Confirmation – draft: please refer to the official version in the *Oxford Bibliographies Online*

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, the by far most prominent account of confirmation, is based on probability theory, and that confirmation really is just a modern version of 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) as well as Fitelson (2006). A widely used introductory textbook is Skyrms (2000).

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

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

- Hájek, Alan (2003), Probability, Interpretations of. In E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*.

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

- Joyce, James M. (2003), Bayes’s Theorem. In E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*.

  An excellent overview on 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.

- Hawthorne, John (2004), Inductive Logic. In E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*.

An excellent overview on inductive logic that is available online.

- Fitelson, Branden (2006), Inductive Logic. In J. Pfeifer and S. Sarkar (eds.), *The Philosophy of Science: An Encyclopedia*. Routledge, 384-394.

  A historically informed and very accessible overview that can should be replaced by Fitelson's entry on confirmation for the *Stanford Encyclopedia of Philosophy* once the latter is published.

- diFate, Victor (2007), Evidence. In J. Fieser & B. Dowden (eds.), *Internet Encyclopedia of Philosophy*.

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

- Huber, Franz (2007), Confirmation and Induction. In J. Fieser & B. Dowden (eds.), *Internet Encyclopedia of Philosophy*.

  An opinionated overview that is available online.

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 & Urbach 2005, Jeffrey 1983, Joyce 1999) and error-statistics (Mayo 1996), both of which are probabilistic, there is the non-probabilistic paradigm of formal learning theory (Kelly 1996). The latter has been inspired by work by Putnam 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.

- Jeffrey, Richard C. (1983), *The Logic of Decision*. 2nd ed. Chicago: University of Chicago Press.

  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 form of a certainty or even a proposition.

- Howson, Colin & Urbach, Peter (2005), *Scientific Reasoning: The Bayesian Approach*. 3rd ed. La Salle, IL: Open Court.

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.

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

  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.

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

  This is the standard reference to formal learning theory.

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

  This is Mayo's *opus magnum* on her error-statistical philosophy of experiment.

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

  Causal decision theory is the main alternative to 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.

- Fitelson, Branden (2001), *Studies in Bayesian Confirmation Theory*. PhD dissertation. Madison, WI: University of Wisconsin.

  This is Fitelson's PhD thesis that should be replaced by his book *Confirmation Theory* once the latter is published.

Anthologies

Most anthologies relevant to confirmation, especially Carnap & Jeffrey (1971), Hintikka & 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 & Eells 2009, Huber & Schmidt-Petri 2009) are indirectly devoted to confirmation.

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

  This is a collection of articles on Carnap's project of inductive logic that has 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 has not been possible in Carnap's early systems.

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

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

- Jeffrey, Richard C. (ed., 1980), *Studies in Inductive Logic and Probability*. Vol. II. Berkeley: University of California Press.

  This is an anthology including David Lewis' "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.

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

  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".

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

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

- Huber, Franz & Schmidt-Petri, Christoph (eds., 2009), *Degrees of Belief*. *Synthese Library* **342**. Dordrecht: Springer.

  This anthology on degrees of belief, which is available as 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 James Joyce's "A Non-Pragmatic Vindication of Probabilism".

- Fetzer, James H. & Eells, Ellery (eds., 2009), *The Place of Probability in Science*. *In Honor of Ellery Eells* (1953-2006). *Boston Studies in the Philosophy of Science* **284**. Dordrecht: Springer.

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

Reference Works

This section lists and annotates the milestones in the literature on confirmation and induction in chronological order from Hume's formulation of the problem of the justification of induction over Popper's falsificationism, Hempel's criteria of adequacy and the ravens paradox, Carnap's syntactic approach to probability and induction, Goodman's "new riddle of induction" and the demise of the syntactic approach, Reichenbach's pragmatic vindication of induction to Kelly's formal learning theory that is inspired by work by Putnam and, finally, modern Bayesian confirmation theory.

Early Work on Induction

While both Bacon (1901), first published in 1620, and Mill (1963), 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 argues that it is impossible to justify induction. According to him 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 (1901), *Novum Organon*. Volume 4 of F. Bacon (1901), *The Works*. Ed by J. Spedding, R.L. Ellis, & D.D. Heath. London.

  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 Popper's falsificationism.

- Hume, David (2000), *A Treatise of Human Nature*. Ed. by D.F. Norton & M.J. Norton. Oxford: Oxford University Press.

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

- Mill, John Stuart (1963), *System of Logic, Ratiocinative and Inductive*. Volumes 7 and 8 of J.S. Mill (1963), *Collected Works of John Stuart Mill*. Ed. by J.M. Robson. Toronto: University of Toronto Press.

  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 of inductive logic.

Non-Probabilistic Theories of Confirmation

Popper's (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 non-probabilistic theories of confirmation, but Reichenbach's work has led almost exclusively to non-Bayesian accounts of confirmation that do, however, take into account statistics. Hempel's seminal papers on the logic of confirmation (1945a; 1945b) are must-reads for anybody interested in confirmation. In his (1945a) Hempel 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*'. He then presents the famous ravens paradox. By the Nicod criterion, a non-black non-raven confirms the hypothesis that all non-black things are non-ravens. But that hypothesis is logically equivalent to the ravens hypothesis that all ravens are black. So a non-black non-raven such as a white shoe can be used to confirm the ravens hypothesis. In his (1954b) Hempel states the prediction criterion of confirmation (which he 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".

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

  This book, which was first published in 1935, is Popper's best-know 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 (1938), *Experience and Prediction. An Analysis of the Foundations and the Structure of Knowledge*. Chicago: University of Chicago Press.

  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.

- Hempel, Carl Gustav (1945a), Studies in the Logic of Confirmation I. *Mind* **54**, 1-26.

  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 (1945b), Studies in the Logic of Confirmation I. *Mind* **54**, 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.

- Glymour, Clark (1980), *Theory and Evidence*. Princeton: Princeton University Press.

  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.

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. His (1962; 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) and Putnam (1963a; 1963b) are important because of their criticism of Carnap's project. Gaifman & Snir (1982) prove important mathematical results for modern Bayesian confirmation theory.

- Kolmogorov, Andrej N. (1956), *Foundations of the Theory of Probability*, 2nd ed. New York: Chelsea Publishing Company.

  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.

- Carnap, Rudolf (1962), *Logical Foundations of Probability*. 2nd ed. Chicago: University of Chicago Press.

  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 Hempel mixes them up when presenting his four conditions of adequacy.

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

  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.

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

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

- Putnam, Hilary (1963a), "Degree of Confirmation" and Inductive Logic. In P.A. Schilpp (ed.), *The Philosophy of Rudolf Carnap*. La Salle, IL: Open Court, 761-783.

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

- Putnam, Hilary (1963b), Probability and Confirmation. *The Voice of America, Forum Philosophy of Science* **10**, U.S. Information Agency. Reprinted in Hilary Putnam (1979), *Mathematics, Matter and Method*. 2nd ed. Cambridge: Cambridge University Press, 293-304.

  This is a more accessible version of the previous paper.

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

  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.

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.

- Milne, Peter (1996), log[P(h|eb)/P(h/b)] is the One True Measure of Confirmation. *Philosophy of Science* **63**, 21-26.

  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 which is opposed to Joyce’s (2003) confirmation-theoretic pluralism.

- Joyce, James M. (1998), A Non-Pragmatic Vindication of Probabilism. *Philosophy of Science* **65**, 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.

- Fitelson, Branden (1999), The Plurality of Bayesian Measures of Confirmation and the Problem of Measure Sensitivity. *Philosophy of Science* **66** (Proceedings), 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.

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

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

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

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

- Maher, Patrick (2006), The Concept of Inductive Probability. *Erkenntnis* **65**, 185-206.

  One of Maher's recent articles on his neo-Carnapian program which 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.

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

  This is a very clearly written and illuminating discussion of 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).

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

  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.

Franz Huber

Formal Epistemology Research Group

Zukunftskolleg and Department of Philosophy

P. O. Box X 216

University of Konstanz

78457 Konstanz

Germany

E-mail: franz.huber@uni-konstanz.de

URL: www.uni-konstanz.de/philosophie/huber