*. Forum Philosophy of Science 10. Washington, DC: US Information Agency, 1963b.

This is a more accessible version of Putnam 1963a. Reprinted in Putnam's *Mathematics, Matter, and Method*, 2d ed. (Cambridge, UK: Cambridge University Press, 1979), pp. 293–304.

Modern Bayesian Confirmation Theory

There are many excellent and important papers in modern Bayesian confirmation theory. The following is an opinionated but representative sample. Milne 1996 exemplifies a position known as confirmation-theoretic monism according to which there is one and only one "true" measure of confirmation. Fitelson 1999 explains why the choice of a measure of confirmation matters even if one is only interested in comparative confirmation. Christensen 1999 and Hawthorne 2005 are much-cited papers on the problem of old evidence, and Fitelson 2008 is an excellent paper on the new riddle of induction. Joyce 1998 is a most influential paper on the foundations of subjective Bayesianism, whereas Maher 2006 defends a particular version of objective Bayesianism. Huber 2008 presents an alternative account of hypotheses evaluation in the Bayesian paradigm.

Christensen, David. "Measuring Confirmation." ***Journal of Philosophy*** **96 (1999): 437–461.**

[DOI: 10.2307/2564707]

Christensen defends a particular measure of incremental confirmation that is able to solve the quantitative problem of old evidence. If formulated in terms of Karl R. Popper measures rather than standard probabilities, it is the same proposal as the one in Joyce 1999 (cited under Textbooks).

Fitelson, Branden. "The Plurality of Bayesian Measures of Confirmation and the Problem of Measure Sensitivity." ***Philosophy of Science*** **66 (1999): S362–S378.**

In this influential paper Fitelson shows that many arguments in the literature on Bayesian confirmation theory are measure sensitive in the sense that their validity depends on which of the many measures of incremental confirmation one considers.

Fitelson, Branden. "Goodman's 'New Riddle.'" ***Journal of Philosophical Logic*** **37 (2008): 613–643.**

[DOI: 10.1007/s10992-008-9083-5]

This is a very clearly written and illuminating discussion of Nelson Goodman's new riddle of induction. Fitelson argues that Goodman's new riddle of induction can be parried in Bayesian confirmation theory if one is willing to make certain assumptions that seem to be necessary on independent grounds (in particular, due to the problem of old evidence).

Hawthorne, James. "Degree-of-Belief and Degree-of-Support: Why Bayesians Need Both Notions." ***Mind*** **114 (2005): 277–320.**

[DOI: 10.1093/mind/fzi277]

The paper argues that the notion of probability used in explicating confirmation is more akin to Rudolph Carnap's logical probability than to subjective probability as it is used in decision theory.

Huber, Franz. "Assessing Theories, Bayes Style." ***Synthese*** **161 (2008): 89–118.**

[DOI: 10.1007/s11229-006-9141-x]

This paper presents an account according to which there are two conflicting values a theory should exhibit: truth and informativeness. The account is given a Bayesian formulation and justification by showing that the most informative among all true theories eventually comes out on top.

Joyce, James M. “A Non-Pragmatic Vindication of Probabilism.” *Philosophy of Science* 65 (1998): 575–603.

In this paper Joyce presents an argument to the effect that credences violating the probability calculus are accuracy dominated in the sense that there exists an alternative credence function that is closer to the truth no matter which possible world turns out to be actual. This epistemic justification has received a lot of attention and is important for Bayesian confirmation theory, because the latter usually assumes that confirmation is a function of an agent’s credences.

Maher, Patrick. “The Concept of Inductive Probability.” *Erkenntnis* 65 (2006): 185–206.

[DOI: 10.1007/s10670-005-5087-5]

One of Maher’s recent articles on his neo-Carnapian program that rejects the idea that subjective probabilities should be interpreted as degrees of belief, a view held by many researchers in Bayesian confirmation theory. Maher defends a logical concept of inductive probability.

Milne, Peter. “Log[P(*h*|*eb*)/P(*h*/*b*)] Is the One True Measure of Confirmation.” *Philosophy of Science* 63 (1996): 21–26.

[DOI: 10.1086/289891]

A much-cited attempt to argue for one particular measure of incremental confirmation as *the* measure of confirmation on the basis of five seemingly obvious principles. Milne’s position in this paper exemplifies confirmation-theoretic monism that is opposed to James M. Joyce’s confirmation-theoretic pluralism (see Joyce 2003, cited under General Overviews.

LAST MODIFIED: 06/29/2011

DOI: 10.1093/OBO/9780195396577-0024

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