

*The Large-Scale Structure of Inductive Inference: Replies to Barroso  
Rojo, de Grefte, and Tricard.*

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I am grateful to the three commentators for their most thoughtful reflections. Each has raised interesting questions that merit careful consideration. Since each has also pursued a different line of thinking, I will respond to each individually.

1. On Maribel Barroso Rojo, “Reasoning with Models in Norton’s Material Theory of Induction”

Maribel Barroso Rojo suggests exploration of an interesting avenue for inductive inference. The material theory, as I have formulated it, takes as its elements propositions that assert scientific facts. Relations of inductive support among them assess their truth or falsity. She proposes that we should take models as the elements instead of propositions. In favor of this proposal is that models have a pervasive presence in science. We should be able to confront them with evidence in a systematic way.

Reconfiguring inductive inference as relations over models faces some interesting questions. Just what is it for models to be supported inductively? Can the material theory be adapted to this new case? In works cited in her review, Barroso Rojo has already begun the study of inductive relations among models in science, using insights from Whewell’s work. She is, it seems to me, well placed to seek answers to these questions. I wish her well in her continuing efforts.

Since models resist simple attributions of truth or falsity, the challenge is formidable. When a model enjoys inductive support on the empirical evidence, just what is supported? It cannot be the truth or falsity of the model, for models are not properly described as either.

Take, for example, what was later called Bohr's 1913 model of the atom. In it, many regularities in atomic emission and absorption spectra are recovered when the model depicts electrons as jumping up and down between their orbits about the atomic nucleus. These orbits are posited to be both discrete and stable, in direct contradiction with the classical physics the model also supposes. The model did just what we seek of good scientific theories. It systematized a large collection of otherwise disparate facts about atoms and their associated spectra. It supported predictions and the development of still more fertile models and eventually the modern quantum theory itself.

Bohr's model is logically inconsistent. Thus, it cannot be true. It is too easy to dismiss it as a simple falsity because of its inconsistency. There was something right about the engagement of Bohr's model with the empirical evidence. In some, as yet unspecified sense, the model does accrue support from that empirical evidence. What sense is it? To say that support accrues just to its instrumental value in making successful predictions is too thin. Bohr's model got something deeper right. The energies it attributed to the stable orbits were vindicated by the later quantum theory. It also got something wrong: these energy states are not the elliptical orbits of spatially localized electrons. Before we have the hindsight of a later theory, just what in the model benefits from inductive support?

To motivate the transition to models, Barroso Rojo has suggested that there are failures in the proposition-based approach I have used. She does not indicate why a model-based approach escapes these failures. How can replacing propositions with models help if the material structure of relations of inductive support is not also altered? In any case, I do not see the failures. One, Barroso Rojo sees, is that the large-scale structure of inductive inference is troubled by infinite regresses and circularities. On the contrary, I have argued at some length in *Large-Scale Structure* that infinite regresses are escaped by the material theory, since the theory is not committed to hierarchical relations of inductive support. Barroso Rojo is right that the material theory admits circularities. However, they are benign. Vicious circularities, in which the circles lead to contradictions, are eliminated by routine scientific practice. If circularities demonstrably leave quantities irreparably indeterminate, they are beyond empirical evidence and strong candidates for non-factual conventions.

Finally, Barroso Rojo has suggested that my example of inductive inferences over the climate involves some sort of regularity or invariance principle that lies outside the factual

background. That is not how I understand the example. Our past shows a warming trend in the climate and we infer inductively that it will continue. That inductive inference is not justified by some nebulous principle that past regularities will persist. Rather it is justified by the specific analyses of climate science, whose factual findings are routinely collected in the many reports of the Intergovernmental Panel on Climate Change.

## 2. On Job de Grefte, “Some Comments on Norton’s *The Large-Scale Structure of Inductive Inference*”

Job de Grefte has raised the interesting question of the import of the material theory of induction for epistemology and especially the associated status of the problem of induction in epistemology. These are issues that have been left open in my writing. As I will explain below, I think these questions are especially challenging and I can offer no final answer to them. I look forward to de Grefte’s further results concerning them.

To explain this assessment, what is at issue is the difference between two areas of research: the logic of inductive inference and the epistemology of belief. The first area is distinguished in taking its basic elements to be propositions. The relations among them are delineated by an applicable logic. One proposition may deductively entail another; or it may merely lend it inductive support. The second area takes its basic elements to be beliefs or mental states. They are related by mental processes. If one harbors this belief, then mental processes lead one also to harbor that belief.

de Grefte reports remarks by Russell and Salmon that I find to assert that the problem of induction arises in the context of the logic of induction. de Grefte disagrees with this reading. What is at issue is the textual exegesis of the writings of Russell and Salmon. We disagree on it. I am happy to leave readers to form their own judgments, since the exegesis of these passages is of little importance to my overall analysis.

What is important to me is that the version of the problem of induction investigated in Chapter 6 of my book is formulated *within* the logic of induction. That this is so does not require the affirmation of authorities like Russell and Salmon. It requires only that we entertain universally applicable rules of induction. Then we are faced with a harmful circularity or a fanciful regress. Both are escaped by reverting to a material theory of induction.

de Grefte and I agree, I believe, that this version of the problem of induction resides fully within the logic of induction. That is the problem I have addressed at length in my writing. de Grefte adds that an additional problem of induction also resides in the epistemological realm. I am unsure. It seems to me that there is no problem of induction in epistemology in so far as we consider only the mental processes connecting beliefs and mental states. That mental processes take us from one belief to a second does not mean that the second belief is justified. Those processes routinely lead us to “jump to the wrong conclusion,” as the familiar saying goes.

For there to be a problem of induction, we need some standard to discern which mental processes realize relations of justification and which do not. Only then can a version of the problem of induction challenge the cogency of our purported justifications. Those standards are supplied by logics of induction and deduction. It follows that the traditional problem of induction in epistemology arises only insofar as the epistemological analysis draws on a logic of induction; and it is a logic prone to the problem, that is, one that employs universal rules.

This last conclusion is hesitant since the framework of epistemology is too nebulous to enable precise analysis. Just what are its mental states and belief states? Just which are the mental processes that connect them? We have learned from investigations in empirical psychology that the answers provided by the comfortable armchair speculations of epistemologists are insecure. For this reason, I am happy and even relieved to leave the resolution of these difficult issues to de Grefte. A responsible resolution will require extensive engagement with the literature in empirical psychology.

Finally, de Grefte argues “that Norton’s material theory plausibly commits him to an externalist epistemology.” May I issue a small correction? The safer claim would be that the material theory of induction commits *epistemologists* to an externalist epistemology; and whether that is so is something for de Grefte, or other scholars, to establish. Before an externalist epistemology can properly be assigned to me, I would first need to adopt the framework of epistemology. That is, I would need to formulate my account of induction in terms of beliefs and mental processes. Only then can we ask whether I should be an externalist epistemologist. I am loath to adopt that framework since, as indicated above, I find it too nebulous for rigorous analysis.

In sum, there is much to be done in discerning the import of the material theory of induction within epistemology and I look forward to what de Grefte learns of it in his investigations.

### 3. On Julien Tricard, “Circularity and Ampliation: A Review of Norton’s *The Large-Scale Structure of inductive inference*”

Julien Tricard has expressed a most welcome, general sympathy with the project of the material theory of induction. He has identified two problems for it concerning circularity and ampliation and, in a spirit of collaboration, has suggested solutions. My sense is that both problems are already adequately addressed within the existing theory. I will try to explain why this is so.

The first concern is that the circularities of inductive support arising in a mature scientific theory may be vicious, contrary to my claim that they are benign. The general idea, if I have grasped it, is that inductive support for a proposition can only be provided by propositions that have antecedently secured support. That antecedence fails if relations of support are circular. Tricard expresses surprise that I did not consider this sort of circularity. I am surprised at his surprise, since a major part of my narrative is to display many benign instances of propositions in science that mutually support each other, analogously to how two sides of an arch support each other.

To motivate the concern that these circular relations are troublesome, Tricard draws on the metaphysics of grounding. In a sequence of propositions  $P_1, P_2, \dots, P_n$ , each is grounded in the next; and a cycle is formed when  $P_n$  is grounded in  $P_1$ . It is, he allows, an open question as to whether this cycle is benign or vicious. Since I do not work in the metaphysics of grounding, I cannot assess which is the case. However, if there is a conflict between the general metaphysics of grounding and the relations of inductive support of the material theory, then I have different diagnosis. The mismatch indicates no failure of the material theory, but a problem in the metaphysics of grounding. That follows since I have considerable confidence in the material theory of induction, but no corresponding confidence in the metaphysics of grounding.

Grounding faces what I have called in Norton (2022, §12.4) the problem of “fatal abstraction.” Sometimes abstraction can be successful. We have abstracted rules of arithmetic that work equally well for counts of apples in baskets and counts of days in a month and a year. However, the abstraction fails if the cases share no substantial commonality once all the

particulars are stripped away. The material theory of induction asserts that the abstraction fails for relations of inductive support; and, I have argued, such failures arise also in the metaphysics of causation (Norton, 2024) and of possibility (Norton, 2022). In short, a mismatch indicates the need for revisions in the metaphysics of grounding. There are many cases in which things depend on other things. If we strip away all the particulars of these many cases, we are left with mere labels  $P_1, P_2, \dots$ , with no further particular properties. Might it be that no, non-trivial general relation of grounding remains?

The second concern is that our experience of the world is finite, yet it is to provide evidential support for scientific propositions of infinite scope. How can such a support arise? Tricard posits that something extra is needed beyond the local, material facts. It would be some principle of a metaphysical character that has infinite scope.

Since this problem appears *prima facie* intractable, it attracted considerable attention in *Large-Scale Structure*. The solution is that an inductive step from some finite body of fact to propositions of infinite scope can be warranted, initially, merely by positing provisionally an hypothesis of infinite scope that is sufficient for the task. Such an hypothesis serves the function of Tricard's metaphysical principle without the metaphysics. The resulting analysis is only provisional. Further inductive investigations, perhaps also employing provisional hypotheses, must provide independent support for the hypothesis. Closure arises when all the hypotheses of infinite scope are supported by other propositions in the science. The result is a mature science with a massively entangled body of propositions of finite and infinite scope that mutually support each other. None are left free-floating without support. That this strategy is actually used successfully in science is shown in the text by examples from the history of science.

Tricard reports my remark that inductive inference requires that we live in a hospitable world. As I think Tricard realized, the remark was not intended by me as some abstract principle that gives a general license to inductive inference. That would be just the sort of principle that the material theory denies. Rather, it is asserted relationally. Take inductive inferences over climate, which is the example of Chapter 2 of *The Material Theory of Induction* (Norton, 2021). To succeed, the world must be hospitable to those specific inductive inferences. The import of this hospitality will vary from case to case. Attempting to abstract a commonality would be a fatal mistake. There is no universal truth of hospitality. It can fail. The world is inhospitable to

the inductive inferences needed to support the now defunct, steady state cosmology of Bondi, Gold and Hoyle.

#### 4. Closing Thoughts

My earlier work, *The Material Theory of Induction*, defended the idea that inductive inferences are warranted by material facts. The *Large-Scale Structure of Inductive Inference* sought to bring a limited closure to this earlier work. Can the material theory of induction, by itself, provide an adequate account of the inductive relations of support within science viewed at the large scale? The reflections by these three commentators have shown me that my focus has been narrow; and I am very grateful to them for this insight. Relations of inductive support have a place in other parts of philosophy, beyond the narrow confines of inductive logic. They have a place in our analysis of models within science (Barroso Rojo), in epistemology (de Grefte) and in metaphysics, such as in the analysis of grounding (Tricard). There is much work to be done to discern the import of the material theory of induction in these and still further parts of philosophy. The resulting challenge goes well beyond my capacities. My hope is that these commentators and still others will take up the challenge. I look forward with pleasure to what may result.

#### References

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