Decision Making: The Complexity of Choice Processes

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ABSTRACT

This article is part of a project in Mathematical and Linguistic Foundations for Intuitive Decisions. It explores decision-making processes in different realities: virtual and real. Linguistic foundations are bases to distinguish these realities, explained through the Discourse Analysis (DA) theory, which takes language effects as caused by ideology, on a virtual plane, and takes evidentiary information as a way to understand the historical record, in the real socio-historical context. The discursive theory studies language production conditions to give rise to meaning oriented by presupposed conditions. We identified this discursive as an early interpretation which gives a meaning in advance and decontaminates other meaning possibilities. We compare such discursive functioning to a mathematical structure of logical reasoning (classical logic), which puts beforehand a "perceived truth" ("speaking intersubjectivity") to eliminate supposed ambiguities, without reference to a particular meaning or context. However, as subjectivity is not crystallized, it can be understood as a place with a dual role: that of disclosing subjection and that of disclosing its subversion, thus breaking the vicious circle of idealism. This means dealing with incomplete, fragmentary and unpredictable information which will re-work meaning and interfere in the subject's choice. We differentiate this situation from classical logic, and we choose polyvalent logic (Neutrosophy) to exemplify it. Instead of interpretation's assigning False or True values, polyvalent logic works with *possibilities* (the propositions assume different values in each possibility) and admits more than two truth values, thus rejecting the principle of bivalence: In addition to the False (F) and True (T) values, polyvalent logic works with a third value, the Indetermined (I), it treats information under uncertainty. We combined the Discourse Analysis theory with Neutrosophy in order to observe meanings/ideas that will draw the paths of decision-making in the field of the Indetermined (I). The comparison of these decision-making mechanisms makes us aware of the fact that we are not be able to claim that this is the definite understanding of the decision-making phenomenon, but it gives us the hope of shedding light on mastering the complexity of choice processes.

Key words: Discourse Analysis; Mathematics; Decision-Making; Classical Logic; Polyvalent Logic.

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1.0 INTRODUCTION

This discussion emerged out of the project on Mathematical and Linguistic Foundations for Intuitive Decisions (Monte-Serrat; Belgacem; Maldonato, 2017). This article takes a brief approach to the abovementioned project by exploring the differences between virtual reality and real reality relating them to the subject's process of choice. On one hand, we can observe the subject who is being put at risk of a strong force that "chooses" for him, on the other, he feels constrained to choose himself and, at this time, we can analyze another functioning process that gives him headlines for decision. However, we intend to provide a near-comprehensive ability to distinguish choice processes in decision-making. In this article, we aim to highlight the intuitive process, since the rational decision-making process has already been addressed in the article "Subject and time in the virtual reality" (Monte-Serrat & Belgacem, 2017).

Linguistic foundations are the basis to distinguish virtual and real reality, which we believe is the first step to understand the decision-making process. We explain this issue through the Discourse Analysis (DA) theory (Pêcheux, 1982, 1988a, 1988b; Pêcheux&Gadet, 1983) to apprehend that the human being has no direct access to reality, but he needs a method or a criterion to relate thought to reality, and he uses language to interpret the world. The DA theory explains that effects of language meaning are caused by ideology (Adorno 1999, Zizek, 1999), differently from other scientific approaches which reduce the meanings of language, understanding the latter as a supposedly neutral instrument to express reality. Mathematical foundations are used to represent some decision-making functions, always differentiating these functions in virtual reality and real reality (different realities involve different processes).

2.0 LITERATURE REVIEW

2.1 Discourse analysis as a linguistic foundation to understand decision-making

Language carries a *semantic function*. According to the DA theory, this function deconstructs the understanding of language neutrality and transparency. When we use language, we depart from an established place based on the understanding that such language is transparent, or better saying, which makes meanings homogeneous and ignores the subjective character of understanding. This reasoning presents discourse as "neutral" ideological conjuncture.

The theoretical perspective of Discourse Analysis by Michel Pêcheux (1988) helps us to analyze the constitution of the subject under the effect of meanings between socio-historical determinations and interpellation by ideology. There is the tragicity (Monte-Serrat & Tfouni, 2017, p. 37) of the subject of discourse under the discursive perspective: he/she can be conceived in the paradox of the functioning of the interpellation mechanism, which gives rise to the subject who, while believed as autonomous and free, has his/her freedom entangled in economic or social determinations.

As symbolic beings, we must be aware of the functioning of ideology through language. We must be attentive to an imposed meaning production in discourse. We (Monte-Serrat, 2013) work with a constitutive division of meaning: the meaning of knowledge (place of logical and "neutral" discourse) and the subject's meaning as a place of subjectivity. When we observe language *production conditions*, we have to take into account a theory of meaning as an effect of metaphoric relations. Pêcheux, in the DA theory (op. cit.), introduced the Saussurean theory of value, which explains the meaning of words by their relations to all other words in the language and by applying it to discourse production conditions (Helsloot&Hak, 2007). As discourse production conditions are important, the DA method works with evidentiary information (Ginzburg, 1989), cognitive practices which allow us to understand how clues and traces, embedded in the historical record, reveal hidden information for observing what cannot be observed at first sight (Herlihy, 2016) and influences the subject's choices.

2.2 Historical context of the 17th century: logical reasoning as a mathematical structure in discourse

In the history of humankind, every single decision has been made by choosing among possibilities under environmental pressures, but we are not conscious that these decisions have grown with a cost in terms of energy in such a way that human beings' ability to choose must have presented itself as a chaotic mass of data devoid of clear structures and regularity. We may consider the fact that adaptation to the socio-historical context must have imposed to human beings fragmentary information with limited cognitive capacities and restricted time limits. This process provokes an individual to be the first of all and quick. In short, this process, on one hand, has inevitably influenced the level of satisfaction to which a human being could aspire in addition to the speed with which a solution could be looked for. On the other hand, it has decreased the capacity to perform operations that are essential to survival, such as measuring quantities, distances and it has affected the individual's functioning of the cognitive economy (Maldonato & Dell'orco, 2010).

Aristotle's formal logic, which allows us to make inferences from premises and, therefore, draw conclusions, has been considered to be at the basis of reasoning, interfering in decision-making in order to make them follow logical canons (Maldonato & Dell'orco, 2010). The contribution of this research is to clarify decision-making processes through the discursive theory, in which language production conditions play an important role. Under the Discourse Analysis method, we can question the change that occurred in the 17th century: a knowledge procedure consisting of systematic observation was adopted by testing and modifying hypotheses. It was a kind of knowledge in which discourses are oriented by a *presupposed condition* (conditions of discourse production). Pêcheux introduced a true innovation in the theory of discourse: his theory of *interdiscourse*, defined as the "'complex whole in dominance' of discourse production conditions" (Pêcheux, 1988, p. 146-153).

This systematic reasoning depends on a body of techniques. It involves making conjectures and predictions, enhancing a certain perspective to develop more sophisticated knowledge (Peirce, 1877, 1908). The way reasoning develops itself through hypothesis, as a conjecture based on preconceived knowledge and through controlled conditions when possible, determines and anticipates logical consequences. The discursive functioning under hypothesis as early interpretation gives a meaning in advance and decontaminates other meaning possibilities. This is a mathematical structure in discourse which puts a "perceived truth" beforehand to eliminate supposed ambiguities. This is how logical reasoning imposes general patterns to thinking, without reference to a particular meaning or context. This kind of discursive functioning works as a shift of the orientation of knowledge and establishes self-evident truths that are considered to be obvious. There is a "right order" of thinking which starts from a true statement "known" to be true to reach a true truth. Criteria of rationality are coherence between thought and action and between means and end.

These anticipated propositions understood as true are detached from a context and work as an idealization of reality (Mortari, 2016, pp. 162-163). They act according to the principle of bivalence of classical logic: every proposition is True or False (op. cit., p. 439). There is a "sanitation" of other possibilities of conclusion; there is a way that prevents ambiguities and places precise meanings.

2.3 Language ideological interpellation

Language functioning is not neutral. It is crucial for the construction of meaning because it constructs a consensus and brings the illusion of a "semantically balanced world" (Pêcheux, 2002). This functioning comes with another process as a consequence of ideological effects, while subjects have nothing to say that is their own (Legendre, 1976, as cited in Haroche, 1992, p. 190). In this case, subjects take their subject-position (Pêcheux, 1988) which dictates "what to say" for the sake of a logically balanced universe: There is a strong force that chooses for him.

Pêcheux (1988, p. 163; 183) explains this process with his "subject-form" along the discursive chain: he/she does not acknowledge his/her subjection to ideology because he/she is constituted under the effects of meaning given *beforehand* in the context they belong to, which dictates what must and what must not be done. Pêcheux (1988) refers to this process as "speaking intersubjectivity" which appears as an effect of language. He/she does not realize that there are other possible meanings. There is an incompatibility between what the subject "has to say" due to his/her "subject-form" influenced by ideology and the subjectivity process that occurs in discursive materiality: they co-exist under the appearance of a paradox (Monte-Serrat&Tfouni, 2013). Interpellation provokes a superposition of meanings in the discursive chain (ideological and unconscious, the latter embedded in subjectivity) working out of a kind of fetishism that surrounds its mode of operation. We state that (Monte-Serrat&Tfouni, 2013, p. 347) subjectivity is not crystallized as ideology suggests and tries to cover up, but it is a place with a dual role: "that of disclosing subjection and that of disclosing its subversion, thus breaking the vicious circle of idealism and interrupting the tragic fate of the subject that is captured by ideological interpellation".

That's why the inaccessibility to the sum of information required, the impossibility of predicting the consequences of each hypothetical action and the unavoidable cognitive-computational limits of individuals put the very concept of rationality back into question, with the consequent shift from the criterion of optimization to that of satisfaction (satisficing) in the choice among alternatives (Simon 1987). It is in with this regard that we state that the real world is composed of a sum of chaotic and ambiguous data that are irreducible to logical-deductive inferences (Maldonato & Dell'orco, 2010). Therefore, taking action means dealing with incomplete, fragmentary information and explicit time constraints that will re-work meaning and interfere in the subject's choice.

3.0 ANAYLYSIS AND DISCUSSION

3.1 Fundamentals of Mathematics to understand Intuitive Decision

Based on the assumption that subjectivity in language is not crystallized and can subvert its ideological effects, we will try to put this reasoning in an algebraic structure. Regarding Mathematics, we choose logic - as a set of principles and methods of inference or valid reasoning -, to address the differences between *logical reasoning* and *intuitive reasoning* (Mortari, 2016, p. 435).

Logic is concerned with whether the premises are a good reason to support the conclusion. There are several systems of logic. In this study, we associate logical reasoning to classical logic and intuitive reasoning to polyvalent logic.

3.1.1 Classical Logic

Classical logic starts from statements we know to be true and, if each statement is true, we can reach a true conclusion. In this process, we are interested in the form rather than in the content of an "implication", of an "assertion that if one particular statement is true, then another particular statement is true" (Eccles, 2007, p. 10). These conditional propositions start from explicit or implicit hypotheses to demonstrate an outcome: if the hypothesis is valid, then, so is the thesis. There is a right order of mathematical language that provides a kind of necessary certainty, anticipating a systematic mathematical interpretation. The principle of bivalence governs classical logic, which is: every proposition is True or False.

In order to understand classical logic, the first concept of Mathematics that we need is the concept of "proposition": "A proposition is a sentence which is either true or false (but not both)" (Eccles, 2007, p. 3). A statement or a proposition is "the key [...] that there must be no ambiguity. To be a statement, a sentence must be true or false, and it cannot be both" (Sundstrom, 2017, p. 1). In order to establish that a statement is true, we often write a mathematical proof and, to "establish that a statement is false, we often find a so-called counterexample" (Sundstrom, 2017, p. 3). There is a need to focus on "what happens *before* we start a proof", as for example: "to make a conjecture

beforehand as to whether the statement is true or false", and "this is often done through exploration" (Sundstrom, 2017, p. 3). The difficulty of this task is due to "not to find a specific answer, but simply to investigate" through some techniques (Sundstrom, 2017, p. 3-4), such as guesswork and conjectures (when we make a guess in mathematics, we usually call it a conjecture); constructing appropriate examples to gather information that provides evidence that a statement is true or false, or we can only say that the conjecture appears to be true; or using *prior knowledge*.

Logical reasoning in Mathematics is concerned with establishing the truth of statements and "this is achieved by giving a proof of the statement. The key idea in most proofs is that of implication" (Eccles, 2007, p. 10), and there are some strategies to solve a problem, such as trying a number, looking for patterns, guessing and testing, drawing a diagram, working backwards, acting it out (Mathematical Reasoning, 2017). Eccles (2007, p. 10) defines proofs as:

> "[A] sequence of statements starting from statements we know to be true and finishing with the statement to be proved. Each statement is true because the earlier statements are true. The justification for such steps usually makes use of the idea of 'implication'; an implication is the assertion that if one particular statement is true then another particular statement is true."

There are statements which lead "to a true proposition whatever values are assigned to the free variable n – this is called a universal statement" (Eccles, 2007, p. 13). Mathematical logic has as an essential point that formal language has used: "We take implication $\rightarrow$ and the universal quantifier $\forall$ as basic […]. The additional connectives $\bot, \exists, \vee$ and $\wedge$ are defined via axiom schemes. These axiom schemes will later be seen as special cases of introduction and elimination rules for inductive definitions" (Schwichtenberg, 2003-2004, p. 1). The symbols are called propositional connectives and build "propositions" (they can be understood as something we can obtain "by applying the following rules") (Dries, 2016, p. 14) in their role of applying a truth value which depends on the truth values of the constituent sentences:

> "Propositional logic is the fragment of logic where new statements are built from given statements using so-called connectives, such as "not", "or" and "and". The truth value of such a new statement is then completely determined by the truth values of the given statements. Thus, given any statements p and q, we can form the three statements ¬p (the negation of p, pronounced as "not p"), p $\vee$ q (the disjunction of p and q, pronounced as "p or q"), p $\wedge$ q (the conjunction of p and q, pronounced as "p and q")."

This leads to more complicated combinations, such as $\neg p \wedge (\neg q)$. We shall regard ¬p as true if and only if p is not true; also, $p \vee q$ is defined to be true if and only if p is true or q is true (including the possibility that both are true), and $p \wedge q$ is deemed to be true if and only if p is true and q is true. Instead of "not true" we also say "false" (Dries, 2016, p. 13).

3.1.2 Polyvalent Logic

Polyvalent logic, with which we associate intuitive reasoning, instead of interpretation's assigning False or True values, works with *possibilities* (the propositions assume different values in each possibility). Polyvalent logic admits more than two truth values and rejects the principle of bivalence: if the principle of bivalence implies determinism, it implies the non-existence of free will (Mortari, 2016, p. 463). In addition to the False (F) and True (T) values, polyvalent logic works with a third value, the Indetermined (I). It treats information under uncertainty conditions (op. cit. p. 467). The fact that we consider the overlapping of reasoning processes in the interpretation of meaning makes us think of the possibility that, during the decision process, there may be more than two options, constituted outside the legal logic. The displacement of the rigid structure of the

proposition "If *P* then *Q*" makes us think of another order of reasoning that takes into account a third option: that of indeterminacy, as something that brings up what has been discarded in order to decontaminate the possibilities between False and True.

In classical logic, the *hypothesis* (Wikipedia, 2017) denotes the antecedent of a proposition, thus if we have the proposition "If *P*, then *Q*", *P* denotes the hypothesis (or antecedent); *Q* denotes the conclusion (or consequent). To prove an implication, we must assume the hypothesis as a provisional idea which requires an evaluation. In this deductive reasoning there is determinism which predicts observations, confirms the predictions and states a law.

Neutrosophy (formed by *neutre/neuter/neutral* and *Sophia* - skill/wisdom - meaning knowledge of neutral thought) is a new branch of Philosophy introduced by Florentin Smarandache (2017) and studies neutralities and their interactions with different ideational spectra.

This theory considers every notion or idea <A> together with its opposite or negation <Anti-A> and the spectrum of "neutralities" <Neut-A> (i.e. notions or ideas located between the two extremes, supporting neither <A> nor <Anti-A>). The <Neut-A> and <Anti-A> ideas together are referred to as <Non-A>. According to this theory every idea <A> tends to be neutralized and balanced by <Anti-A> and <Non-A> ideas - as a state of equilibrium. As a consequence, he generalized the triad thesis-antithesis-synthesis to the tetrad thesis-antithesis-neutrothesis-neutrosynthesis (Smarandache, 2017 a).

The Neutrosophic Algebraic Structures are "based on sets of Neutrosophic Numbers [i.e. numbers of the form a+bI, where a, b are real or complex numbers, and I = Indeterminacy, with I^n = I for n positive non-null integer, 0I = I, I/I = undefined, and nI+mI = (n+m)I]" (Smarandache, 2017). The indeterminacy *"I",* within this structure, can appear in different types, "such as $I_1, I_2, , I_p$ with integer $p \geq 1$, and obtain the *refined neutrosophic numbers* of the form $N_p = a+b_1I_1+b_2I_2+ +b_pI_p$ where $a, b_1, b_2, , b_p$ are real or complex numbers, and a is called the determinate part of N_p, while for each k *in* $\{1, 2, , p\}$ I_k is called the k-th indeterminate part of N_p (Smarandache, 2017). The author explains that elements of Neutrosophic Structures (T, I, F) are composed of two parts: a space and a set of axioms (or laws) acting on (governing) it. If the space, or at least one of its axioms (laws), has some indeterminacy, that structure is a *(T, I, F)*-Neutrosophic Structure. He extended them to the *(T, I, F)-Neutrosophic I-Algebraic Structures* [2015], i.e. algebraic structures based on neutrosophic numbers of the form $a+bI$, but also having indeterminacy related to the structure space (elements which only partially belong to the space, or elements we know nothing about whether they belong to the space or not) or indeterminacy related to at least an axiom (or law) acting on the structure space. Then, he extended them to *Refined (T, I, F)-Neutrosophic Refined I-Algebraic Structures.*

As we are working with intuitive decisions, we choose the polyvalent logic which moves us away from determinism and considers the probabilism of inductive inferences. In place of a hypothesis, we need a model of reasoning to pose a scientific explanation in a structure which emphasizes the maximal relevance of a *set of conditions and axioms* stated, such as a law which "axiomatizes an unrestricted generalization from antecedent *A* to consequent *B* by a conditional proposition – If *A*, then *B*" (Montuschi, 2003, p. 61-62).

The term "causalities" in a scientific explanation was questioned in its role of a mathematical idealization, "with no immediate basis on experience and with no evident connection to the ultimate causes of the natural world" and "with a claim about what would happen in a situation that never exists" (Bolotin, 1998, pp 33-34). Upon the fall of logical empiricism in which the role of logic and mathematics was important to find an understanding as part of a scientific enterprise (Stanford Encyclopedia of Philosophy, 2017), causality rises from scientific explanation began to emphasize maximal specificity for conditions and axioms (Hempel's inductive-statistical model). In this way of reasoning, modern science "cannot claim, and it will never be able to claim, that it has the definite understanding of any natural phenomenon" (Einstein & Infeld, [1938]2017). Albeit this condition of science, we choose Neutrosophy to try to demonstrate how indeterminacy can interfere with meaning and with decision-making.

5.0 CONCLUSION

We explained the role of algebraic structures on the functioning of logical reasoning systems in virtual and real realities. This study showed that decision-making may occur in different ways, depending on whether reality is virtual or real. As we associate virtual reality with logical reasoning, a truth is anticipated and the subject decides on the ambivalence between True and False choices. In real reality, it is necessary to work with the polyvalent logic, which brings, besides the options between False (F) and True (T), the Indeterminate (I). The DA Theory explains that a bivalent choice is ideological; it is not on the materiality of the discursive chain (Monte-Serrat, 2013). Bechtel (2006, pp. 24-25), states that humans observe a sequence of sensory events and not causal relations (cause and effect), which are unobservable. The polyvalent logic, in turn, works with an indeterminacy degree, and the intuitionistic probability is appropriate to observe the discursive chain, since the meaning is not previously given, but constitutes itself in the enunciation (Pêcheux, 1988). We discuss this functioning through the Neutrosophic Theory as a polyvalent logic system based on different assumptions that help to predict observable events.

When we study the formation of meaning, we have to take into account that we are using language to interpret reality, since we do not have direct access to the real things: theories of interpretation are essential in this quest to construct procedures that expose the interpreter's gaze to the opaque levels of meaning-forming strategies at the levels of something that has not been previously determined. When we combine Discourse Analysis, the DA theory (Pêcheux, 1988), with Neutrosophy (Smarandache, 2017), we can observe meanings/ideas that will draw the paths of decision-making in the field of the Indetermined (I).

The DA theory (Pêcheux, 1988) calls into question the transparency of language and breaks the idea of evidence of meaning by giving relevance to the ambiguity, misunderstanding and polysemy of language. This phenomenon cannot be forgotten in scientific research on decision-making, since uncertainty is an element of the emergence of meaning (Pêcheux, 1988). We then think of comparing the scope of the Indeterminacy (I) of the Neutrosophy Theory to a field where there is a network, and it is exactly in such network that a node will happen, which will provoke the emergence of a particular meaning, not given, not predicted: an indeterminate meaning.

Pêcheux (1983) states that the subject cannot be thought of as a conscious, rational, and logical-operative strategist. The author (op. cit. p. 12) states that this concept is a myth and that, in reality, there are symbolic and unconscious interactions which affect the subject's activity. It is with this regard that we compare two algebraic structures as starting points for decision-making: the structure of logical reasoning, with its *hypothesis* (as a virtual truth given beforehand in logical reasoning), and the Neutrosophic structure with a *set of axioms* (that exists between T and F) as a space of Indeterminacy (I). Algebraic structures - as sets of one or more defined finitary operations that satisfy a list of axioms (Cohn, 1981, p. 41) - can coexist with non-algebraic structures, as in *topology*, and this makes us consider time as an important element that interferes with the interpretation of meaning. These mixed structures can explain the functioning of decisions in situations of uncertainty: creativity and time lapse intervene in decision-making, and topology can describe both of them. The relationship between time and the subject in the constitution of meaning depends on the logical movement in which they are inserted, or mathematically speaking, depends on the standards or structures where this relationship is born. The mathematical paradigm is taken to bring a clarification on the subject's constitution in connection with time and helps to clarify the decision-making process. For this task we use intuitionism as a philosophy of Mathematics: "This philosophy, poorly understood at first, stated that in order for a mathematical statement to be true to a mathematician, that person must be able to *intuit* the statement, to not only believe its truth but understand the reason for its truth" (Brower, 2017, p. 490-492):

> "Intuitionistic Logic substitutes constructability for abstract truth and is associated with a transition from the proof of model theory to abstract truth in modern mathematics

> [and] is more rigorous than conventionally founded mathematics, where, ironically, the foundational elements which Intuitionism attempts to construct/refute/refound are taken as intuitively given" (Brower, 2017a).

We emphasize that it is not a question of describing what really happens, but of comparing with the mechanism of the possibility of emergence of meaning. We are aware that we will not be able to claim this is the definite understanding of the decision-making phenomenon. We describe, through Mathematics, that while intuitive perception presents itself as sudden illuminations; it takes the place of something that was uncertain, unpredictable and appears in a mixed perception between emotion and reason: instead of an alternation (or...or) of the logical reasoning of virtual reality, we have a simultaneous emersion of both, emotion and reason, mixed in the field of the indeterminate (I). This understanding of underlying brain mechanisms clarified by Mathematics may help us master the complexity of choice processes.

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