Chapter 1
Theoretical and Manipulative Abduction
Conjectures and Manipulations: The Extra-Theoretical Dimension of Scientific Discovery

More than a hundred years ago, the American philosopher Charles Sanders Peirce, when working on logical and philosophical problems, suggested the concept of *pragmatism* ("pragmaticism", in his own words) as a logical criterion to analyze what words and concepts express through their practical meaning. Many authors have illustrated creative processes and reasoning, especially in the case of scientific practices. In fact, many philosophers have usually offered a number of ways of construing hypotheses generation, but they aim at demonstrating that the activity of generating hypotheses is paradoxical, obscure, and thus not analyzable.

Those descriptions are often so far from Peircean pragmatic prescription and so abstract to result completely unknowable and obscure. To dismiss this tendency and gain interesting insight about cognitive creativity and the so-called “logic of scientific discovery” we need to build constructive procedures, which could play a role in moving the problem solving process forward by implementing them in some actual models. The “computational turn” gave us a new way to understand creative processes in a strictly pragmatic sense. In fact, by exploiting artificial intelligence, logical, and cognitive science tools, philosophy allows us to test concepts and ideas previously conceived only in abstract terms. It is in the perspective of these *actual computational models* that I have founded the central role of *abduction* in the explanation of creative reasoning in science.

This chapter aims at introducing the distinction between two kinds of *abduction*, *theoretical* and *manipulative*, in order to provide an integrated framework to explain some of the main aspects of both creative and *model-based reasoning* effects engendered by the practice of science and everyday reasoning. The distinction appears to be extremely convenient, after having illustrated the *sentential models* together with their limitations (section 1.4), creativity will be viewed as the result of the highest cases of theoretical abduction demonstrating the role of so-called *model-based abduction* (section 1.5). Moreover, I will delineate what I call *manipulative abduction* (section 1.6) by showing how we can find methods of manipulative constructivity.

From this perspective, creativity and discovery are no longer seen as mysterious irrational processes, but, thanks to constructive accounts, they are viewed as
complex relationships among different inferential steps that can be clearly analyzed and identified. I maintain that the analysis of sentential, model-based and manipulative abduction and of external and epistemic mediators is important not only to delineate the actual practice of abduction, but also to further enhance the development of programs computationally adequate in rediscovering, or discovering for the first time, for example, scientific hypotheses or mathematical theorems. In this chapter attention will be focused on those particular kinds of abductive cognition that resort to the existence of extra-theoretical ways of thinking – thinking through doing. Indeed many cognitive processes are centered on external representations, as a means to create communicable accounts of new experiences ready to be integrated into previously existing systems of experimental and theoretical practices. The last part of the chapter is devoted to illustrating the problem of the extra-theoretical explanatory dimension of reasoning and discovery from the perspective of some mathematical cases derived from calculus, where internal and external aspects (optical diagrams) of cognition are at play.

1.1 Computational Modeling as a Pragmatic Rule for Clarity

What I call “computational philosophy”, aims at investigating many important concepts and problems of the philosophical and epistemological tradition in a new way by taking advantage epistemological, cognitive, and artificial intelligence (AI) computational methodologies. I maintain that the results of computational philosophy meet the classical requirements of Peircean “pragmatic” ambitions and nicely tie together both issues related to the dynamics of information and its systematic embodiment in segments of “knowledge”. In the second half of the nineteenth century the great American philosopher Charles Sanders Peirce suggested the idea of pragmatism as a logical criterion to analyze what words and concepts express through their practical meaning. In “The fixation of belief” [1877] Peirce enumerates four main methods by means of which it is possible to fix belief: the method of tenacity, the method of authority, the a priori method and, finally, the method of science, by means of which, thanks to rigorous research, “[...] we can ascertain by reasoning how things really and truly are; and any man, if he has sufficient experience and he reasons enough about it, will be led to the one True conclusion” [Peirce, 1987, p. 255]. Only the scientific method leads to identify what is “real”, that is “true”.

Peirce will more clearly explain the public notion of truth here exposed, and the interpretation of reality as the final purpose of the human inquiry, in his subsequent paper “How to make our ideas clear” [1878]. Here Peirce addresses attention on the notions of “clear idea” and “belief”. “Whoever has looked into a modern treatise on logic of the common sort, will doubtlessly remember the two distinctions between clear and obscure conceptions, and between distinct and confused conceptions” he writes [Peirce, 1987, p. 257]. A clear idea is defined as one which is apprehended so that it will be recognized wherever it is met, and so that no other will be mistaken for it. If it fails to be clear, it is said to be obscure. On the other hand, a distinct idea

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1 Topics and aims of computational philosophy are illustrated in [Magnani, 1997].