A Material Theory of Induction – abridged version

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Abstract
Contrary to formal theories of induction, I argue that there are no universal inductive inference schemas. The inductive inferences of science are grounded in matters of fact that hold only in particular domains, so that all inductive inference is local. Some are so localized as to defy familiar characterization. Since inductive inference schemas are underwritten by facts, we can assess and control the inductive risk taken in an induction by investigating the warrant for its underwriting facts. In learning more facts, we extend our inductive reach by supplying more localized inductive inference schemes. Since a material theory no longer separates the factual and schematic parts of an induction, it proves not to be vulnerable to Hume's problem of the justification of induction.

1. Introduction.

There is a longstanding, unsolved problem associated with inductive inference as it is practiced in science. After two millennia of efforts, we have been unable to agree on the correct systematization of in- duction. (…)
The problem is deepened by the extraordinary success of science at learning about our world through inductive inquiry. How is this success to be reconciled with our continued failure to agree on an explicit systematization of inductive inference?
(….) It is high time for us to recognize that our failure to agree on a single systemization of inductive inference is not merely a temporary lacuna. It is here to stay. In this paper I will propose that we have failed, not because of lack of effort or imagination, but because we seek a goal that in principle cannot be found. My purpose is to develop an account of induction in which the failure becomes explicable and inevitable; and it will do this without denying the legitimacy of inductive inference. We have been misled, I believe, by the model of deductive logic into seeking an account of induction based on universal schemas. In its place I will develop an account of induction with no universal schemas. Instead inductive infer- ences will be seen as deriving their license from facts. These facts are the material of the inductions; hence it is a ''material theory of induction.'' Particular facts in each domain license the inductive inferences admissible in that domain—hence the slogan: ''All induction is local.'' My purpose is not to advocate any particular system of inductive inference. Indeed I will suggest that the competition between the well established systems is futile. Each can be used along with their attendant maxims on the best use of evidence, as long as we restrict their use to domains in which they are licensed by prevailing facts.
(….) Theories of induction must address an irresolvable tension between the universality and the successful functioning of some formal account of induction. The present literature favors universality over function. I urge that we can only secure successful functioning by forgoing universality and that this is achieved in a local, material theory of induction.

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2. The Material View.

Consider two formally identical inductive inferences:

Some samples of the element bismuth melt at 271C°. Therefore, all samples of the element bismuth melt at 271C°.

Some samples of wax melt at 91C°.
Therefore, all samples of wax melt at 91C°.

The first is so secure that chemistry texts routinely report the melting points of elements on the basis of measurements on a few samples, relying on inductive inferences of exactly this type. The second is quite fragile, for reasons that are somewhat elusive, but certainly tied up with the fact that ''wax'' unlike ''bismuth'' is a generic name for a family of substances. Why is there such a difference? Mill ([1872] 1916, 205–206) found this question so troubling that he proclaimed ''Whoever can answer this question knows more of the philosophy of logic than the wisest of the ancients and has solved the problem of induction.''

(…) Let us look at attempts to answer the question in the presently dominant approach to induction embodied by what I call ''formal theories.'' (…) By formal theories, I intend something very broad. They are certainly not limited to accounts of induction within some formalized language or logic. The defining characteristic is just that the admissibility of an inductive inference is ultimately grounded in some universal template. (…) Formal theories must respond to the problem of the melting points by insisting that extra conditions must be added to block misapplications. However, it soon proves to be an insurmountable difficulty to find an augmentation that functions while still preserving the universality of the schema.

2.3. Material Theories of Induction. The natural solution to the problem of the melting points would seem to require explicit discussion of the differing properties of bismuth and wax. All samples of bismuth are uniform just in the property that determines their melting point, their elemental nature, but may well not be uniform in irrelevant properties such as their shapes or locations. Wax samples lack this uniformity in the relevant property, since ''wax'' is the generic name for various mixtures of hydrocarbons. A material theory of induction allows us to use such facts determine the differing strength of the inductions and rapidly resolves the problem.

In a material theory, the admissibility of an induction is ultimately traced back to a matter of fact, not to a universal schema. We are licensed to infer from the melting point of some samples of an element to the melting point of all samples by a fact about elements: their samples are generally uniform in their physical properties. So if we know the physical properties of one sample of the element, we have a license to infer that other samples will most likely have the same properties. The license does not come from the form of the inference, that we proceed from a ''some . . .'' to an ''all. . . .'' It comes from a fact relevant to the material of the induction. There are no corresponding facts for the induction on wax, so the formal similarity between the two inductions is a distraction.

In advocating a material theory of induction, my principal contention is that all induction is like this. All inductions ultimately derive their licenses from facts pertinent to the matter of the induction. I shall call these licensing facts the material postulate of the induction. They justify the induction, whether the inducing scientist is aware of them or not, just as the scientist may effect a valid deduction without explicitly knowing that it implements the disjunctive syllogism. The material postulates determine the characters of the inductions in a material theory. They may certainly be truth conducive, as opposed to being merely pragmatically or instrumentally useful, as long as the material postulates are strong enough to support it. How each induction will be truth conducive will also depend on the material postulate and may well suffer a vagueness inherited from the present induction literature. Chemical elements are generally uniform in their physical

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2.4. All Induction is Local. There has been a long history of attempts to identify facts about the world that could underwrite induction. Best known is Mill's ([1872] 1916, book 3, chap. 3) ''axiom of the uniformity of the course of nature.'' Russell ([1912] 1932, chap. 6) defined the principle of induction in terms of the probability of continuation of a repeated association between ''a thing of a certain sort A'' and ''a thing of certain sort B.'' (…) All these efforts fall to the problem already seen, an irresolvable tension between universality and successful functioning. On the one hand, if they are general enough to be universal and still true, the axioms or principles become vague, vacuous, or circular. A principle of uniformity must limit the extent of the uniformity posited. For the world is simply not uniform in all but a few specially selected aspects and those uniformities are generally distinguished as laws of nature. So, unless it introduces these specific facts or laws, an effort to formulate the limitation can only gesture vaguely that such uniformities exist. Any attempt to characterize them further would require introducing specific facts or laws that would violate universality. On the other hand, if the axiom or principle is to serve its function of licensing induction, it must introduce these specific facts and forfeit universality. So Russell ends up denying action at a distance. If his account is to cover all induction, we must conclude that induction is impossible in any universe hosting action at a distance.

Because of these difficulties, the present material theory of induction is based on the supposition that the material postulates obtain only in specific domains; that is, facts that obtain ''locally.'' As a result, inductive inference schemas will only ever be licensed locally.

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4. Inductions Too Local to Categorize.

(…) Prior to Lavoisier and the establishment of modern chemistry in the late eighteenth and early nineteenth century, it was quite hard to know what sorts of properties of substances were likely to be the same across all samples. Learning which substances were elements and compounds and which mixtures dramatically improved our inferential abilities. To know that something was an element or compound brought a license to infer that all its samples were most likely alike in physical properties. We also learned when to infer that our failure to bring about a transformation might merely be due to our failure to find the right methods or when it could be generalized to an impossibility. From a chemical perspective there were no barriers to transforming inorganic matter into organic matter; it was a case of the former. But our failure to transform lead into gold was a case of the latter. While these all fit the form of enumerative inductions (with some failing) they have become so completely modified by the particular chemical facts in the domain that the characterization has almost no practical value. More examples: Once we learned in the 1920s that the nature and properties of the elements are due to the quantum properties of electrons trapped by atomic nuclei, we had a much stronger basis for knowing which unfilled spaces in the periodic table might really coincide with undiscovered chemical elements, where the table might be expanded and where no such expansion would be possible; and we secured a greater ability to decide when a new substance with certain stable properties might be a new element. After Newton showed us the gravitational forces that act between celestial bodies, we were given a new prescription for inferring to causes. All we needed to show was that some effect could be generated within the repertoire of Newton's system and we could infer to its reality. So Newton himself showed that the moon's gravitational attraction caused our tides and that comets were deflected in their motion about the sun by the force of gravity from the sun. The scheme even licensed inferences to new bodies. The planet Neptune was discovered in the nineteenth century by working back to the location of an undiscovered body that could cause perturbations in the planet Uranus' motion.

In these cases, the added inferential power that comes from knowing more does not come from delivery of some new schema. In the cases above, it is even hard to know what to call the schemas. The inference to the moon's gravity as cause of the tides or to a new planet is not just simply finding an hypothesis that saves the phenomena. It has to do it in the right way. One might be tempted to talk of best explanations, common causes or consiliences. None quite capture the strength of the inference; some inferences to best explanations or common causes can be weak and some strong. The clearest explication of what that right way amounts to is just a local fact: the hypotheses do it in accord with the repertoire of Newtonian gravitation theory. Our confidence in Newton's theory under- writes the strength of the induction.

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6. The Problem of Induction Eluded?

6.1. The Analog of Hume's Problem for the Material Theory. In order to learn a fact by induction, the material theory says that we must already know a fact, the material postulate that licenses the induction. Does some vicious circularity or harmful regress lurk here? One will quickly recognize this concern as the analog of a familiar problem for formal theories of induction, re-expressed in the framework of a material theory of induction. It is just The Problem of Induction, that most celebrated of philosophical problems traditionally attributed to Hume. We shall see that Hume's problem can be set up quite easily for a formal theory, since a formal theory separates factual content from formal schemes. I will argue that the absence of this separation in a material theory results in the same considerations failing to generate a comparable problem for a material theory.

In the usual context, the problem of induction asserts (Salmon 1967, 11) that there can be no justification of induction. A deductive justification would violate its inductive character; an inductive justification would either be circular or trigger an infinite regress. To generate the analogous problem for a material theory, we consider the material postulates that justify inductions in the two cases. Analogous to the deductive justification of induction is the use of a material postulate that is a universal truth known a priori. That justification fails since such a postulate would violate the locality of induction. Analogous to the inductive justification of induction is a material postulate that is a contingent fact. If that fact is the same fact as licensed by the induction, then we have an obvious circularity. If it is a different fact, then we trigger a regress. But, I shall urge, the regress is neither infinite nor demonstrably harmful.

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The regress described here is far from the fanciful meta- meta-meta-inductions remote from actual inductive practice required by a formal theory. It merely describes the routine inductive explorations in science. Facts are inductively grounded in other facts; and those in yet other facts; and so on. As we trace back the justifications of justifications of inductions, we are simply engaged in the repeated exercise of displaying the reasons for why we believe this or that fact within our sciences.

What remains an open question is exactly how the resulting chains (or, more likely, branching trees) will terminate and whether the terminations are troublesome. As long as that remains unclear, these considerations have failed to establish a serious problem in the material theory analogous to Hume's problem. And it does remain unclear. It is possible that serious problems could arise in termination. In principle the chains could end in some sort of circularity, although such circularity was not displayed in any of the examples above. It is also possible that the chains have benign termination. They may just terminate in brute facts of experience that do not need further justification, so that an infinite regress is avoided. Or, more modestly, they may terminate in brute facts of experience augmented by prosaic facts whose acceptance lies outside the concerns of philosophy of science—for example, that our experiences are not fabricated by a malicious, deceiving demon. Perhaps we might doubt that a single such brute fact is rich enough to license a substantial induction. But we should not expect that of a single brute fact. It is more reasonable to expect that enough of them, careful woven together through many smaller inductions, would eventually license something grander. A decision for or against must await the ever elusive clarification of the notion of brute facts of experience and of whether the notion even makes sense.

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7. Conclusion.

My purpose in this paper has not been to advocate any particular scheme of inductive inference from the many that compete in the literature of philosophy of science. Rather I want to suggest that they are all admissible in the right context and to try to explain why we have such a proliferation of them in enduring conflict. I have urged that we resolve the intractable tension between the universality and the successful functioning of an inductive inference schema by forgoing universality and adopting a material theory of induction. In such a theory, the facts that prevail in each local domain in science license inductive inference schemas that are peculiar to that domain. We justify the inductive inferences of the domain by reference to these facts and not by passing through them to universal inductive inference schemas. I have tried to show how the existing schemas for inductive inference all require some local facts for their justification. I have also suggested that any schema with pretensions of universality will fit actual inductions imperfectly and that the fit will become worse as we proceed to narrower domains and the facts licensing the inductions become more specialized. This, I believe, explains a curious phenomenon in science. We can be quite sure of a result in science as long as we look at the particulars of the result and the evidence that supports it, but we often end up struggling to explain by means of standard inductive inference schemas how the evidence can yield that strength of support. (…)

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