Thinking on Thinking: The Elementary forms of Mental Life Neutrosophical representation as enabling cognitive heuristics

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Abstract

Beyond the predominant paradigm of an essentially rational human cognition, based on the classical binary logic, we want to propose some reflections that are organized around the intuition that the representations we have of the world are weighted with appreciations, for example affective ones. resulting from our integration into a social environment. We see these connotations as essentially ternary in nature, depending on the concepts underlying neutrosophy: either positive, negative or neutral. This form of representation would then influence the very nature of the cognitive process, which in complex real-world situations, has to deal with problems of a combinatorial nature leading to a number of cases too large for our abilities. Forced to proceed by shortcuts on the basis of heuristics, cognition would use these assessments of the representations it manipulates to decide whether partial solutions are attractive for solving the problem or on the contrary are judged negative and are then quickly rejected. There is still the case of a neutral weighting that allows processing to continue. Thus a neutrosophical conception of our representations of the world explains how our cognition functions in its treatment of combinatorial problems in the form of producing processing accelerating heuristics, both in terms of partial solutions selection and processing optimization.

Keywords: Cognition, heuristics, neutrosophy, value judgment, sentiment

1. Introduction

This article offers some thoughts on human cognition, but also makes the link with artificial intelligence. Here, it is only the beginning of an opening, based on the idea that a certain way of representing information would influence how cognition unfolds. It is not an idea demonstrated by experiments, or even an elaborate theory, but rather an intuition that nevertheless has a general explanatory value.

Thus this text is more a philosophical reflection, an abstract one, the elaboration of a hypothesis and the beginning of its discussion. This hypothesis concerns the kernel of cognition and goes beyond the approach that the intelligence is above all logic, such as the classical binary logic (known as boolean logic and the logic of first order predicates). Although this vision is predominant, it may give too much importance to a deterministic and dialectical logical aspect.

2. Cognition beyond logic

The main characteristic of human beings is their ability to foresee part of their immediate future in their environment, and thus to increase their chances of survival. In this way, they can both reduce the risks of the various dangers surrounding them and make the best use of available resources. This is possible, in addition to its perceptual system, through its cognitive system (the brain) capable of processing and retaining information.

Human cognition is the rapid search for (sub-optimal) solutions through cognitive mechanisms based on available information. The relevance of this task depends on the time and effort invested, and especially on the quality of the logical processing (intelligence) but also on the quality and quantity of the information mobilized. However, cognition is mainly studied in the Western world in terms of logic, or rationality, leaving in shadow the mechanisms for selecting information but also the forms of organization of this information and the basic forms of processing, manipulation and storage associated. In particular, little is said about how to choose one solution over another, and which may not be (sometimes by far) rationally the best.

In philosophy, Boudon refined the model taken from the economic world of the rational actor. According to the economist Becker, awarded the Nobel Prize for this paradigm, rationality would first of all be in action [1]: what a person does would be the result of a rational calculation of benefits versus costs among the possible solutions. Thus, by his reflection a person chooses the action which carries out for him the maximum of advantages for the minimum of costs (disadvantages). It is a variant of the popular law of the least effort, which perhaps however comes closer to reality.

Boudon extends the rationality [2] from a purely economic level to various aspects including those emotional, and among them those that are in fact social. The expected benefit of an action can also be immaterial: for example, emotional or symbolic. Finally, the reason for rationality can be supplemented by what the actor considers to be good reasons for him [3]: valid reasons in his own eyes.

To revisit this approach, without being significantly contradictory, here we will consider some of these elementary forms of mental life, in order of complexity, and think on their potential influence on cognition, how it could be modeled. So by looking at the how, we can better see the thinking mechanism as a whole.

3. The basis for cognition: representations

Cognition is a processing of data according to largely logical operations aiming at a certain objective: obtaining a solution to a problem. So not every problem necessarily has a solution, especially if we lack a determining element, then it is an indeterminate problem in our world of knowledge. A sub-optimal solution can however often be found, and in the case where the problem is determined, sometimes at the cost of a very great distance from the optimal solution (but most of the times not). In the worst case it is always possible to act randomly, that is to say in a sort of blind, non-rational way. For example, between two alternatives that do not seem to differ significantly from each other in terms of the cost-benefit ratio, it is possible to choose by flipping a coin. However, this is the worst solution: it is better to think, and if possible well and sufficiently.

The solution chosen, and with it the possible solutions that can be envisaged, therefore depend on the data available, then on those informations (representations) that are actually used. So, the more or less rational treatment of this whole produces in the long run one or several solutions of various qualities.

Often the actor, acting in a so-called autonomous way, therefore not a predetermined one, will choose between several solutions that he found according to some criteria of choice specific to him, according to his own good reasons.

The idea proposed here is limited to considering that these choice criteria are partly of a certain nature, and that these types of choices are made throughout cognitive processes. Even that they decide to stop the search for more solutions, considering the ones foreseen (and not yet fully developed, particularly in terms of benefits and costs) are sufficient. These are not solutions investigated in detail, but just crude preliminary views.

Before going further in the discussion, let us consider the data on which the thinking is made. A specific word is used to designate them: they are mental representations [4], and they form as a whole our vision of the world [5], i.e. all our knowledge about the world, initially understood in a synthetic way. If the representations are the processed information, the global conception of the vision of the world is also a preferential orientation in the space of possible solutions.

A representation is quite simply what in our eyes characterizes a thing, or also an abstract concept. Our representations are constructed from our senses, in compatibility with the representations we already have before, but also from the messages we receive, for example from other people. Representations are in fact the only information we have at our disposal. They are our representation of reality, but not objective ones, although it appears as such to us. Our worldview is subjective, and so are our representations, but yet they are also largely shared with the other people with whom we interact the most. These are collective representations to groups of people, also called social representations [6]. They are also social in another sense: in them are hidden social aspects [7]. Thus if the rational actor evolves

according to his selfish interest he is never less caught up in a social world.

Deriving more or less directly from this social coloring, representations also have an evaluative component, they are seen with appreciations (affects, sentiments): what they represent is more or less liked or valuated by us. Every representation inseparably carries a value judgment: I like this, or I don't like it. To varying degrees, the appreciation/affect may be more or less strong, positive or negative (see Fig. 1). He may also be more or less consciously absent, i.e. neutral, or only in appearance. The key is to consider this neutrality as such.
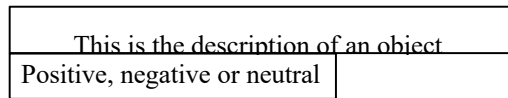
This is the description of an object

Positive, negative or neutral

Figure **Error! No sequence specified.**. Concept of colored representation by an appreciation

4. Cognition and language

As our representations can be partly formed or adapted by information that we receive, finally off our senses and from others. There is transmission of information between people in an intersubjective way. An affective tingling of information can occur depending on the sender or the transmitter, as well as the content of the message, in particular the objects that are represented there.

Thus our representations are of such a nature that they can be transmitted, at least in part, in an intersubjective manner, allowing their sharing, which forms the culture of the group [8]. Messages (and also about representations) can be emitted via different means by a person, including gesture and speech. Thus they are mostly symbolic because of their representative nature, but also because they are transmitted by symbols. Languages being precisely a kind of organization (and coding) of symbols [9]. Remember that the appreciative and affective aspect of representations is constructed in this intersubjectivity.

So we can say that a representation is an organized collection of symbols with an emotional-affective-valuative tincture.

As a result, the cognitive treatment of representations potentially induces by their nature also an evaluative aspect of an emotional-affective-valuative type.

Before going further in the conceptualization of representations, and that which results from it on cognition we propose a detour by artificial intelligence on the basis of the symbolic content of linguistic-type representations, that is to say that they are representative in a language composed of symbols, thus provided with a semantic content carried by an arbitrary container, but conventional (shared) in a group. A strong link exists between culture and language, the first being mainly shared symbolic representations transmitted intersubjectively via symbols that the second organizes into a set of units called words (of the vocabulary representing their semantics).

5. Artificial intelligence and compression

A major axis of artificial intelligence, the computerized processing of semantic information, is constituted by learning systems. Their functionality is gradually achieved by an evolutionary process which is called learning and which consists essentially in the treatment of examples to be imitated, accompanied by the correction of the result produced. Living beings also develop their capacities by learning, with for humans in addition the transmission of symbolic information in a preponderant way in the last phases of development.

Since a few years the culmination of artificial intelligence is neural networks with so-called deep learning. In fact it is the networks that are deep, composed of many layers of neurons, and not learning that remains a classic reinforcement, as a reward in case of the expected result achieved. Such systems are able to perform complex tasks that are not achieved by algorithmic ways (detailed and deterministic designation of the steps to be performed). In particular, they manage to reproduce the major and complex aspects of living beings: sound and visual perception. Speech recognition makes it possible to dictate texts to a computer as one would to a secretary, and artificial vision makes it possible to identify objects, to classify them according to various categories with an accuracy rate exceeding that of a human.

Although these systems were originally inspired by living nature (neurons), their internal functioning is quite different.

However some analogies can be made. The most disturbing one is that they work on representations, and even in some cases linguistic representations. They process representations by representing them with other, more representative, representations. The result is a process of compressing information to keep only the essential semantics appropriate for the task at hand, eliminating the rest which in this context is considered as disruptive noise [10]. Part of the argument in favor of a compression as the essential type of operation lies in the fact that the learning mechanism does not consist only in isolating what is important and that it is necessary to reproduce, but also in a dual way to reject all that is not relevant. The challenge is not just to find the task-significant information but rather to selectively remove everything that is not useful, and that only brings a disturbing noise. These aspects are at the heart of the problem of generalization and its opposite, over-learning, which reproduces isolated examples too closely, losing their character of generality.

Some systems are capable of processing the natural language of humans, such as a common language like English, and can perform translations into other languages with results close to a human translator. Although partial, a semantic information is treated there (that is, without any conscience), represented in linguistic form (by the equivalent of words forming a dictionary allowing the representation as DTM = Document Text Matrix [11]).

Thus, lessons from knowledge gained in one field, the living or the artificial, can be used to better understand the other.

In this way our proposal extends to both.

Recent work in the field of understanding how deep learning works is expanding our idea. While remaining at an intuitive level, here are some elements taken from a new theory [10, quoted above] explaining what happens in such artificial neural networks that were previously considered as black boxes (meaning it is impossible to know how they work internally).

An innocuous remark makes it possible to concretize at the most minimal what is fundamentally a learning which progresses: "It somehow smells right". Yet this point is essential as the beginning of the reasoning behind our approach. The learning system must at least have a sense of what is going in the right direction: this is that allows the principle of reinforcement.

Let us now turn to the last piece of our puzzle which will allow us to put everything in place to finally form the overall picture.

6.   Conditioning cognition: forms of representation

This element has already been announced: if the representations are of a certain form, then their treatment is a priori organized for this type of form. The data format conditions the processor, and the processing.

Different forms of representation are possible on the basis of different conceptions of human thought. We see them as elementary forms of representations, which produce elementary forms of thought, and thus correspond to elementary forms of mental life, hence our title in reference to one of the founding books of sociology, for us the most emblematic: "The Elementary Forms of the Religious Life" by Durkheim [12].

During its development, for every human being, cognitive abilities increase, in fact in stages due to different conceptions according to the stages of mental development identified by Piaget [13] in children.

We are inspired by him here without however taking up his points, considering just what seems to us to be the most elementary. In a first stage, by babies, there is in some way no consciousness, no self or world. Then there's the self. Then there's the world, then others. We can call this an ontological conception: it is, it exists, there is X, in short it can be denoted simply by a name, like X. However, this elementary form of thought does not allow real cognition, neither real information processing because there are only constants and no variables. Nothing can change. This form of thinking is very common among all adults, it is the most elementary because it leads to a passive vision and not that of an active social actor. It does not lead to action, to carrying out acts because until the notion of time is absent: there is no future. So no possibility of change, therefore of action. This is, in a way, ad æternam. The human being is then not in touch with these elements of his environment. He can't think on them, and therefore act on them.

The next stage is characterized by the "there is", and the supplementary "there is not", with as transition link with the

previous stage: "it is the same", a label is given, a name like X. So far, everything is identical with the previous elementary form of thinking that now will be extended. This can be seen as a lexical stage, different things exist. But the "there is" is now completed by the "there is not", which is its opposite. In addition to the presence of X, there is now also the non-presence of X: noted for example not-X, it is the absence of X. Not to be confused with nothing (which is more complex): X may be present or absent. The "there is no" is characteristic of disappearance, for example when closing the eyes or by occultation, one object hiding another. These two possibilities, these alternatives, are the basis of cognition, and allow choice and therefore action through the fact that a preference becomes possible: either I prefer there is X, or I prefer there is no X. Then autonomy appears. And indeed the valuation or affect too: "I like" or "I don't like", and it goes with it together.

The stages described here are not as distinct as those of Piaget, they overlap, include and extend. The "there is no" is opposed to the "there is" forming the opposite. Thus the binary appears and the logic of the same name also: either "there is", or "there is not": X or not-X, one and the other being mutually exclusive.

Although these conceptions of thought are the prerogative of the infant, they continue to exist in adults, and this in a preponderant way compared to other more evolved forms of thought. Thus, at first glance, one merely notices the existence of something without thinking anything about it. There is this and that and other things: a perception of the environment, a representation of a situation as a collection of objects. Our other most frequent and fundamental conception is opposition: there is or there is not. What also gives one thing and its opposite: day and night, hot and cold, big and small ... The importance of this simplifying binary conception of two situations sliced diametrically away in opposite is the most prominent form of mental life. It is the emblematic form of a choice. Almost all popular proverbs are representative of such an opposition. Cognition is then limited to the choice between two alternatives, whose basic variant is to do this or nothing (coming before doing this or doing that, which is actually composed of two such alternatives producing ipso-facto the triplet doing this or doing that or doing nothing, with the particular case of that being the opposite of this). We will then arrive at this ternary form of thought, following the end of the discussion already started about appreciation, affect, or feeling.

Without being possible to claim that it is after, but here it is after in our explanation, there is the appreciation, affect or feeling. Every thought, or representation, is completed by an appreciation that tints it: positive or negative, meaning I like that or I don't like that. Although it may seem binary, in our opinion it is totally different. First this is associated with the X information: I like X. Actually, it's: X plus I like X or I don't like X. In the following binary version of thought, there is X or there is not X and moreover I like X or I do not like X. The variations of X and its related appreciation can be joint or separate. This emotional aspect, this feeling, can be more or less intense, pronounced. It can also be weak, weak enough that under certain circumstances it may not appear either consciously or unconsciously. So we have three states to deal with, although it is in fact a gradation (that is precisely a more evolved representation that we will see next). But since the learning treatment consists in representing representations by more representative ones and in fact more reduced (compressed) representations, then the gradation is sometimes reduced to these three states (either positive, or neutral or negative).

Then this three-state design is called neutrosophical, we will come back to it in the next section.

We therefore consider that a representation is an description of X accompanied by an appreciation about X, at least in three states: positive, negative or neutral, either I like X, or I don't like X, or I am indifferent at X in this simple representation stage (the most elementary).

Finally it is this stage of representation, with an appreciation-affect-feeling consisting of three states, which is characteristic of human cognition in our opinion. At least one such hypothesis seems to us to be reasonably formulated on the basis of the elements partially presented here.

It follows that this type of representation conditions cognition.

Before discussing it let us show what other concepts of representation are possible in a human context that is social and therefore emotional or sentimental. A first one of those representations that associated information with an affect would be a gradation from "I don't like it at all" to "I really like it a lot". This corresponds to a weighting. A variant, perhaps more restrictive, is a quantitative valuative formulation. It's like counting, numbering. Considering quantities: for example, 5 sheep, 8 people ...

The stage stated previously would be in complexity after because a gradation can be also negative, and is continuous. It's actually a probabilistic approach. Note that it allows to represent the three-state variant. However this form with three states possesses a quality of the kind that the least in fact can do more. Some things are not continuous: there is

or there is not (or in some context are considered not continuous). Thus in treatment, there is the possibility of choosing a solution, there is the possibility of abandoning a forseen solution, and by default to continue treatment (searching for better). These are not things that can be done halfway, it is either this or that, and this is all that is possible because it is all that can exist. Indeed, this ternary connotation is also binary at first: I continue or I stop my cognition. And then in more detail, I stop because I like or I stop because I don't like (that part of a potential solution). Thus the three states are in fact representative of two binary variables: there is an appreciation or not, and it is positive or negative. It is this aspect (by default) that there is no appreciation that let continue the cognitive process, showing the importance of a neutral representation.

Finally we need to see in more detail what a cognitive process is. It aims to find a solution to a problem, and that is one of the kind of operational research. To find the best solution we must examine all possible alternatives, it is combinatorics, and the reality is that in almost all cases of the real world it is a combinatorial explosion: a very large number of cases. It is impossible to examine all these cases, we must limit ourselves to a few who seem good candidates: those "that seem to smeel good". Cognition is reduced to using heuristics, i.e. indicators of potentially good solutions. For example, in the complex problem of finding the shortest path to a point in a city (the primary problem of operational research), at a crossroads, the road that will be attempted first will be the one whose next crossroads would be closest to the destination, that is using an heuristics (in the simplest example).

So what is the primary heuristic in humans? It's whether he likes it or not.

7.   Neutrology as enabling the main heuristic of cognition

As cognition has to solve real-world problems that most often lead to a combinatorial explosion; the number of cases to be treated being far too large for the capacities of our brain (or the time we can devote to it). The only way out for survival (and therefore evolution) was to use shortcuts of thought in cognitive treatment. The worldview is a concentration of our practical knowledge and offers us typical behaviors or thoughts in many circumstances without us having to think much. The representations to be mobilized are probably activated more by our attraction for certain objects than their relevance to the real situation. Finally, cognitive treatment seeks to be minimal to provide a rapid response in urgent cases and also by economy (or laziness). Cognition proceeds as much as possible by heuristics that help to approach good solutions, satisfying in the concrete context. The details are left out at first, and some of the solutions foreseen are selected on the basis of experience and their appeal, or the impression that they induce to be part of the right way. Other solutions are quickly dismissed because being negative. Then cognitive processing in the search for the best path to the solution uses heuristics to not have to explore all possibilities. And the control of this treatment relies on the additional ternary information associated with the representations that indicates our appreciation for this object: positive, negative or neutral.

This three-state logic is that of neutrosophy which represents by a triplet of real numbers between 0 and 1 the belonging to each of the three states true, false, or neutral (or also with the meaning of indeterminate). Instead of a simple probability designating the veracity of an assertion, neutrosophy provides three probabilities (weights or appreciations), those of veracity, falsity and indeterminacy (or neutrality). This is much more general, and allows it to include other types of simpler logical representations, including fuzzy logic [14] and its numerous variants as well as traditional classical binary logic.

Here, we do not use the full capacity of this ternary representation for the decision to continue cognitive treatment, but simply the predominant aspect, if it is significant enough. For the rest of cognition, however, the continuous aspect is considered.

Let us now look in a few points at what neutrosophical representation more precisely is, according to the section we gave in a previous article [15].

8.   Some information about neutrosophy

Recent trends in the use of neutrosophy can be found in the reference work edited by Smanradache and Pramanik entitled "New trends in neutrosophical theory and its applications" [16]. In the aforementioned article we also proposed data compression according to the physiological laws of human perception, indicating that the nature of such a compression process is fundamentally based on a three-state representation, which is an additional corroborating element for the theory that neural networks, living or artificial, elaborating their functioning by learning, rely on data compression [10, quoted above].

The inspiration for the neutrosophical representation of reality comes from the philosophy called neutrosophy. This

representation is general and makes possible to unify in particular the various (apparently very distinct) variants of logic: classical logic, also called binary logic or boolean logic, fuzzy logic and its numerous varieties, and itself, a three-state logic, characterized by a neutral state [17]. Note that the three-state approach is central in natural language speech processing too, specially for sentiment analysis (which aims to discover a positive, negative or neutral connotation by the sender beyond the semantic content of his message) [18].

In summary, instead of a logical value with two states false (0) or true (1), the neutrosophical approach considers a representation by a triplet (t.i,f) where these three real values t, i and f represent the equivalent of probabilities for truth (t), indetermination or neutral state (i) and falsity (f) respectively. We prefer to speak of membership functions according to the vocabulary used in fuzzy logic. These three values are between 0 and 1. Thus the two classical binary logic values 0 and 1 are represented respectively by (0,0,1) and (1,0,0). Now a simple probability p of having the value true and therefore (1-p) of having the value false is represented by (p,0,1-p). In this particular case the neutrosophical representation mainly brings a general formulation, and thus it also makes possible to represent this conception which it encompasses in its generality.

The operations on neutrosophical triplets, preferably called simple neutrosophical numbers (for single value, in the sense of mono, a single triplet), can be defined in various ways, either using arithmetic operators (e.g. multiplication for the logical AND) or functional operators (such as minimum, maximum, etc). For example the complement of (t,i,f) can be defined as (f,1-i,t), but other conventions may be more appropriate depending on the applications. Let us return now on the preceding case of an operator with two operands, as the logical AND mentioned before, let us consider this time the logical OR, i.e. the union together. For two simple neutrosophical numbers A and B represented by the triplets (t_a, i_a, f_a) and (t_b, i_b, f_b) then their union A OR B will be the triplet $(\max(t_a,t_b), \max(i_a,i_b), \min(f_a,f_b))$.

Although a neural network is organized according to the learning algorithm, cleverly chosen and parameterized to use internally representations adapted to the problem to be solved, in particular it can perform a referential change, a projection and other operations that can be geometrically illustrated (and which in fact produce appropriate data compression). This autonomous organization is however costly in terms of learning time but also in terms of the quality of the performance produced. If for a given application, it is known that a representation is generally chosen for powerful classical algorithms, then it is highly likely that the network will choose a similar representation relatively close. Indeed often for a specific application it is preferable to start from a network pre-trained on a problem either more general or rather close, which precisely means to start from a relatively appropriate representation.

9.　Conclusion

Thinking on cognition reveals the importance of aspects other than the pure logical (binary) treatment that is nevertheless put forward by Western civilization. Without rejecting the successively extended model of the rational actor we propose an intuition that we think can give rise to ideas explaining the cognitive functioning of living beings and that can partly be adapted to artificial intelligence systems based on neural networks with deep learning or other training algorithms.

The rational cognition of the actor, in terms of maximizing his benefits while reducing his costs, which has been extended to consider social aspects presenting not strictly economic benefits, then expanded to include the reasons that the actor himself finds good, is completed in our hypothesis of an evaluation throughout the treatment and for all the information processed. These are our representations, social and shared collectively, which allow us to understand the essential objects and concepts related to the real world. Taken together these representations form our immediate knowledge, which can be mobilized because it is contained in our brain and also constitutes our vision of the world, which is in fact the only apprehension we have of it, and therefore we think it is objective, whereas it is only subjective, including precisely our appreciations.

The form of the representations determines how to process them, and our hypothesis is therefore that a representation of an object includes an appreciation of this object, according to a ternary weighting: positive, negative or often neutral. This corresponds to a neutrosophical representation. From this particular form, and specific to the living, corresponding to an additional valuative, emotional or sentimental content, flows the organization of their processing. Thus cognition is not only logical, but takes into account the imperatives of life in a social world, and propagates the appreciation, emotional or sentimental aspect, throughout the treatment chain, until solutions to the problems to be solved appear, which are in fact marked by values in themselves. In this way, solutions and beginnings of solutions can emerge as a function of experience (rational valuation) and affects (also indirectly contained in experience).

Moreover, this valuable content makes it possible to act on the very mechanism of the search for solutions, which is

the basic scheme of operational research, having to consider the combinatorial explosion of the large number of cases to be treated in the universe of possible solutions. These beginnings of solutions are progressively pruned according to the predominance of the positive or the negative (acceptance or rejection of a partial solution) or then in the case of the neutral, the process just continues. So, this evaluation acts as a heuristic for rapid selection of solution elements, and in fact each representation carries within itself a part of these heuristic shortcut elements. In the end, the chosen solution is then naturally characterized by a good acceptance of the actor which contributes to facilitate its implementation.

Thus the aspect of ternary logic of neutrosophy is none other than the orientation for preference by the living cognition, that which allows filtering, retention of relevant characteristics, and thereby data compression in the learning process. Furthermore, in artificial neural networks with deep learning their functioning that can be explained according to this recent theory that the information is compressed to the essential necessary for the considered treatment.

Finally, the question may be asked whether this essential characteristic of an appreciative connotation of representations in the cognition of the living is not perhaps also inherent in any mechanism of learning by reinforcement, thus also in artificial intelligence.

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