Creativistic Philosophy: Exploring the Limits of Formalization, #2[1]—From Astrology to "Artificial Intelligence"

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(Khalili Collections, 2021)[2]

[2] This image displays an astrolabe, a device in which astronomical information was encoded and which could be used to make observations and (analog) calculations, e.g., to predict positions of the sun and moon. Such devices where used for astronomy, navigation, and astrology.

At the time I am writing this, three bodies from interstellar space have been observed crossing our solar system.[3] Similarly, like such a block of rock and ice approaching the sun from far out in space, let me approach my topic from the outside. Let's begin this journey from a historical, or even prehistorical, perspective, at a time when our ancestors began to observe the starry sky and discover patterned regularities in it.

Astronomy is perhaps the most ancient of the natural sciences. Initially, in several ancient cultures, it served practical purposes of navigating space, both on sea, for example, in the maritime cultures of the Pacific Ocean, and on land, for example, in the desert cultures of Australia, and of measuring time, for example to determine the right times for agricultural activities. We might think here of ancient structures like stone circles that are thought to encode some astronomical information as well as of calendars developed in various cultures.

Daily, monthly, and yearly cycles observable in the skies obviously match cycles on earth, cycles of light and darkness, sleep and wakefulness, temperature, vegetation, and the tides. Therefore, the idea that the more complex patterns of motion of some celestial bodies, the planets, might be correlated to the more complex, less regular events on earth, and that the irregular appearance of comets might be foreboding extraordinary events like natural disasters and wars, did not seem far-fetched. So it is not astonishing that several cultures developed astrology, which then provided an incentive for increasing the accuracy of observations. These ideas were later discarded, but the resulting body of ever more accurate astronomical observations was one of the scaffolds for the development of science and mathematics.

Other areas in which mathematical knowledge developed were trade and accounting, surveying or measuring the earth—the original meaning of the term "geometry" – both for agricultural purposes or for settlement, as well as architecture, construction and civil engineering, for example in the field of irrigation.

The development of mathematics and logic can be viewed as part of the broader development of information technology. Human civilization can be viewed as a process in which cultural, i.e., non-genetic, information is acquired and developed. The most important inventions in the course of the development of civilization are those that deal with the way information, or knowledge in the widest sense of the word, is stored, transmitted, represented, and processed. The earliest information technology to be developed is human language itself, and within it some subsystems like quantifiers and numbers that might not have been present in its earliest forms.

[3] The first object confirmed to be an interstellar object passing through the solar system is known as 1I/'Oumuamua, was discovered in 2017; the second, discovered in 2019, is called 2I/Borisov; and the third, discovered in 2025, is known as 3I/ATLAS.

Initially the bandwidth of civilization, i.e., the amount of information that could be handed, or rather "mouthed," from one generation to the next, was limited by what small groups of people could keep in their memories. People developed ways to increase the accuracy of transmission of information by the use of poetic and musical devices such as rhyme, rhythm, alliteration, melody, and ceremony, as memory aids.[4] By the invention of painting, they could increase the bandwidth slightly. The invention of agriculture led to the increase of the number of people in communities and provided the basis for an increase of the total bandwidth by allowing for the specialization of some people in certain crafts or activities.

Eventually, the invention of writing made it possible vastly to increase the amount of information that could be transmitted from generation to generation. More recent advances in information technology include printing and paper, telegraphs and telephones, radio and TV broadcasting, computers, smartphones, and the internet.

This process was accompanied by the further development of mathematics and logic, and the simultaneous development of mathematical, logical, and other notations for the natural sciences, commerce, engineering, and other purposes. The development of notational systems, mathematics, and logic can themselves be viewed as information technologies. They made it possible to represent information more exactly and concisely. Moreover, exact reasoning processes, processes of logical derivation or calculation became possible.

This process lead to the development of the two connected notions of formal theories and of algorithms. In formal theories, rules of inference are used to derive statements from a set of initial statements, or axioms, and further statements can be derived from statements already derived before. The statements and rules of inference are formulated in some system of logical notation, often extended by mathematical notations.[5] The derivational, or deductive approach as such might be traced back to the *Elements* of Euclid who, in the realm of geometry, started with some axioms and then demonstrated the validity of statements in the form of step-by-step derivations from these axioms, or proofs.[6]

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[4] Another factor, at least in some cultures, was managing the available bandwidth by controlling what information was allowed to be transmitted. For example, in many Australian cultures, talking about the dead was tabooed, so information about specific ancestors or genealogies was not transmitted further, helping to keep the information channel free for more important information. This might have contributed to the extraordinary stability of these cultures and the longevity of some of the information that did make it into the oral tradition.

[5] This derivation- and rule-based approach can be extended to systems in which not only statements are derived, but arbitrary strings of symbols, e.g., expressions of "formal languages". For our purposes, however, I will only consider formal theories in which statements are derived.

[6] See (Thomas, 1939).

The other notion developed during the history of mathematics is that of an algorithm. An algorithm is a procedure for calculation. It describes how to solve a certain type of task. This term is a corruption of "al-Khwarizmi," the name of a 9th century mathematician, one of the founders of algebra, who compiled a number of calculation methods known at the time, for example, for solving quadratic equations. The name actually refers to the region he came from, known as Khwarazm.[7] Both Euclid and Al-Khwarizmi did not use special mathematical notation and formulated mathematical equations and methods for solving them in normal language. Subsequently, notational systems where developed both for the statements (axioms, theorems) and also for rules of inference and calculation methods.

Since some calculation methods involved cumbersome repetitive steps, people tried to mechanize some of the work, so mechanical calculators where developed. This development culminated in modern computers (Copeland 2020).

In the first half of the 20th century, mathematicians made several attempts to define the concept of calculation exactly and systematically by developing an exact definition of the concept of algorithm. Several formalizations of the concepts of algorithm or calculation were developed. These include, among others, the "Turing machine," the "lambda calculus" and "general recursive functions." It turned out that these different formalizations where equivalent to each other, i.e., any function for which an algorithm could be formulated in one of these formalisms could also be expressed in the others, and vice versa. We may think of these different ways of formulating algorithms as simple programming languages. I will assume in the rest of this series that an "algorithm" is a calculation procedure formulated in any of these "programming languages" or in any other programming language that has been shown to be "Turing complete," i.e., capable of expressing any computable function that can be formulated as a Turing machine. Since the different concepts of algorithm have been shown to be equivalent, I am not going to get into any of them specifically.[8]

Algorithms are applied to inputs and yield outputs. For a given input, we can formulate a statement of the form "algorithm A yields output y for input x." It is then possible to construct a formal theory that produces all of these statements for a set of inputs. So, for any output the algorithm calculates for a given input, the corresponding statement can be derived in the formal theory. On the other hand, for any given formal theory, an algorithm can be constructed that takes the natural numbers 1, 2, 3, etc. as input and enumerates all statements derivable in the formal theory, starting with the axioms, by systematically applying the rules of inference to the axioms and all

[7] An excellent introduction into the history of ideas (of philosophy, scholarship and science) in the Islamic world from late antiquity into the Middle Ages, which includes a discussion of al-Khwarizmi, is (Starr, 2013).

[8] Readers interested in technical details may look into textbooks on the matter, e.g., the two books I have referred to in the first installment of this series, see (Keller, 2025).

previously derived statements (or "theorems"). So the concept of formal theories is equivalent to the concept of algorithms. We can use these two notions interchangeably.

In the course of developing precise formulations of the concept of algorithms and formal theories, researchers investigated what types of tasks can actually be solved with the help of algorithms and formal theories. It became clear that there are limits to computability. In the equivalent formulation of tasks as formal theories, this means that there are limits to formalizability. This question is the subject of computability theory, which we could therefore also call "formalizability theory." In mathematics, but also, as we will see, in physical reality, there are things that cannot be described completely within the framework of a single formal theory or algorithm.

In the age of "artificial intelligence" (AI), which we might view as the next big thing in the age-old history of information technology, all kinds of information and knowledge are transferred into AI models. These are actually algorithms, or formal theories, which are automatically generated by other algorithms from some "learning data" like sets of examples (e.g., input-output-pairs). Many people believe in the possibility of "Artificial General Intelligence" (AGI), artificial "human level" intelligence, or even "Superintelligence." By applying computability theory to AI, I am going to shine a critical light on these topics.

In ancient times, the success of early mathematics and astronomy (mis-)led people to belief in astrology. A set of methods that was successful in some areas, like the prediction of events observable in the sky, was, without sufficient foundation, transferred to other areas, like the prediction of events in people's lives. It was overstretched, resulting in astrology, which eventually turned out to be unwarranted. We can predict the path of a comet entering the solar system from interstellar space, but we cannot predict what is going to happen in our lives tomorrow.

Something similar is happening nowadays in AI. There is a more than superficial analogy between the wrong predictions of astrologers and the errors of AI systems that are commonly referred to as "hallucinations." And just as the ancient astrologers tried to fix the errors by making more and more accurate astronomical observations, their modern counterparts are trying to improve the accuracy of their systems by increasing the size of the training data sets and the power of the hardware, not seeing the fundamental problems that, ironically, have already been known since the middle of the 20th century when computability theory was developed.

This technology has and will have its useful applications, but it is shrouded in clouds of hype, misconceptions, and overblown expectations. In subsequent installments, I am going to shine some light into these clouds, in order to separate the astronomical part of AI, so to speak, from its astrological part.

REFERENCES

(Copeland, 2020). Copeland, B.J. “The Modern History of Computing.” In E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*. Winter Edition. Available online at URL = <https://plato.stanford.edu/archives/win2020/entries/computing-history/>.

(Keller, 2025). Keller, A. “Creativistic Philosophy: Exploring the Limits of Formalization, #1.” *Against Professional Philosophy*. 3 August. Available online at URL = <https://againstprofphil.org/2025/08/03/creativistic-philosophy-exploring-the-limits-of-formalization-1/>

(Khalili Collections, 2021). Khalili Collections. “Planispheric Astrolabe.” *Wikimedia*. Available online at URL = <https://commons.wikimedia.org/wiki/File:Khalili_Collection_Islamic_Art_sci_0430_front.jpg>

(Starr, 2013). Starr, S.F. *Lost Enlightenment: Central Asia's Golden Age from the Arab Conquest to Tamerlane*. Princeton NJ: Princeton Univ. Press.

(Thomas, 1939) Thomas, I. *Greek Mathematical Works, Volume I: Thales to Euclid*. Trans. I. Thomas. Loeb Classical Library 335. Cambridge MA: Harvard Univ. Press.