Review Essay

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A review of Lorenzo Magnani, 2000, *Abduction, reason, and science: Processes of discovery and explanation*. Dordrecht: Kluwer Academic Publishers.

A deeply constitutive intuition that is included in all systems of modal logic is that if 'p' then 'possibly p.' In other words, to show something possible one merely constructs an actual model. An equally compelling intuition is that appearance is not reality. It is in such a context and with such intent that Professor Lorenzo Magnani presents and then attempts to resolve the central puzzle of abduction. The book is both difficult and rewarding, affording a new perspective on abduction, a wealth of contextual information, and most important, exemplifies a mode of doing philosophy of science that seems a welcome departure from the traditional focus on purely conceptual arguments.

Magnani begins with Plato's *Meno*. Nicely, it illustrates the fundamental problem of abduction in terms of the two poles cryptically indicated above, and prepares us for the long and complex journey that Magnani's embrace of the first intuition requires. The excursion into Plato both grounds his discussion and affords a perspective on the manner in which abduction has been discussed in the philosophical literature.

He sees philosophers as having offered a number of ways of construing hypothesis generation, however, "All aim at demonstrating that the activity of generating hypotheses is paradoxical, rather illusory or obscure, implicit and not analyzable" (p. 1). He supports this view by offering three influential accounts: Plato's doctrine of reminiscence, Kant's notion of schematism and Polanyi's notion of tacit knowledge. The doctrine of reminiscence, seen in part by Magnani as the first of the non-rationalist attempt to dismiss discovery as a constructable procedure analogous to the logical processes, provides the paradigm that Magnani will eschew. Whether found in Kant, Polanyi, Popper or Reichenbach, this will be replaced by a complex account that offers a constructive rational alternative. That is, Magnani, disregarding the most abstract level of philosophical analysis, will offer the architecture of abductions, both in a general theoretical sense, and then with numerous examples of successful abductive procedures, first in artificial intelligence, especially programs

written to do medical diagnosis, and them more broadly in science and with more mundane problem solving tasks.

Whatever the construal of Plato's discussion as supporting philosophical doubts as to the possibility of new knowledge, short of a transcendent account of the sort that Plato appears to offers in, for example, the *Republic*, the *Meno* offers a purchase from which Magnani can begin to construct a "psychological" model very far from the "philosophical" meaningfulness of Socratic "doubt" (p. 14).

This requires some elaboration. The philosophic doubt in the *Meno* is must often associated with Meno's paradox, which in questioning whether anything new can be learned, challenges the genus of which abduction is an essential species. Magnani sees this aspect of the dialogue to be the basis for Polanyi's notion of tacit knowledge. Magnani looks elsewhere; he looks to the doubt engendered by the constructive task of expressing the Pythagorean theorem. This he connects with the Kantian notion of schematism, but we find no philosophical analysis of this historically central and philosophically controversial notion. Rather, Magnani looks to the constructive interaction between Socrates and the slave boy – the pedagogic center piece of the dialogue – what is as often as not, seen the paradigmatic example of what educators know as "Socratic teaching." Here the essential doubt is not the philosophical but the practical. The slave boy is confronted with an error and in perceiving it as such knows that he does not know.

Magnani then sets the stage for the rest of the book. "Tacit knowledge and Kantian schematism are not so mysterious and non-analyzable, and can be modeled" (p. 11). The discussion that follows affords some of the key elements. The first comes from Simon, who he quotes: "our ability to know what we are looking for does *not* depend on our having an effective procedure for finding it: we need only an effective procedure for *testing* candidate" (p. 12).

From Turner he takes the notion that the slave boy possesses "subroutines that generate each inferential step, plus subroutines that matched the outcomes and recorded a failure to match" (ibid.). The boy is led to see error through a subroutine to make the visual comparison (using the oft-reproduced drawing that facilitates the understanding of the proof in countless demonstrations in philosophy of education classes). What is key to the psychological model is that philosophic doubt is replaced with a constructive procedure in which doubt plays an efficient role in moving the problem solving process forward.

It will be the task of the remainder of the book to elaborate such a constructive procedure, both by offering an abstract account and by

proffering a wealth of actual models within artificial intelligence and in ordinary and scientific reasoning, where abductions are in fact successfully performed. Thus, the actual is taken as the possible and the philosophical concern with the illusion of apparent new knowledge is forgotten.

In turning from the philosophical to the constructive account of abduction Magnani leaves foundational discussions behind, but his theoretic constructions permit of an interesting perspective on the underlying philosophic structure of his argument. In the elaboration of theoretic abduction, Magnani analyses the abductive process as a complex of inferential procedures: the S-T (Select and Test) Model that sees abduction as essentially involved in a complex procedure of inductive extrapolation, deductive elaboration and testing. Using, what will become a major focus of his discussion, Magnani sees the S-T Model as basic to medical diagnosis, and especially as instrumentalized through computer programs that make useful diagnoses of medical conditions, moving within a structured diagnostic space. A selection of diagnostic hypotheses from within the space are generated by induction by abstraction from observed date (this is abduction proper). This leads to deductions of new clinical data that are to be expected in light of the diagnostic hypothesis, prompting additional clinical evidence to be obtained, reforming the diagnostic hypothesis, etc. This complex of orchestrated moves, including abductions in the limited sense of hypotheses generation on the basis of data and in respect of a determining space within which plausible hypotheses are to be generated, as well as more non-controversial uses of induction, and deduction in the name of subjecting hypotheses to the test of empirical falsification and subsequent modification, will constitute what abduction is seen to be, in the large.

Magnani has a great deal to say about aspects of this model including the centrality of models (chapter 2, part 4), the role of inconsistency (chapter 6), as included in belief formation and cognitive models (chapter 2, part 2 and chapter 3, part 2, respectively) and hypothesis withdrawal (chapter 7). But more important for us is the structure of his overall argumentation strategy. Implicit in Magnani's work is a classic argument trope, as in for example, Russell's argument against the unreality of binary relations as found in, e.g. Bradley. The account to be critiqued sees predicates such as 'small' as incoherent, since the same object, the fourth finger in the classic example, can be both small and large in respect of either the third or pinkie finger. Russell offers the theory of binary relations as an obvious corrective for this philosophical error, which arises from construing all adjectives as properties (unary relations) rather than, as in this case, binary relations. Once this is realized the paradox evaporates and the obvious

analysis of the facts of relative size is both expressible and understandable. Similarly for abduction, the error is to see abduction merely in relation to one source of the abductive process (hypothesis creation) which when isolated from the rest of the process seems non-rational. It is only when the abductive process is seen as a complex relationship among inferential steps, including abduction in creating hypotheses in relation to the inductive and deductive moves that constitute hypothesis selection, that the mysterious aura of abduction disappears, and its obvious nature is both analyzable and identifiable in a wealth of actual examples. That is, those who thought that abduction could be explained on its own were forced into error since abduction is best understood in terms of the complex role it plays within the entire hypothesis generating routine (chapter 2).

Seeing abduction as essentially involved in a complex of other logical moves and epistemological procedures reflects the basic distinction, just mentioned, that is the distinction between abduction in the sense of creation of hypotheses, and in the sense of selection from among hypotheses created. The first of these Magnani paraphrases as 'generation of plausible hypotheses" and selection is seen as resting on inference "to the best explanation" (p. 20). This of course reflects the dichotomy in Reichenbach and Popper between discovery and justification, but it is by conjoining them and looking for elements that essentially reflect their interaction that Magnani moves beyond the standard view which sees only justification as logically grounded.

Hypothesis selection is grounded in many ways, but most essentially, for Magnani, it derives its rational basis from its participation in the entire abductive procedure. It is this insight which drives the remainder of the text, which includes numerous examples of successful abductive practice; and within the context of successful practice, expands the traditional sentential (logical) account in a number of significant ways. He spends considerable time on what he calls "model based" abductions, and then entire chapters on manipulative and visual abduction, strategies for generating hypotheses that are often ignored by philosophers limited to sentential accounts, but which offer compelling evidence of successful abductive practice in science and ordinary life. But the myriad examples are best seen as relevant to the deep philosophical issues when the overall structure of the argument is concerned. So, far we have identified two argumentation tropes: the proof of possibility by offering actual models, and second, the dissolving the appearance of paradox by showing that a seeming property is actually a relation. But there is more to the argument that shifts it into a "new key." It is this, last that I find as interesting as anything Magnani has to say about abduction. This requires more details.

Magnani's text is extremely complex; it is full of information about the widest range of issues relevant to his concerns. He has complex presentations of artificial intelligence programs, and focuses on his own interest in diagnostic programs. This presents one of the major problems for the reader. Since his argument is based on numerous examples of successful strategies and sees their success as an index of the value of his project, the book overwhelms the reader with references. In one three page section Magnani presents more than a dozen acronyms of successful artificial intelligence programs that do in fact develop and assess hypotheses, make diagnoses, etc. (pp. 49–51). Even where a brief sentence or so indicates their purpose, and in doing so persuasively presents exemplars of successful abductive practice, readers may find themselves at a loss. Of course, if the reader is appropriately grounded in the vast literature that Magnani affords in a bibliography of 20 pages approximating some 500 entries, the reference to particulars can be deeply informative. For the rest of us we must rely on the sheer weight of putative examples. This deserves a comment.

I see Magnani to be presenting what informal logicians have come to call convergent argument (see Govier, 1987). The various threads of argument, and they extend far beyond artificial intelligence to include scientific and more mundane problem solving strategies, all support to some degree or other the general contention that abductions are actual and so possible. The central philosophical issues remaining is to offer an account that is sufficiently persuasive so as to make the success of abductive process rationally intelligible. It is this, rather than skeptical doubts that make the traditional view in philosophy of science despair of accounting for 'discovery.'

Magnani offers such an account, but it is the connection between the account and the examples that ultimately give Magnani's work its power. For Magnani is showing us how to do epistemology in a way far different from the recent analytic tradition. Magnani, like his predecessors offers an account of broad generality drawing upon an abstract analysis in terms of equally abstract logical characterizations as in the description of the S-T Model. But rather than rely on these, or explore the connections among them in the usual way, Magnani accepts the abstract outline as if it were trouble free and moves on to bring forward the problem solving and artificial intelligence accounts of procedures, indicating both that, and at times how, the complex abstract aspects of hypothesis generation and evidence interact to afford the warrant for abductions.

Spelling out how the subroutines that result in sound abductive inferences function takes Magnani far from the usual philosophical discussions.

His concern with the actual practice of abduction helps him to see the roots of abduction in the manipulation of images and objects. As elementary a task as identifying objects in a closed bag by feel or sound illustrates the naturalness with which the pool of plausible hypothesis may be constrained in actual problem solving situation. But the real basis of the constraints that permit the process to be effective is most readily seen by moving to his central concern with medical diagnosis.

Medical diagnosis serves Magnani's purposes for a number of reasons. First, he sees it as satisfying the generally S-T Model that he has offered in the preceding chapter where his theoretical position is laid out. Second, it offers the concrete evidence that is necessary to support the convergent argument based on a wealth of actual examples. Third, it enables him to develop more of the "psychological" that focuses on the cognitive models of abduction that support its constructive nature. But, to me, most importantly it affords the ability to bring into view the information context in terms of which hypothesis generation is constrained, and seen as less arbitrary than in the traditional non-rational view of discovery typical of those who Magnani wants to transcend. The key is his characterization of medical diagnoses as embedded in a Knowledge Based System (KBS). To see how this functions we first return to the basic S-T Model now construed in terms of medical diagnosis. "(M)edical diagnosis can be broken down into two different phases: first patient data is abstracted and used *to select hypotheses*, that is hypothetical solutions of the patient's problem (selective abduction phase); second these hypotheses provided the starting condition for forecasts of expected consequences which should be compared to the patient's data in order to evaluate (corroborate or eliminate) those hypothesis from which they come (deduction-induction cycle) (p. 72). So far this is nothing new, but what comes next sets the stage for the solution to the problem of abduction.

"In the case of medical KBS's the epistemological architecture which exploits that abduction-deduction-inference cycle (ST-MODEL) starts with an abstraction of the data which characterized the problems to be solved (diagnoses, therapy, monitoring). An abstraction can be considered as a process of structuring incoming data in a smaller set of entities, according to the kind of medical knowledge available and the features of the problem at issue. The efficacy of such operations depends on the accumulated expertise, which determines the organization of personal knowledge so that problems can be easily recognized and state in a way that guarantees their solution by efficient use of available knowledge" (ibid.). This background permits selective abduction, construed as "guessing a set of hypotheses starting from problem features identified

by abstraction. Once hypotheses are selected they need to be ranked . . . so as to plan the evaluation phase by first testing a preferred hypothesis" (p. 73). In the medical domain there are plausible criteria for such ranking. Magnani lists "parsimony, danger, cost, curability and so on," but then quickly adds: "The worth of the hypothesis to be tested is, of course, connected to epistemic and pragmatic collections of reasons that trace back to the belief in its truth and general relevance for medical action" (ibid.).

This connects with the cognitive model users of KBS employ. Magnani sees two main strategies "forward reasoning" which he considers strong reasoning, that is, reasoning from a well understood and internalized knowledge base to offer a diagnoses, and "backward reasoning" seen as weak, reasoning from data in the absence of an adequate and relevant knowledge to plausible hypotheses. He cites literature on expert and novice medial practitioners that identify forward reasoning as common to more experienced medical reasoners and backward reasoning to novices (pp. 79ff).

This discussion moves to the instrumentalization of diagnoses in computer programs that do analyses based on KBS's where he identifies the basic commitments that enable them to reflect the cognitive architecture of the expect practitioner: "knowledge about the work (*ontological commitment*) and some sort of procedure (*inferential commitment*) for interpreting this knowledge in order to construct plans of action" (p. 82). He then, typical to his approach throughout, offers examples of well functioning diagnostic and other medical programs that function to select and evaluate hypotheses as strong evidence for the coherence and constructability of abductive procedures. Given his articulation of the basic model in terms of medical diagnosis, Magnani draws lessons for science in general and for medical education. Not surprisingly he moves toward an information based medical knowledge and away from a relatively decontextualized problem solving approach. We will return to this later, but first let us look more closely at what Magnani has done.

Magnani offers a solution to the problem of abduction by looking broadly, the relational aspects of abduction seen within the entire context of hypothesis selection and test, rather than narrowly as in the positivist tradition. Although his model is parasitic on the adequacy of logical procedures, he eschews presenting his views in logical terms – that is, you find no formal or even informal models of either the deductive or inductive process. He assumes that this is in place. Nether does he attempt to develop an account of abduction by looking at the microstructure (whether formal or informal) of the reasoning. He rather assumes that this is solved in the actual selection and inferential procedures of abductive practice.

This relies heavily on the fact that artificial intelligence models guarantee that such procedures are both constructable and understandable. They are after all programs, written, elaborated and improved by programmers for cogency, so questions as to their constructability are answered by concrete example.

But most important, he ties the abductive process to knowledge contexts that rationally limit the choice of hypotheses. That is why the diagnostic model is so crucial. Although vast and demanding, the domain of medical knowledge and acceptable medical applications, replete with scientific underpinnings, is available and codifiable. Since the knowledge is guided by practical needs and successful treatment, the connection between medical knowledge and particular issues is well constructed and has been traditionally available in the codification of medical knowledge in encyclopedia and in terms of the areas of medical specialization. Thus, for medical diagnosticians knowledge is in place and ready to be utilized. This is a far different context then traditional philosophy of science contends with, where abstraction and odd examples replace effective knowledge and institutionalized practice. After all, Nelson Goodman's now-classic "new problem of induction", at its core that problem of abduction, called for an analysis that would account for choosing on purely logical grounds between the predicate 'grue' and the predicate 'green', where the former was green up until, e.g. 3000, and blue thereafter. With such as focus it is no doubt that hypothesis generation seems mysterious.

This points to the "new key" that I see Magnani's work to indicate. Recent philosophy of science has included an increased focus on the actual details of scientific practice. But often does so at the price of addressing traditional metalogical issues that still remain important to epistemologists (and educators). Movements like evolutionary epistemology that see the growth of knowledge in terms of the actual history of ideas are welcome approaches to philosophical questions. But if actual knowledge is to be understood we need some of the structure that supports that improvement. Unless evolution in epistemology is to be another deus ex machina, as was the doctrine of reminiscence, some version of the positivist plan to account for the logical structure of knowledge is heeded. But on what level of analysis should this be done?

Magnani's bold move is to look at the detailed activities involved in understandable and successful knowledge development, and to look to the construction of this knowledge in areas where its architecture can be clarified. He points to the vast domain of artificial intelligence where both effectiveness and underlying intelligibility is guaranteed. He focuses on medical diagnosis, but there are vast areas in the field, generally called

"data mining" that might even better make his case. Programs that explore for petroleum, that determine weather patterns, the very search engines that we utilize every day, are all based on algorithms that do abductions. Philosophic doubt is irrelevant, the structure is there to be seen. Or is it?

It is clear that such abductive procedures are effective and now available for close inspection. Mainly psychologists and computer scientists do this. But how are they related to central epistemological issues? One way is the way that Magnani makes available to the reader. They present an underlying architecture that can be elaborated and understood (S-T Model). But the S-T Model assumes just what the philosopher wants analyzed. Logicians have so despaired of making sense of the deductive apparatus as used in actual argument that an entire field of informal logic has been developed to account for the short comings of formal models. And deductive logic had persuasive models available, in just the sense that inductive logic was fraught with formalist uncertainty (e.g. the Bayesian and anti-Bayesians). Magnani indicated essential areas where modern logic helps to clarify the situation, in particular the availability of non-monotonic logics, that is logics that are sensitive to changing and even contradictory premise base for deductions. But most central to his scheme is the notion of inference to the best explanation, that is, logical procedure for choosing among possible alternatives. Magnani cites this and uses it essentially in his discussion, but offers no hint of the problematic that this concept generates. Rather he accepts the fact that choices are made and so best explanations are selectable. This falls far short of the sort of logical clarity that even reconstructed positivists might rightfully require. For unless there is a clear logic for understanding best explanation, and its cousin, most worthy hypothesis (that is a selection procedure to determine relevance, testability, fecundity and the like) the old doubt about abduction returns.

This prompts our return to an earlier remark. Argumentation theorists and informal logicians with an essential interest in the dialogical interchange that arguments afford have been struggling with the problem of from whence normative force is to be obtained (see van Eemeren et al. 1996 for an overview; also Johnson, 2000). A dispute that is mirrored in the critical thinking movement and that abuts on educational policy struggles with just the distinction that Magnani makes when he discusses forward and backward reasoning. That is, are reasoning skills of a general sort most useful, or rather does instruction in reasoning require a firm grounding in disciplinary knowledge and procedures (see Weinstein, 1993). If Magnani is correct in seeing the basic problem of hypothesis creation as parasitic on a body of knowledge both for the selection and evaluation of hypotheses,

then abductive reasoning seems to point away from general procedural skills towards skills embedded in knowledge sets replete with proven inferential procedures. In medical education this points away from the recent fascination with clinical experience early on and seems to point back to the need for disciplined learning and basic knowledge. In schooling this points away from critical thinking in the general sense that most of its advocates recommend and to something more like what I have called "applied epistemology," that is thinking in terms of disciplinary norms and in light of disciplinary knowledge (Weinstein, 1994). That is a lesson that those who know my work in critical thinking and informal logic would expect me to draw, but I think it is legitimately extrapolatable from Magnani's work.

This excellent and demanding book opens up the door to a deeply informed attitude in epistemology, requiring of philosophers that they do more than analyze concepts, demanding that they become familiar with the wealth of actual knowledge gathering practices available in the special discipline and now articulated in terms of constructable algorithms in artificial intelligence programs. This is not to substitute description for normativity, but rather reconceptualizes what the grounds of normativity are. It should be no surprise that a book on abduction expresses a fundamental and deep pragmatism in just the sense that Pierce would applaud.

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