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Abductive Theory of Cognition. The Eco-Cognitive Model

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Abstract Abduction is a procedure in which something that lacks classical explanatory epistemic virtue can be accepted because it possesses a virtue of another type: Gabbay and Woods contend (GW- Model) that abduction presents an *ignorance-preserving* or (ignorance-mitigating) character (GABBAY – WOODS 2005). From this point of view abductive reasoning is a *response* to an ignorance-problem. Abductive reasoning is an ignorance-preserving accommodation of the problem at hand. Is abduction really ignorance- preserving? To better answer this question I will describe my *eco-cognitive model* (EC-model) of abduction some examples taken from the areas of both philosophy and epistemology. It will be demonstrated that through abduction, knowledge can be enhanced, even when abduction is not considered an inference to the best explanation in the classical sense of the expression, that is an inference inevitably characterized by an empirical evaluation stage, or an inductive stage, as Peirce called it. Peirce provides various justifications of the knowledge-enhancing role of abduction, even when abduction is not conceived an inference to the best explanation, that is an inference inevitably characterized by an empirical evaluation phase, as I just said. These justifications basically resort to the conceptual use of *evolutionary* and *metaphysical* ideas, which resort to indicate that abduction is constitutively akin to truth, even if certainly always ignorance-preserving or mitigating in the sense that the "absolute truth" is never reached through abduction. Finally, other two examples of knowledge-enhancing abduction will be indicated: abducing *conventions* and abducing *scientific models*.

Keywords: abduction, ignorance-preservation, EC-Model, creativity.

> There never was a sounder logical maxim of scientific procedure than Ock- ham's razor: Entia non sunt multiplicanda praeter necessitatem. That is to say; before you try a complicated hypothesis, you should make quite sure that no simplification of it will explain the facts equally well.
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> Charles Sanders Peirce, *Pragmatism and Pragmaticism*, 1903

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1. Abduction as a Kind of Ignorance-Preserving Cognition

As I have described in my book on abductive cognition, (MAGNANI, Lorenzo (2009: chapter two) following Gabbay and Woods' contention, it is clear that "[…] abduction is a procedure in which something that lacks epistemic virtue is accepted because it has virtue of another kind" (GABBAY, Dov – WOODS, John (2005: p. 62). For example: "Let *S* be the standard that you are not able to meet (e.g., that of mathematical proof). It is possible that there is a lesser epistemic standard *S'* (e.g., having reason to believe) that you do meet" (WOODS, John (2013: p. 370). Concentrating the attention on this cognitive feature of abduction, and adopting a logical framework centered on practical agents, (GABBAY, Dov – WOODS, John (2005) maintain that abduction (seen as a *scant-resource* strategy, which proceeds in absence of knowledge) presents an *ignorance-preserving* (or, better, an *ignorance mitigating*) character. Of course "[…] it is not at all necessary, or frequent, that the abducer be wholly in the dark, that his ignorance be total. It needs not be the case, and typically isn't, that the abducer's choice of a hypothesis is a blind guess, or that nothing positive can be said of it beyond the role it plays in the subjunctive attainment of the abducer's original target (although sometimes this is precisely so)" (WOODS, John (2013: p. 249). Hence, abductive reasoning is a *response* to an ignorance-problem: one has an ignorance-problem when one has a cognitive target that cannot be attained on the basis of what one currently knows. Typically ignorance problems trigger one or other of three responses. In the first case, one overcomes one's ignorance by attaining some additional knowledge (subduance). In the second instance, one yields to one's ignorance (at least for the time being) (surrender). In the third instance, one abduces (WOODS, John (2013: chapter eleven) and so has some positive basis for new action even if in the presence of the constitutive ignorance.

From this perspective the general form of an abductive inference can be formally rendered as follows. Let α be a proposition with respect to which you have an ignorance problem. Putting T for the agent's epistemic target with respect to the proposition α at any given time, K for his knowledge-base at that time, K^* for an immediate accessible successor-base of K that lies within the agent's means to produce in a timely way,[1] R as the attainment relation for T, $\tilde{A}$ as the *subjunctive* conditional relation, H as the agent's hypothesis, $K(H)$ as the revision of K upon the addition of H, $C(H)$ denotes the conjecture of H and H^C its activation. The general structure of abduction can be illustrated as follows (GW-schema)[2]:

1. $T!\alpha$	[setting of T as an epistemic target with respect to a proposition α]
2. $\neg(R(K, T))$	[fact]
3. $\neg(R(K*, T))$	[fact]

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[1] K^* is an accessible successor of K to the degree that an agent has the know-how to construct it in a timely way; i.e., in ways that are of service in the attainment of targets linked to K. For example if I want to know how to spell "accommodate", and have forgotten, then my target can't be hit on the basis of K, what I now know. But I might go to my study and consult the dictionary. This is K^*. It solves a problem originally linked to K.

[2] That is Gabbay and Woods Schema.

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4. $H \notin K$ [fact]

5. $H \notin K^{*}$ [fact]

6. $\neg R(H,T)$ [fact]

7. $\neg R(K(H),T)$ [fact]

8. If $H \rightsquigarrow R(K(H),T)$ [fact]

9. H meets further conditions $S_1 , ..., S_n$ [fact]

10. Therefore, $C(H)$ [sub-conclusion, 1-9]

11. Therefore, H^C [conclusion, 1-10].

It is simple to see that the typical epistemic feature of abduction is captured by the schema. It is a given that H is not in the agent's knowledge-set. Nor is it in its immediate successor. Since H is not in K, then the revision of K by H is not a knowledge-successor set to K. Even so, $H \rightsquigarrow (K(H),T))$. So we have an ignorance-preservation, as required (cf. WOODS, John (2013: p. 370).

[*Note*: Basically, line 9. indicates that H has no more plausible or relevant rival constituting a greater degree of subjunctive attainment. Characterizing the S_i is the most difficult problem for abductive cognition, given the fact that in general there are many possible candidate hypotheses. It involves for instance the *consistency* and *minimality* constraints. These constraints correspond to the lines 4 and 5 of the standard AKM schema of abduction,[3] which is illustrated as follows:

1. E
2. $K/\nrightarrow E$
3. $H/\nrightarrow E$
4. $K(H)$ is consistent
5. $K(H)$ is minimal
6. $K(H) \rightsquigarrow E$
7. Therefore, H
(GABBAY, Dov – WOODS, John (2005: pp. 48–49)

where of course the conclusion operator $\rightsquigarrow$ cannot be classically interpreted][4].

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[3] The classical schematic representation of abduction is expressed by what (GABBAY, Dov – WOODS, John (2005) call AKM-schema, which is contrasted to their own (GW-schema), which I am just explaining in this subsection. For A they refer to Aliseda (ALISEDA, Atocha (1997, ALISEDA, Atocha (2006), for K to Kowalski (KOWALSKI, Robert (1979), Kuipers (KUIPERS, Theo (1999), and Kakas *et al.* (KAKAS, Antonis – KOWALSKI, Robert – TONI, F. (1993), for M to Magnani (MAGNANI, Lorenzo (2001) and Meheus (MEHEUS, *Joke* – VERHOEVEN, Liza – VAN DYCK, Maarten and PROVIJN, Dagmar (2002). A detailed illustration of the AKM schema is given in (MAGNANI, Lorenzo (2009: chapter two, subsection 2.1.3).

[4] The target has to be an explanation and $K(H)$ bears R^{pres} [that is the relation of presumptive attainment] to T only if there is a proposition V and a consequence relation $\rightsquigarrow$ such that $K(H) \rightsquigarrow V$, where V represents a *payoff proposition* for T. In turn, in this schema explanations are interpreted in consequentialist terms. If E is an explanans and E' an explanandum the first explains the second only

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Finally, in the GW-schema $C(H)$ is read "It is justified (or reasonable) to conjecture that H" and H^C is its activation, as the basis for *planned* "actions".

In summary, in the GW-schema T cannot be attained on the basis of K. Neither can it be attained on the basis of any successor K^* of K that the agent knows then and there how to construct. H is not in K: H is a hypothesis that when reconciled to K produces an updated $K(H)$. H is such that if it were true, then $K(H)$ would attain T. The problem is that H is *only hypothesized*, so that the truth is not guaranteed. Accordingly Gabbay and Woods maintain that $K(H)$ *presumptively* attains T. That is, having hypothesized that H, the agent just "presumes" that his target is now attained. Given the fact that presumptive attainment is not attainment, the agent's abduction must be considered as preserving the ignorance that already gave rise to her (or its, in the case for example of a machine) initial ignorance-problem. Accordingly, abduction does not have to be considered the "solution" of an ignorance problem, but rather a response to it, in which the agent reaches presumptive attainment rather than actual attainment. $C(H)$ expresses the conclusion that it follows from the facts of the schema that H is a worthy object of conjecture. It is important to note that in order to solve a problem it is not necessary that an agent actually conjectures a hypothesis, but it is necessary that she states that the hypothesis is *worthy of conjecture*.

In short, considering H justified to conjecture is not equivalent to considering it justified to accept/activate it and eventually to send H to experimental evaluation. H^C denotes the *decision* to release H for further work in the domain of enquiry in which the original ignorance-problem arose, that is the activation of H as a positive *cognitive* basis for action. Woods usefully observes:

> There are lots of cases in which abduction stops at line 10, that is, with the conjecture of the hypothesis in question but not its activation. When this happens, the reasoning that generates the conjecture does not constitute a positive basis for new action, that is, for acting *on* that hypothesis. Call these abductions *partial* as opposed to full. Peirce has drawn our attention to an important subclass of partial abductions. These are cases in which the conjecture of H is followed by a decision to submit it to experimental test. Now, to be sure, doing this is an action. It is an action *involving H* but it is not a case of acting *on* it. In a full abduction, H is activated by being released for inferential work in the domain of enquiry within which the ignorance-problem arose in the first place. In the Peircean cases, what counts is that H is withheld from such work. Of course, if H goes on to test favorably, it may then be released for subsequent inferential engagement. But that is not abduction. It is induction (WOODS, John (2013: p. 371).

We have to note that this process of evaluation and so of activation and adoption of the hypothesis, is not abductive, but inductive, as Peirce postulated. Woods adds: "Epistemologists of risk-averse bent might be drawn to the idea that what I am calling partial abduction is as good as abduction ever gets and that complete abduction, inference-activation and all, is a mistake that leaves any action prompted by it without an adequate rationale. This is not an unserious objection. Suffice it to say that there are real life contexts of reasoning in which such conservatism is given

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if (some authors further contend if and only if) the first implies the second. It is obvious to add that the AKM schema embeds a D-N (deductive-nomological) interpretation of explanation, as I have already stressed in (MAGNANI, Lorenzo (2001: p. 39).

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short shrift, in fact is ignored altogether. One of these contexts is the criminal trial at common law. Another is various kinds of common sense reasoning" (WOODS, John (2013: p. 371).

In the perspective of the GW-schema it cannot be said that testability is intrinsic to abduction, such as it is instead contended in the case of some passages of Peirce's writings.[5] This activity of testing, I repeat, which in turn involves degrees of risk proportioned to the strength of the conjecture, is rigorously cognitive/epistemic and inductive in itself, an experimental test, and it is an intermediate step to release the abduced hypothesis for inferential work in the domain of enquiry within which the ignorance-problem arose.

Through abduction the basic ignorance – that does not have to be considered total "ignorance" – is neither solved nor left intact: it is an ignorance-preserving adjustment of the problem at hand, which "mitigates" the initial cognitive "irritation" (Peirce says "the irritation of doubt").[6] As I have already stressed, further action can be triggered – in a defeasible way – either to find further abductions or to "solve" the ignorance problem, possibly leading to what the "received view" has called the *inference to the best explanation* (IBE).

It is clear that in the perspective of the GW-schema the inference to the best explanation – if considered as a truth conferring achievement justified by the empirical approval – cannot be a case of abduction, because abductive inference is constitutively ignorance-preserving. In this perspective the inference to the best explanation involves the generalizing and evaluating role of *induction*. Of course it can be said that the requests of originary thinking are related to the depth of the abducer's ignorance.

2. Abduction as Evidentially Inert Knowledge-Enhancing Cognition
2.1. The Eco-Cognitive Model (EC-Model) of Abduction: Cutdown and Fill-Up Problems

From a general philosophical perspective (with, and beyond, Peirce) the condition 9. (cf. the GW-schema) is, as Woods himself says "more a hand-wave than a real condition. Of course the devil is in the details. […] I myself I am not sure" (WOODS, John (2011: p. 242). Obviously consistency and minimality constraints were stressed in the "received view" on abduction illustrated by many classical logical accounts, more oriented to describe selective abduction (MAGNANI, Lorenzo (2001) – for example in diagnostic reasoning, where abduction is merely seen as an activity of "selecting" from an encyclopedia of pre-stored hypotheses – than to analyze *creative* abduction (abduction that generates new hypotheses)[7].

For example, to emphasize the puzzling status of the consistency requirement, it is here sufficient to note that Paul Feyerabend, in *Against Method* (FEYERABEND, Paul Karl (1975), appropriately attributes a great relevance to the role of contradiction in generating hypotheses, also against the role of similarity, and so implicity celebrates the value of creative abductive cognition. Speaking of induction and not of

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[5] When abduction ends at line 10. (cf. the GW-schema), the agent is not prepared to accept $K(H)$, because of supposed adverse consequences.

[6] "The action of thought is excited by the irritation of doubt, and ceases when belief is attained; so that the production of belief is the sole function of thought" (PEIRCE, Chales Sanders (1987: p. 261).

[7] I have proposed the dichotomic distinction between selective and creative abduction in (MAGNANI, Lorenzo (2001).

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abduction (this concept was relatively unknown at the level of the international philosophical community at that time), he establishes a new "counterrule". This is the opposite of the neopositivistic one that it is "experience" (or "experimental results") which constitutes the most important part of our scientific empirical theories, a rule that formed the core of the so-called "received view" in philosophy of science (where inductive generalization, confirmation, and corroboration play a fundamental role). The counterrule "[…] advises us to introduce and elaborate hypotheses which are inconsistent with well-established theories and/or well-established facts. It advises us to proceed counterinductively" (FEYERABEND, Paul Karl (1975: p. 20). Counterinduction is seen more reasonable than induction, because appropriate to the needs of creative reasoning in science: "[…] we need a dream-world in order to discover the features of the real world we think we inhabit" (p. 29). We know that counterinduction, that is the act of introducing, inventing, and generating new inconsistencies and anomalies, together with new points of view incommensurable with the old ones, is congruous with the aim of inventing "alternatives" (Feyerabend contends that "proliferation of theories is beneficial for science"), and very important in all kinds of creative reasoning.

Since for many abduction problems there are usually many guessed hypotheses, the abducer needs reduce this space to one. This means that the abducer has to generate the best choice among the members of the available group: "It is extremely difficult to see how this is done, both formally and empirically. Clause (9) [in the GW-model] is a place-holder for two problems, not one. There is the problem of finding criteria for hypothesis *selection*. But there is the prior problem of specifying the conditions for *thinking up* possible candidates for selection. The first is a 'cutdown' problem. The second is a 'fill-up problem'; and with the latter comes the received view that it is not a problem for logic" (WOODS, John (2011: p. 243, emphasis added).

Here we touch the core of the ambiguity of the ignorance-preserving character of abduction. Why?

- Because the cognitive processes of generation (fill-up) and of selection (cutdown) can both be completely sufficient – even in absence of the standard inductive evaluation phase – to *activate* and accept [clause (11) of the GW-schema above] an abductive hypothesis, and so to reach cognitive results relevant to the context (often endowed with a knowledge-enhancing outcome, such as in the case of abducing conventions in science and of abducing scientific models. In these cases the instrumental aspects (which simply enable one's target to be hit) often favor both abductive generation and abductive choice, and they are not necessarily intertwined with plausibilistic concerns, such as consistency and minimality.

In these special cases the best choice is instantly reached without the help of an experimental trial (which fundamentally characterizes the received view of abduction in terms of the so-called "inference to the best explanation"). Not only, we have to strongly note that the generation process alone can suffice, like it is demonstrated by the case of human *perception*, where the hypothesis generated is immediate and unique. Indeed, perception is considered by Peirce, as an "abductive" fast and uncontrolled (and so automatic) knowledge-production procedure. Perception, in this philosophical perspective, is a vehicle for the instantaneous retrieval of knowledge that was previously structured in our mind through more structured inferential processes. Peirce says: "Abductive inference shades into perceptual judgment

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without any sharp line of demarcation between them" (PEIRCE, Chales Sanders (1955: p. 304). By perception, knowledge constructions are so instantly reorganized that they become habitual and diffuse and do not need any further testing: "[…] a fully accepted, simple, and interesting inference tends to obliterate all recognition of the uninteresting and complex premises from which it was derived" (PEIRCE, Chales Sanders (1931-1958: 7.37).

My reference to perception as a case of abduction (in this case I strictly follow Peirce) does not have to surprise the reader. Indeed, at the of center of my perspective on cognition is the emphasis on the "practical agent", of the individual agent operating "on the ground", that is, in the circumstances of real life. In all its contexts, from the most abstractly logical and mathematical to the most roughly empirical, I always emphasize the cognitive nature of abduction. Reasoning is something performed by cognitive systems. At a certain level of abstraction and as a first approximation, a cognitive system is a triple (A,T,R), in which A is an *agent*, T is a *cognitive target* of the agent, and R relates to the *cognitive resources* on which the agent can count in the course of trying to meet the target-information, time and computational capacity, to name the three most important. My agents are also *embodied distributed cognitive systems*: cognition is embodied and the interactions between brains, bodies, and external environment are its central aspects. Cognition is occurring taking advantage of a constant exchange of information in a complex distributed system that crosses the boundary between humans, artifacts, and the surrounding environment, where also instinctual and unconscious abilities play an important role. This interplay is especially manifest and clear in various aspects of abductive cognition.

It is in this perspective that we can appropriately consider perceptual abduction as a fast and uncontrolled knowledge production, that operates for the most part automatically and out of sight, so to speak. This means that – at least in this light – GW-schema is not canonical for abduction. The schema illustrates what I call "sentential abduction" (MAGNANI, Lorenzo (2009, chapter one), that is, abduction rendered by symbols carrying propositional content. It is hard to encompass in this model cases of abductive cognition such as perception or the generation of models in scientific discovery (cf. MAGNANI, Lorenzo (2012). My perspective adopts the wide Peircean philosophical framework, which approaches "inference" *semiotically* (and not simply "*logically*"): Peirce distinctly says that all inference is a form of sign activity, where the word sign includes "feeling, image, conception, and other representation" (PEIRCE, Chales Sanders (1931-1958: 5.283). It is clear that this semiotic view is considerably compatible with my perspective on cognitive systems as embodied and distributed systems: the GW-Schema is instead only devoted to illustrate, even if in a very efficacious way, a subset of the cognitive systems abductive activities, the ones that are performed taking advantage of explicit propositional contents. Woods seems to share this conclusion: "[…] the GW-model helps get us started in thinking about abduction, but it is nowhere close, at any level of abstraction, to running the whole show. It does a good job in modelling the ignorance-preserving character of abduction; but, since it leaves the S_i of the schema's clause (T) unspecified, it makes little contribution to the fill-up problem" (WOODS, John (2011: p. 244).

In a wide eco-cognitive perspective the cutdown and fill-up problems in abductive cognition appear to be spectacularly *contextual*. I lack the space to give this issue appropriate explanation but it suffices for the purpose of this study to remember that,

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for example, one thing is to abduce a model or a concept at the various levels of scientific cognitive activities, where the aim of reaching rational knowledge dominates, another thing is to abduce a hypothesis in literature (a fictional character for example), or in moral reasoning (the adoption/acceptance of a hypothetical judgment as a trigger for moral actions). However, in all these cases abductive hypotheses which are evidentially inert are accepted and activated as a basis for action, even if of different kind.

The backbone of this approach can be found in the manifesto of my EC-model of abduction in (MAGNANI, Lorenzo (2009). It might seem awkward to speak of "abduction of a hypothesis in literature," but one of the fascinating aspects of abduction is that not only it can warrant for scientific discovery, but for other kinds of creativity as well. We must not necessarily see abduction as a *problem solving device* that sets off in response to a cognitive irritation/doubt: conversely, it could be supposed that esthetic abductions (referring to creativity in art, literature, music, etc.) arise in response to some kind of esthetic irritation that the author (sometimes a *genius*) perceives in herself or in the public. Furthermore, not only esthetic abductions are free from empirical constraints in order to become the "best" choice: as I am showing throughout this paper, many forms of abductive hypotheses in traditionally-perceived-as-rational domains (such as the setting of initial conditions, or axioms, in physics or mathematics) are relatively free from the need of an empirical assessment. The same could be said of moral judgement: they are eco-cognitive abductions, inferred upon a range of internal and external cues and, as soon as the judgment hypothesis has been abduced, it immediately becomes prescriptive and "true," informing the agent's behavior as such. Assessing that there is a common ground in all of these works of what could be broadly defined as "creativity" does not imply that all of these forms of creativity are the same, contrarily it should spark the need for firm and sensible categorization: otherwise it would be like saying that to construct a doll, a machine-gun and a nuclear reactor are all the same thing because we use our hands in order to do so!

To conclude this subsection I have to say some words about the role of heuristics. From an eco-cognitive point of view, in more hybrid and multimodal (cf. MAGNANI, Lorenzo (2009: chapter four) (not merely inner) abductive processes, such as in the case of manipulative abduction,[8] the *assessment/acceptation* of a hypothesis is reached – and constrained – taking advantage of the gradual acquisition of consecutive external information with respect to future interrogation and control, and not necessarily thanks to a final and actual experimental test, in the classical sense of empirical science.

In summary, at least four kinds of actions can be involved in the manipulative abductive processes (and we would have to also take into account the motoric aspect (*i*) of inner "thoughts" too). In the eco-cognitive interplay of abduction the cognitive agent further triggers internal *thoughts* "while" modifying the environment and so (*ii*) acting on it (thinking through doing). In this case the "motor actions" directed to

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[8] The concept of *manipulative abduction* – which also takes into account the external dimension of abductive reasoning in an eco-cognitive perspective – captures a large part of scientific thinking where the role of action and of external models (for example diagrams) and devices 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 and/or selection of hypotheses. Manipulative abduction happens when we are thinking through doing and not only, in a pragmatic sense, about doing (cf. MAGNANI, Lorenzo (2009: chapter one).

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the environment have to be intended as part and parcel of the whole embodied abductive inference, and so have to be distinguished from the *final* (*iii*) "actions" as a possible consequence of the reached abductive result.

In this perspective the proper experimental test involved in the Peircean evaluation phase, which for many researchers indicates in the most acceptable way the idea of abduction as inference to the best explanation, just constitutes a *special* subclass of the process of the adoption of the abductive hypothesis – the one which involves a final kind (*iv*) of actions (experimental tests), and should be considered ancillary to the nature of abductive cognition, and inductive in its essence. We have indeed to observe again that in Peirce's mature perspective on abduction as embedded in a cycle of reasoning, induction just plays an evaluative role.

2.2. Abductive Virtues Vindicated. How Does Abduction Supply Knowledge?

Even if abduction, in the perspective of the formal GW-model above, is ignorance-preserving (or ignorance mitigating), truth can easily emerge: we have to remember that Peirce sometimes contended that abduction "come to us as a flash. It is an act of insight" (PEIRCE, Chales Sanders (1931-1958: 5.181) but nevertheless possesses a mysterious power of "guessing right" (PEIRCE, Chales Sanders (1931-1958: 6.530). Consequently abduction, preserves ignorance, in the logical sense I have described above, but also can provide truth because has the power of guessing *right*. We have also contended that in the logical framework above the inference to the best explanation – if considered as a truth conferring achievement justified by empirical approval – cannot be a case of abduction, because abductive inference is instead constitutively ignorance-preserving.

If we say that truth can be reached through a "simple" abduction (not intended as involving an evaluation phase, that is coinciding with the whole inference to the best explanation, fortified by an empirical evaluation), it seems we face with a manifest incoherence. In this perspective it is contended that even simple abduction can provide truth, even if it is epistemically "inert" from the empirical perspective. Why? We can solve the incoherence by observing that we should be compelled to consider abduction as ignorance-preserving only if we consider the empirical test *the only way* of conferring truth to a hypothetical knowledge content. This clause being accepted, in the framework of the technical logical model of abduction I have introduced above the ignorance preservation appears natural and unquestionable. However, if we admit that there are ways to accept a hypothetical knowledge content different from the empirical test, simple abduction is not necessarily constitutively ignorance-preserving: in the end we are dealing with a disagreement about the nature of *knowledge*, as Woods himself contends. As I have indicated at the end of the previous subsection, those who consider abduction as an inference to the best explanation – that is as a truth conferring achievement involving empirical evaluation – obviously cannot consider abductive inference as ignorance-preserving. Those who consider abduction as a mere activity of guessing are more inclined to accept its ignorance-preserving character.

However, we are objecting that abduction can be in this last case still knowledge-enhancing.

At this point two important consequences concerning the meaning of the word *ignorance* in this context have to be illustrated:

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(1) abduction, also when intended as an inference to the best explanation in the "classical" sense I have indicated above, is always *ignorance-preserving* because abduction represents a kind of reasoning that is constitutively provisional, and you can withdraw previous abductive results (even if empirically confirmed, that is appropriately considered "best explanations"), in presence of new information. From the logical point of view this means that abduction represents a kind of nonmonotonic reasoning, and in this perspective we can even say that abduction interprets the "spirit" of modern science, where truths are never stable and absolute. Peirce also emphasized the "marvelous self-correcting property of reason" in general (PEIRCE, Chales Sanders (1931-1958: 5.579). So to say, abduction incarnates the human perennial search of new truths and the human Socratic awareness of a basic ignorance which can only be attenuated/mitigated. In sum, in this perspective abduction always preserves ignorance because it reminds us we can reach truths that can always be withdrawn; ignorance removal is at the same time constitutively related to ignorance regaining;

(2) even if ignorance is preserved in the sense I have just indicated, which coincides with the spirit of modern science, abduction is also knowledge-enhancing because new truths can be and "are" discovered which are not necessarily best explanations intended as hypotheses which are empirically tested.

A similar argumentation, which resorts to better explain the problem of abduction as ignorance-preserving, is provided by Woods, who notes that some philosophers accept the Gabbay-Woods schema (GW-schema) for abduction but at the same time dislike its commitment to the ignorance-preservation claim. Woods' answer resorts to say that this hesitancy flows from how those philosophers *epistemologically* approach the general question of knowledge. It is not logic of abduction in question but the epistemological adopted perspective (WOODS, John (2013: chapter eleven). I have just contended that knowledge can be attained in the absence of evidence; there are propositions about the world which turn to be true by virtue of considerations that lend them no evidential/empirical weight. They are true beliefs that are not justified on the basis of evidence. Is abduction related to the generation of knowledge contents of this kind? Yes it is.

Abduction is guessing reliable hypotheses, and humans are very good at it; abduction is akin to truth: it is especially in the case of empirical scientific cognition that abduction reveals its more representative epistemic virtues, because it provides hypotheses, models, ideas, thoughts experiments, etc., which, even if *devoid of initial* evidential support, constitute the fundamental rational building blocks for the generation of new laws and theories which only later on will be solidly empirically tested.

In the following subsection I will illustrate this intrinsic character of abduction, which shows why we certainly can logically consider it a kind of ignorance-preserving cognition, but at the same time a cognitive process that can enhance knowledge at various level of human cognitive activities, even if the empirical evaluation lacks.

2.3. Why Does Abduction Enhance Knowledge? Instinct, Inference, and Synechism: Mind and Matter Intertwined

Peirce provides various justifications of the productive knowledge-enhancing role of abduction. They basically resort to the conceptual exploitation of evolutionary and

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metaphysical ideas, which clearly show that abduction is constitutively akin to truth, certainly ignorance-preserving – because the "absolute truth" is never reached through abduction – but also knowledge-enhancing. Peirce himself notes that abductive guesses are belief-inducing and truth making. Not only, it cannot be said that unevidenced belief is itself evidence of malfunction and disorder, and so of falsity.

First of all Peirce considers hypothesis generation a largely instinctual endowment[9] of human beings given by God or related to a kind of Galilean "*lume naturale*": "It is a primary *hypothesis* underlying all abduction that the human mind is akin to the truth in the sense that in a finite number of guesses it will light upon the correct hypothesis" (PEIRCE, Chales Sanders (1931-1958: 7.220). Again, the example of the innate ideas of "every little chicken" is of help to describe this human instinctual endowment:

> How was it that man was ever led to entertain that true theory? You cannot say that it happened by chance, because the possible theories, if not strictly innumerable, at any rate exceed a trillion – or the third power of a million; and therefore the chances are too overwhelmingly against the single true theory in the twenty or thirty thousand years during which man has been a thinking animal, ever having come into any man's head. Besides, you cannot seriously think that every little chicken, that is hatched, has to rummage through all possible theories until it lights upon the good idea of picking up something and eating it. On the contrary, you think the chicken has an innate idea of doing this; that is to say, that it can think of this, but has no faculty of thinking anything else. The chicken you say pecks by instinct. But if you are going to think every poor chicken endowed with an innate tendency toward a positive truth, why should you think that to man alone this gift is denied? (PEIRCE, Chales Sanders (1931-1958: 5.591).

The naturalistic view of instinct involves at least two aspects: *evolutionary/adaptive* and *perceptual* – as a "certain insight" (PEIRCE, Chales Sanders (1931-1958: 5.173): the instinctual insight that leads to a hypothesis is considered by Peirce to be of "the same general class of operations to which Perceptive Judgments belong"[10] (*ibid*.) Hence, Peirce considers the capacity to guess correct hypotheses as instinctive and enrooted in our evolution and from this perspective abduction is surely a property of naturally evolving organisms:

> If you carefully consider with an unbiased mind all the circumstances of the early history of science and all the other facts bearing on the question […] I am quite sure that you must be brought to acknowledge that man's mind has a natural adaptation to imagining correct theories of some kind, and in particular to correct theories about forces, without some glimmer of which he could not form social ties and consequently could not reproduce his kind (PEIRCE PEIRCE, Chales Sanders (1931-1958: 5.591).

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[9] Instinct is of course in part conscious: it is "always partially controlled by the deliberate exercise of imagination and reflection" (PEIRCE, Chales Sanders (1931-1958: 7.381).

[10] I have described perception as abduction in the subsection 2.1 above.

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Peirce also says "Thought is not necessarily connected with brain. It appears in the work of bees, of crystals, and throughout the purely physical world; and one can no more deny that it is really there, than that the colours, the shapes, etc., of objects are really there" (PEIRCE, Chales Sanders (1931-1958: 4.551). It is vital to explain the meaning of this important statement.

First of all it has to be noted that instincts themselves can undergo modifications through evolution: they are "inherited habits, or in a more accurate language, inherited dispositions" (PEIRCE, Chales Sanders (1931-1958: 2.170). Elsewhere Peirce seems to maintain that instinct is not really relevant in scientific reasoning but that it is typical of just "the reasoning of practical men about every day affairs". So as to say, we can perform instinctive abduction (that is not controlled, not "reasoned") in practical reasoning, but this is not typical of scientific thinking:

> These two [practical and scientific reasoning] would be shown to be governed by somewhat different principles, inasmuch as the practical reasoning is forced to reach some definite conclusion promptly, while science can wait a century or five centuries, if need be, before coming to any conclusion at all. Another cause which acts still more strongly to differentiate the methodeutic of theoretical and practical reasoning is that the latter can be regulated by instinct acting in its natural way, while theory of how one should reason depends upon one's ultimate purpose and is modified with every modification of ethics. Theory is thus at a special disadvantage here; but instinct within its proper domain is generally far keener, and surer, and above all swifter, than any deduction from theory can be. Besides, logical instinct has, at all events, to be employed in applying the theory. On the other hand, the ultimate purpose of pure science, as such, is perfectly definite and simple; the theory of purely scientific reasoning can be worked out with mathematical certainty; and the application of the theory does not require the logical instinct to be strained beyond its natural function. On the other hand, if we attempt to apply natural logical instinct to purely scientific questions of any difficulty, it not only becomes uncertain, but if it is heeded, the voice of instinct itself is that objective considerations should be the decisive ones[11].

I think that the considerations above do not mean, as some commentators seem to maintain (RESCHER, Nicholas (1995, HOFFMANN, Michael (1999, PAAVOLA, Sami (2005), that instinct – as a kind of mysterious, not analyzed, guessing power – "does not" operate at the level of conscious inferences as in the case of scientific reasoning. I think a better interpretation is the following that I am proposing here: certainly instinct, which I consider a simple and not a mysterious endowment of human beings, is at the basis of both "practical" and scientific reasoning, in turn instinct shows the obvious origin of both in natural evolution. If every kind of cognitive activity is rooted in a hybrid interplay with external sources and representations, which exhibit their specific constraints and features, it does not appear surprising that "[…] the instincts conducive to assimilation of food, and the instincts conducive to reproduction, must have involved from the beginning certain tendencies to think truly about physics, on the one hand, and about psychics, on the other. It is somehow more than a *mere* figure of speech to say that nature fecundates the mind of man with ideas which, when those ideas grow up, will resemble their

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[11] Cf. Arisbe Website, http://www.cspeirce.com/menu/library/bycsp/l75/ver1/l75v1-01.htm. The passage comes from MS L75 Logic, regarded as semeiotic (The Carnegie application of 1902).

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father, Nature" (PEIRCE, Chales Sanders (1931-1958: 5.591). Hence, from an evolutionary perspective instincts are rooted in humans in this interplay between internal and external aspects and so it is obvious to see that externalities ("Nature") "fecundate" the mind. In this perspective abduction represents the most interesting fruit of this "fecundated" mind.

Beyond the multifarious and sometimes contrasting Peircean intellectual strategies and steps in illustrating concepts like inference, abduction, perception and instinct, which of course are of great interest for the historians of philosophy,[12] the perspective I am describing here seems able to clearly focus on some central recent cognitive issues which I contend also implicitly underlie Peircean thoughts: nature fecundates the mind because it is through a disembodiment and extension of the mind in nature that in turn nature affects the mind. If we contend a conception of mind as "extended", it is simple to grasp its instinctual part as shaped by evolution through the constraints found in nature itself. It is in this sense that the mind's abductive guesses – both instinctual and reasoned – can be classified as hypotheses "akin to the truth" concerning nature and the external world because the mind grows up together with the representational delegations[13] to that "nature" (external world) that the mind itself has made throughout the history of culture by constructing what some present-day biologists call cognitive niches.[14] In this strict perspective hypotheses are not merely made by pure *unnatural* chance.[15]

Peirce says, in the framework of his *synechism* that "[…] the reaction between mind and matter would be of not essential different kind from the action between parts of mind that are in continuous union" (PEIRCE, Chales Sanders (1931-1958: 6.277). This is clearly seen if we notice that "[…] habit is by no means a mental fact. Empirically, we find that some plants take habits. The stream of water that wears a bed for itself is forming a habit" (PEIRCE, Chales Sanders (1931-1958: 5.492). Finally, here the passage we already quoted above, clearly establishing Peirce's concerns about the mind: "Thought is not necessarily connected with brain. It appears in the work of bees, of crystals, and throughout the purely physical world; and one can no more deny that it is really there, than that the colours, the shapes, etc., of objects are really there" (PEIRCE, Chales Sanders (1931-1958: 4.551).

To conclude, seeing abduction as rooted in instinct vs. in inference represents a conflict we can overcome, following Peirce, simply by observing that the work of abduction is partly explicable as an instinctual biological phenomenon and partly as a "logical" operation related to "plastic" cognitive endowments of all organisms. I entirely agree with Peirce: a guess in science, the appearance of a new hypothesis, is

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[12] For example, in the latest writings at the beginning of XX century Peirce more clearly stresses the instinctual nature of abduction and at the same time its inferential nature (PAAVOLA, Sami (2005: p. 150). On the various approaches regarding perception in Peircean texts cf. (TIERCELIN, Claudine (2005).

[13] Representational delegations are those cognitive acts that transform the natural environment in a cognitive one (a *cognitive niche*).

[14] Cf. (LALAND, Kevin – ODLING *SMEE*, John – FELDMAN, Marc (2000, LALAND – ODLING-SMEE – FELDMAN *LALAND*, Kevin – ODLING-SMEE, John – FELDMAN, Marc (2001, ODLING-SMEE – LALAND – FELDMAN 2003). I have illustrated in detail the concept of cognitive niche in chapter six of (MAGNANI, Lorenzo (2009).

[15] This is not a view that conflicts with the idea of God's creation of human instinct: it is instead meant on this basis, that we can add, with Peirce, the theistic hypothesis, if desired.

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also[16] a biological phenomenon and so it is related to instinct: in the sense that first of all we can analogize the appearance of a new hypothesis to a "trustworthy" chance variation in biological evolution (PEIRCE, Chales Sanders (1931-1958: 7.38), even if of course the evolution – for example – of scientific guesses does not conform to the pattern of biological evolution (COLAPIETRO, Vincent (2005: p. 427). An abduced hypothesis introduces a change (and a chance) in the semiotic processes to advance new perspectives in the co-evolution of the organism and the environment: it is in this way that they find a continuous mutual variation. The organism modifies its character in order to reach better fitness; however, the environment (already artificially – culturally – modified, i.e. a cognitive niche), is equally continuously changing and very sensitive to every modification. In summary, the fact that abduction is akin to truth is guaranteed at both the metaphysical and evolutionary levels: the case of instinct and the case of perception described by Peirce are striking, both provide abductions that are immediately and spontaneously generated but at the same time activated and efficacious, certainly not "in sufferance" (as Woods would say, referring to the case of the standard activity of abducing hypotheses in natural science), and so in need of empirical evaluation.

I have just illustrated the philosophical and evolutionary justifications provided by Peirce, which substantiate the truth-reliability of abductive cognition. However, some actual examples of knowledge-enhancing abductions active in science, that are evidentially inert,[17] have to be indicated.[18] I can quote here the epistemological problems of guessing conventions and of guessing models in science. In empirical science abducing *conventions* favors and increases knowledge even if these hypotheses remain evidentially inert – at least in the sense that it is not possible to empirically falsify them. Consequently abduced conventions are evidentially inert but knowledge-enhancing at the rational level of science. Moreover, in science we do not have to confuse the process of abducing models with the process of abducing fictions: the recent epistemological conundrum concerning fictionalism presents to us the epistemic situation in which the models abduced by scientists reveal themselves not to be "airy nothings" at all, and certainly different in their gnoseological status from literary fictions. Scientific models instead play fundamental "rational" knowledge-enhancing roles: in a static perspective (for example when inserted in a textbook) scientific models can appear fictional to the epistemologist, but their fictional character disappears if a dynamic perspective is adopted. Abduction in scientific model-based reasoning is not a suspicious process of guessing fictions.

3. Conclusion

The status of abduction is very controversial. When dealing with abductive reasoning misinterpretations and equivocations are common. What did Peirce mean when he considered abduction both a kind of inference and a kind of instinct or when he considered perception a kind of abduction? Does abduction involve only the generation of hypotheses or their evaluation too? Are the criteria for the best

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[16] Of course this conclusion does not mean that artifacts like computers do not or cannot perform abductions. The recent history of artificial intelligence in building systems able to perform diagnoses and creativity clearly illustrates this point.

[17] That is not inferences to the best explanation in the classical sense of the expression, involving an empirical evaluation phase.

[18] I have illustrated in detail this important issue in (MAGNANI, Lorenzo (2013).

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explanation in abductive reasoning epistemic, or pragmatic, or both? Does abduction preserve ignorance or extend truth or both? The paper has tried to answer these questions centering the attention to the the so-called ignorance-preservation character of abduction, such as it is illustrated by the GW-Model (Gabbay-Woods model) of abduction.

I have contended that certainly abductive reasoning is a response to an ignorance-problem. Nevertheless, through abduction, knowledge can be enhanced, even when abduction is not considered an inference to the best explanation in the classical sense of the expression, that is an inference necessarily characterized by an empirical evaluation phase. To study this conundrum I exploited my *eco-cognitive model* (EC-model) of abduction and illustrated certain Peirce's *evolutionary* and *metaphysical* ideas, which aim at confirming that abduction is constitutively *akin to truth*, even if certainly always ignorance-preserving or mitigating, at least in the sense that the "absolute truth" is never reached.

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