Creative Abduction as Active Shaping of Knowledge in Science and Ethics

1. The *inexplicability* of creativity

Creativity is certainly a necessary part of what we use to define "intelligence", but the literature associates to creativity many diverse notions. This ambiguity has brought to a lack of consensus in the research community. The common thought associates to creativity unusual and mysterious qualities that drive the concept of creativity to a confused verbosity, often inexplicable and incomprehensible. Statements like "to break the rules", "to think different", "to destroy one Gestalt in favor of a better one", and "to arrange old elements into a new form", elaborated since the 1950s in creativity research, on the basis of psychological research, do not contribute in clarify the topic, and seem to lead to the Freudian conclusion that creativity simply cannot be understood. It has been the view supported by many philosophers involved, in the last century, in the study of conceptual change in science. They came to distinguish between a logic of discovery and a logic of justification (i.e. the distinction between the psychological side of creation and the logic argument of proving new discovered ideas by facts). The consequent conclusion was that a logic of discovery (and a *rational* model of discovery) could not exist: scientific change is cataclysmic and irrational, dramatic, incomprehensible and discontinuous.

In AI research, however, since Simon, two characteristics seem to be associated to creativity: the *novelty* of the product and the *unconventionality* of the process that leads to the new product (see Buchanan, 2001). Hence, in a strictly *pragmatical* sense, once we can clarify what behavior we are looking for, we could implement it in a machine: it is a methodological criterion to define and consider just those practical effects we conceive to be associated with novelty and unconventionality.

2. The abductive framework

If we decide to adopt this kind of methodology, however, it is necessary to develop a cognitive model of creativity able to represent not only the product novelty and unconventionality, but also some features commonly referred to the entire creative process: the expert use of background knowledge and ontology (defining new concepts and searching heuristically among the old ones), and the modeling activity developed in the so called "incubation time" (generating and testing, transformations in the space of the hypotheses). *Abductive reasoning* stands as a candidate to solve the question, and offers an approach to model creative processes of hypotheses generation in a completely explicit and formal way.

We consider abduction as 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: the process of reasoning in which explanatory hypotheses are formed and evaluated.

As already stressed elsewhere, beside the common theoretical (model-based) and formal accounts of abduction, it is fundamental to underline the importance of a particular kind of model-based reasonig, *manipulative* reasoning, where creativity takes shape by codifying new information by means of manipulations of external *epistemic mediators* (see Magnani, 2002).

The concept of *manipulative abduction* is devoted to capture the role of action in reasoning: it provides otherwise unavailable information that enables the agent to solve a problem by performing abductive processes of generation or selection of hypotheses. It is an expert manipulation of objects directed by abductive movements that imply the strategic application of old and new *templates* of behavior mainly connected with extra-theoretical components: <u>esthetical, ethical, and emotional.</u>

The *hypothetical* character of manipulations in creativity is clear: they are a sort of test, they can be developed to examine further chances, or discarded, they are provisional creative organization of experience and some of them become in their turn hypothetical *interpretations*

of experience, suggesting new worldviews. Step by step the new interpretation - that at the beginning is completely "practice-laden" - relates to more "theoretical" modes of understanding (narrative, visual, diagrammatic, symbolic, conceptual, simulative).

To use an expression derived from Hutchins (1995), a cognitive anthropologist, by manipulations the agent builds external epistemic mediators that function as a source of new knowledge in the cognitive activity. In this light manipulative abduction in science represents a kind of redistribution of the epistemic and cognitive effort to manage objects and information that cannot be immediately represented or found internally. It is possible to have a better understanding by rendering explicit some of the manipulative *templates* of behavior that are active in creative abduction: 1. action elaborates a *simplification* of the reasoning task and a redistribution of effort across time when we "need to manipulate concrete things in order to understand structures which are otherwise too abstract" (Piaget 1974), or when we are in presence of *redundant* and unmanageable information; 2. action can be useful in presence of *incomplete* or *inconsistent* information - not only from the "perceptual" point of view; 3. action as a *control of sense data* illustrates how we can change the position of our body (and/or of the external objects) and how to exploit various kinds of prostheses (Galileo's telescope, technological instruments and interfaces) to get various new kinds of stimulation; 4. action enables us to build *external artifactual models* of task mechanisms instead of the corresponding internal ones, that are adequate to adapt the environment to agent's needs; 5. in science experimental action shows a sensibility to the aspects of the phenomenon which can be regarded as *curious* or *anomalous*; manipulations have to be able to introduce potential inconsistencies in the received knowledge; 6. action exhibits a preliminary sensibility to the *dynamical* character of the phenomenon, and not to entities and their properties, common aim of manipulations is to practically reorder the dynamic sequence of events in a static spatial one that should promote a subsequent bird's-eye view (narrative or visual-diagrammatic).

3. A cognitive theory of the abductive modeling activity

Abduction is a complex *epistemic process* that works through *imagination*: it suggests a new direction in **reasoning** by *shaping* new possible explaining object and hypotheses (**c.f. the templates mentioned above**). In this sense imagination should not be confused with an act of intuition. Peirce describes abduction as a *dynamic* modeling process that fluctuates between states of dubt and states of **belief**. To solve the dubt, and some eventually linked anomalies, the agent puts into effect a process of information gathering that responds at once to the "problem" frame, to the agent's evolving understanding of the situation and to its changing requirements. **By imagination here we mean this process of knowledge gathering and shaping, a process that leads to *see* things *as* we would not otherwise have seen them, "a blind but indispensable function of the soul, without which we should not have no knowledge whatsoever" (Kant, 1929, A78-B103, p.112).** Scientific creativity, it is pretty obvious, involves seeing the world in a particular new way: scientific understanding involves coming to see some aspects of reality in a particular way, and creativity depends on coming to see things in a new way. Suggestions in describing this process come from a theory developed in the area of computer vision: the *active perception* approach (see Thomas, 1999).

This approach developed from the will to understand cognitive systems in terms of their environmental *situatedness*: instead of being used to build a comprehensive inner model of its surroundings, the agent's perceptual capacities are simply used to obtain *whatever* specific pieces of information are necessary for its behavior in the world. The agent *constantly adjusts its vantage point*, updating and refining its procedures, in order to uncover a piece of information. This means to specify how to efficiently examine and explore, and thus *interpret*, an object of a certain type. It is a process of attentive and controlled perceptual exploration by means of the agent is able to collect

the necessary information: **a purposefully moving through what is being examined, actively picking up information rather than passively transducing (c.f. Gibson, 1979).**

As suggested for instance by Lederman and Klatzky (1990), this view of perception may be applied to all sense mode, but could be easily explained by considering the haptic mode. Mere passive touch, in fact, tell us little, but by actively exploring an object with our hands we can find out a great deal. Our hands incorporate not only sensory transducers, but musculature which, under central control, moves them in appropriate ways: hefting something tells about its weight, running fingers around the contours provides shape information, rubbing it reveals texture. As already stressed by C. S. Peirce, "A man can distinguish different textures of cloth by feeling: but not immediately, for he requires to move fingers over the cloth, which shows that he is obliged to compare sensations of one instant with those of another" [5.221].

Thomas (1999) proposes to think of the fingers together with the neural structures that control, for example, running them and that analyze the afferent signals that they generate as a sort of (perceptual) *instrument* to gather knowledge: a complex of physiological structures capable of active testing for some environmental property.

The study of manipulative abduction already outlined can gain from a similar approach. To give a clarifying example, we have studied the role of particular epistemic mediators (*optical dyagrams*) in non-standard analysis, and their role in grasping and teaching abstract and difficult mathematical concepts (see Magnani and Dossena, 2002). The external model does not give full available knowledge, but, on the contrary, the agent is constantly engaged in an epistemic dialogue between the diagrams and its internal knowledge to understand an already existing information or to "create" a new one. **And, as Kant describes geometrical construction: "[…] I must not restrict my attention to what I am actually thinking in my concept of a triangle (this is nothing more than the mere definition); I must pass beyond it to properties which are not contained in this concept, but yet belong to it" (Kant, 1929, A718-B746, p. 580).**

The important thing here is not to have representations (also common men could have knowledge, for instance, about the history of painting, its products, colors, and techniques. But the creative one questions his "representations" in a different way), but how our *epistemic* instruments act in searching through the entire space of available knowledge to create new hypotheses and information. **The agent does not first build up an inner representation of the surrounding environment (*its current situation*) and then queries that: it queries the environment itself, when it needs specific information. The world is actively explored rather than passively registered.**

It is the entire active process of negotiation to constitute creativity, not the final product (a new model or theory) or an act of internal intuition. Creativity arises not when we actually see, but when we are *seeing nothing in particular* (something not yet defined and conceptualized) *as something*, whatever it may be. **It is an important aspect of scientific research: the ability to see things as we would not otherwise have seen them, and explore the world in new (creative) and useful ways (Tycho Brahe saw the Sun as rising over the horizon, whereas Kepler, a Copernican, saw the Earth turning towards the Sun (c.f. Hanson, 1958)).**

4. Creativity and morality

The role of an active process of information gathering by *mediators* to shape knowledge, however should not be restricted to the scientific activity. An often neglected side of human creativity is, in fact, related with emotional and ethical aspects, and concerns the active shaping of values in a moral world.

The role of hypotheses and manipulation of the world is clear in Kant's moral doctrine. When he speaks about pure moral rules, in fact, he says that them could be applied to the concrete experience as a kind of "typification", a figurative envisioning of a non existing

world, based on a metaphoric mapping, as a means for judging a given moral situation (Johnson, 1993).

For Peirce all knowing is *inferring* and inferring is not instantaneous, it happens in a process that needs an activity of comparisons involving many kinds of models (signs) in a more or less considerable lapse of time. All sensations or perceptions participate in the nature of a unifying hypothesis, in the case of emotions too. In Peircian sense emotions too express a kind of model-based reasoning and have and "inferential" character. In decision making emotions play a distinguished role: they make the decision process speed, surely related to what we care about, and lead directly to actions. But they are also usually considered irrational because of the serious disadvantages they present: failure to consider other options, lack of consideration of accurate and relevant information, not sharability in group situation, when the decisions have be adopted collectively. It is important to understand that emotions are not inherently irrational, for example they can be usefully intertwined with cultural aspects.

In general we can say that moral deliberations relate to a sort of selection or creation of principles (rules, prototypes) and to their application to concrete cases. We can both just select (or create, if we do not have any) moral principles (rules, prototypes) and apply them to concrete cases or looking for the best ones among them according to some ethical meta-criteria. When we create new ethics, we provide new knowledge and new rules about problems and situations not yet clearly covered from the moral point of view. In this last case we certainly are in front of a particular case, but the problem is not only the one of ethically solving the case at hand by applying already available ethical concerns – indeed we lack a satisfactory moral knowledge to handle the puzzling situation. Instead we need create something new, for example new good reasons first of all able to provide an acceptable intelligibility of the problem. Once created, it will be possible to see the new principle and the new moral knowledge as a crystallization of the various insights emerged out of a peoples' and/or expert experience and thinking.

The role of cognitive delegations to external objects and structures has to be extended to the case on human organizations, so viewed as *cognitive* "mediating" structures endowed with moral aspects. In this light it is possible to introduce the concept of *moral mediator*. Moral mediators play an important role in reshaping ethical worth of human beings and collectives. They especially involve a continuous reconfiguration of social orders aiming at rebuilding new moral perspectives and chances. These mediators represent a kind of redistribution of the moral effort through managing objects and information in such a way that we can overcome the poverty and the unsatisfactory character of the moral options immediately represented or found internally. *Moral mediators* are also used to exploit latent constraints in the human-environment system. These new constraints grant additional and precious ethical information. **When we act in a way so that we spend more quality time with our partner to save our marriage, for example, then our actions automatically can cause variables relating to "unexpected" and "positive" contents of the relationship to covary with perceptible new released informative, sentimental, sexual, and in general bodily variables. Prior to the adoption of the new reconfigured "social" order of the couple, there is no active constraint between these hidden and overt variables causing them of carry information about each other.**

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