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Introduction: Algorithmic Thought

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Abstract

This introduction to a special section on algorithmic thought provides a framework through which the articles in that collection can be contextualised and their individual contributions highlighted. Over the past decade, there has been a growing interest in artificial intelligence (AI). This special section reflects on this AI boom and its implications for studying what thinking is. Focusing on the algorithmic character of computing machines and the thinking that these machines might express, each of the special section's essays considers different dimensions of algorithmic thought, engaging with a diverse set of epistemological questions and issues.

Keywords

algorithm, artificial intelligence, cognition, computation, epistemology, technology, thinking

This special section of *Theory, Culture & Society* offers an exploratory examination of *algorithmic thought*. This examination is exploratory because there is much new knowledge to be discovered on this topic; developing this investigation also means advancing into uncharted territory. The aim of this exploration, however, is not strictly to map an area of study: the articles in this collection search for that space or occasion of thought that is produced or made possible by algorithmic operations, which are today most significantly instantiated by computing machinery.[1] This special section will provide some answers regarding what algorithmic thought is or can be; one of its main goals, however, is to bring up more questions about this subject. The authors featured in this collection (Wolfgang Ernst, Luciana Parisi and myself, M. Beatrice Fazi) will move from different perspectives, bringing in their own long-term proposals.

If an algorithm is a finite sequence of well-defined steps to solve a problem, investigating the possibility of algorithmic thought means asking whether these step-by-step procedures for problem-solving can stand as a mode of thinking and, if they can, inquiring about what this mode of thinking accounts for. At the same time, positing

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algorithmic thought as an object of study – and thus accepting the possibility of such a construct – involves recognising algorithms (and the machines that implement them) as agents of thought or expressions of it. Although this recognition is partially predicated on a well-established isomorphism between computation and cognition, it is not limited to or uniquely based on it. To explain this important point, I situate this special section within the context of research on artificial intelligence (AI). This contextualisation allows me to describe the setting of this collection of articles and clarify the current state of the debates to which they contribute.

The phrase 'artificial intelligence' has been around since the 1950s; its origin story describes a 1956 workshop (the Dartmouth Summer Research Project on Artificial Intelligence, organised by the computer and cognitive scientist John McCarthy at Dartmouth College) as the occasion where this name was coined (see Moor, 2006). The evocative phrase has been a powerful publicity tool for what was then a new field of research and what today can boast a remarkable array of interdisciplinary inputs and outputs. However, although AI research is a broad area to be approached and appreciated alongside a rich background of concurrent contributing endeavours, 'artificial intelligence' as a name remains opaque, also because of the difficulty of agreeing on what the artificial creation of intelligence should do. Here, what has been called the 'AI effect' comes to mind. This describes artificial intelligence as a moving target: there are different formulations of the AI effect, but one of the most popular is through the adage attributed to the computer scientist Larry Tesler: 'AI is whatever hasn't been done yet' (see Hofstadter, 1980: 601). Interestingly, current AI developments in *machine learning* – a set of computational techniques automating analytic methods and, in whose study and application, the distinction between artificial intelligence, statistics and data science has been blurred – demonstrate the appeal of this motto. Thanks to the successes of machine-learning techniques, after a period of relative quiescence in both funding and interest, over the past ten years or so AI research has gained much popularity again, becoming an area of study whose concrete accomplishments are given much attention by academia, business, industry, government and the general public. A series of fortunate technical circumstances contributed to the present AI boom: the creation and availability of data have increased, while data storage has become easier and cheaper, computer processing power has kept exceeding previous limits and information can be more accurately classified. These technical circumstances can be summarised with a slogan: 'better computation and better data'. Together, they explain some of the latest tangible advances in the field and why, for instance, AI techniques that have been around for decades (e.g. artificial neural networks) have only recently found their most successful application yet (for example, in *deep learning*).

This AI renaissance is said to generate great value for individuals and society as a whole; the surrounding narratives, however, swing like a pendulum between self-congratulatory claims about a relentless race for innovation and admonitory reports about the existential risks of a future of machine supremacy and human obsolescence. As a way of surpassing the polarity of these utopian or dystopian accounts, historians emphasise that previous periods of enthusiasm and excitement in AI research have often been followed by lengthy stretches of disappointment, when the technology did not live up to the hype. Favourable seasons in public and private support for AI research have come and gone in cyclical ways. Nonetheless, it is possible to contend that there is something specific to the present surge of interest in AI; this is a specificity that permits us to say that, this time, the technology will stick around, both in terms of its technical applications and its larger sociocultural implications. AI is everywhere today, and this is because computation is everywhere too. Media theory has long led the way in describing and assessing the 21st-century 'softwarization' (Manovich, 2013) of society and culture, whose contours are being shaped by the speeds and scales of what engineering and design call 'ubiquitous computing' (Weiser, 1993). The current AI boom has certainly been propelled by the swift success of certain computational techniques, which are, in turn, established on the cumulative achievements of other computational situations and conditions. Although the future of machine learning is unknown, the prospect that the demand in the AI domain will grow appears very likely because of the likelihood of the increasing scope and reach of computation in our contemporary world.

Because artificial intelligence is both a concept and practice that continues to reach more and more people and their everyday lives, it is important to stress that one of the greatest assets of AI as an area of research and development is its interdisciplinarity. If AI has survived the precariousness of cyclical spells of successes and failures, this is also because some of the core questions it addresses are questions shared by many contributing fields, such as psychology, philosophy, neuroscience, biology, robotics, computer science, linguistics and anthropology. These are questions about mind, agency, experience, knowledge, meaning, language, representation, perception and purpose – questions that endure but also evolve as the fields that address them endure and evolve too. The foundational aspect of these interdisciplinary questions is evident; because they are foundational, these are questions that cannot be easily compartmentalised, nor should they be. The 21st-century AI resurgence sees AI techniques being pragmatically used in a variety of scenarios, from healthcare to banking via urban planning; however, it has always been the case that different empirical outlooks and theoretical paradigms were part of the AI enterprise before the latter became mainstream. Government, business and industry (and the general public too) might like to think of AI as the crown jewel of science, technology, engineering and mathematics (that is, of the STEM disciplines); usefully, however, historical perspectives remind us that what is considered to be the founding paper of AI research – Alan Turing's article 'Computing Machinery and Intelligence' (Turing, 1950) – was published in *Mind*, a leading academic journal in philosophy. The present AI boom has not constrained this interdisciplinarity but expanded it, extending this kind of porous intellectual questioning upon which AI research thrives to new contributors and interlocutors. For example, and still within the realm of philosophy: traditionally philosophical investigations of artificial intelligence mostly originated from subfields close to cognitive science, such as philosophy of mind, language and logic. Today, however, AI is a topic of study for a much larger set of philosophical endeavours and agendas, such as those of aesthetics, hermeneutics, political theory and, of course, ethics, which has become a buzzword even among those who consider AI to be primarily a STEM concern.

The literature on AI is developing apace within the humanities. This growing body of research looks at the historical, social and cultural manifestation of artificial intelligence – at its political economies, epistemes and discourses. This stream of the literature also searches for those ideological and material circumstances that are productive of the vision of a future of computational automation, trying to understand the challenges and stakes of such a future by doing what the humanities excel at: uncovering and evaluating conditions of possibility. Importantly, these humanities propositions listen and speak to cognitive science; nonetheless, they are external to the latter. Here I can explain a previous comment of mine: earlier, I said that exploring the intellectual possibility of algorithmic thought involves considering algorithms as agents or expressions of thought and that this consideration is in part – only in part – based on the well-established isomorphism between computation and cognition. I can now add that the story of establishing this isomorphism is the story of cognitive science itself. Cognitive science is an academic area that studies mind and intelligence and whose goals, remits, histories and intellectual puzzles often intersect with AI research. One of the central theses of cognitive science is that cognition should be understood in terms of representations in the mind and in terms of those computations that operate on these representations. Because the emerging humanities literature on artificial intelligence is born outside of cognitive science, it can sidestep this analogy between computation and cognition, providing AI research with different relations and traditions in the study of machine thinking, along with alternative terminologies, methods, research cultures and interests.

The set of articles that forms this special section offers this alternative entry point to AI research; these contributions are aware of and receptive to the principles and traditions of cognitive science, yet they are not bound to either of them, wanting instead to rework the role that the humanities (in the specific, media theory and philosophy of technology) can play in studying computation and technoscience. I can explain this alternative entry point to AI that the articles provide by first justifying my editorial choice of focusing on the expression ‘algorithmic thought’ rather than the more usual formulation ‘artificial intelligence’. This choice also emphasises some of the aims and scopes of this special section: while this collection must be situated within the context of the contribution of the humanities to AI research, its attention to ‘thought’ rather than ‘intelligence’ and its consideration of the qualification ‘algorithmic’ rather than ‘artificial’ evidence some of the defining ways in which this humanities’ tradition of work on thinking is mobilised and, at the same time, challenged.

Cognition, *reason* and *thought* are not synonymous, even though they are all used to refer to mental activity. While ‘cognition’ is a term that has been directly taken up by the natural and social sciences and largely employed to denote mental activities that lead to forms of knowledge or information processing, ‘reason’ and ‘thought’ feature in the vocabulary of the arts and humanities more prominently. ‘Reason’ and its cognate ‘rationality’ are generally employed in a narrower sense than ‘thought’: reason is the faculty of drawing logical inferences, whether deductively, inductively or abductively. ‘Thought’ is a much more protean term; it remains productively ambiguous within and beyond the humanities. Definitions of thought might derive from theories of thinking but also be informal and shaped by the uses of this word in colloquial speech or by competing individual or social notions of it. ‘Thought’, then, as the name for the act or an instance of thinking and the noun for what is in the mind: thought as an idea, an opinion, a cerebration, a deliberation, a conjecture, a concept and as the process of using or exercising the mind; what allows to represent, plan, interpret, judge, evaluate, predict, imagine, comprehend, remember, believe, explain and decide.

Thought is what thinking does; thought is the result of the act of thinking. The striking circularity of these definitions is a testament to the complexity of thought but should not be seen as an obstacle to studying it. Precisely because there is no consensus on what is called thinking, we can create different images of it: some will be useful to describe what living beings do well, and some could depict what machines are good at. What are the events that can be said to be productive of this machine thought? If thought is assumed to be of an existential value to living beings, can it be distinctive – in its own, characteristic form – of the ontology of machines too? While asking these and related questions, it is useful to stress again that this special section marks this machine thought, to be investigated, as 'algorithmic': this is not the potential, possible thinking of any machine but the thinking of machines that are algorithmic because they are general-purpose devices programmed to carry out a set of logical operations automatically, according to well-defined rules. Algorithmic thought is the action or process of thinking in algorithmic terms. This aspect is significant because it helps us address the distinctiveness of how this machine that might think operates and then link the exploration of this distinctiveness to genealogies in the history of mathematics and formal reasoning that have attempted to put calculative procedures into such algorithmic terms. In this sense, studying algorithmic thought involves tapping into a long tradition of intellectual insights that have linked formalisation and axiomatisation to the longed-for discovery and mechanical exploitation of the rules for calculative thinking.

This special section argues for a revived, resolute attention to the algorithmic character of computing machines. An emphasis on the symbolic organisation and alphanumerical formulation of digital calculation and an understanding of the latter as actual mechanical operations are central to the three essays in this themed collection. These essays are considerably different in their approaches, aims and arguments; there is also unity, however, and this is to be found precisely in the algorithmic, which serves as the common starting ground for these three different explorations of computation and its thinking procedures. Because computing machines are addressed in their algorithmic formulation, computation is productively engaged with in terms of *logos*: this is notoriously a difficult concept of ancient Greek origin, which I am using here to stress how this special section never loses sight of the logico-mathematical inception of computing – as a method, as a theory and as a practice.

Each paper in this special section explores a different perspective on computational logos. Although the logico-mathematical character of computation is the starting ground for these ventures, it does not, however, dictate their end point: the logico-mathematical foundation of computing shapes computation as a method, theory and practice, but the operations of algorithms, in their actual effect, construct what logos can be in a computational context. Here is then how the work on thinking found in the humanities is both mobilised and challenged by the study of algorithmic thought that this special section proposes. This collection is born within the humanities but also problematises that dismissal of calculation that is often produced and iterated by the humanities against that old foe of theirs: instrumentality. The three articles offer different responses to this common dismissal, but they all share the unifying contention that the instrumentality of computational technology needs to be engaged with – both critically and speculatively – if we are to understand what algorithmic thought can be.

For Wolfgang Ernst, computational logos should not be detached from its technical implementation. In his article for this special section, ‘Existing in Discrete States: On the Techno-Aesthetics of Algorithmic Being-in-Time’, Ernst coins the neologism ‘techno*lógos’* to emphasise the material medium of computing – the materiality of the computational artefact that turns the abstract algorithm into a temporal event. This temporality is the condition of computing itself; radical media archaeology is the method proposed to analyse such a temporal condition of technological configurations and their effects. According to Ernst’s proposition, techno*lógos* needs to be revealed, disclosed or brought forth by media archaeology. If there is thinking in the algorithmic or if algorithms can be said to think, this capacity manifests via the execution and implementation of the techno-mathematical process that an algorithm is onto a material substratum. This hypothesis reminds us of the ‘embodied mind’ thesis developed within cognitive science; Ernst refers to this in his article, though the epistemic agency that he describes is to be situated within the technological processuality of an artefact, not in its prosthetic association with a biological referent.

A study of algorithms as actual computation is also proposed in Luciana Parisi’s contribution, ‘Interactive Computation and Artificial Epistemologies’. The article describes algorithms as dynamic, pragmatic procedures, stressing how the symbolic order of computation might intertwine with material practices through interactive processes of meaning-making. The essay reflects on how the development of modern computing ended claims about the universality of mathematical formalism; it asks whether a speculative consideration of algorithmic thought can challenge the biocentric understanding of thinking that is implicit in the colonial and capitalist legacies of technoscientific epistemology. Drawing on Sylvia Wynter’s work on the sociogenic principle and Gilbert Simondon’s notion of technical mentality, Parisi explores ludics (which was proposed by the logician Jean-Yves Girard) to consider the socio-techno-genetic strategies of algorithms and the potential of the latter to overturn or debunk racialised and gendered categories of thought. Ludics approaches formalism as an interactive logic of rules, and Parisi works with that approach to understand algorithms as acts capable of intervening in the semiotic orders of knowledge.

Finally, my own article in this special section, ‘Beyond Human: Deep Learning, Explainability and Representation’, examines computational procedures that transcend the epistemic boundaries of human cognitive representation. Deep learning is my case study; these AI techniques have generated much interest thanks to their technical accomplishments but also because the knowledge that they produce remains partially implicit and in need of human interpretation. Reflecting on the philosophical implications of this black-box character of deep learning, I address the question of explainability in AI, which I consider in order to unfold a study of algorithmic thought that focuses on the incommensurability between human and machine modes of abstracting. The concept of incommensurability was independently proposed in 1962 by the philosophers of science Thomas Kuhn and Paul Feyerabend to discuss the possibility of theory comparison. I draw from those debates and argue that explainability in AI is a communicational and representational issue, as well as a translation failure. Here the question of computational logos comes to the fore as I describe these deep-learning systems as being both within and beyond logos: they are logical because they are computational but also a-logical because, currently, they remain in part inexpressible or unrepresentable by humans (where 'logos', according to its etymology, means 'reason' or 'proportion' but also 'word', 'discourse' or 'speech').

The articles in this special section show that the question of what algorithmic thought is or can be is not settled; there are no foregone conclusions, even though some premises, such as the algorithmic specificity of these artificial modes of thinking, need to be acknowledged. This special section then draws attention to how thinking thought, in its machine implementation and expression, remains a key issue for 21st-century intellectual inquiries.

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Note

1. 'Algorithms are the procedures that specify how the computer should do a job. Although humans can carry out algorithms, they cannot do so nearly as fast as a machine; modern computers can do a trillion steps in the time it takes a human to do one step. The magic is nothing more than a machine executing large numbers of very simple computations very fast. Programs are the bridge: algorithms encoded in special-purpose languages that translate to machine instructions that control a computer' (Denning and Tedre, 2019: 2–3).

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