it the best of both worlds. A mechanism tracks the antecedents of a conclusion and when an inconsistency arises only these antecedents are subject to a paraconsistent logic, otherwise the full deductive power of classical logic is applied.

The final two chapters in this book by Norton and Nersessian provide interesting historical accounts of inconsistencies in Newtonian Gravitation theory and Maxwell's derivation of electrodynamics. Nersessian argues that a method of generic modelling allows creative development and advancement of a theory to such an extent that considerations of consistency do not initially come into play.

Overall this is a diverse collection of articles giving a good overview of the problem of inconsistency in science and its impact on creative development.

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Lorenzo Magnani, ***Abduction, Reason, and Science: Processes of Discovery and Explanation.*** New York: Kluwer Academic/Plenum Publishers (2001), xvii + 205pp., $85.00 (cloth).

One of my favorite definitions from Bierce's *Devil's Dictionary* goes as follows:

Observatory, n. A place where astronomers conjecture away the guesses of their predecessors.

This definition displays the sort of skepticism towards scientific explanation that was preeminent among philosophers of science for most of the 20th century. Popper famously argued that hypothesizing is an inherently illogical procedure. Thus, we cannot rationally put any stock in a hypothesis prior to undertaking tests that might disconfirm it. Harmon offered some defense of explanation, as inference to the best explanation, but the skeptical view still holds sway.

However, abduction (a term coined by Peirce for the logic of explanation) has also become a topic of much interest in other disciplines, namely artificial intelligence (AI) and cognitive science. In these disciplines, abductive reasoning in science is studied so as to sharpen our understanding of scientific practice (as in medical diagnosis, chapter 4) and to perhaps find ways to improve or surpass it. This work has helped to establish renewed interest in, and hope for, a logical or at least rational account of scientific explanation.

The cross-disciplinary nature of recent work on abduction explains the approach adopted by Magnani in his new book. Magnani thoroughly reviews the now copious literature on the subject from all quarters and proposes a framework for representing abduction that addresses the concerns of researchers from each domain. AI researchers, cognitive scientists, and philosophers of science will all find something worthwhile and stimulating in this book. In this review, however, I will focus mostly on topics of interest to philosophers of science.

In chapter 1, Magnani introduces some of the central themes of the book, especially the concept of a *generate-and-test* procedure for modelling abductive inference, the concept of *defeasability* for representing the doubt that attaches to hypotheses, and *impasse* for recognizing when a hypothesis is in conflict with evidence or previously held beliefs. Most of these ideas will be familiar to philosophers of science, but Magnani will make some novel of use them later on.

The presentation of this chapter is somewhat labored since Magnani spends most of it discussing Plato's doctrine of reminiscence and Kant's notion of the synthetic a priori. Both Plato and Kant described hypotheses as truths grasped by the mind from a non-natural source. These views serve as a foil for Magnani's cognitive view of hypotheses as provisional explanations generated by interacting mental procedures. Unlike transcendent truths, such hypotheses are open to doubt. Nonetheless, Magnani will argue, hypotheses can be rational.

In chapter 2, Magnani raises a distinction between *theoretical abduction* and *manipulative abduction* and proceeds to review the literature on the former. Theoretical abduction is, roughly speaking, abduction resulting from strictly mental processes. Manipulative abduction, which involves using props as aids to reasoning, is broached in chapter 3. Magnani distinguishes between *sentential* and *model-based* accounts of abduction. Sentential accounts use variations of formal logic to represent beliefs, hypotheses, and the relationships among them. Various nonmonotonic logics are employed in order to deal with the possibility that a hypothesis is inconsistent with other statements. Model-based accounts use computational data structures and procedures to represent concepts and mental procedures. Model-based accounts do a better job of modelling the performance of *actual* reasoners whereas sentential accounts display the performance of *ideal* reasoners.

Magnani elaborates on his concept of *manipulative abduction* in chapter 3. Put briefly, manipulative abduction is the incorporation of props, such as diagrams, into explanation. In some cases, we use props to represent information that is difficult to store internally. We might, for example, use toy cars to reconstruct an auto accident. In other cases, a prop can help to supply new information. When Galileo pointed his telescope at Jupiter and discovered four of its moons, for example (64), he had not hypothesized that the moons would be there. Instead, the telescope enabled him to collect potentially new information on the vague question of what Jupiter really is. Here, the prop helps both to define the question and to generate an acceptable answer.

Also, props need not be external to the reasoner. Magnani (56) discusses what appear to be thought experiments by Faraday on the relation of magnetic and electrical fields. Thought experiments can certainly be abductive in the sense that they are a form of trial and error akin to the generate and test method of theoretical abductions. It would have been instructive, then, if the literature on thought experiments had been reviewed in this section.

In chapter 4, we find the first worked-out example of Magnani's *select-and-test model of analogy* (outlined in chapter 2). On this model, when an anomaly is detected, the observer selects some plausible explanations from a set of available options. This procedure is called *selective abduction.* Expectations are deduced from the selected hypothesis and compared with further evidence. A conflict invokes inductive procedures guiding a new selection, whereas confirmation leads to further monitoring. Magnani discusses the NEOANEMIA program which illustrates how this framework performs in the case of diagnosing and selecting treatments for patients who display symptoms of anemia. Although Magnani also introduces *creative abduction*, the generation of a novel hypothesis, it is not elaborated in his model of abduction.

In chapter 5, Magnani introduces some recent, cognitively motived themes in abduction, namely *visual abduction* and *temporal abduction*. Visual abduction involves hypothesizing using visual imagery in the "mind's eye". A visual image can be a hypothesis in the sense that we might "picture" an object or state of affairs that caused the effect we need to explain. Different images will describe scenes that are more or less plausible as explanations. When confronted with a scene that requires explanation, we might select among remembered images the one that best explains the scene, or we might generate a new image creatively. Images can be related by considering how one image can be transformed into the other. For example, an image of a square might be very closely related to an image of a diamond since the first can be transformed into the latter in a single step by the cognitive function *rotate-object-90-degrees*. The difficulty of sorting out which image is the *best* explanation of another could be accomplished, for example, by determining which explanatory image is closest to the explanandum in terms of the number of operations required to transform one into the other. More sophistication can be achieved by weighting the transformations differently (112–114).

Similarly, *temporal abduction* concerns the role that time plays in the process of abduction. For the sake of tractability, we make assumptions about time when forming explanations. We assume that some conditions, such as the state of a house, persist through long periods whereas other conditions, such as the state of a discharging gun, are transient. On occasion, the need to form a strong explanation may require us to rethink such assumptions. To rethink assumptions about the duration, rate, etc. of events, we need to be able to represent time explicitly in any comprehensive account of abduction. Magnani's point here is, to my knowledge, original and very well taken—this topic is certainly one that calls for further exploration.

Chapter 6 concerns abduction as a means of "governing" inconsistencies. The relevant inconsistencies include disagreement between theory and observation, such as classical mechanics and the advancing perihelion of Mercury, or conceptual inconsistencies such as the wave and particle nature of light. Such inconsistencies inevitably arise and, Magnani argues, necessitate some means of dealing with them, namely abduction. In the face of inconsistencies, a scientist might engage in a number of abductive inferences, such as making auxiliary hypotheses, fingering incorrect assumptions, or blaming chance or methodological slips. On the Popperian view, such maneuvers must be regarded as merely theraputic whereas, Magnani claims, they fit seemlessly into a system of relating theory and evidence.

Magnani illustrates this claim further in chapter 7. He examines the role of abduction in the withdrawl of hypotheses in science. We might expect that a hypothesis must be withdrawn in the event that another hypothesis becomes more acceptable given the available evidence. But, as noted above, a scientist has a number of options. Consider the case of so-called "constructions" in Freudian psychoanalysis (149–155). During psychoanalysis, the analyst listens to the evidence offered by the patient and proposes "constructions" that are explanations of the evidence in terms of the Freudian view of motivation. As hypotheses, constructions must be either abandoned or extended when inexplicable evidence is given. How does the analyst know which option to pursue? The answer, Magnani argues, is *negation as failure.* That is, the analyst searches for a satisfactory extension to the current construction and abandons it only if the search is unsuccessful. In other words, the analyst takes the failure to find a satisfactory extension as evidence that none exists. He must then generate and test a new construction. This strategy, Magnani claims, is often pursued in scientific hypothesizing. Another example is furnished by Poincaré who viewed scientific principles, such as the conservation of energy, as conventions (pp. 156–162). He argued that although such conventions are arbitrary and therefore not falsifiable, there may be reasonable grounds to favor one convention over the other. Magnani argues that the procedure envisaged by Poincaré is another instance of negation as failure. A principle may reasonably be withdrawn when it ceases to be fecund, that is, to produce new avenues of research. The failure to accomodate new insights is taken as evidence that no more are forthcoming as long as the principle is held. In this way, principles, although they are not theories, are governed by abductive reasoning. Thus, they are not merely ad hoc as Popper argued (162) but subject to reasoned acceptance and rejection.

I admire Magnani's approach to the problem of abduction in this book. He claims, I think, that abduction is an integral part of the cycle of scientific reasoning in which each component presupposes the logic of the others. Thus, no part can be considered irrational. I tend to accept this claim even though Magnani has not clinched it. Skeptics will still find grounds for objection that Magnani has not establihsed the rationality of abduction as such. For example, Magnani presents the NEOANEMIA program as an exemplar of his select-and-test account of abduction. He claims that it models how reasoning about anemia *should* occur, not how it actually occurs in doctors' minds (88) and describes its performance as satisfactory (85). But how do we judge that it does satisfactorily model how diagnosis *should* occur? A simple comparison of the program's performance with that of the relevant doctors would beg the question. Magnani does not offer any other basis for comparison, thus his assertion remains open to question. The same could be said of the generate-and-test account in general.

In any case, Magnani opens up a promising avenue of progress on this perennial topic in the philosophy of science. The book is a challenging read as the discussion is carried on mostly in the abstract with too few elaborated examples, compounded by Magnani's liberal and unelaborated use of technical jargon. Nevertheless, this book presents a thorough review of the literature within a unified frame of reference, and provides many insights bound to stimulate interested readers.

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David Howie, ***Interpreting Probability: Controversies and Developments in the Early Twentieth Century.*** Cambridge: Cambridge University Press (2002), xi + 262 pp., $60.00 cloth.

Bayesian methods (broadly construed) have been enjoying something of a renaissance lately in many areas of inquiry, including statistics (Bernardo and Smith 2000), artificial intelligence (Pearl 2000), psychology (Glymour 2001), philosophy (Talbott 2001, Swinburne 2002), and sociology of science (Press and Tanur 2001). This has resparked the age-old and ever-heated debate between Bayesians and non-Bayesians (of various ilks) concerning the foundations of probability and statistical inference.