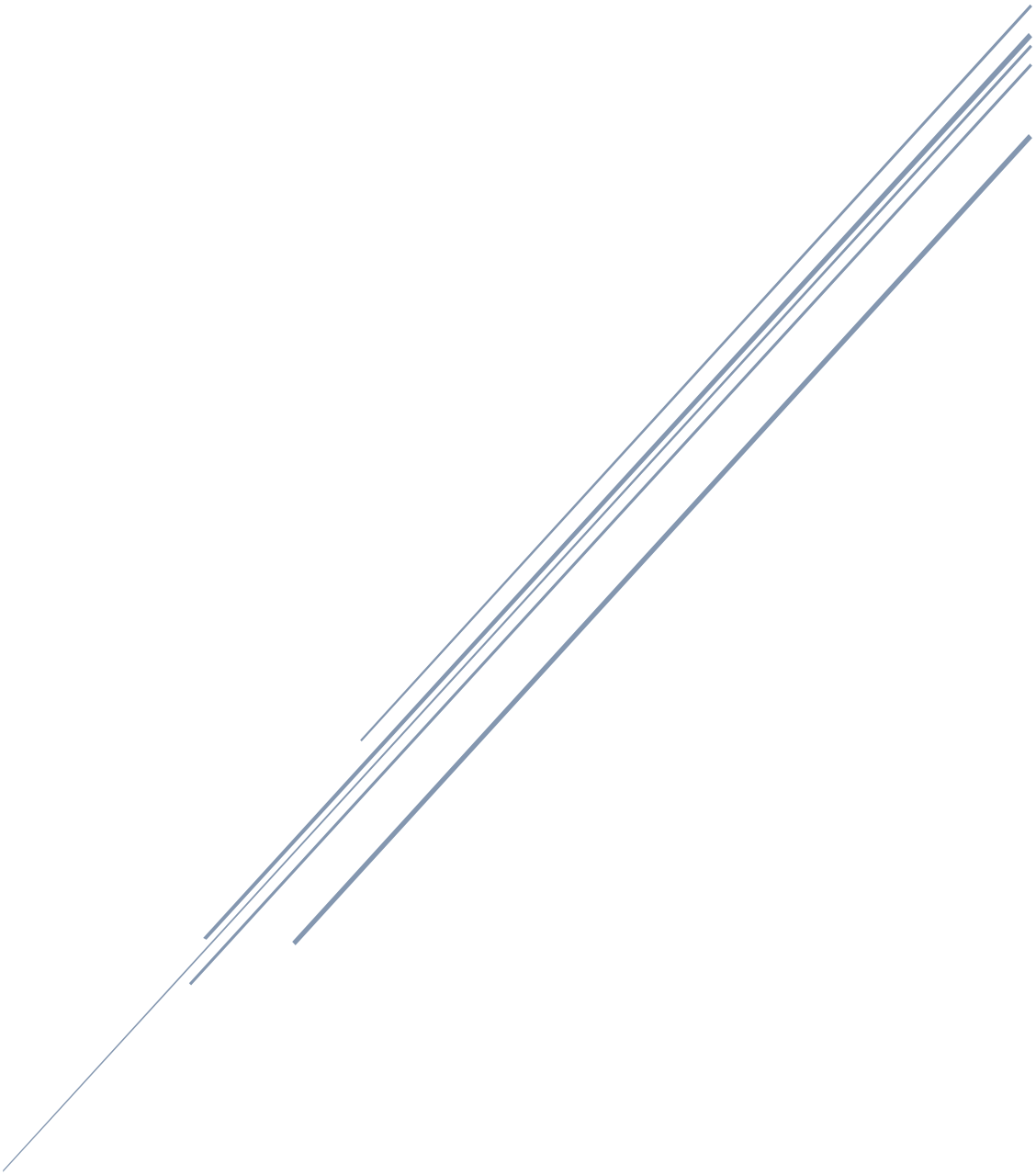
SCIENCE IN THE AGE OF AI: A HISTORICAL REVIEW

November 2023



THE ROYAL SOCIETY

UNIVERSITY OF CAMBRIDGE

‘Public attitudes toward computers have revealed deep contradictions at the heart of twentieth- and twenty-first-century life: acclaimed as liberatory, they are also condemned as instruments of control that increasingly dictate the contours of human life; often seen as revolutionary, they also reinforce existing power structures; heralded as engines of innovation, they are also conservative, lingering manifestations of nineteenth-century industrial thinking and Cold War militarism. Computers have been framed both as a mirror for the human mind and as an irreducible “other,” so different from people that humanness must be defined (and protected) against them.’

- *Abstractions and Embodiments: New Histories of Computing and Society*[1]

[1] Janet Abbate and Stephanie Dick, eds., *Abstractions and Embodiments: New Histories of Computing and Society* (Baltimore: Johns Hopkins University Press, 2022), https://doi.org/10.56021/9781421444383.

Executive Summary

Recommendations for policy makers:

- **Champion *public* science, reject AI's role in the privatization of science.** Overreliance on AI tools in the sciences will burden the UK research sector with structural dependencies on for-profit infrastructure at the expense of other opportunities.

- **Science is not one thing but many—do not put all eggs in the 'AI' basket.** Overestimating the potential of AI at the expense of other approaches could, ironically, *impede* rather than compel scientific discoveries in the UK.

- **Beware predatory infrastructure**. Counteract the normalization of mass surveillance in western democracies. Interrupt the reproduction of racial, gender, and colonial injustices that persist as hidden assumptions in appeals to a vague 'AI' future.

- **Regulate harm *before* it happens, not after.** 'Licensing agencies should require firms to demonstrate that their AI meets clear requirements for security, non-discrimination, accuracy, appropriateness, and correctability before being deployed.'[2]

Recommendations for the scientific community:

- **The history of science questions data positivism.** Reject a positivist caricature of science that treats the messiness of past discoveries as redundant rather than constitutive of genuine insights. Alternate methods must be championed too.

- **Fight for a standard of open source that the Open Source Initiative (OSI) approves**. OSI are the stewards of what constitutes open source software. Big Tech seeks to abuse the term to skirt regulation and bolster their power.

Methodology

This review works with both historical sources and some contemporary critical literature. It offers a brief look at various themes in the history of computing that lend perspective on what the widespread use of AI in the sciences could entail in the future. Lastly, it provides a set of historical references to those committed to continuing analysis about the relative merit of scientific practices past, present, and future.

[2] Gianclaudio Malgieri and Frank Pasquale, 'Licensing High-Risk Artificial Intelligence: Toward Ex Ante Justification for a Disruptive Technology', *Computer Law & Security Review* 52 (April 2024): 105899, https://doi.org/10.1016/j.clsr.2023.105899.

Analytical Framework

What is a technology?

The term 'technology' undergirds the Royal Society's project on *The Role of Disruptive Technologies in Transforming Science and Society*. For historians of the subject, a robust definition of 'technology' has proven elusive. Without such a definition in place, one risks legitimising false and superficial equivalences between, say, AI and the microscope. Are they truly comparable? To avoid endorsing historical disanalogies in search of meaningful analogies, a working definition from Jon Agar, an esteemed historian of technology, will be used. Agar defines technology as a 'designed, material means to an end.'[3] This definition combines a *technique* for a desired end (e.g., use of a swimming stroke for mobility through water) with a *contrivance* (e.g., something earthen like an artefact). A swimming stroke on its own is not a technology because it lacks a contrivance. A paddle, however, would count as a technology. To nuance this definition further, Agar points to an additional characteristic of technology: its power to 'intervene between scales.' A few examples bear this out. Bicycles intervene across geographical scales (as do aircrafts and cars). Each get us from one place to another more quickly than human motion would on its own. A refrigerator intervenes across the thermodynamic scale. A lamp intervenes across scales of luminosity.

What scale(s) does 'AI' intervene between? Clarity on this contentious question would foreground its operative qualities within and across different sciences and societies. Historians have a unique role to play here. Pasquinelli and Joler, for instance, argue that machine learning is 'an instrument to see and navigate the space of knowledge.'[4] They position it as akin to a lens for knowledge; 'an instrument of knowledge magnification that helps to perceive features, patterns, and correlations through vast spaces of data beyond human reach.'[5] This formulation is satisfying at first blush. By this view, AI is like the microscope. Unlike luminosity and thermodynamics, however, 'knowledge' is plastic to its own evaluation. Efforts to reduce knowledge to a stable set of axioms have failed spectacularly in the past, as in the logical positivism movement of the 1930s. Today, historians challenge a resurgent strain of 'data positivism' in machine learning, which positions all knowledge as reducible to statistics, including—problematically—'knowledge' about sensitive categories such as race, sexuality, or gender.[6]

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[3] Jon Agar, 'What Is Technology?', *Annals of Science* 77, no. 3 (2 July 2020): 381, https://doi.org/10.1080/00033790.2019.1672788.

[4] Matteo Pasquinelli and Vladan Joler, 'The Nooscope Manifested: Artificial Intelligence as Instrument of Knowledge Extractivism' (visual essay, KIM HfG Karlsruhe and Share Lab, 1 May 2020), http://nooscope.ai.

[5] Pasquinelli and Joler. They call this tool a 'nooscope,' a portmanteau of the Greek words *skopein* 'to examine, look' and *noos* 'knowledge'.

[6] It is by this logic that some advance claims – and legislation – premised on the pseudoscientific notion that machine learning tools can 'identify' or 'predict' the face of a homosexual, criminal, or member of an ethnic community. Matthew L. Jones, 'How We Became Instrumentalists (Again): Data Positivism since World War II', *Historical Studies in the Natural Sciences* 48, no. 5 (November 2018): 673–84, https://doi.org/10.1525/hsns.2018.48.5.673; see also: Tiffany Nichols, 'Patenting Automation of Bias: Algorithmic Race and Ethnicity Classifications: Protecting Neutral Technology or Disparate Treatment by Proxy?', in *Abstractions and Embodiments: New Histories of Computing and Society*, ed. Janet Abbate and Stephanie Dick (Baltimore: Johns Hopkins University Press, 2022), 102–25, https://doi.org/10.56021/9781421444383.

When comparisons to past technologies are unhelpful

The frailty of the AI-as-lens metaphor reveals the burden of expecting too much from a direct comparison between two technologies. If judged by Agar's definition, statistics would not count as a technology, given its lack of a physical form. AI, in contrast, is physical; it becomes operant on the back of a daunting assemblage of digital infrastructure and human labour. Approaching AI as a mode of infrastructure and approach to labour allows one to bypass its status as a floating signifier or 'suitcase word' used, depending on the decade, to refer to symbolic techniques (1950-1960s), expert systems (1970-1980s), or connectionist/non-symbolic techniques (1940s-).[7] That AI is predicated on large-scale digital infrastructure remains, in contrast, consistent with when the term was first coined in 1955.[8]

As a science, the character of 'AI' has been methodologically inconsistent and at times self-contradictory. As a technology, in contrast, its material contingencies have been relatively uniform, if still heterogeneous (e.g., time sharing in the 1960-1970s, GPUs in the 2010-2020s). It is on this basis that this report focuses on themes in the broad history of digital computing (and not the microscope or printing press) as appropriate points of comparison for policy makers tasked with speculating about the future of AI in the sciences.

Relevant themes from the history of computing

Philip E. Agre, an AI practitioner turned respected critic, equates his experience of learning to recognise computing's historical contingencies to the process of seeing the glasses on one's face.[9] Each process denaturalises what might otherwise be taken for granted, offering a new perspective on the familiar. To summarise what follows in this report, much has been taken for granted in the history of computing, shaped as it has been by state and industrial efforts to sort, rank, and order files, bits, and numbers.[10] Alongside these orderings have come a set of shifting ideals, practices, and justifications for how to sort, rank, and order *social* phenomena, such as who counts as a citizen, refugee, successful mortgage applicant, enemy combatant, deserving mother, criminal, or candidate. The following themes speak to how digital computing has figured in the creation and maintenance of these social orderings.

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[7] In more recent work Pasquinelli argues, 'The inner code of AI is constituted not by the imitation of biological intelligence but by the *intelligence of labour and social relations.'* Matteo Pasquinelli, *The Eye of the Master: A Social History of Artificial Intelligence* (London ; New York: Verso, 2023), 2.

[8] John McCarthy et al., 'A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence', John McCarthy's Home Page, 31 August 1955, http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html; Ronald Kline, 'Cybernetics, Automata Studies, and the Dartmouth Conference on Artificial Intelligence', *IEEE Annals of the History of Computing* 33, no. 4 (April 2011): 5–16, https://doi.org/10.1109/MAHC.2010.44.

[9] As cited in: Maya Malik and Momin M. Malik, 'Critical Technical Awakenings', *Journal of Social Computing* 2, no. 4 (December 2021): 380, https://doi.org/10.23919/JSC.2021.0035.

[10] Jon Agar, *The Government Machine: A Revolutionary History of the Computer*, History of Computing (Cambridge, Mass: MIT Press, 2003); Jonnie Penn, 'Inventing Intelligence: On the History of Complex Information Processing and Artificial Intelligence in the United States in the Mid-Twentieth Century' (PhD Dissertation, Cambridge, University of Cambridge, 2020).

The Influence of the Private Sector

The pursuit of profit

In popular culture, the digital computer is sometimes thought of as an emancipatory tool, one that frees us from labour or toil. It is also a technology sold to make a profit. These two characterisations are not mutually exclusive. Equally, however, they are not one and the same; an increase in sales of computing tools does not translate into an increase in liberty. While much has been made of computing's liberatory qualities, less is understood about its many lives as a vehicle to make profit. This is true, remarkably, even while the largest public companies in the world—known colloquially known as 'Big Tech'—are uniformly engaged in the business of information technology.

Following their initial development in the 1940s and 1950s, the number of digital computers in operation in the U.S. grew at an exponential rate. While only two digital electronic computers were in operation in 1950, 243 machines were operational in 1955, with 5,400 in 1960, 25,000 in 1965 and 75,000 in 1970.[11] Today that number is estimated to be in the hundreds of millions, and in the billions globally. That the bulk of early adoption occurred in industry was no accident. Behind industrial investments was the hope that these devices would order and help to solve *management* issues like scheduling, optimization, and relations with labour unions.[12] Devon Kennedy, a historian of computing, notes that these industrial aims left an indelible mark on the foundations of computer science. He writes, 'Theoretical computer science's fundamental questions about the managing of complexity, the representation of problems, the rating of methods to solve them, was born in and defined by mid-century efforts to manage capital.'[13] About the history of software development after the 1970s, Laine Nooney adds, 'Throughout it all, we can clearly see the intractable role financial speculation and the construction of markets played in people's desire to even imagine what shape innovation might take.'[14] The profit motive, in other words, has long been key to the history of digital computing.

Links between the histories of financialisaton and digitisation invite reflection on the popular assumption in technology culture that the search for profit translates causally into, say, productivity gains, increased life expectancy, or significant technological innovation. In his history of living standards in the United States, Robert Gordon positions the 1970s as the juncture at which standards began to diminish, in part—ironically—*due* to that country's embrace of computing and network technologies.[15] That tech workers and tech companies have actively and purposely benefited from a legacy of extractive economic norms is captured

[11] Nathan Ensmenger, *The Computer Boys Take Over: Computers, Programmers, and the Politics*, History of Computing (Cambridge, Mass: MIT Press, 2010), 28.
[12] Thank you to Kennedy for this reference and insight. An example of which is cited in: William Voris, *Production Control: Text and Cases* (Homewood, Illinois: R. D. Irwin, 1956), 362.
[13] Devin Kennedy, 'Virtual Capital: Computers and the Making of Modern Finance, 1929-1975' (Doctoral dissertation, Harvard University, Graduate School of Arts & Sciences, 2019).
[14] Laine Nooney, *The Apple II Age: How the Computer Became Personal* (Chicago: The University of Chicago Press, 2023), 261.
[15] Robert J. Gordon, *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*, The Princeton Economic History of the Western World (Princeton, New Jersey: Princeton University Press, 2017).

in Cory Doctorow and Rebecca Giblin's account of platform economics.[16] In an effort to clarify the seismic differences between state and corporate agency in altering the direction of scientific research (and, by proxy, the role of profit in discovery), Thomas Haigh compares Google's 'Moonshot' projects, which commanded a budget in the low millions, to NASA's moonshot initiative, which cost 600 billion.[17] From this perspective, the need to turn a profit could be construed as a constraint on scientific discovery, rather than its de facto enabler.

The pursuit of scale

Entangled in the recent history of computing and profit is the aspiration to scale. The celebrated anthropologist Anna Lowenhaupt Tsing attributes computing's image as immaterial to, among other things, the culture of 'scale' and 'scalability' that tech corporations and developers lionise as a—if not *the*—indicator of success in commerce and design. Seeing the world through the lens of scalability, to return to Agre's metaphor, obscures 'our ability to notice the heterogeneity of the world; by its design, scalability allows us to see only uniform blocks, ready for further expansion.'[18] In other words, the race for scale has drawn attention away from that which does *not* scale, including aspects of the natural world. The historian of computing Nathan Ensmenger captures the irony of this narrative, which lingers around present-day conceptions of AI:

> Despite repeated claims that the defining characteristic of the information society is "the displacement in our economy of materials by information," as Wired magazine editor Kevin Kelly has described it—or, in the even more succinct and memorable words of MIT professor Nicholas Negroponte, the inevitable shift "from atoms to bits"—what has in fact occurred is a massive increase in our interaction with our physical environment.[19]

To summarise the complexities signalled to above: financialisation, meaning the process by which financial institutions, markets, etc., increase in size and influence, has at important points in the history of computing, prefigured and proceeded co-extensively with digitisation, meaning the adaptation of a system, process, etc. to be operated with the use of computers and the internet. This historical coupling troubles conceptions of contemporary AI as value neutral. Overuse of AI in the sciences could, in principle, subject those areas of study to the gravitational pull of financial speculation and the construction of markets and away from basic research, spoiling concerted efforts at the latter.

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[16] Rebecca Giblin and Cory Doctorow, *Chokepoint Capitalism: How Big Tech and Big Content Captured Creative Labor Markets and How We'll Win Them Back* (Boston: Beacon Press, 2022).
[17] Thomas Haigh, 'Hey Google, What's a Moonshot?: How Silicon Valley Mocks Apollo', *Communications of the ACM* 62, no. 1 (19 December 2018): 24–30, https://doi.org/10.1145/3292519.
[18] Anna Lowenhaupt Tsing, 'On Nonscalability', *Common Knowledge* 18, no. 3 (1 August 2012): 505, https://doi.org/10.1215/0961754X-1630424.
[19] Nathan Ensmenger, 'The Cloud Is a Factory', in *Your Computer Is on Fire*, ed. Thomas S. Mullaney et al. (Cambridge, Massachusetts ; London England: The MIT Press, 2021), 32.

Infrastructure and Skills

'Technology is neither good nor bad; nor is it neutral'[20] - Kranzberg's first law of technology.

The history of Y2K, or the Millennium bug, provides perhaps the most memorable example, globally, of when our modern structural dependencies on computing were rapidly drawn into view. In the late 1990s, institutions were forced to address what they would do if key digital infrastructure suddenly failed, in that case due to a simple error in timekeeping techniques. Y2K illuminated how technical choices made by programmers—in that case, importantly, *in the 1960s*—had knock-on effects four decades later for parties wholly disconnected from the initial design decisions. Infrastructural choices *last*. That these infrastructural choices have impacts far beyond their purview was noted, at the time, by U.S. Congressman Jim Turner, who observed that 'Every facet of our life now depends upon our computers working well.'[21]

Zachary Loeb, a historian of computing, summarises the set of interdependencies exposed by the Millennium bug as follows. 'At its core, Y2K is the story of an economic problem that became a technical problem, which in turn became a social problem.'[22] That, still today, digital infrastructure has a distinct influence on matters of labour, gender, race and other sensitive aspects of daily life is difficult to deny. 'Computers have become the infrastructure of our infrastructures,' argues historian Paul Edwards.[23] The burdensome politics of infrastructure are not, however, felt equally. History suggest that they differ depending on one's positionality and place in society, as the following will capture.

Gendered and low-paid labour

As historical research by Lorraine Daston, Matthew L. Jones, Stephanie Dick, Simon Schaffer and others has shown, an equivocation of value between man and machine has long been central to the human history of mathematical calculation, and critically from the nineteenth century onwards.[24] It was in that that period of industrialization when 'calculation' came to be seen as something 'merely mechanical' rather than as evidence of genius. It was in this same period that calculation became the domain of human computers, to be executed in settings akin to a factory by low paid labourers and, over time, re-gendered as menial work best suited for women.

That this erroneous re-gendering has had lasting consequences is captured by the historian if computing Mar Hicks, whose research shows how in the 1950 to 1970s, Britain lost its initial

[20] Melvin Kranzberg, 'Technology and History: "Kranzberg's Laws"', *Technology and Culture* 27, no. 3 (July 1986): 545, https://doi.org/10.2307/3105385.
[21] As cited in: Zach Loeb, 'Waiting for Midnight: Risk Perception and the Millenium Bug', ed. Stephanie Dick and Janet Abbate, vol. Abstractions and Embodiments: New Histories of Computing and Society (Johns Hopkins University Press, 2022).
[22] Loeb.
[23] As cited in: Loeb.
[24] Matthew L. Jones, *Reckoning with Matter: Calculating Machines, Innovation, and Thinking about Thinking from Pascal to Babbage* (Chicago ; London: The University of Chicago Press, 2016); Lorraine Daston, 'Enlightenment Calculations', *Critical Inquiry* 21, no. 1 (1994): 182–202; Lorraine Daston, *Rules: A Short History of What We Live By*, The Lawrence Stone Lectures (Princeton: Princeton University Press, 2022); Simon Schaffer, 'Babbage's Intelligence: Calculating Engines and the Factory System', *Critical Inquiry* 21, no. 1 (1994): 203–27.

stature in the science of digital computing when it arbitrarily and repeatedly stonewalled networks of skilled women technologists from accessing its domestic IT workforce.[25] In the decades following the war, British industrialists habitually excluded women technologists from promotion, pension benefits, and access to equal pay, exacerbating a labour shortage of their own creation. They sought to position computing as managerial rather than clerical; as something that was masculine and aspirational rather than feminine and routine. Success in this lamentable endeavor helped to lose Britain its lead in computing. This trend—the exclusion of women to benefit men—repeats throughout the histories of computing.[26] Meredith Broussard, for instance, describes its present-day instantiations in AI as 'technochauvanism.'[27]

AI as a theory of labour dressed as 'automation'

Astra Taylor fits such dynamics within a broader phenomenon of 'fauxtamation.' Taylor, a technology critic, argues that industrialists' invoke an aspiration to 'automate' a given task as a means to dehumanize marginalised contributors (e.g., women, ghost workers) and justify the extraction of labour at a lower cost without simultaneously compromising the performance of human-free automation.[28] By this view, the troubling history of gender in computing is indicative of a broader phenomenon about computing and labour. The media theorist and historian Matteo Pasquinelli goes as far as to position AI as a 'labour theory' of machine intelligence. He writes:

> When industrial machines such as looms and lathes were invented, in fact, it was not thanks to the solitary genius of an engineer but through the imitation of the collective diagram of labour: by capturing the patterns of hand movements and tools, the subdued creativity of workers' know-how, and turning them into mechanical artefacts. Following this theory of invention, which was already shared by Smith, Babbage, and Marx in the nineteenth century… [I argue] that the most sophisticated "intelligent" machines have also emerged by imitating the outline of the collective division of labour.[29]

For the purposes of this brief review document, it is suffice to say that scientists in the UK would be in the right to think about and even question the full set of contributors who produce, maintain, or structure the AI tools, data, and services they confront, and to inquire after how such arrangements could be organised to protect against gender and racial biases,

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[25] Marie Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing*, History of Computing (Cambridge, MA: MIT Press, 2017).

[26] J. Abbate, 'Women and Gender in the History of Computing', *IEEE Annals of the History of Computing* 25, no. 4 (October 2003): 4–8, https://doi.org/10.1109/MAHC.2003.1253885; Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing*, History of Computing (Cambridge, Mass: MIT Press, 2012); Kate M. Miltner, 'Girls Who Coded: Gender in Twentieth Century U.K. and U.S. Computing', *Science, Technology, & Human Values*, 7 May 2018, https://doi.org/10.1177/0162243918770287; Ensmenger, *The Computer Boys Take Over*.

[27] Meredith Broussard, *Artificial Unintelligence: How Computers Misunderstand the World* (Cambridge, Massachusetts: The MIT Press, 2018).

[28] Astra Taylor, 'The Automation Charade', *Logic Magazine*, August 2018, https://logicmag.io/05-the-automation-charade/; Mary L. Gray and Siddharth Suri, *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass* (Boston: Houghton Mifflin Harcourt, 2019).

[29] Pasquinelli, *The Eye of the Master*, 6.

or deep colonial injustices. In time, one hopes that technology providers ensure, or gain certification for, their use of responsible AI supply chains.

Predatory Infrastructure

Who decides what type of infrastructure ought to be adopted—and with it, which labour theory and incumbent political economy to prioritise? Recent historical and critical analysis by Yarden Katz, David Ribes, and Seda Gürses suggests that public institutions have had to face disingenuous rhetoric and marketing when making choices about how to manage their own infrastructure. Gürses positions the economics of AI in the 2010s and 2020s as a form of 'predatory infrastructure' in which large technology companies abuse rhetoric about the field's exceptionalism in order to enlist small and medium enterprises, like universities, into pay-as-you-go software systems like Microsoft 365.[30]

By this view, AI is a heavily marketed loss leader that need not live up to its hype in order to drive significant profits. That it may not live up to its marketed potential is caught in recent debates over the diminished quality of results from GPT-4 since its public launch in the spring of 2023. It is also seen in a recent study of StackOverflow that questions whether large language models are a threat to the existence of digital public goods.[31] Meredith Whittaker positions the use of disingenuous rhetoric as a problem that is endemic to AI research. She writes, 'Big tech's control over AI resources made universities and other institutions dependent on these companies, creating a web of conflicted relationships that threaten academic freedom and our ability to understand and regulate these corporate technologies.'[32]

Considering the longevity of decisions made about digital infrastructure investments, and the difficulty of opting out once those decisions are made, scientists should be mindful of this predatory trend. They might ask themselves or their teams: how could we reach the same ends by different means? Incidentally, disingenuous rhetoric has been chronicled by historians (myself included) as a recurring pattern in the history of manufactured cognition—one that dates back to Charles Babbage.[33]

Global data

Cognitive injustice

Those who study the systematically oppressed and colonised are deeply familiar with how ideas about knowledge have been weaponised to shape notions of 'humanness' and dignity,

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[30] Seda Gürses, How Big Tech captured our public health system, interview by Arun Kundnani, 18 May 2022, https://www.youtube.com/watch?v=RBAIbZ2fKKc&t=1581s; Yarden Katz, 'Manufacturing an Artificial Intelligence Revolution', *SSRN Electronic Journal*, 2017, https://doi.org/10.2139/ssrn.3078224; Stephen C Slota et al., 'Prospecting (in) the Data Sciences', *Big Data & Society* 7, no. 1 (January 2020): 205395172090684, https://doi.org/10.1177/2053951720906849.

[31] Maria del Rio-Chanona, Nadzeya Laurentsyeva, and Johannes Wachs, 'Are Large Language Models a Threat to Digital Public Goods? Evidence from Activity on Stack Overflow' (arXiv, 14 July 2023), http://arxiv.org/abs/2307.07367.

[32] Meredith Whittaker, 'The Steep Cost of Capture', *Interactions* 28, no. 6 (November 2021): 51, https://doi.org/10.1145/3488666.

[33] Histories of Artificial Intelligence: A Genealogy of Power: https://www.ai.hps.cam.ac.uk/about-0/themes

often hierarchically.[34] 'The term "research" is inextricably linked to European imperialism and colonialism,' writes Linda Tuhiwai Smith. 'Just knowing that someone measured our "faculties" by filing the skulls of our ancestors with millet seeds and compared the amount of millet seed to the capacity for mental thought offends our sense of who and what we are.'[35] In ancient Greece, Aristotle advocated for the subjugation of women, ethnic groups, animals and plant life on the premise that the ability to reason was naturally endowed only to men of good birth. As Alison Adam has shown, similar thinking underlies pivotal work in the logicist tradition from Descartes, Kant, and George Boole, which inspired the epistemological concerns of early AI research.[36] Similarly, Wendy Chun argues that contemporary machine learning practices remake aspects of eugenics by conjuring and concretizing (in, for example, platform infrastructure) homophily, the mid-twentieth century sociological principle that like attracts like.[37] Today, major platforms like Facebook and TikTok use machine learning techniques to segment and sort audiences into segregated neighborhoods, even as those segmentations ferment into political polarization and social disruption.

As the examples above capture, notions of who qualifies as 'human' have been long been shaped, sustained, and imposed through acts of administration. Only recently have historians begun to trace how the logics of contemporary AI projects build on and extend this actuarial legacy. Visions of what we might today describe as a digitally automated society have emerged in complex ways from genealogies of statecraft, modern insurance, mass surveillance, and modern accounting and administrative practices. Techniques developed in plantation accounting[38], colonial state administration[39], eugenic theory[40], the design of slave ships[41], Victorian factory systems,[42] Adam Smith's vision of modern capitalism[43], and mid-century American dreams of owning 'slave' robots,[44] among other bitter sources, now exist as part of the air that contemporary developers breath, often unknowingly.[45] Specifically, as Chun has shown, foundational concepts in the history of statistics, such as linear regression, the correlation coefficient, and maximum likelihood, emerged from their creators' (e.g., Francis

[34] As an example: Caitlin Rosenthal, *Accounting for Slavery: Masters and Management* (Cambridge, Massachusetts: Harvard University Press, 2018).
[35] Linda Tuhiwai Smith, *Decolonizing Methodologies: Research and Indigenous Peoples*, Second edition (London: Zed Books, 2012), 1.
[36] Alison Adam, *Artificial Knowing: Gender and the Thinking Machine* (London ; New York: Routledge, 1998).
[37] Wendy Hui Kyong Chun and Alex Barnett, *Discriminating Data: Correlation, Neighborhoods, and the New Politics of Recognition* (Cambridge, Massachusetts: The MIT Press, 2021).
[38] Rosenthal, *Accounting for Slavery*.
[39] Agar, *The Government Machine*.
[40] Laura Kurgan et al., 'Homophily: The Urban History of an Algorithm', E-Flux Architecture, 5 March 2023, https://www.e-flux.com/architecture/are-friends-electric/289193/homophily-the-urban-history-of-an-algorithm/; Chun and Barnett, *Discriminating Data*.
[41] Simone Browne, *Dark Matters: On the Surveillance of Blackness* (Durham: Duke University Press, 2015).
[42] Schaffer, 'Babbage's Intelligence'.
[43] Penn, 'Inventing Intelligence: On the History of Complex Information Processing and Artificial Intelligence in the United States in the Mid-Twentieth Century'.
[44] O. O. Binder, 'You'll Own "Slaves" by 1965', *Mechanix Illustrated*, January 1957, http://blog.modernmechanix.com/youll-own-slaves-by-1965; Ruha Benjamin, *Race after Technology: Abolitionist Tools for the New Jim Code* (Medford, MA: Polity, 2019).
[45] For those seeking a short summary of the above, well known AI critic Meredith Whittaker summarises these histories in a recent op-ed Meredith Whittaker, 'Origin Stories: Plantations, Computers, and Industrial Control', *Logic Magazine*, 17 May 2023, https://logicmag.io/supa-dupa-skies/origin-stories-plantations-computers-and-industrial-control/.

Galton, his protégé Karl Pearson, and Ronald Fisher) fascinations with the metrics of eugenics and Social Darwinism, which time has revealed to be pseudoscientific. Given disputed claims about the use of AI to recognize the shape of a criminal's face, or a homosexual's face, it would be unwise to expect this trend to abate without action from the scientific community.[46]

Characterising AI's relation to racial capitalism and data colonialism

Undergirding the dense histories of statecraft and administration outlined above is the history of modern capitalism across its many varieties. In 2019, Shoshana Zuboff argued for the centrality of AI techniques to the set of extractive economic norms naturalised in the present day as, in her words, 'surveillance capitalism.'[47] Zuboff's account is, however, incomplete. It neglects the longer history of capitalism dating back to the long sixteenth century. This includes it inextricable origins in colonialism and its complex role in creating and perpetuating notions of racial difference.[48] Per *Histories of Racial Capitalism*, a 2021 volume on the subject, modern capitalism cannot be understood without taking into account two recurring logics that have influenced the idea of racial difference. 'First,' the editors summariase, 'the violent dispossessions inherent to capital accumulation operate by leveraging, intensifying, and creating racial distinctions. Second, race serves as a tool for naturalizing the inequalities produced by capitalism, and this racialized process of naturalization serves to rationalize the unequal distribution of resources, social power, rights, and privileges.'[49] From this vantage, AI and surveillance capitalism will almost assuredly act with a similar force in the future, projecting a scientific guise upon economically motivated understandings of racial difference.

The use of AI tools within scientific and technological research already rely on a critical if obscure level of human infrastructure, as seen in Chat-GPT's dependence on low-pay content moderators in Kenya and in the use of reinforcement learning from human feedback (RLHF).[50] Divides over labour standards, fair renumeration, and types of authority are likely to firm around existing geopolitical and trade boundaries, such as between the Global North and Global South. Mejias and Couldry position this direction of travel as a form of data colonialism. They summarise this view as follows, 'Over the long-run [colonialism] provided the essential preconditions for the emergence of industrial capitalism… [such that] we can expect that data colonialism will provide the preconditions for a new stage of capitalism. The appropriation of human life through data will be central.'[51] To advance this scenario, they add, AI tools will be critical.

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[46] Trenton W. Ford, 'Is Your Face Gay? Conservative? Criminal? AI Researchers Are Asking the Wrong Questions', Bulletin of the Atomic Scientists, 20 May 2022, https://thebulletin.org/2022/05/is-your-face-gay-conservative-criminal-ai-researchers-are-asking-the-wrong-questions/.

[47] Shoshana Zuboff, *The Age of Surveillance Capitalism: The Fight for the Future at the New Frontier of Power* (London: Profile Books, 2019).

[48] Nick Couldry and Ulises Ali Mejias, *The Costs of Connection: How Data Is Colonizing Human Life and Appropriating It for Capitalism*, Culture and Economic Life (Stanford, California: Stanford University Press, 2019).

[49] Destin Jenkins and Justin Leroy, eds., *Histories of Racial Capitalism*, Columbia Studies in the History of U.S. Capitalism (New York: Columbia University Press, 2021), 3.

[50] Billy Perrigo, 'Exclusive: OpenAI Used Kenyan Workers on Less Than $2 Per Hour to Make ChatGPT Less Toxic', *TIME Magazine*, 18 January 2023, https://time.com/6247678/openai-chatgpt-kenya-workers/.

[51] Nick Couldry and Ulises A. Mejias, 'Data Colonialism: Rethinking Big Data's Relation to the Contemporary Subject', *Television & New Media*, 2 September 2018, 2, https://doi.org/10.1177/1527476418796632.

Skills: Atrophy as a Result of Methodological Homogenization?

In *The Tangle of Science*, their 2022 study of how to understand reliable knowledge in scientific inquiry, Cartwright et. al. argue, 'The reliability of any one product in science generally rests on a vast, amorphous network of other heterogeneous scientific products, usually unnoted and undersung, that woven together, as in a Jacana bird's nest, help provide the secure support it needs.'[52] The group conclude that this irreducible tangle of contingencies is more important to the achievement of reliable results in the sciences than other features often touted as fundamental, be it the scientific method, rigour, or objectivity. In other words, to oversimplify the thinking behind scientific scholarship would be to put its reliability at risk.

In the same way that Jacana birds are likely to follow certain customs in the creation of their nests, the history of data science suggests trends that encode practitioners' activities in ways that deserve attention as these methods spread ever deeper in the sciences.[53] In their history of data science and machine learning, Ribes et. al. challenge data science practitioners for 'prospecting' theory and authority from other disciplines without adequately noting their borrowings. They write:

> Data science is characterized by engaging heterogeneous data to tackle real world questions and problems. But data science has no data of its own and must seek it within real world domains. We call this search for data "prospecting" and argue that the dynamics of prospecting are pervasive in, even characteristic of, data science. Prospecting aims to render the data, knowledge, expertise, and practices of worldly domains available and tractable to data science method and epistemology. Prospecting precedes data synthesis, analysis, or visualization, and is constituted by the upstream work of discovering disordered or inaccessible data resources, thereafter to be ordered and rendered available for computation.[54]

The reproducibility crisis that emerged after the 2010s foregrounds how statistical techniques can be 'hacked' to undermine the credibility of scientific knowledge. In combination with the predatory economics of AI, outlined above, this problem raises difficult questions about what the ubiquitous use of statistical techniques in the sciences might do to the power of public oversight (ex. peer review, open-source publications, reproducibility standards). Might an alternative research culture premised around dependencies on privately owned pay-to-play compute infrastructure undermine the quality of scientific knowledge? Similarly, might an overreliance on AI techniques impoverish science by positioning digital methodologies as implicitly or explicitly superior to alternative methodologies?

An orthogonal approach is captured in Steven Epstein's historical account of 'lay expertise' during the AIDS crisis in the 1990s. In that period, non-expert communities earned and held

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[52] Nancy Cartwright et al., *The Tangle of Science: Reliability beyond Method, Rigour, and Objectivity* (New York: Oxford University Press, 2022), 1.

[53] Chris H. Wiggins and Matthew L. Jones, *How Data Happened: A History from the Age of Reason to the Age of Algorithms*, First edition (New York, NY: W.W. Norton & Company, 2023); Henry M. Cowles, *The Scientific Method: An Evolution of Thinking from Darwin to Dewey* (Cambridge, Massachusetts: Harvard University Press, 2020).

[54] Slota et al., 'Prospecting (in) the Data Sciences', 1.

authority over research areas that trained professionals did not yet understand.[55] Due to their enmeshment in networks of patient advocacy, members of the American gay community could articulate aspects of the disease with more acumen than medical doctors or researchers. For a similar form of lay expertise to emerge as a sustainable norm for the use of AI in the sciences, stricter attitudes would be needed to monitor and expose disingenuous claims of 'open source' AI made by industry. For instance, Meta Platforms, Inc., the parent company to Facebook, WhatsApp, and Instagram, claimed in 2023 that its LLaMA-2 model is open source. The Open Source Initiative, the steward of the rules that define open source software, stated in response that it is *not* open source.[56] Such distortions of the truth must be protected against to ensure that the rigour and spirit of scientific discovery, across a plurality of forms and participants, persists as further AI tools are developed.

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[55] Steven Epstein, *Impure Science: AIDS, Activism, and the Politics of Knowledge*, Reprint, Medicine and Society 7 (Berkeley, Calif.: Univ. of California Press, 1996).
[56] David Gray Widder, Sarah West, and Meredith Whittaker, 'Open (For Business): Big Tech, Concentrated Power, and the Political Economy of Open AI', *SSRN Electronic Journal*, 2023, 3, https://doi.org/10.2139/ssrn.4543807.

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