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Creative Abduction as Active Shaping of Knowledge. Epistemic and Ethical Mediators

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Abstract

The concept of *manipulative abduction* is devoted to capturing the role of action in many interesting situations: action provides otherwise unavailable information that enables the agent to solve problems by starting and performing a suitable abductive process of generation or selection of hypotheses. Many *external representations*, even if in some cases inert from an epistemological point of view, can be transformed into what is called *epistemic mediators*, active in creative abductive reasoning. An often neglected side of human creativity is related to emotional, artistic, and ethical aspects, and concerns the active shaping of values in an esthetical and ethical world. I will present some aspects of this kind of reasoning in the case of scientific and ethical thinking; moreover, I will illustrate some aspects of what I call “ethical mediators” in their activity of shaping and reshaping ethical worth of human beings and collectives.

The Inexplicability of Creativity

Creativity is certainly an important aspect of our definition of “intelligence” but the literature associates many different notions to creativity. This ambiguity has brought to a lack of consensus in the research community. The common views associate to creativity unusual and mysterious qualities that drive the concept of creativity to a confused verbosity. 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”, present in the field of psychological research on creativity since 1950s, certainly do not clarify the topic, and seem to lead to the Freudian conclusion that creativity cannot be understood. This conclusion has also been supported by many philosophers who studied conceptual change in science during the second half of the last century. They distinguished between a logic of discovery and a logic of justification (i.e. 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 conceptual change is cataclysmic and irrational, dramatic, incomprehensible and discontinuous. Many other studies already argued that creativity can be understood (Boden, 1991, Sternberg, Kaufman, and Pretz, 2002), but paid attention mainly to the psychological and experimental aspects, disregarding the philosophical, logical, and computation ones.

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. Hence, in a strictly *pragmatic* sense, when we can clarify what behavior we are looking for, we could implement it in a machine: a methodological criterion enables us to define and consider just those practical effects we conceive to be associated with novelty and unconventionality (cf. Buchanan, 2001).

I maintain we can overcome many of the difficulties of creativity studies developing a theory of abduction, in the light of Charles Sanders Peirce’s first insights.

Abduction and Epistemic Mediators

If we decide to adopt this kind of methodology it is necessary to develop a cognitive model of creativity able to represent not only “novelty” and “unconventionality”, but also some features commonly referred to as the entire creative process, such as 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). The philosophical concept of *abduction* may be a candidate to solve this problem, and offers an approach to model creative processes of hypotheses generation in a completely explicit and formal way, which can fruitfully integrate the narrowness proper of a merely psychological approach, too experimentally human-oriented.

Theoretical and Manipulative Abduction

A hundred years ago, C. S. Peirce (*CP*, 1931-1958) coined the concept of abduction in order to illustrate that the process of scientific discovery is not irrational and that a methodology of discovery is possible. Peirce interpreted abduction essentially as an “inferential” *creative process* of generating a new hypothesis. Abduction has a logical form (fallacious, if we model abduction by using classical logic) distinct from deduction and induction. Reasoning which starts from reasons and looks for consequences is called *deduction*; that which starts from consequences and looks for reasons is called *abduction*.

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. There are two main epistemological meanings of the word abduction (Magnani, 2001): 1) abduction that only generates “plausible” hypotheses (“selective” or “creative”) and 2) abduction considered as inference “to the best explanation”, which

also evaluates hypotheses. To illustrate from the field of medical knowledge, the discovery of a new disease and the manifestations it causes can be considered as the result of a creative abductive inference. Therefore, “creative” abduction deals with the whole field of the growth of scientific knowledge. This is irrelevant in medical *diagnosis* where instead the task is to “select” from an encyclopedia of pre-stored diagnostic entities. We can call both inferences ampliative, selective and creative, because in both cases the reasoning involved amplifies, or goes beyond, the information incorporated in the premises.

*Theoretical abduction*¹ certainly illustrates much of what is important in creative abductive reasoning, 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. It fails to account for those cases in which there is a kind of “discovering through doing”, cases in which new and still unexpressed information is codified by means of manipulations of some external objects (*epistemic mediators*). The concept of *manipulative abduction*² captures a large part of scientists’ and physicians’ thinking where the role of action is central, and where the features of this action are implicit and hard to be elicited

Peirce uses the terms “inference” and “inferential process” to refer to abduction. It is useful to try to clarify the meaning of the term “inference” as considered by Peirce’s thought. Peirce stated that all thinking is in signs, and signs can be icons, indices or symbols. Moreover, all *inference* is a form of sign activity, where the word sign includes “feeling, image, conception and other representation” (CP 5.283), and, in Kantian words, all synthetic forms of cognition. Feelings, images, simulations, etc., are currently characterized as forms of model-based reasoning (Magnani & Nersessian, 2002). Consequently, following Peirce, we can say that a considerable part of thinking activity is *model-based* (cf. footnote 1), that most of the forms of constitution of phenomena are characterized in a model-based way. I use the term “model-based reasoning” following Nersessian (1995), that is, to indicate the construction and manipulation of various kinds of representations, not necessarily sentential and/or formal. Scientific concept formation, scientific discovery, and – as we will see – diagnostic reasoning are often related to *heuristic* procedures that resort to mental/internal but also to external “models” and representations.

Peirce gives an interesting example of model-based abduction related to sense activity: “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” (CP 5.221); this idea surely suggests that abductive movements also have interesting extra-theoretical

characteristics and that there is a role in abductive reasoning for various kinds of manipulations of external objects (cf. below, the problem of “action-based, manipulative abduction”). One more example is given by the fact that the perception of tone arises from the activity of the mind only after having noted the rapidity of the vibrations of the sound waves, but the possibility of individuating a tone happens only after having heard several of the sound impulses and after having judged their frequency. Consequently the sensation of pitch is made possible by previous experiences and cognitions stored in memory, so that one oscillation of the air would not produce a tone.

Model-based thinking activity also exploits *external models*. We have seen that the concept of manipulative abduction is devoted to capturing the role of action on external models in hypothetical and creative reasoning. This kind of manipulation provides otherwise unavailable information that enables the agent to solve a problem by performing abductive processes of generation or selection of hypotheses. An expert manipulation of objects directed by abductive movements that implicates the strategic application of old and new *templates* of behavior mainly connected with extra-theoretical components also esthetical, ethical, and emotional.

Manipulative abduction happens when we are thinking *through* doing and not only, in a pragmatic sense, about doing. It refers to an extra-theoretical behavior that aims at creating communicable accounts of new experiences to integrate them into previously existing systems of experimental and linguistic (theoretical) practices. Gooding (1990) refers to this kind of concrete manipulative reasoning when he illustrates the role in science of the so-called “construals” that embody tacit inferences in procedures that are often apparatus and machine based. The embodiment is of course an expert manipulation of objects in a highly constrained experimental environment, and is directed by abductive movements that imply the strategic application of old and new *templates* of behavior mainly connected with extra-theoretical components, for instance emotional, esthetical, ethical, and economic.

Epistemic Mediators

Recent research, taking an ecological approach to the analysis and design of human-machine systems, has shown how expert performers use action in everyday life to create an “external” model of task dynamics that can be used in lieu of an internal model (Kirlik, 1998). Not only a way for moving the world to desirable states, action performs an *epistemic* and not merely performatory role that is very relevant to abductive reasoning.

The whole activity of manipulation is devoted to build various external *epistemic mediators* that function as an enormous new source of information and knowledge. I derive this expression from the cognitive anthropologist Hutchins (1995), that coins the expression “mediating structure” to refer to various external tools that can be built to cognitively help the activity of navigating in modern but also in “primitive” settings. Any written procedure is a simple example of a cognitive “mediating structure” with possible cognitive aims: “Language, cultural knowledge, mental

¹ Magnani (2001) introduces the concept of theoretical abduction. He maintains that 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., cf. below in this paper.

² Manipulative abduction and epistemic mediators are introduced and illustrated in Magnani (2001).

models, arithmetic procedures, and rules of logic are all mediating structures too. So are traffic lights, supermarkets layouts, and the contexts we arrange for one another's behavior. Mediating structures can be embodied in artifacts, in ideas, in systems of social interactions [...]” (pp. 290-291).

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 (for example exploiting the resources of visual imagery).³

The *hypothetical* character of manipulations in creativity is clear: they are a sort of test, they can be developed to examine further chances, they are a 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).

A Cognitive Theory of the Abductive Modeling Activity

We can say abduction is a complex *process* that works through *imagination*: it suggests a new direction in reasoning by *shaping* new possible ways for explaining object and hypotheses (cf. 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 doubt and states of belief. To solve the doubt, and some eventually linked anomalies, the agent implements a process of information gathering which at the same time relates to the “problem”, to the agent's evolving understanding of the situation and to its changing requirements. By imagination here I mean this process of knowledge gathering and shaping. A process, that Kant considered “blind”, 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 permits us to see some aspects of reality in a particular way and creativity relates to this capacity to shed new light. Suggestions which make us able to further analyze this process come from a theory developed in the area of computer vision: the *active perception* approach (see Thomas, 1999).

This approach aims at understanding 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 seen as 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 re-

sorts to the need of specifying how to efficiently examine and explore and to the need of “interpreting” an object of a certain type. It is a process of attentive and controlled perceptual exploration through which 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 (cf. Gibson, 1979).

As suggested for instance by Lederman and Klatzky (1990), this view of perception may be applied to all sense modes: for example, it can be easily extended to the haptic mode. Mere passive touch, in fact, tells 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: lifting something tells about its weight, running fingers around the contours provides shape information, rubbing it reveals texture. As already stressed by Peirce in the quotation I already reported above, when dealing with the hypothesizing activity of what I call manipulative abduction, “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” (CP 5.221).

Thomas (1999) suggests we can think of the fingers together with the neural structures that control, for example, running them so that we can consider 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 that I outlined above, can gain from this approach. To give an example, the role of particular epistemic mediators (*optical diagrams*) in non-standard analysis has been studied, and so their function in grasping and teaching abstract and difficult mathematical concepts (see Magnani and Dossena, 2002). In this case the external models (mathematical diagrams) do not give full available knowledge, but, on the contrary, compel the agent to engage a continuous epistemic dialogue between the diagrams and its internal knowledge to the aim of understanding an already existing information or at “creating” a new one (cf. also the geometrical example in the following section).

It is clear that humans and other animals make a great use of perceptual reasoning and kinesthetic abilities. We can catch a thrown ball, cross a busy street, read a musical score, go through a passage by imaging if we can contort our bodies to the way required, evaluate shape by touch, recognize that an obscurely seen face belongs to a friend of ours, etc. Usually the “computations” required to achieve these tasks are not accessible to a conscious description. Mathematical reasoning uses language explanations, but also non-linguistic notational devices and models. Geometrical constructions represent a relatively simple example of this kind of extra-linguistic machinery we know as characterized in a model-based and manipulative - abductive - way.

Creativity and Ethical Mediators

The active process of information gathering through *mediators*, to shape knowledge, should not be restricted to the

³ For example it is difficult to preserve precise spatial relationships using mental imagery, especially when one set of them has to be moved relative to another.

scientific activity and so to the “epistemic” side of them. An often neglected side of human creativity is, in fact, related to emotional, artistic, and ethical aspects, and concerns the active shaping of values in an esthetic or in an ethical world. In the case of morality the role of hypotheses and manipulation of the world is clear in Kant’s moral doctrine. When Kant considers pure moral rules, in fact, he says that they could be applied to the concrete experience through 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).

As already outlined above, 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 an “inferential” character. In decision making emotions play a distinguished role: they make the velocity of the decision process, 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 been 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 to create something new, for example new good reasons first which can 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 emerging from peoples’ and/or experts’ experience and thinking.

The role of cognitive delegations to external objects and structures has to be extended to the case of human actions and organizations, so viewed as cognitive “mediating” mechanisms endowed with moral aspects. In this light it is possible to introduce the concept of *ethical* (or *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 aimed 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 spontaneously 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 to carry information about each other. It is also well-known that also “trained” emotions⁴ play an important creative role in moral deliberations.

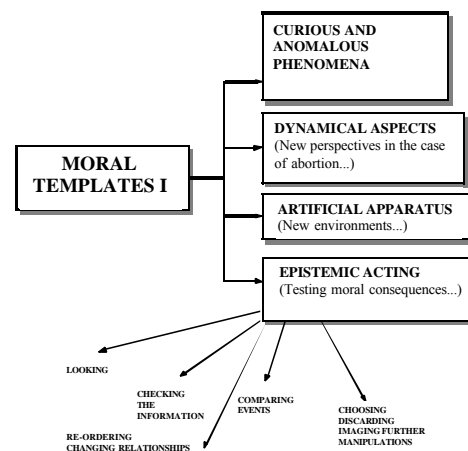


Figure 1. Conjectural moral templates I.

Templates of Moral Doing

It is difficult to establish a list of invariant behaviors that are able to illustrate manipulative reasoning in ethics. As illustrated above, certainly the expert manipulation of non-human objects in real or artificial environments implies the application of old and new *templates* of behavior that exhibit some regularities. As I have said it is important to remember they are embodied and implicit, as tacit forms of acting: I am not referring here to the moral actions and manipulations that simply follow previous explicit and devised plans. Anyway, this moral activity is still conjectural: these templates are embedded hypotheses of moral behavior (creative or already cognitively present in the people’s mind-body system, and ordinarily applied) that enable a kind of moral “doing”. Hence, some templates of action and manipulation can be *selected* in the set of those available and pre-stored, others have to be *created* for the first time to

⁴ That is not just shaped by biological evolution but also by cultural aspects.

perform the most interesting accomplishments of manipulative moral inference.

Some common features of these “tacit” templates that enable us to manipulate external human and non-human things and structures to achieve moral effects are related to (Figure 1): 1. sensibility to the aspects of the moral situation which can be regarded as *curious* or *anomalous*; manipulations can also be performed to be able to introduce potential inconsistencies in the received knowledge (we suddenly adopt a different attitude with respect to our wife/husband to get some reactions we can regard as interesting – or “unexpected” – to confirm or discard hypotheses about her/feelings or to develop further hypotheses about them; in an investigation about a crime we spontaneously engage further manipulations of the evidence to get more interesting data to morally shape the suspect); 2. preliminary sensibility to the *dynamical* character of the situation at hands, and not only to entities and their properties, common aim of manipulations is to practically reorder the dynamic sequence of the events correlated to the main problem to promote the subsequent possibility of new possibilities and options for action (a women in front of decision in favor of abortion spontaneously tries to modify the dynamical aspects of her behavior and the structure of her human relationships to try to establish new perspectives able to make her able to envisage a possible decision different from the first one first envisaged); 3. referral to manipulations that exploit *artificial* created feelings and environments to free new possibly stable and repeatable sources of information about hidden moral knowledge and constraints (when dealing with the moral problem of capital punishment we can spontaneously handle people, for example with statistics, interviews, scientific research, associations, to artificially reconfigure social orders in a way suitable to get real and not hypocritical information, for example about the real relief generated in the victim’s relatives by killing the criminal); 4. various contingent ways of spontaneous moral acting: *looking* from different perspectives, *checking* the different information available, *comparing* subsequent events, *choosing*, *discarding*, *imaging* further manipulations, *re-ordering* and *changing relationships* in the world by implicitly *evaluating* the usefulness of a new order (for instance, to help memory) (in the ethical case they certainly are all useful ways for getting suitable evidence and for stimulating the derivation of further consequences to test our previously established moral judgments; analogous of all these manipulative templates are active in epistemic settings, as illustrated in Magnani, 2001).

More features of our tacit templates and ethical mediators are related to the following additional issues (Figure 2): 5) moral spontaneous action that can be useful in presence of *incomplete* or *inconsistent* information – not only from the “perceptual” point of view – or of a diminished capacity to morally act upon the world: it is used to get more data to restore coherence and/or to improve deficient knowledge; 6) action as a *control of sense data* illustrates how we can change the position of our body (and/or of the external objects) to reconfigure social orders, collective relationships, and how to exploit various kinds of artificially created events to get various new kinds of stimulation: action pro-

vides some tactile, visual, kinesthetic, sentimental, emotional, and bodily information (e.g. in taking care of people, cf. below in the following subsection), otherwise unavailable; 7) action enables us to build new *external artifactual models* of ethical mechanisms and structures (for example through “institutions”) instead of the corresponding “real” and “natural” ones.⁵ For instance, we can substitute to the “natural” structure “family” an environment more adequate to agent’s moral needs. In this case we aim at reconfiguring relationships for instance when we exploit the social reshaping role of the “houses” were children molested inside family are recovered, to rebuild in a whole artificial framework their moral perception for example of the sexual molestation received and of the related bad feelings. Something similar occurs in the case of the addicted people. We also establish structures to implicitly favor good manners, for example fences, barriers in the lines, etc.

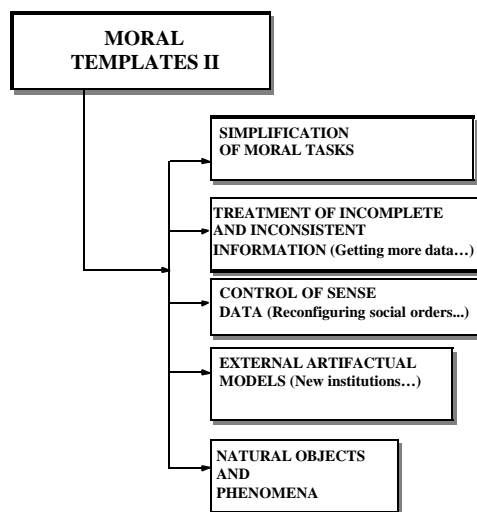


Figure 2. Conjectural moral templates II.

Moral Mediators

The whole activity of manipulation is also devoted to build various external *moral mediators*⁶ that function as an enormous new source of information and knowledge. Therefore, 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 (for example exploiting the resources in terms of merely internal/mental moral principles, utilitarian envisaging, and model-based moral reasoning).

⁵ Of course these “real” and “natural” structures are also artificial, because we can think of a “family” as a kind of not merely natural institution.

⁶ I derive this expression from the one “epistemic mediators” I introduced in Magnani (2001, chapter 3): these consist of external representations, objects, and artifacts that are relevant in scientific discovery and reasoning processes.

Not only a way for moving the world to desirable states, action performs a moral and not just merely performatory role: people structure their worlds to simplify and solve moral tasks when they are in presence of incomplete information or possess a diminished capacity to morally act upon the world when they have insufficient opportunities to know. *Moral mediators* are also used to exploit latent constraints in the human-environment system. These elicited new constraints grant us additional and precious ethical information: when we spontaneously act in a way in which we spend more quality time with our partner to save our marriage, then our actions automatically 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

Conclusion

What I call *theoretical abduction* (sentential and manipulative) certainly illustrates much of what is important in creative abductive reasoning both in humans and computational programs, especially the objective of selecting and creating a set of hypotheses that are able to dispense good (preferred) explanations of data, but fails to account for many cases of explanations occurring in science or in everyday reasoning when the exploitation of the environment is crucial. The concept of *manipulative abduction* is devoted to capture the role of action in many interesting situations: action provides otherwise unavailable information that enables the agent to solve problems by starting and performing a suitable abductive process of generation or selection of hypotheses. Many external things, even if usually inert from the epistemological point of view, can be transformed into what is called *epistemic mediators*, which are illustrated in the second part of this paper, together with an analysis of the related notion of “external representation steps in a way that discharges the “internal” mind of a computational load. To define a cognitive system it seems we can no longer identify it only with internal processing devices.

By exploiting the concept of “thinking through doing” and of manipulative abduction I have tried to shed new light on some of the most interesting cognitive aspects of creative ethical reasoning of what I call “ethical mediators”. Indeed, I contend that the whole activity of manipulation can be seen as an activity for building various external “ethical mediators” that function as an enormous new source of information and knowledge. Furthermore, while describing morality “through doing” a list of “moral templates” as forms of invariant behaviors that are able to illustrate manipulative ethical reasoning is furnished. These templates are forms of behavior which are inclined towards providing ethical outcomes. The application of old and new (creative) moral templates of behavior exhibits some regularities and expresses expert manipulation of human and non-human objects in real or artificial environments. These templates are embodied and implicit as tacit forms of acting. They are embedded hypotheses of moral behavior (creative or already

cognitively present in the people’s mind-body system, and ordinarily applied) that enable a kind of moral “doing”. Hence, some templates of action and manipulation can be selected in the set of those available and pre-stored, while others have to be created for the first time in order to perform the most interesting accomplishments of manipulative moral inferences. These “tacit” templates enable us to manipulate external human and non-human things and structures to achieve moral effects.

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