Epistemic Mediators and Manipulative Abduction in Model-Based Reasoning

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Science expresses one of the most creative forms of human reasoning. It has been stressed that scientific discovery is a mysterious process, involving irrationality and any kind of "unexplainable" feelings and emotions. By rejecting that point of view, the recent epistemological and cognitive studies concentrate on the concept of abduction, as a rational means to originate and refine new ideas.

I maintain that abduction is the process of "inferring" certain facts and/or laws and hypotheses that render some sentences plausible, that "explain" or "discover" some (eventually new) phenomenon or observation; it is the process of reasoning in which explanatory hypotheses are formed and evaluated. In (Magnani, 2001a) I have introduced the concept of theoretical abduction, as a form of internal processing. There are two kinds of theoretical abduction, "sentential", related to logic and to verbal/symbolic inferences, and "model-based", related to the exploitation of internalized models of diagrams, pictures, etc. Moreover, I have described two main epistemological meanings: 1) abduction that only generates "plausible" hypotheses ("selective" or "creative"), and 2) abduction considered as inference "to the best explanation", which also evaluates hypotheses.

Traditional cognitive science and computational accounts concerning abduction aim at illustrating discovery and creativity processes in terms of "theoretical" and "internal" aspects. A neglected issue, worth of a deepest investigation inside artificial intelligence and cognitive science, is that "discovery" and hypotheses generation are often related to a complex cognitive task involving the use and the manipulation of the external world. Theoretical abduction certainly illustrates and cognitively integrates much of what is important in creative reasoning in science, in humans and in computational programs, but fails to account for many cases of explanations occurring in science when the exploitation of environment is crucial. The concept of manipulative abduction[1] aims at capturing a large part of scientist's thinking where the role of action is central, and where the features of this action are implicit and hard to be elicited: action can provide otherwise unavailable information that enables the agent to solve problems by starting and by performing a suitable abductive process of generation or selection of hypotheses.

Concrete manipulations of the external world and of external representations constitute a fundamental passage in scientific discovery: by a process of manipulative abduction it is possible to build prostheses (epistemic mediators) for human minds, by interacting with external artifacts and representations in a constructive way. In this manner it is possible to create "implicit" knowledge through doing and to produce various opportunity to find, for example, anomalies and fruitful new risky perspectives. As a kind of model-based reasoning (Magnani & Nersessian, 2002, Magnani, Nersessian, & Pizzi, 2002) and of embodied and unexpressed knowledge manipulative abduction holds a key role in the processes of scientific comprehension and discovery. I have called "templates" some prototypical manipulative behaviors which account for the most common cognitive and epistemic acting related to scientific discovery.

I have exploited the concepts of manipulative abduction and of epistemic mediator to study some explanatory and creative aspects in the case of mathematical reasoning (discovery of non-Euclidean geometry and non-standard analysis) by stressing the cognitive role played by some interesting geometrical diagrams ("mirror" and "unveiling") as epistemic mediators able to perform various cognitive tasks (discovery of new properties or new propositions/hypotheses, provision of suitable sequences of models as able to convincingly verifying theorems, etc.). The concepts have also been useful to increase knowledge on "chance" discovery and production as a kind of event related to the transformations of the "attractors" responsible of some cognitive system performances (Magnani, Piazza, & Dossena, 2002).

References

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[1] I introduced the concept of epistemic mediators and of manipulative abduction in (Magnani, 2001a). Their role in geometrical reasoning is illustrated in Magnani (2001b).