How Metaphors Influence Ontology, Epistemology, and Methods in AI: Rethinking the Black Box

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In this response paper, I explore how metaphors influence ontology, epistemology, and methodology within AI. Using the example of the black box metaphor, I demonstrate that an over-reliance on one metaphor forecloses potential futures, limiting discourse, research and policy. I thus conclude that reflexivity about our use of metaphors is necessary and that we should strive to utilise a range of metaphors to capture the full scope of concepts we aim to express. To establish the foundation for my thesis I examine and critique two articles: "The Ethnographer and the Algorithm: Beyond the Black Box" (Christin, 2020) and "Prediction Promises: Towards a Metaphorology of Artificial Intelligence" (Möck, 2022).

Keywords: Metaphorology, Blackbox AI, Ethnography

Introduction

Metaphors are essential in how we create meaning in the world. They help us bridge the gap between complex concepts and our understanding, allowing us to work with these ideas and create new knowledge (Lakoff & Johnson, 2008; Möck, 2022). "Artificial Intelligence is a metaphor, and AI as a technoscientific discipline in between science and engineering, is a highly metaphorically loaded field of scientific inquiry" (Möck, 2022). In this paper, I explore how metaphors influence ontology (the nature of reality), epistemology (the nature of knowledge), and methodology (how one obtains knowledge) within AI (Killam, 2013; Rawnsley, 1998). I use the example of the black box metaphor to demonstrate that an over-reliance on one metaphor forecloses potential futures, limiting discourse, research and policy. Consequently, it is important to be more reflexive about our use of metaphors and strive to utilise a range of metaphors to capture the full scope of concepts we aim to express. I examine and critique two articles to establish the foundation for my thesis and then discuss my argument.

In section one of the paper, I examine the first article, "The Ethnographer and the Algorithm: Beyond the Black Box" (Christin, 2020). This article was selected for its relevance to the research question and the author's focus on the black box metaphor. Thus, in this section, I provide an overview of Christin's argument regarding the problematic opacity of algorithms, followed by her three strategies for conducting ethnography on algorithms. This section concludes with a short critique of Christin's article and possible counter-arguments.

The second article, "Prediction Promises: Towards a Metaphorology of Artificial Intelligence" (Möck, 2022), is discussed in section two. This article provides essential counter-points to Christin's article and is a necessary scaffold for my thesis, outlined in the subsequent section. In order to ensure that my argument and discussion are narrowly focused, the review of Möck's article only includes aspects that relate to my research question. These aspects include how metaphors shape knowledge and the problem of the black box metaphor. I conclude this discussion by considering the strengths and potential missed opportunities in Möck's article.

In section three, I explore how metaphors influence ontology and epistemology and thus inform methodology in AI. To illustrate my argument, I use Christin's article as an example to suggest that her focus on the black box metaphor may prevent her from going "beyond the black box".

In the fourth and final section, I consider options for how we might address the problem of the black box metaphor. While I consider two documented alternative metaphors and suggest one of my own, this paper's thesis indicates that

no one metaphor should be relied upon but that instead, a more reflexive process of enquiry and a range of metaphors may serve us better as we seek to broaden our metaphorical landscape and thus future possible outcomes.

1. "The Ethnographer and the Algorithm: Beyond the Black Box"

Dr. Angèle Christin's article responds to Seaver's (2017) call for concrete "tactics" to study algorithms ethnographically (Christin, 2020). Christin uses the black box metaphor as a heuristic for algorithmic opacity, and as such, this metaphorical imagery pervades the article and framing of her ethnographic strategies. In this discussion, I outline Christin's arguments regarding the problem of algorithmic opacity and her proposed three ethnographic strategies for studying algorithms. Furthermore, I relate Christin's use of the black box metaphor and associated light imagery where relevant, as it is central to her article and my thesis.[1]

1.1. Algorithms are opaque…opacity is problematic

Christin asserts that "algorithms are profoundly opaque and function as inscrutable "black boxes" that can only be analysed in terms of their inputs and outputs" (Christin, 2020). From this position, Christin examines why algorithms are opaque and why this is important and then relates different methods for rendering them transparent or, at least, less opaque. Christin provides a robust discussion of the opacity of algorithms[2], citing Burrell's (2016) analysis that technical opacity has the following characteristics: (1) Algorithms are intentionally secret (companies that own the algorithms recognise their intrinsic value and thus guard them as intellectual property); (2) technical illiteracy may be unavoidable, even when the code is available (the code being too technical for most people to understand); (3) machine learning algorithms have become unintelligible to even highly trained engineers, and (4) the scale of these systems is so large that we cannot fathom which part is responsible for which outcome (Burrell, 2016; Christin, 2020). Christin suggests that these dimensions have resulted in "scholars refer[ring] to algorithms as "black boxes", or devices that can only be understood in terms of their inputs and outputs" (Christin, 2020). Drawing on the work of Pasquale (2015) and Eubanks (2018), Christin argues that the opacity of the algorithms, or black boxes, to use her terminology, is "particularly problematic" as "algorithms are increasingly making decisions hidden behind corporate walls and layers of code…since algorithms are often biased, [as] they draw on historical data…that end up "automating inequality" (Christin, 2020).

1.2. Christin's three ethnographic strategies

After establishing that algorithmic opacity can create harmful outcomes, Christin builds on Seaver's (2017) ethnographic work by offering three ethnographic strategies for studying computational systems: Algorithmic refraction, algorithmic comparison, and algorithmic triangulation. Christin refers to these as enrolment strategies, i.e. ways to use the algorithms as a central part of the ethnographic methodology.

Algorithmic refraction is "derived from physics, [and] refers to the changes in direction and strength that occur whenever a wave of light or sound passes from one medium to the next" (Christin, 2020). Christin applies the idea of refraction to algorithmic systems to invite the ethnographer to consider what changes occur in the presence, or sites, of algorithmic systems. Extending this metaphor allows us to see algorithms as "prisms" that can both "reflect and reconfigure social dynamics" (Christin, 2020). Thus, by studying their use, development and situatedness in social contexts, Christin suggests that ethnographers can begin to understand better (and see through) the "complex chains of human and non-human interventions that together make up algorithmic systems." (Christin, 2020). For example, suppose one was interested in how the algorithm for TikTok worked. In that case, one might study how the use of the platform changed the humans within its ecosystem (users), how the platform (algorithm) adapted based on their behaviour, and how users spoke about it as a result. These "outputs" would indicate changes due to the algorithm. Inferences could then be made about the algorithm and its operation on the human and non-human actors within that system.

Algorithmic comparison involves using multiple sites to examine algorithms through a similarities and differences approach (Christin, 2020). For instance, to study bias in algorithms, we might compare decision-making tools in Human Resources and finance (e.g. hiring algorithms and credit scoring tools), examining the similarities and differences of how they operate and impact users and applicants. Such a comparison would reveal "not only the uses of algorithmic systems but also their inner workings, regardless of how opaque" (Christin, 2020).

Christin proposes directly addressing the methodological requirements of ethnography – saturation, positionality, and disengagement – through *algorithmic triangulation* (2020). To address *saturation* (how large a sample should be), she suggests using various social media platforms to recruit the theoretical sample (Christin, 2020). To understand positionality, the ethnographer can examine how they are perceived and interacted with on these platforms. For disengagement (the challenge of leaving the site and saying goodbye to informants), Christin suggests this can be facilitated by the algorithmic platform being studied (2020).

1.3. Critique – Beyond the Black Box

Assessing Christin's article by her own goal to "offer a toolkit of practical strategies" / "tactics" for conducting ethnographic studies on algorithms (2020), one must ask, are these three strategies helpful to ethnographers? As "tactics", one would expect these to be described in sufficient detail, allowing readers to replicate them in their research (Hennink *et al.*, 2020). I would argue that Christin's algorithmic comparison and algorithmic triangulation discussion does this well, as it incorporates examples from her fieldwork and concretely demonstrates how these strategies would be enacted and to what benefit.

However, algorithmic refraction seems comparatively less tangible (and thus less useful). In discussing this strategy, Christin uses the light metaphor (more than in the other two strategies). Christin refers to algorithmic tools as "prisms that both reflect and reconfigure social dynamics", providing "a useful strategy for ethnographers to bypass algorithmic opacity" (Christin, 2020). Algorithmic refraction may, thus, be more challenging to implement as the steps were less descriptive (despite an example); this causes one to question whether this is a tactic or a way to understand what is happening in the algorithmic system (a theory, perhaps).

While it is beyond the scope of this paper to provide a thorough evaluation of algorithmic triangulation, such an exploration would be valuable regarding whether this approach allows for sufficient reflexivity (Forberg & Schilt, 2023; Markham, 2020). Christin's tactics and discussion could arguably be strengthened by considering the scholarship on ethnography in digital contexts (Forberg & Schilt, 2023; Markham, 2020).

My second criticism of Christin's (2020) article is that while she bases her choice of the black box metaphor on Burrell's (2016) four characteristics of algorithmic opacity, she does not consider alternative metaphors. Christin does not justify why the black box is the best metaphor to use, nor does she recognise that this metaphor might foreclose alternate interpretations of the conceptual space. Thus, my argument is not that the black box is a poor metaphor but that, as "the black box has become the leading image to express opacity in AI" (Möck, 2022), it is crucial to understand what implications this has on research, policy and public discourse. In order to provide the necessary scaffold for my thesis, I will now examine my second article.

2. "Prediction Promises: Towards a Metaphorology of Artificial Intelligence"

Möck's article focuses on the "epistemic significance of metaphors" (2022, p. 121). It explores how philosophical theory can address and reframe the metaphorical images that "co-constitute and shape leading paradigms within socio-technical systems" (Möck, 2022). Möck discusses the "epistemic status of metaphor"; she draws heavily on Hans Blumenberg's work on phenomenology and suggests a methodological framework for a metaphorology of AI (Möck, 2022). To illustrate her argument, Möck provides two examples: the expert and the black box metaphor. Unfortunately, a full review

of Möck's paper is beyond the scope of this paper; thus, I will discuss only the two specific aspects that provide the necessary scaffold for my thesis[3]: "the epistemic status of metaphors" and her critique of the black box metaphor.

2.1. How metaphors shape knowledge

Möck asserts that "metaphorical notions serve the communication purpose of making complex concepts graspable" and that metaphors not only reveal what technology is presently capable of (or at least perceived to be capable of), but importantly, metaphors foreshadow what technologies are "supposed to become" (Möck, 2022). However, while metaphors can serve as an "epistemic bridge", helping us to articulate concepts that would otherwise not have words, they also risk obscuring meaning (Möck, 2022). Consider the example of war as a metaphor for debate (*win the argument, shoot holes in the argument*) (Lakoff & Johnson, 2008). While on the one hand, this highlights the combative nature that often arises (the metaphor is a useful epistemic tool), on the other hand, it forecloses the possibility of a mutually beneficial outcome. In war, there is only one winner. Thus, when the war metaphor is invoked, this is the frame of reference through which we see the discussion. However, if we used a dance metaphor instead, we might expect a more mutually beneficial process and outcome (Lakoff & Johnson, 2008). Thus, Möck asserts that we need to analyse our metaphors to understand how we have made sense of our technologies, as this may foreshadow and foreclose future possibilities.

2.2. The problem of the black box metaphor

"…the black box has become the leading image to express opacity in AI" (Möck, 2022). Wiener and Ashby initially used the black box metaphor in cybernetics as both "metaphor and theory". As a theory, the black box model enabled cyberneticians to study the brain's response to its environment despite not understanding how it worked. Thus, the black box functioned as an epistemic tool, serving as a theoretical model and a metaphor for a closed system that was not understood (Möck, 2022). Latour further explored this concept, introducing the term "unboxing", the "process of not only making the inner technical operations of the algorithm transparent but situating the technology within its contextual materiality" (Möck, 2022). This history coalesces into the concept of the metaphor we use today, where writers use the black box to refer to the lack of explainability and interpretability of algorithms.

Möck raises two concerns about the black box metaphor: Firstly, that by focusing too narrowly on the black box, we risk simplifying the problem in AI to a problem only about the algorithm; we fail to see it as "a problem that emerges within socio-technical systems" (Möck, 2022). A broader understanding of the context in which the black box operates demonstrates the additional power and epistemic dynamic at play between the makers and users of black boxes, where not only is the black box's creator superior to those unable to see inside, but the black box itself ultimately becomes superior to all (including its creator), as it has "superhuman capabilities" (Möck, 2022). Secondly, Möck questions "if the constant reproduction of the image of the black box in research might help manifest this dynamic" (Möck, 2022) i.e. if by constantly referring to the black box, even with the positive intention of promoting an agenda of unboxing, we may unwittingly be causing a "closure of debate and strengthen an epistemology of non-understanding that sticks with us in the box's materiality" (Möck, 2022). I will explore these concerns in greater detail in the context of my argument in section three.

2.3. Critique – Towards a Metaphorology of Artificial Intelligence

Möck's analysis of the epistemic value of metaphors is particularly useful for scholars, providing a foundation for research on metaphors in AI. Furthermore, she makes a novel contribution in her article by advancing Hans Blumenberg's metaphorology to include political considerations critical for a framework in the AI context (Möck, 2022). Möck's proposed metaphorology of AI, thus, recommends that we engage along four dimensions: (1) Examine the *history* of AI metaphors, (2) reveal *motivations* of AI researchers through the metaphors they use, (3) understand "what metaphors of AI can tell us about humans and their needs", and (4) consider the "political aspects of the imaginaries and the material-political embeddedness of the dominant narratives" (2022, p. 126). This framework provides a tangible way for scholars

to research AI metaphors, as Möck exemplifies in her article. However, while Möck uses two examples to demonstrate how this helps to surface and explore each of the four epistemic dimensions of the metaphor, the framework does not seem to encourage the search for alternative metaphors, nor an exploration of what these metaphors might be missing. Möck might argue that her frame of reference is philosophical[4] and that her goal is to frame the issue, not to solve it, i.e. not to provide alternate metaphors, but to elucidate the problems with those being used. That may be a defensible stance for Möck. However, to ensure that we widen the metaphorical landscape and increase the possibilities for future research, policy and discourse, one could argue that we need an approach that generates more metaphors, not only questions the ones we have. In section four, I consider alternative questions to stimulate the generation of more metaphors to address this critique (Maas, 2023).

3. Why New Metaphors for AI Might Support Different Futures

In this section, I explore how metaphors influence ontology and epistemology and thus inform methodology in AI. I use Christin's (2020) example of the black box metaphor to demonstrate that an over-reliance on one metaphor forecloses one's ontological framework, thus potentially limiting epistemological and methodological choices, with implications for future discourse, research and policy.

3.1. The black box metaphor – influences ontology and epistemology

At its core, this is primarily a critique of language, which I argue is valid for two reasons. Firstly, language matters (Lakoff & Johnson, 2008). The metaphors we use have a real-world impact: They shape innovation, spur or halt investment, inform the study of technologies, and help to set regulatory agendas (Ganesh, 2022; Maas, 2023). For example, the current narrative of the potential of Artificial General Intelligence to become a *superintelligence,* capable of solving the world's most intractable problems, has arguably contributed to driving significant investment and research. In terms of regulatory implications, conceiving this future technology as a *superintelligence* has implications for the nature of the regulation that is developed (Maas, 2023). If it is *intelligent,* what legal rights does it have? If it can solve all problems, should we risk over-regulation, thereby slowing it down?

Secondly, if we accept Christin's position that addressing the opacity of algorithms is necessary and that ethnography is a valuable method to do so, then language and metaphor are central, as they are core to the ethnographic method (Rabinowitz *et al.*, 2018; Geertz, 1973; Marcus, 2021; Gullion, 2021; Seaver, 2017). Thus, to understand Christin's ontological and epistemological frame of reference concerning algorithms, I have tried to adhere to Marcus' call to "follow the metaphor" and let Christin's language speak rather than our assumptions about what might typically be constructed by ethnographic research (Marcus, 2021).

3.2. The black box metaphor – locks us in

Christin's article is well-intentioned and arguably both necessary and helpful – her specific strategies respond to Seaver's call for concrete ethnographic strategies to study algorithms (Christin, 2020; Seaver, 2021). However, Möck might point out that Christin's use of the black box metaphor and associated language may reinforce the "box's materiality" with unintended consequences (Möck, 2022). We can see how this metaphor has influenced Christin's language throughout the article and her resulting approach to methodology.

By conceptualising the algorithm as a black box, Christin's ontological and epistemological frame of reference becomes scientific. The algorithm occupies one side of a light spectrum, representing the greatest opacity/darkness. As a result, the ethnographer works to "shed light on the complex intermingling of social, cultural, and technological aspects of computational systems in our daily lives", rendering the algorithms transparent (Christin, 2020). Christin develops her ethnographic strategies from this frame, as the "concept of refraction is derived from physics" (Christin, 2020).

While using metaphors in technology and science may be unavoidable, "the less familiar we feel with a technology, the greater our need for visual language as a set of epistemic

crutches" (Sommerer, 2022). The use of the black box metaphor invites a particular framing of algorithms and the systems that create them, one that risks excluding humans by "obscure [ing] our view of the people behind the algorithmic systems and their value judgements…falsely suggest[ing] that algorithms are independent of human prejudices" (Sommerer, 2022). Ontologically, the black box occupies a materialist paradigm, where the algorithm's inner workings are sealed off, solidified and unknowable. Christin offers ways to render this black box knowable within this scientific paradigm through tools like refraction. The implication for epistemology is that by using the tools, the ethnographer can shed light on the algorithm or the system, thus creating knowledge that was not accessible before. While this may not be Christin's intention, one might argue that such language could suggest an empirical, if not post-positivist, epistemology (Lincoln & Guba, 2013; Malik & Malik, 2021; Omodan, 2022). Christin may disagree with this assessment. My intention is not to suggest that empiricism (nor post-positivism) is at odds with ethnography (Williams, 2020), but merely that as the metaphor creates ontological and epistemological paradigms, a more explicit explanation of one's epistemological framework becomes necessary.

To summarise – by framing algorithms as black boxes, Christin's ontological frame of reference positions algorithms as material, closed systems that are difficult to access. Consequently, knowledge of the system must be gained through direct means. Unsurprisingly, Christin's methodological strategies are thus empirical and inspired by the scientific paradigm (e.g. refraction). While this may be fruitful, offering new tangible strategies for ethnographers to study algorithms (Christin, 2020), there is a risk that by focusing on the "box's materiality", we might be "distract[ed] from the ethical or epistemic problems of these models" (Möck, 2022). If it is material, it cannot become non-material. Thus, once the black box metaphor has been asserted, it is difficult to move beyond it, even if that is the stated intention.

3.3. The black box metaphor – has real-world implications

The black box metaphor has implications for policymakers, who continue to see algorithms' opacity as intractable and a growing risk to humanity because we do not have control over them (Sommerer, 2022). However, the less control humans are perceived to have over these systems, the less responsibility they subsequently have, which increases the power of these systems and reduces the agency and accountability of the people involved in creating them (Maas, 2023; Sommerer, 2022). Thus, researchers are increasingly concerned about the continued use of this metaphor (Lehr & Ohm, 2017; Maas, 2023; Marcus, 2021; Möck, 2022; Sommerer, 2022).

Furthermore, some scholars suggest that this metaphor is neither technically accurate nor practically helpful (Murray-Rust *et al.*, 2022). Others argue that "the steps of playing with the data are actually quite articulable" and that the black box creates a "misimpression that machine-learning systems spring into being fully formed and are impenetrable" (Lehr & Ohm, 2017). To reconsider such a ubiquitous metaphor, however, alternative solutions will be required. Thus, in the final section, I explore possible solutions to prevent metaphorical foreclosure when discussing algorithms.

4. New metaphors, new frames, new futures

As researchers continue to address algorithmic opacity, one might consider a new metaphor to address the problems arising from an overreliance on the black box metaphor (Sommerer, 2022). Seaver's ethnographic work on recommender systems is one potential source of inspiration (Seaver, 2021). Seaver's metaphorical landscape includes human and other organic images, like the gardener whose "curation" "maintains[s] balance in the garden", that is, the algorithmic system (Seaver, 2021). Seaver's garden metaphor, relates the algorithm to something more organic and tangible, something that is curated and nurtured by the human gardeners who care for it and conscientiously prune it according to an intentional design. By following the metaphor, we understand Seaver's ontological frame as different to Christin's. In Seaver's worldview, humans have more agency; through their care, they can shape algorithms. However, even Seaver notes that some of his respondents refer

to themselves not as gardeners but as data cleaners (Seaver, 2021), suggesting that the garden metaphor does not paint the complete picture.

Another alternative to the black box is the "algorithmic veil" articulated by Lucia Sommerer (2022), whose primary concern with the black box metaphor is that it "falsely suggests that the algorithms are independent of human prejudice" (2022). In her description, the algorithmic veil overcomes this issue as it is an item that, by definition, relates to the human form, inviting one to draw it back to see behind it. The veil is of a different nature to the black box, suggesting that the algorithm would inhabit a different ontology and epistemology, one that is less fixed, more translucent and something with which humans could interact (perhaps more co-constitutive) (Sommerer, 2022). By their very nature, veils allow one to see the subject beneath the veil (despite obscuring the image to the onlooker), it may be possible to both identify the obscured image and reveal the true image if the veil is lifted. Arguably, this could be likened to people trying to make sense of how an algorithm performs. Unfortunately, Möck did not fully develop this metaphor, so it is not clear how it should be interpreted. As a result, one might argue that aspects of algorithmic opacity are missing and that this image does not sufficiently demonstrate the vast complexity and interconnectedness of these systems.

Finding both metaphors unable to fully explain algorithmic opacity, I tried to develop a new metaphor. Consider the metaphor of a spider's web that spans a multi-dimensional space. The spider's web metaphor may offer some benefits over the black box in that it is organic (thus allowing humans to act on and in the system); it inherently demonstrates high levels of interconnectivity; it is highly complex yet transparent, so it does not feel as intractable; and is sensitive to interdependencies (i.e. things that affect one part of the web impact other parts). If we used this metaphor to extend Christin's article, one could imagine a title: "Beyond the black box – into the spider's web". By conceiving of algorithmic opacity as a spider's web rather than a black box, the ethnographer might consider other techniques such as: Detangling (what concepts, narratives, and stakeholders are weaved together and enmeshed in the narratives and systems?), locating the source of attachments (as a spider's web attaches to objects for structural integrity, the ethnographer might ask what socio-technical or political foundations underpin the narratives revealed through the ethnography); and looking for who/what is caught in the web (who are the algorithms acting on and to what effect?).

However, simply offering an alternate metaphor misses the overall point of this argument (Maas, 2023). If we rely only on one metaphor for our understanding and shaping of how we see algorithms (or any concept), then we narrow our frame of reference to only that particular image; like an aperture, it forecloses other ways of seeing algorithmic opacity, other research agendas and thus potential futures. Similarly, it foreshadows likely outcomes by framing algorithms in a particular way (Maas, 2023). Over-reliance on any metaphor (even a powerful one) can risk consumers and users of those metaphors becoming unreflective.

The solution is not to abandon metaphors; they are critical epistemic bridges between complex, inarticulable concepts and our current language framework. However, we must be more reflexive in using and consuming these metaphors (Möck, 2022). We need to interrogate our use of metaphors to make explicit the work they are doing. Möck's metaphorology of AI has been discussed as a valuable approach to deepening our understanding of the metaphors we use and their histories, socio-political contexts, and implications. Maas (2023) provides an additional method by which we can examine our metaphors and metaphorical landscapes. This framework has an advantage over the more philosophical metaphorological framework, as it encourages the development of a broader range of metaphors.

Maas' (2023) five-step process for evaluating metaphors invites one to ask a series of questions about the metaphor in question: (1) What foundational metaphors are being used?; (2) What other metaphors could describe the same features?; (3) What aspects does the

metaphor capture well?; (4) What aspects does the metaphor not capture, and what are its consequences?; and (5) What are the regulatory implications of this metaphor? It is the second question that, I believe, brings the most significant opportunity for increasing the range of metaphors used to describe a conceptual space.

This approach could be used to create language that better captures the metaphorical landscape of concepts, like algorithmic opacity, ensuring a broader range of metaphors to describe the phenomena in AI. However, this approach may be practically challenging, as it can be hard to find powerful metaphors.

Conclusion

"Metaphor is pervasive in everyday life, not just in language but in thought and action…Our ordinary conceptual system…is fundamentally metaphorical in nature" (Lakoff & Johnson, 2008). The implications of this are critical in artificial intelligence, the term being a metaphor itself, where we must be intentional and reflexive about the language we use and consume. In this paper, I explored how metaphors influence ontology and epistemology, informing methodology, through a critical review of two articles.

While providing tangible strategies for ethnographic fieldwork, Christin's reliance on the black box metaphor provided a focusing example for my thesis. Drawing on Möck's discussion of the importance of metaphors and her critique of the black box, I argued that to move "beyond the black box," we must expand our metaphorical range when considering concepts like algorithmic opacity. Having argued that the black box is limited as a singular metaphor, I recognise that the solution is not simply to provide a single better metaphor, as this, too, would risk limiting other possible conceptions and possibilities of meaning.

The future of AI research and policy would benefit from greater reflexivity, where we examine the metaphors, we use and consume and introduce a broader range of metaphors. This approach will ensure that we expand the description of our concepts and thus our understanding of these technologies; in so doing, we increase the range of possible future outcomes.

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