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Reason and Logic

Carlo Cellucci

Abstract: This paper discusses the approaches of Frege, Nagel, Hanna and Cooper to reason, logic and their relationship, it points out their limitations and outlines an alternative approach hopefully not subject to those limitations.

1. *The Reduction of Reason to Logic*

The relation between reason and logic goes back at least to 1292-1075 BC, when the so-called Memphite Theology stated that the Memphis God Ptah created everything through his mind and by his word.[1] This is the remotest origin of the dictum: "In the beginning was the *logos*" and "through it everything was made."[2] It is also the remotest origin of the relation between reason and logic. For, on the one hand, the Greek word *logos* was translated into Latin as 'ratio', which originated the Italian 'ragione', the French 'raison' and then the English 'reason'. On the other hand, *logos* is the root of 'logic'.

[1] See Memphite Theology, col. 53-58.
[2] John 1.1, 1.3.

The relation between reason and logic has been widely discussed from Parmenides to Kant and beyond. Recent literature on the subject, however, is not copious, perhaps because many people consider Frege's approach to be conclusive. In particular, Frege's strongly anti-naturalistic and anti-evolutionistic approach has deeply influenced philosophy in the last century. An example is provided by Nagel and Hanna. One of the few dissenting voices is Cooper. In this section we will summarize their views.

1) According to Frege, "if beings were even found whose laws of thought flatly contradicted ours and therefore frequently led to contrary results even in practice," then the psychologist logician would say: "Those laws hold for them, these laws hold for us." [3] Conversely, Frege would say: "We have here a hitherto unknown type of madness."[4]

Thus, for Frege, logic is constitutive of rationality. Humans are rational if they obey the laws of logic, irrational otherwise. There can be only one logic since there is only one truth, and the laws of logic are "laws of truth."[5] Logic is normative, for its laws "prescribe universally the way in which one ought to think if one is to think at all."[6] They "provide the norm for holding something to be true."[7] Moreover, logic is "independent of our sensation, intuition and imagination, and of all construction of mental pictures out of memories or earlier sensations."[8] For in logic we are

[3] Frege 1964, 14.
[4] *Ibid*.
[5] *Ibid*., 13.
[6] *Ibid*., 12.
[7] Frege 1979, p. 146.
[8] Frege 1959, 36.

concerned “with objects given directly to our reason and, as its nearest kin, utterly transparent to it.”[9]

Thus Frege reduces reason to logic, a logic whose laws are laws of truth, prescriptive, objective and independent of humans and of the world.

Frege’s approach is strongly anti-naturalistic, and specifically anti-evolutionistic. He states that, “in these times when the theory of evolution is marching triumphantly through the sciences,” the question is likely to be asked whether the laws of logic have “always been valid” and will “always retain their validity,” since “man, like all other living creatures, has undergone a continuous process of evolution.”[10]

But, when such question is asked, “the laws of how men do in fact think are being confounded” with “the laws of valid inference.”[11] They “are nothing other than the unfolding of the content of the word ‘true.’”[12] If they depended on evolution, “there would be no science, no error and no correction of error; properly speaking, there would be nothing true in the normal sense of the word,” so “a dispute about the truth of something would be futile.”[13] Everything would be “in continual flux,” there “would no longer be any possibility of getting to know anything about the world.”[14]

The laws of logic do not depend on evolution. They are “true and will continue to be so even if, as a result of biological evolution, human

[9] *Ibid*., 115.
[10] Frege 1979, 4.
[11] *Ibid*.
[12] *Ibid*., 3.
[13] *Ibid*., 133.
[14] Frege 1959, vii.

beings were to come" to deny them, for such laws are "independent of being thought by anyone and of the psychological makeup of anyone."[15] They "do not belong to the individual mind (they are not subjective), but are independent of our thinking" and "are only grasped by thinking."[16] They "are boundary stones set in an eternal foundation, which our thought can overflow, but never displace," and "do not make explicit the nature of our human thinking and change as it changes."[17]

2) According to Nagel, "the idea that our rational capacity was the product of natural selection would render reasoning" unreliable, for then "there would be no reason to trust its results in mathematics and science, for example."[18] Unless "it is coupled with an independent basis for confidence in reason, the evolutionary hypothesis is threatening rather than reassuring."[19]

My belief that "I follow the rules of logic because they are correct" cannot be based merely on the statement that "I am biologically programmed to do so," rather "I have to be justified independently in believing that they are correct."[20] Therefore, "the recognition of logical arguments as independently valid is a precondition of the acceptability of an evolutionary story about the source of that recognition. This means that the evolutionary hypothesis is acceptable only if reason does not need its support."[21]

[15] Frege 1979, 174.
[16] *Ibid*., 148.
[17] Frege 1964, 13.
[18] Nagel 1997, 135.
[19] *Ibid*.
[20] *Ibid*., 136.
[21] *Ibid*.

Contrary to what the evolutionary hypothesis suggests, the laws of logic are "independent of my mind, of my conceptual capacities," and even "of my existence."[22] The "basic methods of reasoning we employ are not merely human but belong to a more general category of mind."[23] They "would have to be among the capacities of any species that had evolved to the level of thinking – even if there were no vertebrates, and a civilization of mollusks or arthropods ruled the earth."[24]

3) According to Hanna, reason is based on logic because "human rationality is essentially our cognitive capacity for logic."[25] Thus logic is constitutive of rationality. All rational animals possess a "logic faculty."[26] The latter is "a cognitive faculty that is innately configured for representing logic and is the means by which all actual and possible logical systems are constructed."[27] Such faculty is innate because "it is an intrinsic part of the mind of a rational animal."[28]

The logic faculty "is not necessarily restricted to humans," indeed it "seems quite conceivable and thus logically possible that there could be Martian logicians."[29] Properly, however, the logic faculty belongs to humans. For, not only they can "cognize according to the principles of some logic or another," but are "also capable of explicitly or reflectively

[22] *Ibid.*, 66.
[23] *Ibid*., 140.
[24] *Ibid*.
[25] Hanna 2006, 113.
[26] *Ibid*., 25.
[27] *Ibid*.
[28] *Ibid*.
[29] *Ibid*.

doing logic, that is, of self-consciously grasping the principles" of "logic."[30]

Such principles are innate, "unrevisable and a priori."[31] The status of empirical laws is too weak to account for them, so naturalism is incapable of explaining and justifying the principles of logic. Indeed, "logic is a moral or 'prescriptive' science and not merely a factual or 'descriptive' one."[32]

We know the principles of logic by intuition. The latter "is *a priori*, which is to say that it is undetermined by inner, proprioceptive, and outer sensory experiences."[33] It is "authoritative, which is to say that" it "is intrinsically compelling."[34] It "is cognitively indispensable, which is to say that every process of reasoning" must "ultimately bottom out in an intuition of some logical principle of deductive inference," otherwise "there would be a vicious infinite regress of deductive inferential justificatory groundings."[35] On the other hand, however, "intuition is fallible, which is to say that it is always possible for an intuition to be wrong."[36]

4) According to Cooper, "this thing called Reason, whatever it may be, is based on principles called Laws of Logic." [37] Such laws "are not independent of biology but implicit in the very evolutionary processes that

[30] *Ibid*., 112.
[31] *Ibid*., 30.
[32] *Ibid*., xxii.
[33] *Ibid*., 171.
[34] *Ibid*.
[35] *Ibid*., 172.
[36] *Ibid*.
[37] Cooper 2001, 3.

enforce them. The processes determine the laws."[38] Thus "logical rules have no separate status of their own but are theoretical constructs of evolutionary biology."[39]

Therefore "logic is reducible to evolutionary theory."[40] The "commonly accepted systems of logic are branches of evolutionary biology. The foundations of logical theory are biological. The principles of pure Reason" are "in the final analysis propositions about evolutionary processes. Rules of reason evolve out of evolutionary law and nothing else."[41]

Reason cannot "be addressed independently of evolutionary theory," and "reasoning is different from all other adaptations in that the laws of logic are aspects of the laws of adaptations themselves. Nothing extra is needed to account for logic."[42] The laws of logic "are not just products of historic evolutionary processes, but are themselves formulable as part of the theory of those processes."[43]

The reduction of logic to evolutionary theory can be carried out by showing that "from general evolutionary theory one can derive a special branch of population biology known as life-history strategy theory."[44] Such theory "in turn implies decision theory, which in turn implies inductive logic or probability theory, and so on up through deductive logic."[45]

[38] *Ibid*., 2.
[39] *Ibid*.
[40] *Ibid*.
[41] *Ibid*.
[42] *Ibid*., 5.
[43] *Ibid*., 12.
[44] *Ibid*., 21.
[45] *Ibid*.

Although the approaches of Frege, Nagel, Hanna, on the one hand, and Cooper, on the other hand, are different, they are all inadequate, although for different reasons. To show this, we need consider the nature of reason and rationality.

2. *Reason and the Relation Between Means and Ends*

As it has been already mentioned, 'reason' derives from the Latin 'ratio,' one of whose meanings is 'relation'. In fact reason is a matter of the relation of means to some given ends, for it is the capability of choosing appropriate means for some given ends. Thus reason does not concern the choice of ends, but rather the choice of appropriate means for some given ends. Strictly related is the concept of rationality, since rationality is the exercise of reason.

This concept of reason is not limited to human beings but extends to all organisms, since all organisms are capable of choosing appropriate means for some given ends. In particular, in so far as they survive, all organisms are capable of choosing appropriate means for the end of survival.

It might be objected that the concept of reason as the capability of choosing appropriate means for some given ends is only a relative one, since it does not require that the ends themselves be appropriate.

For example, Rescher states that "the pursuit of what we want is rational only in so far as we have sound reasons for deeming this to be want-deserving."[46] If our ends "are themselves inappropriate," we "are not

[46] Rescher 1988, p. 99.

being fully rational."[47] Thus "the rationality of ends is essential to rationality as such."[48] The "rationality of our actions hinges critically" not only "on the suitability of the means by which we pursue" our ends, but also "on the appropriateness of our ends."[49] Therefore "rationality consists in the intelligent pursuit of appropriate ends."[50]

This objection, however, is unjustified because requiring that ends themselves be appropriate would lead to an infinite regress. For suppose we state that some given ends are appropriate. In order to state this, we must have some sound reasons for deeming them to be appropriate. The question then arises: Why are those reasons sound? If we answer that they are sound because we have some sound reasons for deeming them to be sound, the question arises: Why are those reasons sound? And so on, *ad infinitum*.

So we cannot assert that some given ends are appropriate without falling into an infinite regress. Therefore reason cannot concern the choice of ends, but only the choice of appropriate means for some given ends. Indeed, already Aristotle warned that "we deliberate not about ends, but about means to ends."[51]

One might wonder whether the concept of reason might be made less relative by saying that reason is the capability of choosing appropriate means for ends which are conformable to human nature. To give an answer to this question we must consider what human nature is.

[47] *Ibid*., p. 96.
[48] *Ibid*., p. 103.
[49] *Ibid*., p. 100.
[50] *Ibid*.
[51] Aristotle, *Nicomachean Ethics*, Γ 3, 1112 a 11-12.

3. *Human Nature*

Human nature is the result of two factors: biological and cultural evolution. In explaining what human nature is, biological evolution plays an important role, because our biological makeup has a basic importance in determining what we are.

Many people deny that the essence of man consists in being an animal organism. In their view, cultural evolution has nothing to do with biological evolution, since our biological makeup has no importance in determining what we are. There is no biological basis of our most important behaviors, they are only a result of cultural evolution.

This view depends on the belief that human beings are essentially different from all other organisms because they possess an immaterial mind – a variant of the immortal soul – which is the container of ideas. The latter form a separate world which is what is called ‘culture’, to which only human beings have access.

This view, however, is unjustified. The claim that our biological makeup has no importance in determining what we are contrasts, for example, with the fact that identical twins, reared away from their co-twin, have about an equal chance of being similar to the co-twin in terms of personality, interests, attitudes as those who have been reared with their co-twin.

Culture is not a separate world to which only human beings have access. It is rather a shared system of cognitions, beliefs and behaviors that organisms develop or acquire from others, and transmit to succeeding generations non-genetically. Systems of this kind do not belong to human

beings only but to several animal species, which transmit behaviors from one generation to the other through a mix of imitation and social learning.

That such systems do not belong to human beings only is an aspect of the fact that culture has a biological basis, since it depends on the biological makeup of organisms.

Cultural evolution too depends on the biological makeup of organisms. It consists of the modifications or expansions that shared systems of cognitions, beliefs or behaviors undergo in the succeeding generations.

Admittedly, cultural and biological evolution are distinct. The former does not reduce to the latter for at least two reasons.

First, biological evolution is slow, it takes thousands of unfavorable mutations before a favorable one emerges. Cultural evolution is much faster, being a result of non-genetic interactions between billions of organism.

Second, certain kinds of organism are capable of doing things that are not strictly necessary for survival. Such is the case of human beings who, in the course of biological evolution, have been confronted with situations which did not occur in their evolutionary past. The world changes continually and irregularly, so human beings have to deal all the time with new situations. If their problem-solving resources were always strained to the limit, they might easily fail when certain critical situations occurred, and if such failure had frequently occurred in our evolutionary past, we would not be here to tell. To be able to cope with vital issues during times of peak demand, human beings must have excess capacity to spare for other issues at slack times. Thanks to it, in normal times they may

engage in activities that are not directly useful for survival. Such things are a result of cultural evolution.

But, even if cultural and biological evolution are distinct and the former does not reduce to the latter, cultural evolution depends on the biological makeup of organisms, thus it develops on the basis of biological evolution. So between cultural and biological evolution there is no opposition but rather continuity.

In view of this, it is unjustified to say that cultural evolution has nothing to do with biological evolution since our biological makeup has no importance in determining what we are. This overlooks that the subject of cultural evolution is an organism which is a result of biological evolution.

We may now give an answer to the question whether the concept of reason might be made less relative by saying that reason is the capability of choosing appropriate means for ends which are conformable to human nature. The answer must be a negative one. Since human nature is the result of biological and cultural evolution, there is no fixed invariable human nature. Ends conformable to human nature are relative to human nature at the present stage of evolution.

Biological evolution does not work by design: it has gone this way but could have gone otherwise. Nature may be an engineer, but not one proceeding according to a preconceived design, rather one proceeding without prior goals. Therefore the concept of reason is relative to the contingent character of human nature, which is a contingent result of biological and cultural evolution.

Even survival is only a relative end. It is an end for most human beings, not for all of them, and there is no ultimate reason why it should be

absolutely preferable. After all, survival is an ultimately impossible end for the species. All animal species arise and die out and there is no evidence that the human species might be an exception.

Hume even states: “It is not contrary to reason to prefer the destruction of the whole world to the scratching of my finger.”[52]

An end would be absolutely preferable only if there existed an ultimate purpose of the world. Some religions claim that such an ultimate purpose exists, but this is an unproven assumption, so it all boils down to a matter of faith.

4. *Logic and Nature*

The approach to reason outlined in the previous sections entails that there is a strict relation between logic and evolution.

If reason is the capability of choosing appropriate means for some given ends, logic may be expected to have a strict connection with reason, indeed to be an important part of it. For logic is that reasoning faculty which permits to choose appropriate means for some given ends.

The connection between logic and reason, however, cannot be explained in terms of the view of Parmenides, Plato and Aristotle that the world is intrinsically rational since it has been ordered by a divine mind, and logic is ultimately based on this fact. There is no evidence for this. The connection can be explained only in terms of the fact that logic and reason are both a result of biological evolution, which has endowed humans with them.

[52] Hume 1978, p. 416.

Actually, biological evolution has endowed not only human beings but, to a certain extent, all organisms with reason and logic.

Reason has been traditionally viewed as a higher faculty belonging to human beings only, which permits them to overcome the limitations of their biological makeup – limitations within which other animals are instead constrained. Logic has been viewed as the organon of reason meant as such higher faculty.

But it is not so. For without a reasoning faculty no organism could survive, so reason and logic must belong to all organisms. To say that reason is a higher faculty belonging to human beings only is to misjudge the nature of reason. Logic can be said to be the organ of reason only if reason is intended not as a higher faculty belonging to human beings only, but as the capability of choosing appropriate means for some given ends, starting from survival, a capability which is the result of biological evolution. Logic implements that capability by providing means to put it into act.

That logic is a capability which is the result of biological evolution entails that there is a strict relation of logic with nature. Biological evolution is the basis of this relation.

Logic meant as a capability which is the result of biological evolution may be called ‘natural logic’. Such logic belongs to all organisms.

In addition to natural logic, however, there is also an ‘artificial logic’, which consists of that set of problem solving techniques that some organisms have as a result of cultural evolution.

Both natural and artificial logic are essential for survival. All organisms acquire knowledge about the environment, thanks to which they assume behaviors that, when successful, ensure their survival. Now, in order to acquire such knowledge, they must make hypotheses about the environment. They make them by means of their natural logic and, in the case of human beings, of their artificial logic as well. Therefore logic, natural or artificial, is the organon of reason in acquiring knowledge.

Natural and artificial logic are distinct, and the latter cannot be reduced to the former, since they are a result of biological and cultural evolution, respectively, and cultural evolution cannot be reduced to the biological one. That natural and artificial logic are distinct does not mean, however, that they are opposed: between biological and cultural evolution there is no opposition but rather continuity. While artificial logic is a comparatively recent business, human beings had problem solving capabilities already hundred thousand years ago, and such capabilities were essential for their survival. Even artificial logic ultimately depends on those problem solving capabilities.

5. *Logic and Language*

Against the continuity between natural and artificial logic, those who deny that the essence of man consists in being an animal organism argue that, through cultural evolution, human beings have made a qualitative leap. The deciding factor in such qualitative leap has been language, which is then the key factor in the superiority of human beings over non-human animals. In particular, logic requires language, so it belongs to human beings only.

This, however, is unjustified. The thoughts human beings think are those that are made possible by their biological makeup. As computers can only run the software their hardware permits them to run, so human beings can only think the thoughts their biological makeup permits them to think. They can think human thoughts just because they have human brains, which give them the urge to think and the competence to succeed. Language is simply a piece of the biological makeup of human beings. The superiority of the latter over non-human animals is only an anthropocentric prejudice. As non-human animals can do things human beings cannot do, so human beings can do things non-human animals cannot do.

Specifically, as regards language, there is abundant evidence that pre-verbal infants and non-human animals have logical capabilities which do not depend on language. They can make inferences about space, time, number etc.. Pre-verbal infants have a naive theory of the world, by means of which they can predict movements of objects by gravity. Some non-human animals can represent the geometric structure of the environment to themselves. Numerical abilities in infants and in a variety of non-human animals provide evidence for the existence of language-independent representations of numerosity. Thus pre-verbal infants and non-human animals show logical capabilites although they do not possess a language.

6. *Biological and Cultural Role of Knowledge*

We have said that reason is the capability of choosing appropriate means for some given ends. Obviously, the primary end of all organisms is survival, since without that end no other end could possibly exist.

Now, organisms may survive only if they use the energy sources present in the environment and avoid the dangers which could destroy them. To do so they must acquire knowledge about the environment. All organisms acquire such knowledge, thanks to which they assume behaviors that, when successful, ensure their survival.

Being essential for survival, knowledge is a natural phenomenon which occurs in all organisms. All organisms are cognitive systems, and life itself owes its existence and preservation to a cognitive process.

Serving to solve the problem of survival, knowledge plays a biological role. It plays such role not only with respect to single organisms but also with respect to whole species.

The function of knowledge is not only to avoid short-term menaces to the survival of single organisms. The latter, at any rate, can be ensured only for a limited time span: all organisms eventually die. The case of genes is different. They hold the information to build and maintain cells and pass genetic traits to offspring. With respect to species, the function of knowledge is to provide such information. This is the biological role of knowledge with respect to species.

Knowledge, however, plays not only a biological role but also a cultural one. This is implicit in the very concept of culture which, as we have already stated, consists of a shared system of cognitions, beliefs and behaviors that organism develop or acquire from others and transmit to succeeding generations non-genetically. Thus culture is a system of knowledge.

The cultural role of knowledge does not reduce to the biological one because it is not confined to survival. This does not mean that the cultural

role of knowledge is opposed to the biological one. On the contrary, it is continuous with it. It is a development and strengthening of the biological role, and cannot exist without it.

The continuity between them appears, for example, from the fact that, even in its cultural role, knowledge can affect biological evolution. The system of knowledge of which a culture consists enables organisms to modify the environment making it more suitable to them, and to develop tools for survival. These changes in the environment may determine changes in the evolution process.

That, even in its cultural role, knowledge can affect biological evolution, holds not only of the human species but also of other species. Some of them are capable of modifying the environment by means of the artifacts they produce. Others, though incapable of modifying the environment, choose an environment which can affect biological evolution. Thus cultural evolution can shape biological evolution as well as the other way round. Therefore, even in its cultural role, knowledge plays a biological role since it serves to solve the problem of survival.

Generally, both in its biological and cultural role, knowledge is a problem-solving activity that develops in sustained interaction between organisms and their environment, since it is oriented towards the solution of problems, starting from that of survival.

7. *Biological Evolution and Cultural Evolution*

In the human species, in addition to the cultural role of knowledge, there is also cultural evolution: in successive generations non-genetically transmitted knowledge can be modified and expanded.

Just as the cultural role of knowledge is not opposed to the biological one but is simply a development and strengthening of it, the same holds of cultural and biological evolution. Between them there is no opposition but rather continuity, for the subject of cultural evolution is the same as that of biological evolution.

On the other hand, this does not mean that cultural evolution reduces to biological evolution. As we have already pointed out, the world changes continually and irregularly, so organisms are confronted all the time with new situations. The means derived from biological evolution are not enough to cope with them, more powerful means are needed. These are provided by cultural evolution.

Cultural evolution determines a significant difference between human beings and the simplest organisms. While the latter have little control upon their environment, thanks to cultural evolution human beings may exert a considerable control upon it. Admittedly, for most of their evolutionary process, they have been in a condition not too dissimilar from that of the simplest organisms, and hence have been forced to devote most of their efforts to survival. Afterward, however, thanks to cultural evolution the situation has changed, and today human beings may devote only a comparatively limited part of their efforts to survival. Nevertheless, in order to survive, they must continue to modify the environment and develop tools to that end. Thus survival is a primary end of knowledge also in its cultural role.

8. *Scientific Knowledge and Evolution*

That the cultural role of knowledge is not opposed to the biological one but continuous with it also holds of natural science. The latter is a cultural artifact with a biological role since it contributes to solve the survival problem. In this respect natural science can be viewed as an extension of the activities by means which our oldest ancestors solved their survival problem.

Such activities and those underlying natural science depend on somewhat similar cognitive processes.

Our hunting ancestors solved their survival problem, for example, by making hypotheses about the location of predators or prey on the ground of hints they found in the environment – crushed or bent grass and vegetation, bent or broken branches or twigs, mud displaced from streams, and so on. Much in the same way scientists solve problems by making hypotheses on the ground of hints they find in nature.

9. *Logic and Reason*

We have said that logic may be expected to have a strict connection with reason, and indeed to be an important part of it. This raises the question whether logic is only a proper part of reason or the whole of it.

In the last century there has been an increasing tendency to consider logic as the whole of reason, and hence as identical to it, or at least as its defining character.

Specifically, the concept of reason to which logic has been considered identical is that of a higher faculty which belongs to humans only and permits them to overcome the limitations of their biological makeup.

Considering logic as the whole of reason, however, results into an impoverished concept of reason which excludes emotions, feelings or any biologically or culturally specific codes from the sphere of rationality. In that perspective, any human act influenced by these factors will be termed irrational.

This is in conflict with the results of the neurosciences, which show that no human act is ever totally independent of all these factors, except perhaps in people with a damaged ventromedial prefrontal cortex. What is more, the factors in question play an essential role in rationality.

Thus the notion of rationality suggested by the view that logic is the whole of reason does not suit human beings, and, on the other hand, does not account for the positive role emotions, feelings or any biologically or culturally specific codes play in rationality.

10. *Natural and Artificial Logic*

We have distinguished between natural and artificial logic, but have also stressed that they are not opposed since there is continuity between biological and cultural evolution on which these two logics depend. Then Frege's and Nagel's claim that they are sharply separated is unjustified.

In particular, the claim that the laws of logic are independent of being thought by anyone and of the psychological makeup of anyone,

overlooks that our rational capacity is a product of biological evolution. The laws of logic are a product of organisms which are an outcome of biological evolution, and so depend on the neural makeup with which evolution has endowed them.

Moreover, the claim that the idea that our rational capacity was the product of natural selection would render reasoning unreliable – since then there would be no reason to trust its results in mathematics and science – is based on the decision: I want mathematics and science to be absolutely reliable. Such decision is only an expression of a wish, in fact an impossible one. For mathematics and science cannot be more reliable than the hypotheses on which they are based, and those hypotheses cannot be absolutely reliable. They can only be plausible, namely compatible with the existing data, and could very well turn out to be incompatible with the future ones.

Finally, the claim that the truth of the laws of logic is something independent of my mind, of my conceptual capacities, and even of my existence, is a flight into the supernatural. Simply, there is no evidence for it.

11. *The Role of Logic*

What is the role of logic, either natural and artificial, in human and non-human organisms?

As we have already stated, to survive all organisms must acquire knowledge about the environment. To that aim they must make hypotheses about the environment, and they make such hypotheses by means of logic,

either natural or artificial. The primary role of logic is then to find hypotheses about the environment to the end of survival.

Specifically, all organisms survive making hypotheses about the environment essentially by the analytic method.[53] For example, as we have already mentioned, our hunting ancestors solved their survival problem by making hypotheses about the location of predators or prey on the basis of hints they found in the environment.

Some of the hypotheses about the environment are incorporated in the cognitive architectures of organisms. Biological evolution has hardwired organisms to perform certain operations, building some logical structure in several features of their biological makeup. Such operations are essential to escape from danger, search for food, seek out mates. Thus all organisms have some innate capabilities that have a biological function, and are a result of biological evolution.

'All organisms' includes the most elementary ones, even prokaryotes, the unicellular organisms which were the first form of life on the earth. Through their rudimentary sense organ, prokaryotes got data about different states of the environment, such data were memorized in their genome, they were inherited and used by prokaryotes of successive generations to regulate their behavior in accordance with the state of the environment.

That the primary role of logic is to find hypotheses about the environment to the end of survival means that there is a strict connection between logic and the search of means for survival, and that, since

[53] On the analytic method, see Cellucci 2008.

generally all organisms seek survival, logic does not belong to human beings only but to all organisms.

12. *Logic and Evolution*

That logic belongs to all organisms does not mean that non-human organisms choose appropriate means for some given ends on the basis of learned logical cognitions. Even several human beings too do not choose such means on that basis. They use logical means such as induction, the cause-effect relation, the identity principle, and generally make inferences, without having attended any logic course.

They can do so because biological evolution has designed them to do so. Of course, ‘designed’ not in the sense ‘directed toward a goal’. While an ice cream machine is directed toward the goal of producing ice creams since it has been designed for that goal, biological evolution is not directed toward the goal of survival. Indeed, it is not directed toward any goal at all.

Not only biological evolution has designed human beings to use logical means, but natural logic is itself a result of biological evolution. On average, the natural logic we have inherited increases the possibility of surviving and reproducing in the environment in which our remotest ancestors evolved. Then the first and deepest origin of reason and logic is biological evolution, which has provided human beings with the capabilities that have permitted them to survive.

This means that reason and logic depend on the world, indeed they are somehow forced by it. Thus logic is not an arbitrary creation but reflects facts and properties of the world.

The importance of reason and logic derives from the fact that the world changes continually and irregularly, so organisms are confronted all the time with the need to adapt to new situations. To deal with them they need logic, which helps them to cope with them, thus increasing their overall adaptive value.

The logic useful to this end is not only natural but also artificial logic, though an artificial logic including not only deductive propositional inferences but also non-deductive non-propositional ones.

Biological evolution has incorporated in organisms information concerning their evolutionary past. It has also incorporated in them certain kinds of capabilities and behaviors, by which they may cope with situations similar to those that already occurred in their evolutionary past. Moreover, they can cope with them automatically, namely, with no need for the single organism to reinvent the means to cope with them. To that end, natural logic is enough.

But, since the world changes continually and irregularly, it presents situations dissimilar from those that already occurred in the evolutionary past of organisms. To cope with them, the means incorporated in organisms by biological evolution are generally insufficient, new means are necessary. To provide them is the task of artificial logic, a logic which, like natural logic, is based on the analytic method and includes non-deductive and non-propositional inferences, but is essentially richer than natural logic since it includes more refined kinds of inference.

13. *Limitations of Current Approaches*

From what we have said it is clear why the approaches by Frege, Nagel, Hanna, Cooper are inadequate.

1) Frege and Nagel claim that the laws of logic are independent of our thinking. But this contrasts with the fact that logic, both natural and artificial, is a result of biological evolution. Thus logic essentially depends on the world and the cognitive architectures with which biological evolution has endowed humans. Therefore logic is not objective in the sense that it is independent of us, but only in the sense that it depends on what the world is, including us in it.

2) Hanna claims that there exists a non-empirical logic faculty involving principles which are innate, unrevisable and *a priori*. But there is no evidence for this. He himself admits that "the logic faculty thesis is an ambitious and controversial doctrine that is not likely to be demonstrated decisively by any single line of argument."[54] Such doctrine is in conflict with the fact that, being innate, logical principles are a result of biological evolution. Moreover, founding our knowledge of such principles on intuition amounts to explaining *obscura per obscurius*, and considering intuition both authoritative and fallible seems incoherent.

3) Cooper claims that artificial logic is reducible to evolutionary theory, but this depends on the assumption that inductive logic can be identified with probability theory. Such assumption is unwarranted because there are conclusions obtained by induction which are plausible although they have probability zero. Such is the case, for example, of all general laws of physics.

[54] Hanna 2006, 47.

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