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Towards Ethical AI: Mathematics Influences Human Behavior

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Synopsis

Mathematics plays an important role in the linguistic structure of artificial intelligence (AI). We describe the linguistic process as a unique structure present both in human cognition and in cognitive computing. The close relationship with both AI and human cognition is due to this unique structure, which paves the way for AI to interfere with the behavior of those who interact with it. We highlight the role of mathematicians in designing algorithms—the core of the AI linguistic process—and in defining steps and instructions for AI. Because algorithms, through AI, interfere with the thought of those who interact with AI by providing anticipated solutions that prevent users from making free choices, we investigate how we can apply ethical principles to guide interactions between users and intelligent systems in order to address this issue. We contend that by integrating ethical principles in the mathematical modeling of algorithms, we can avoid manipulation, inequality, and black boxes in the protection of individual rights. As such, ethical considerations are highly important for those working with algorithms, which highlights the humanistic side of mathematics.

Keywords: artificial intelligence, mathematics, language universal structure, subjectivity, ethics.

Introduction

Mathematics, ethics, and human behavior are united by the common thread of language. Broadly speaking, a language is a dynamic system of conventional spoken or written symbols through which individuals express their ideas. It would be useful to point out that there is a distinction between the dynamic linguistic process, which is structural, and natural languages (Portuguese, English, Chinese, Italian etc.) or even the language of mathematics. The dynamic linguistic process must be conceived as a very primary stage, which provides structure so that people can express themselves through natural languages or mathematical language. Expression of mathematical ideas involves elementary practices of counting, measuring, and describing ideas using specific symbols, which are used to represent a mathematical object, and also to combine the object with a proper syntax for some mathematical concepts belonging to a mathematical theory (i.e. mathematical semantics). For this to happen, mathematical language relies on a dynamic linguistic structure. The formal language of mathematics, despite having been developed specifically for practices like calculating and measuring, likewise employs the use of specific symbols which represent mathematical objects as well as rules of combination that determine the suitable syntax for expressing mathematical concepts. That is, various types of symbols are employed in both natural language and the language of mathematics.

We can clarify, then, that we are working with the concept of language, in its function of expressing ideas to build information, on two levels: a primary and structural level (language as a dynamic and abstract process) and language as languages spoken in the world (Portuguese, Chinese, French etc.) or combination of numbers, symbols (in the case of mathematical language, for example). Language in its familiar conceptualization deals with letters, lines, numbers, and so on. In this article we present a less well-known conceptualization of language in its dynamic and fundamental nature so that ideas (expressed in words or numbers, for example) make sense and become intelligible information to humans. See Figure 1.

Language, therefore, can be understood beyond its common sense, as a structure that captures information from the environment and transforms it into cognition (dynamic process). This structure plays a critical role in the linguistic cognitive process through which we acquire knowledge and understanding. Mathematical symbols, letters, sounds, lines, and the like only become in-

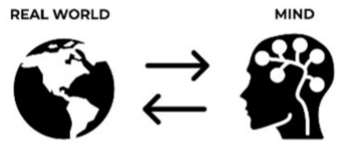

Figure 1: Some linguistic theories view language as something concrete, as a reason-based relationship. Language also encompasses the linguistic process, an abstract and dynamic structure responsible for capturing stimuli from external reality and taking them to the central cognitive system, which organizes these stimuli under logical reasoning. (Figure created by the first author. Icons taken from http://www.flaticon.com; art by Paulo Motta Monte Serrat.)

telligible information when they are organized by the primary structure of the linguistic cognitive process. This linguistic process encodes both the direct and indirect external stimuli received in our daily lives, allowing us to understand the world with which we interact.

What is new in this article is that, by conceiving language as something abstract, as a dynamic process, we can observe that this same linguistic dynamic process, intended to express ideas and build information, is also present in artificial intelligence.[1] This observation makes this dynamic process an intriguing unique structure, which lends itself to transporting stimuli to cognition: it takes stimuli to human cognition, and it takes data and information to the cognitive core of intelligent systems. Thus this unique structure serves as a 'bridge' for the exchange of information between intelligent systems and the human beings who make use of them. It is this unique structure (dynamic linguistic process) in its role as a bridge between human and machine, which leads us to investigate how Mathematics interferes in everyday human behavior. Indeed, we can investigate how mathematics interferes with human behavior by analyzing this linguistic structure.

[1]We use the term 'AI' to denote intelligent systems, machines, and net-living.

Here, we discuss the role of mathematics in the construction of intelligent systems in order to ascertain the extent to which mathematical algorithms (sets of commands that must be followed for a computer to perform tasks) interfere with the behavior of individuals who use these systems. Next, we assess whether there is compliance with ethical principles in this process. The unusual aspect of human language — understood as a process and not as a substance — is what leads us to relate mathematics, human behavior and ethics in this article.

This article is divided into seven sections. Section 1 explains the concepts of language and linguistic process, and how they are related to artificial intelligence and intelligent systems. Section 2 focuses on how this linguistic structure is common to both natural language and the language used by artificial intelligence. Then, in Section 3, we show how systems equipped with digital technology (intelligent systems or 'net-living') act on human cognition. We show, by contrasting some aspects of human cognition with cognitive computing, that aspects of human cognition overlap with the cognition of artificial intelligence so that artificial intelligence can interfere in the interpretative, creative, and determinative capabilities of its users. Language, cognition, interpretability, and behavior in intelligent systems are the subject of Section 4, which shows that the encoding and decoding of linguistic systems are performed both by individuals and by artificial intelligence, reinforcing the idea that language and cognition are part of the same linguistic process, which intertwines cognition with psychological and decision reactions. In Section 5, the linguistic process is related to intelligent systems, neuroengineering, and mathematics, which shows the repercussions on copyright and ethics. This section demystifies the supposed neutrality of intelligent systems, proving that the linguistic processes of humans and machines overlap when generating intelligible information. Section 6 reinforces the idea that intelligent systems are not neutral and in fact interfere with human behavior by showing that the origin of their behavior stems from mathematical work in the core of intelligent machines. To conclude, in Section 7 we offer a general overview explaining that studying the unique structure of the linguistic process shows how artificial intelligence affects human behavior. We hope that this study, on the one hand, helps mathematicians understand their role in the neuroengineering of intelligent systems — which involves making relevant ethical considerations — and on the other hand, helps generate awareness of the potential of intelligent systems to interfere with human cognition and behavior.

1. The Linguistic Process as a Bridge that Connects Human Cognition to Artificial Intelligence

This section is dedicated to explaining the universality of the structure of the linguistic process, and how it plays a role both in human cognition and AI cognition. First, we note that language can be conceived of in two manners: the common conceptualization (as languages spoken in the world) and also a more abstract conceptualization at a primary level (in the form of a dynamic linguistic process). We then explain the cognitive-linguistic process of AI. We show that the human and AI linguistic processes are similar in that they are both dynamic processes involving language. We contend that there is a single structure (common to both humans and machines) that is responsible for collecting external stimuli and transporting them to a central system that organizes them in a logical, intelligible way.

To understand what language is, one must be aware that the external world — which consists of lights, scents, textures, and so on — is only interpreted as such after the relevant stimuli reach the human mind, which organizes them logically through the linguistic process. Language, therefore, is subject to a dynamic linguistic process that makes it intelligible. That is to say, a language consists of symbols (letters, numbers, digits, etc.) of a given language (English, French, Chinese, etc.) which is subject to a linguistic dynamic process.

The structure of the human linguistic process can be found in AI as well; that is, AI undergo processes that transform stimuli (in AI the stimuli are the data collected) into intelligible information. This linguistic structure is the cognitive core of a machine, which determines how that intelligent system will process the collected data in order to carry out the tasks for which it was designed. This linguistic architecture is fundamental to the system, as it is what makes the system 'intelligent', allowing it to understand what it should do. It is a cognitive nucleus represented by a sequence of mathematical formulas, called an algorithm, which gives the machine the ability to interpret, encode, and decode tasks.

The algorithm (the core of a machine) establishes a systematic procedure designed to interpret a task and produce an answer or a solution. The algorithm consists of a table of values and relations that determine the answer or solution given by the intelligent system and can be generically conceived as the cognitive system of the machine. For example, the core of a cell phone application specially designed to monitor time, the core of a statistical data analysis system, and so on, guide the respective intelligent systems in the execution of the tasks for which they were programmed.

Figure 2 shows that because humans design the algorithms of intelligent systems, machine cognition is intertwined with human cognition. The fact that humans and machines are 'equipped' with a linguistic process with a single structure means that there is sharing in the information construction process. In other words, when both are exposed to stimuli (human) or to data collected (intelligent system), which will be transformed into information, the same and only dynamic linguistic process comes into action, in the role of a 'bridge', making cognition of 'AI users' communicate with 'AI cognition'.

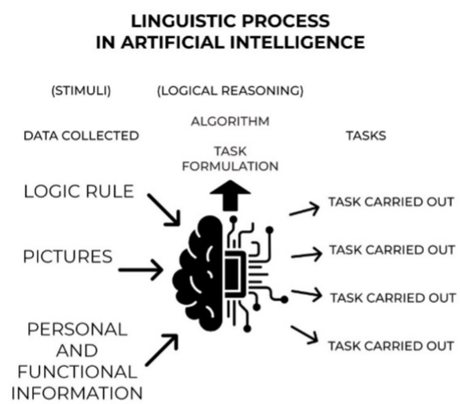

Figure 2: Data feeds AI — An AI program identifies a given object from the algorithm designed by the data scientist. The intelligent system looks for patterns in the collected data and interprets them according to its core (algorithm) to, in the end, perform an expected task. (Figure created by the first author. Icons taken from http://www.flaticon.com; art by Paulo Motta Monte Serrat.)

Artificial intelligence streamlines everyday tasks, but it can also induce changes in the private, public, and professional life of humans who interact with it [60, 58]. Clarifying how this interference of AI can occur in the daily lives of users of intelligent systems depends on considering the primary and fundamental aspect of language as a process, as a structure that unites human cognition with machine cognition. In this case, the conceptualization of language as languages spoken in the world (Italian, English, Portuguese, etc.) is in the background.

The unique and universal structure of the linguistic process defines the relationship between human linguistic processes and those of intelligent systems [39, 40], which may lead to a certain task or interpretation [33]. As a rule, in humans, stimuli are captured and taken to the central nervous system where they are processed through the process of cognition [14, 45, 40] (Figure 3). When humans engage with intelligent systems, they receive the stimuli generated by the systems. It should be noted that, when humans use AI, they receive stimuli already processed and interpreted by algorithms that make up the core of AI systems (Figure 2). That is to say, AI users receive stimuli with implicit interpretations that are directed by AI algorithms (Figure 2). The key point is that AI users adhere to the interpretations given by intelligent systems without realizing that other interpretations are possible.

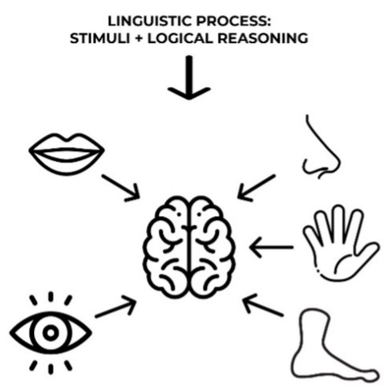

Figure 3: The capture of stimuli from the outside world by organs of the human body and the distribution of these stimuli to the central cognitive system, which organizes these stimuli into a logical sequence making them interpretable and intelligible. (Figure created by the first author. Icons taken from http://www.flaticon.com; art by Paulo Motta Monte Serrat.)

Because the linguistic process is the same in both humans and machines, human manipulation of the algorithms that make up the core of intelligent systems affect the cognition of users of those systems. This means that when neuroengineering technicians develop the cognitive core of AI systems using mathematical algorithms, they indirectly interfere with the cognition of AI users, making the users unknowingly adhere to certain purposes or interpretations.

The link between human and AI cognition through the unique linguistic process leads to ethical questions about the use of intelligent systems. Little is known yet about the deep learning tools being used in the core of the systems which influence their users' behavior. The core of the system must be aligned with the appreciation of data protection and privacy laws. Users of intelligent systems have their choices affected or their ability to make decisions impaired. This effect of using artificial intelligence cannot be ignored.

The absence of a generic theory that relates artificial intelligence and cognitive computing [21] to human cognition and behavior makes it difficult to identify the origins of AI interference in human behavior. We seek to raise awareness that human activity in creating mathematical algorithms is not a neutral zone. Although artificial intelligence has emerged as a technological revolution and is everywhere, it also needs to be improved in terms of protecting the rights and privacy of its users. There needs to be government attention to regulate the development of algorithms that are ethically sustainable, thus avoiding harm to users of intelligent systems. Imposing ethics and sustainability not only on human behavior, but also on artificial intelligence behavior [49] ensures ethical practices for future generations.

2. Putting the Human Linguistic Process and the AI Linguistic Process Side-by-Side

Language and cognition are activities that imply a human role in the process of finding objects and formulating a type of perception about them [24]. Figures 2 and 3 illustrate how human cognition is linked to AI cognition, which is based on algorithms. Both undergo the same linguistic process that starts from stimuli to arrive at an interpretation or task [39, 45]. The linguistic process depends on axiomatic characteristics — related to the context from which the stimuli come — and logical characteristics — linked to the logical reasoning that organizes the stimuli in a chain, making them intelligible to the human being [39, 40] (see the characteristics of context and logic represented in Figures 2 and 3).

In the virtual world of AI, the axiomatic characteristic is present in the values assigned to the elements that make up the algorithms, and the logical characteristic is linked to the chaining order designed for the algorithm (for example: if P, then Q). With these two characteristics, the linguistic process of AI has the necessary structural linguistic elements to act as a mediating bridge in shaping the perception of its users [39, 40], providing means for them to achieve tasks or goals through intelligent systems.

The key to clarifying how AI influences human behavior lies in the core of AI: algorithms. Mathematicians are responsible for designing these algorithms so that intelligent systems can perform certain tasks. When users adhere to the stimulus provided by intelligent systems, they unconsciously adhere to the interpretation already designed by mathematicians when they determine the core algorithms of systems. This relationship between the mathematician, the algorithm that constitutes the system's cognition, and the user who adheres to the system's cognition shows that there is power in the hands of mathematicians.

The emphasis on understanding this relationship between mathematicians, intelligent systems, and their users is intended to generate awareness that intelligent systems permeate human activities and that, because of this, they ought to obey ethical criteria. Intelligent systems are present in the relationship between people and formal education [4], in the relationship between people and informal knowledge [26, 23], in society's relationship with formal or agreed research networks [29], and in society's relationship with shared resources [41], among other things. Both the digitization of information through AI and the interpretation of this information performed by human AI users are subject to processing done by a unique linguistic structure: the cognitive linguistic dynamic process. This process is abstract, it is not explicit because it refers to the dynamic 'functioning' of the language and not exactly to the symbols or letters used in a spoken language. The existence of this shared linguistic structure for interpreting information is recognized by several linguists [47, 27, 11, 8]. Its elements indifferently integrate human cognition and cognitive computing [39, 40, 35].

3. Intelligent systems acting on human cognition

The unique structure of the linguistic process — which goes from stimuli to cognition to interpretations or tasks — is the bridge that connects cognitive computing to human cognition. The dynamic linguistic process is present in intelligent systems (Figure 2), whose algorithmic core mimics human intelligence to interpret information and perform tasks.

Algorithms consist of a core sequence of mathematical codes which, in addition to being related to a language of symbols (letters, numbers, signs, etc.), involves determining the behavior of the system. The way that systems interpret data and perform certain tasks depends on the logical chain that systems employ to process collected data; these core aspects of AI are similar to those of human cognition. Once the overlapping of cognitive functions is identified, human users are subject to making choices or interpreting events according to the logical chaining predetermined by intelligent systems. this occurs without users noticing that their interpretation is being directed towards the target previously determined by artificial intelligence algorithms.

The overlap between the linguistic process of AI and that of humans leads to close interaction between AI and humans through the following basic characteristics [39, 40]: the axiomatic one, responsible for collecting stimuli from the environment and transporting them to the central nervous system, and the logical one [31], in charge of organizing these stimuli in a way that forms understandable information (these two features are represented in Figure 2). In the following subsections, some structural details of how intelligent systems interfere with their users' cognition are clarified. That is, we describe how cognitive computing interacts with humans and how creativity and decision-making — which are natural to human cognition — are transferred to the core of intelligent systems.

3.1. Human Cognition versus Cognitive Computing

Human cognition makes information intelligible, capturing patterns that will be repeated by neural activity [45, 56]. These captured patterns of stimuli reflect the social environment and are fitted into a logical sequence [39, 40, 45, 31] to integrate cognitive functions. Human cognition is formed by capturing stimuli (performed by the body), which reveals its axiomatic characteristic, and also by logical reasoning. It is known that ideology and logical reasoning are linked to cognitive representations disconnected from context [34, 42, 43].

So far, little has been known why AI information processing has not been successful in ruling out subjective human experiences such as affect, sensitivity, morality, and intention. In line with what is argued in this article, it is observed that the cognitive linguistic process condenses perception, the self, alterity; experience and function; level and content [12]. The overlap between human cognition of users and the cognition of intelligent systems entails the mixing of human subjectivity with information processing by AI.

The connection between cognition and the body, as depicted in Figure 3, is an integral part of many works by renowned linguists and philosophers. For Ricoeur [50], the language of human beings has two dimensions: somatic and cognitive. According to Merleau-Ponty [32], the dimension of human sensitivity is related to the experience of the body. Husserl [25], in turn, associates speech (logos) with the body (phusis). Giroux [20] teaches that ideology (which we relate to the logical feature of language structure) builds human perception to generate a critical view of the world, promoting or distorting thought and action. These authors, in short, relate the cognitive linguistic process to the body and to logical reasoning, noting that logical cognition detaches itself from the context of reality, yielding a theoretical cognition (idealistic).

Human cognition processes information under a continuous learning system that, from a social environment, tries to predict future states [12]. In this way, human cognition regulates reasoning or decision-making. Computational cognition, in turn, follows the same path: its linguistic structure captures stimuli from the environment in the form of data and processes it to make decisions and make information intelligible. Intelligent systems are inanimate and depend on guidance given by technicians who model their cores by developing algorithms. The K-NN method is an example of how algorithm-driven computational cognition works [21]: computer technicians design algorithms that pre-set values for the machine's cognition. Those systems in turn direct interpretation of these algorithms [35].

The similarity of human and machine cognitive structures makes it possible for machines to interfere with the interpretive and decision-making activites of users who interact with intelligent systems. The role of algorithm designers is essentially linked to questions about copyright, creativity, and ethics in the use of systems. This connection arises precisely because there is a mix of human and machine cognition when humans interact with mobile applications, text editors, and modeling platforms, for example [36, 37, 39]. Interactions with intelligent systems affect the cognition of human users [39]; as such, these interactions must be evaluated and questioned. It is necessary to observe the path taken in the construction of information and in decisions, and to assess to what extent machines interfere with the creative activity or decision-making capabilities of users.

3.2. Creativity and decision-making through cognition

The human cognitive linguistic process has, as a final step, creativity, and cognition. Intelligent systems can collect and organize data according to modes of reasoning that are pre-established by algorithms. Technicians aim to develop artificial intelligence or cognition that can create and make decisions like humans. Polya [27, 48] makes the distinction between the functioning of human cognition and the functioning of cognitive computing clear. According to Polya, mathematics has two faces: one that is deductive and one that is inductive. While the universal structure of the human linguistic cognitive process, human language, is both deductive and inductive [39, 40], the creative processes of machines deal well with the deductive characteristic of mathematics, which is aligned with the logical chain intended to predict a given meaning or interpretation [31, 51]. In the human-machine comparison, machines have not yet reached the perfection of human creativity, not reaching the 'state of the art' when mimicking individuals in inductive linguistic processing

Ethical application of mathematics must take into account the cognitive linguistic process, articulating language (use of symbols, signs, algorithms, etc.), creativity and decisions. An algorithm organizes the sequence of tasks within the bounds of logical reasoning in order to construct meaning or information. This algorithm, at the core of an intelligent system, will influence the creative and decision-making capabilities of its user during their interaction with the machine. See for example Figure 4.

As such, we must be aware that:

1. the programming languages of systems contain specifications for algorithms designed by developers;
2. these algorithms are influenced by the contextual and subjective experience of the system developers. They describe the sequence of tasks under a logical chain that indicates 'in advance' which will be the 'best' decision or interpretation to be carried out by the user of the intelligent system. Since the system incorporates a prior logic, it can interfere with the user's choice without the latter realizing it.

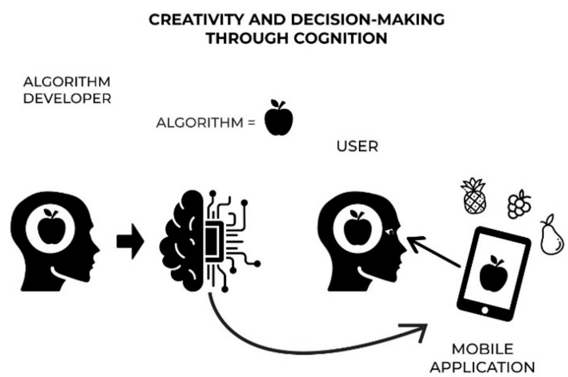

Figure 4: This figure shows cognition as part of the linguistic process. Left to right: A technician has a certain idea and models the AI to reproduce an information (represented by the apple). He designs an algorithm for a mobile app to reproduce this information. The user who interacts with this application will think or decide influenced by this information, without realizing that he could think or decide according to other information options existing in the context in which he lives (represented by the other fruits). For example: the app is designed to find steakhouses in the surrounding areas where the user is. The user activates the app that indicates 'only' steakhouses that 'pay' to appear in that search app. There are other steakhouses in the vicinity, but the user is not aware of these options, and ends up choosing a steakhouse suggested by the app. There is a direct interference in the user's decision-making. (Figure created by the first author. Icons taken from http://www.flaticon.com; art by Paulo Motta Monte Serrat.)

3. algorithms result from subjective decisions by developers and cannot be considered 'neutral' or raw material. They, when inserted in intelligent systems, are already 'infected' with a prior choice, with their own semantics, which will influence the user's decision-making.

In the linguistic process of artificial intelligence, systems operate according to algorithms specially designed by developers for specific purposes. AI systems direct interpretations and decisions (which are put into practice by the user) through their algorithmic cores. The creative and decision-making capabilities of AI systems are limited by their technician-designed algorithms [35]. Human creativity, on the other hand, goes further: the creative and innovative insight that humans have [19] does not just result from rational thinking to achieve.

The creativity presented by AI stems from a creation dependent on previously established principles within the core of the intelligent system. Human creativity surpasses AI creativity because it goes beyond the logical chain of rational thought, adding the individual's subjective experience to the creative act [37]. Artificial intelligence, as it is not human, is not endowed with subjectivity. When it comes to creativity linked to subjectivity, AI begins to absorb data from human users, through platforms and applications. This is one of the reasons why users' privacy and copyright cannot be neglected [49]. They need to be protected because they are not something in the public domain. The distinction between human creativity and machine creativity is important for the discussion of ethical aspects little explored in user-machine interaction processes and in platforms designed to replicate creativity in AI.

Human creativity, linked to copyright and ethics, resembles the inductive aspects of mathematics *in statu nascendi* (in the process of invention) [48, page *vii*]. The creativity of artificial intelligence, in turn, stems from elements previously established in algorithms. Both humans and AI undergo creative processes based on the architecture of the linguistic process [39].

It is important to note that users of intelligent systems can be led to make interpretations and decisions based only on the information that is offered by those systems, and not based on an environmental input. This brings us to the issue of ethics in mathematics, since technicians who design and model the algorithmic cores of intelligent systems are in effect developing products that interfere with the interpretative behavior of human users.

4. Language, Cognition, and Interpretability/Behavior in Intelligent Systems

The user-intelligent system interaction results in the overlapping of the linguistic processes carried out by the AI and the individual user. This is a dynamic linguistic process with a unique structure that provides the opportunity for systems to interfere in the interpretation and decision-making of users, without them being aware of it. This user-system interaction can also lead to the stifling of human creativity, as the systems, during the interaction with the user, offer him a preconceived logic for the decision process. Human cognition and creativity are intertwined with sensations, perceptions, judgments, and reactions [2]. The complexity of the human-machine interaction sheds light on the bases of the human evaluation process before decision-making [35].

Much research on cognition and consciousness shows that information processing is accompanied by subjective aspects such as affect, sensitivity, morality, and intention [16, 12]. Language, cognition, and interpretability/behavior are part of the linguistic process, whether of individuals or of intelligent systems. Computational modeling deals with all aspects of the linguistic process, mimicking human cognition [35]. The mathematical modeling of intelligent systems directly affects the user's subjectivity. Algorithms interfere with the formation of interpretations, drive decisions, and behaviors. The user is influenced by the algorithmic sequence, having his gaze guided, directed towards the construction of meanings or decisions. This ability of mathematics at the core of intelligent systems to guide the gaze of human users has ethical implications that cannot be ignored.

5. The Linguistic Process Related to Intelligent Systems, Neuroengineering, and Mathematics

Neuroengineering involves the application of knowledge of cognition, computation, and mathematics to develop intelligent systems. The modeling of algorithms that make up the core of intelligent systems is the responsibility of scientists and engineers, but discussions about AI and the linguistic process ought not to be confined to those people alone; because the linguistic process transcends the limits of engineering and mathematics, it must be discussed in an interdisciplinary way. In particular, we think it is important to consider ethical principles when using mathematics to model algorithms, which interfere with human cognition and consciousness. The mathematics used in cognitive computing must be linked to ethical principles as it interferes in the interpretive activity and in the decisions made by users of intelligent systems.

The mathematical modeling of the algorithmic core of intelligent systems involves the use of equations, submodels, hypotheses, restrictions, initial conditions, and boundary conditions [9, 17]. Parameters and relations inserted in the algorithmic cores of intelligent systems determine the behavior of those systems [54] and, as a result, the behavior of users who interact with them. Systems learn their users' tastes and decisions, and suggest in advance products to be consumed or tasks to be performed, imposing their decisions on users instead of allowing the user to enjoy their freedom to make choices.

5.1. Neuro-engineering and its effects on human language and cognition

Neuroengineering connects living neural tissues with non-living constructs and acts on the brain–computer interface in order to stimulate the brain and facilitate the treatment of diseases. In this article we are more interested in the fact that neuro-engineering operates on the structure of the cognitive process. The use of mathematics to develop algorithms for devices that use AI allows neuroengineering to act at the heart of the linguistic process of intelligent systems. This causes interference in the cognitive-linguistic process of individuals who use AI.

Examples of intelligent systems whose cores were developed by neuro-engineering are the computing devices that are embedded in everyday objects. These devices allow sending and receiving data, suggest music to users with recommendation accuracy, suited to that user's preferences [1, 59, 10, 52, 15]. The success of these systems is based on neuro-engineering, which designs algorithms capable of identifying user preferences and making suggestions to users even before they make their choices.

As much as there is rigidity in medical procedures, it is necessary to be alert to those involving neuro-engineering regarding their compliance with ethical principles. Users of intelligent systems put their subjectivity and cognition at risk since they are exposed to values and relationships predetermined by the algorithms of the system.

In 2021, Mark Zuckerberg launched the Meta virtual platform, which mediates the relationship between users and the real world. Users of Meta wear 3D glasses which superimpose virtual tools on the physical world that are intended for online purchase on e-commerce sites [55], for example. Companies that create applications with this technology interfere with the cognition and subjective characteristics of their users' experience because Meta observes users, draws conclusions, and makes suggestions on how users should decide or act.

These examples show how AI can affect the subjectivity of individuals by inserting values and relationships that directly affect cognition and the choices that AI users make. Neuroengineering, in these cases, is used to assess user behavior, and from there, interfere in their next decisions by limiting their opportunity to choose something offered outside of the offered alternatives. This stems from the universal structure of language and has many ethical implications, which we must think about when using such intelligent systems.

6. Subjectivity and Ethics in Intelligent systems

To understand our call for an ethical treatment of mathematics, it is necessary to understand how human behavior, subjectivity, and ethics are related to intelligent systems. We chose, in this interdisciplinary article, to discuss these things by means of a common feature: the unique structure of the linguistic process. This linguistic process, which involves perceiving stimuli, organizing information, reasoning logically, and making decisions, is present both in human beings and in artificial intelligence. The linguistic architecture collects stimuli from the environment and takes them to the central cognitive system — either a human brain or the algorithmic core of a given intelligent system — that will order these stimuli according to a logic so that they are intelligible. This is how information originates and influences the behavior and decisions of individuals, whether or not they are using an intelligent system (Figures 2 and 3).

As shown above, AI interferes with our choices, anticipating ideas or options; this influences our behavior and causes biases in the interpretation of a given subject. The discussion of these issues becomes urgent at times when we can be led to behave in a way that suffocates our subjectivity or ability to make decisions.

Ethics is related to subjectivity, to the qualities that define a person's intelligence, emotions, motivations and behavior. Ethics, therefore, is concerned with a sum of qualities that define who we are. Ethical considerations guide our decisions and play a part in determining our futures. If intelligent systems anticipate our decisions, they are also anticipating our futures, which is a problem. Companies that use intelligent systems to sell their products aggravate this problem. The possibility of conflict between the interests of companies and those of system users is very high; it may even be the case that intelligent systems prompt users to behave inconsistently with their ethical values. The awareness that intelligent systems can interfere with the cognition of their users brings to light the issue that the ethical principles of users can be compromised due to AI interference with their decisions, ultimately affecting users' quality of life.

When humans freely experience reality without any restrictions, they end up synthesizing new ideas [45, 19]. However, interaction with AI can impede this process: the AI reduces the users' perspective of choice by providing them with very linear and anticipated solutions. This in turn drives the users' decision making.

Ethical issues related to the use of AI have been much debated [13, 22, 53]. Although normative ethical guidelines regarding technology based on AI have been developed and many excellent results have been achieved, there continue to be situations where the subjectivity of users is stifled.

Researchers and academics dedicated to the study of artificial intelligence [28] call for private companies, research institutions, and public sector organizations to commit to issuing principles and guidelines for ethical AI. However, a lack of clarity about what exactly constitutes ethical AI frustrates such attempts. The discussion of the universal linguistic process in this article dispels the fog that surrounds the relationship between AI and ethics. There will be greater transparency, justice and equity [28], (concepts related to ethical principles), when these concepts are properly allocated mathematically in the algorithm of the intelligent system. This will make smart systems sustainable and consistent in the future.

The relationship between ethics and privacy is complex because not only should the public actions of organizations be guided by ethical considerations, but also because the collection and use of data by intelligent systems must be done in a responsible manner [60, 57]. Ethical principles must be sustainable to face technological developments that affect various aspects of our lives. Intelligent systems must have their algorithmic core modeled under ethical conditions so as not to harm their users' behavior and decision-making. Rigor and transparency are needed in all areas of knowledge that are related to AI.

Programming languages, designed to develop intelligent systems, use mathematical notation to write the algorithms of these systems. The mathematical modeling of these algorithms will specify each of its tasks, determining the semantic load of each one. It is this semantic load inserted in the algorithmic core that will act on the cognitive function of intelligent system users. Laws and ethical principles must also be taken into account when a task of an algorithm is being modeled, as they will also interfere in the design of AI users' behavior and decisions [49].

Using Perelman's argumentative reasoning [44], we identify the common thread of the linguistic process that is also present in mathematics applied to intelligent systems. The cognitive linguistic dynamic process is present in humans and also in mathematics applied to intelligent systems: both make use of the articulation of axiomatic and logical features to build information. Mathematics makes use of the cognitive linguistic process when modeling the core of an intelligent system, designing the sequence of tasks of the algorithm. The shared structure of human cognition and cognitive computing [39] (Figures 2 and 3) is subject to the application of ethical principles that will guide interactions between users and intelligent systems. In this way, it is possible to integrate the dynamics of cybernetic relations not directly achieved by laws and ethical principles [6, 38, 7]. By integrating ethical principles in the mathematical modeling of algorithms, we can avoid manipulation, inequality, and black boxes in the protection of individual rights and privacy. As such, ethical considerations are highly relevant for those working with algorithms and mathematics [39, 40, 35].

7. Conclusion

We have shown that the unique structure of the linguistic process is present in both human cognition and cognitive computing. In this way, it is possible to understand how intelligent systems — applications and internet platforms, for example — interfere with the cognition of those who interact with these systems.

The discussion of the interference of intelligent systems on human interpretations, behavior, and decisions leads us to call for the application of ethical principles in the development of AI in order to avoid or minimize possible deleterious effects on the subjectivity of AI users. We have looked at the role of mathematics in the structure of the computational cognitive process that merges with the cognition of individuals. The cores of intelligent systems consist of mathematical algorithms that describe steps that define instructions for solutions or tasks. When users interact with intelligent systems, the algorithmic cores merge with their cognition, suggesting early solutions for users even before they can make their decision; importantly, users do not notice when this occurs.

The complexity of the discussion about the ethical treatment of mathematics that influences human behavior is softened through the presentation of illustrations in this article. We made use of this resource precisely because of the difficulty in describing the abstract structural elements of the cognitive linguistic process. We also introduced real-world examples so readers interested in the subject can understand that the core — mathematical algorithm or sequence of steps — of intelligent systems is designed by mathematicians. This core contains a sequence of tasks that direct the interpretation or behavior of users who interact with such systems. This is a reality that must be evaluated based on ethical principles, as it affects AI users by feeding their decisions and attitudes.

We hope that this clarification of the architecture of the linguistic process will help mathematicians to understand their role in the behavior of intelligent systems so that they can evaluate the ethical aspects involved.

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