Misled by Metaphor: The Problem of Ingrained Analogy

Andrea Sullivan-Clarke
University of Windsor
Department of Philosophy

Nancy Leys Stepan's historical analysis of the analogical reasoning used in nineteenth century research on human variation highlights an interesting feature of scientific discourse: metaphors imported from larger society can negatively impact scientific practice. In this paper, I consider the roles of analogical reasoning in scientific practice and demonstrate how it can mislead the scientists relying on it. One way, the problem of ingrained analogy, results when the correspondences of a metaphor become entrenched in the minds of scientists. Previous solutions, offered by Turbayne (1971) and Recker (2004, 2010), lack the resources to address the problem. Thus, I propose introducing novel critique from relevant outsiders as a method to mitigate the power of scientific metaphors to mislead.

Metaphor is an essential part of scientific reasoning.[1] The scientists that rely on metaphor, however, are not necessarily aware of its implicit influence, making it easy for the correspondences implied by a metaphor to be taken for granted, affecting scientific practice. In "Race and Gender: The Role of Analogy in Science," historian Nancy Leys Stepan's (1986) discussion of nineteenth century research on human difference highlights this

I am indebted to Jeffrey Dunn and Tamara Beauboeuf for their timely and insightful comments on an earlier draft and Pierre Boulos for our conversation about historical examples. I am also grateful to the anonymous reviewers, who offered much needed suggestions and comments.

1. See Arber (1947), Bailer-Jones (2008), Bartha (2010), Black (1962), Boyd (1993), Carloye (1971), Cat (2001), Darden (1982), Garfield (1986), Harré (1988), Hesse (1966), Kay (2000), Kuhn (1993), Leatherdale (1974), Recker (2004, 2010), Ruse (1973), and Turbayne (1971).

Perspectives on Science 2019, vol. 27, no. 2

doi:10.1162/posc_a_00303

particular worry, demonstrating a need for scientific communities to critically examine the use of metaphor in their practice. It is easy for metaphors "to become dogmatic and to be seen as literally true" because scientific discourse is closely associated with "objectivity and reality" (Stepan 1986, p. 275).

In the nineteenth century, scientists like Paul Topinard, Samuel George Morton, Havelock Ellis, and Carl Vogt relied on societal metaphors that linked gender to race as well as those that linked animals with what they called the "lower races" (Stepan 1986, p. 264).[2] According to Stepan, nineteenth century scientists used their research to establish a hierarchy of superiority that suggested Caucasian males were more intelligent or rational, less likely to be criminal, and more likely to be sexually normal than members of non-white groups, females, and other social groups (such as the poor, the criminal, and the sexual deviate) (Stepan 1986, p. 264). Interestingly, the results of this research met with little resistance. Its findings were not only consistent with the expectations of a racially homogeneous scientific community, but also with those of the general society.

Metaphors are a social product of a historically situated community, and often scientists draw from everyday language in order to address their epistemic needs. When doing so, scientists run the risk of importing implicit assumptions and/or biases of the metaphor into their practice.[3] Through the lens of their metaphors, nineteenth century scientists of human variation saw the categories of race and gender in a new way, demonstrating how a metaphor can further a scientific research program. Yet, as Stepan notes, "a metaphor or analogy does not directly present a preexisting nature but instead helps 'construct' that nature" (Stepan 1986, p. 274). Scientists, working under the influence of the metaphor, collect data consistent with the metaphor and overlook data that runs counter to it (Stepan 1986, p. 274). The associations posited by the metaphor are so strong that nature is understood through the filter of a metaphor that takes hold in the community and "becomes part of the logic of science itself" (Stepan 1986, p. 274). When a scientific metaphor is taken for granted by its community, it results in negative epistemic consequences: scientists may be misled about the phenomenon.

Notably, it is not only the scientists, who may be harmed. Given that science routinely informs social and political policy, the truths that scientists

2. Nineteenth century scientists of human variation used the term, "lower races," to represent the non-white races.

3. For example, Kay (2000) notes that the selection and use of analogies underwriting the concept of "genetic code" were products of patronage, the backgrounds of community members, the research in other disciplines, and even the ideology of the cold war. See especially, Kay 2000, chps. 3, 4.

endorse may have long lasting social impacts as well. Thus, Stepan's question of how metaphors change or how knowledge generating communities can prevent themselves from being misled by metaphor is critical (Stepan 1986, pp. 274–6).[4]

In this paper, I refer to a community's uncritical acceptance of a metaphor as the problem of ingrained analogy, and I illustrate how it impacts the critical social discourse connected with scientific practice. Further, I consider alternative solutions for dealing with this problem—such as those presented by Colin Turbayne (1971) and Doren Recker (2004, 2010). I contend that each account lacks the resources to provide a critique that sufficiently addresses the problem of ingrained analogy. As a point for future consideration, I propose that scientific communities incorporate external criticism into their discourse of practice insofar as the community lacks the critical resources to independently critique their metaphors.

The Problem of Ingrained Analogy and Scientific Practice

Analogical reasoning, which includes metaphor and analogy, assumes various roles in scientific practice. Jordi Cat reveals some of the roles for analogical reasoning in his explication of James Clerk Maxwell's scientific metaphors.[5] Metaphor, according to Cat, "organizes" phenomena and produces a vocabulary that "mediates" between mathematical formalism and the phenomenon (Cat 2001, 402–3). In short, metaphors serve an illustrative function by enabling researchers to connect the abstract formulas of theory with the "concrete, familiar ideas" shared via a "cognitive relation" offered by the metaphor (Cat 2001, p. 425). Terms—like mass, stress, and work—were imported into physics from economics, making it possible for models to "suggest experiments and introduce additional structure in the theoretical structure of the phenomena" (Cat 2001, pp. 425–32).

In their discussion of scientific metaphor, Keith Holyoak and Paul Thagard (1995) identify four distinct roles for analogical reasoning in science: the identification of analogues for modeling phenomena, further developing a theory, evaluating a theory or hypothesis, and educating those new to the discipline, as well as the general public (Holyoak and Thagard 1995, p. 189).

4. Scientific knowledge often informs the policies of social communities. The removal of the American Indian to reservations and the institution of black slavery, were supported by nineteenth century research on human variation, if not informed by it.

5. Cat cites that "Maxwell speaks of 'a method of scientific metaphor'" (Cat 2001, p. 398). This method, Maxwell maintains, is "capable of generating science" (Cat 2001, p. 430; originally found in Maxwell 2011, p. 227). As such, these metaphors are not "a trivial extension of metaphors in ordinary language" nor is there a general account of scientific metaphor (Cat 2001, pp. 397–8).

When scientists rely on metaphor, there are two roles for analogical reasoning that are critical to understanding the problem of ingrained analogy: the further development of a scientific theory by informing the design of experiments and the evaluation of theories and hypotheses. In his research on evaluating analogical arguments, Paul Bartha distinguishes between these two roles, describing one as the broad (metaphor) use and the other as the narrow (analogical arguments) use of analogical reasoning.[6] Both work in conjunction, comprising most of the critical discourse involving a scientific community's practice.[7]

The broad role for analogical reasoning is the use of a metaphor that directs scientific enquiry based on what is believed to be relevantly similar or different between two or more analogues. For the purposes of this paper, comparisons between only one source and target analogue will suffice. The correspondences of similarity and difference that ground a metaphor offer insight as to how that metaphor becomes firmly planted in the minds of a community. Initially, scientists make a comparison between two analogues: the target analogue and the source analogue. The target analogue is the phenomenon currently under investigation; it is less familiar. In contrast, the source analogue is something that is more familiar or better understood. For example, scientists may appeal to waves in the water as a source analogue in order to hypothesize about sound waves (target analogue), or they may use the sexual behavior of guinea pigs as a source analogue to learn more about human sexual behavior (target analogue).[8] Based on an initial comparison between the source and target, scientists become interested in other similarities and differences between the two analogues.

The set of correspondences based on the similarities between the two analogues is referred to as the positive analogy and the set of differences is the negative analogy (Hesse 1966, pp. 8–10). [9] The remaining features—those that scientists do not know to be similarities or differences between

6. In *By Parallel Reasoning* (Bartha 2010, p. 12).

7. The account of analogy present in Bartha (2010) focuses on the narrow role for analogy, the individual arguments. The problem of an ingrained analogy, however, involves both metaphor and the arguments it generates.

8. Holyoak and Thagard cite the research of Vitruvius, who refers to waves in liquids to understand the behavior of sound waves (Holyoak and Thagard 1995, pp. 10–11). Rebecca M. Jordan-Young describes different experiments conducted on guinea pigs as models for humans (Jordan-Young 2010, pp. 26–7). See, Young et al. (1965) and Phoenix et al. (1959).

9. The terms positive, negative, and neutral analogies are used in Hesse (1966) but originate with Keynes (1921). Paul Bartha describes these analogies as domains of propositions of similarity and difference between the source and target analogues (Bartha 2010, p. 14).

the source and target—comprise the neutral analogy. Motivated by the positive analogy and constrained by the negative analogy, scientists conduct their research in order to discover whether features in the neutral analogy are actually similarities or differences. For example, scientists relied on the sets of similarities and differences between guinea pigs and humans to develop a research program on human sexual behavior.

Motivated by the likelihood of discovering a possible correspondence suggested by the neutral analogy, scientists rely on the narrow role of analogical reasoning to construct arguments based on the similarities and differences in the positive and negative analogies of the metaphor. The premises of each argument from analogy are comprised of the known correspondences in the positive and negative analogies, while the conclusion will be a hypothetical correspondence from the neutral analogy. For example, drawing on the similarities between humans and guinea pigs—to include "shar[ing] many physiological functions" and having similar structures like "the Circle of Willis"—psychologists generated arguments about the sexual behaviors of guinea pigs and the behavior of humans who were described as intersexed.[10] In her book *Brain Storm: The Flaws in the Science of Sex Differences*, Robin Jordan-Young states that once scientists discovered the introduction of adult sex hormones to adult guinea pigs did not change their sexual behaviour, they assumed that sexual behaviour of guinea pigs was influenced by the introduction of sex hormones prenatally (Jordan-Young 2010, pp. 27–8). Based on the similarities between humans and guinea pigs, researchers relied on guinea pigs as models to understand the sexual behaviours of intersexed individuals, individuals who are born with a combination of reproductive/sexual anatomy that doesn't conform to the typical definitions of female or male. Researchers believed that the physiology and sexual behavior of intersexed individuals were the result of having been subjected to an excess of adult hormones while in the womb (Jordan-Young 2010, pp. 27–8).

Unlike a metaphor, which motivates a variety of different research programs, the narrow role (an argument from analogy) informs the design of the experiments used to test hypotheses and plays a significant part in data collection. The conclusion of an argument from analogy, what Bartha refers to as the hypothetical analogy, is a possible correspondence under investigation; simply put, it is an accepted fact about the source that will be hypothetically extended to the target through the analogical inference (Bartha 2010, p. 14). As is typical of all analogical arguments, the greater

10. For information on shared physiological functions between humans and guinea pigs, see Wagner and Manning (1976); Terril and Clemons (1998); Vanderlip (2003). For similarities of brain structure between the two, see Librizzi et al. (1999).

the number of relevant similarities and the lack of relevant differences support the argument's conclusion.[11] When scientists collect data using experiments based on the analogical argument, the data is considered decisive. Once satisfied with the results of their experiments, scientists add the newly determined statement of similarity or difference to either the positive analogy (if both analogues share the feature in question) or the negative analogy of the metaphor (if the two analogues differ).

Research guided by metaphor is an iterative process, even though the scientists themselves are unaware of their use of analogy (Dunbar 2000, pp. 52–5).[12] I offer a sketch of the recursive exchange that occurs between the broad and narrow roles for analogical reasoning in science by combining the accounts of scientific practice from Stepan (1986) with the roles for analogical reasoning from Holyoak and Thagard (1995) and Cat (2001); see Diagram 1.

When scientists determine that a particular metaphor is epistemically promising, represented by the top of the diagram, they embark on a research program to uncover the possible correspondences of similarity and difference. A metaphor serves as a guide for the research of the community when the number of scientists relying on the positive, negative, and neutral analogies increases. Scientists design their experiments with the goal of ascertaining whether some feature of the neutral analogy should be incorporated into the positive or negative analogies of the metaphor, (moving from Reasoning from Analogy to Design Experiments). Referencing the analogies of the metaphor, scientists also interpret and collect data in support of the conclusion of the analogical argument. The modified version of the metaphor—one that has the new information added to its positive or negative analogies—guides the community further, motivating new analogical arguments that contain the previously incorporated information in its premises. Thus, in a manner similar to a Kuhnian paradigm, the iterative process of metaphor guides the research program (Stepan 1986, p. 272).[13]

11. Hesse (1966) introduced constructing analogical arguments as tabular representations. Bartha (2010) uses this type of reconstruction as a way to assess the argument's plausibility, see pages 94–7. See also Diagram 2.

12. In "How Scientists Think in the Real World," psychologist Kevin Dunbar examines the "reasoning strategies" of individual scientists, noting that analogical reasoning plays a key role in "generating hypotheses, designing experiments, and interpreting data" (Dunbar 2000, p. 52). However, his research also reveals an unsettling feature of individual scientists' use of analogical reasoning: scientists are unlikely to remember their use of analogy at any given point in their research (Dunbar 2000, p. 55).

13. Stepan notes that when an analogy assumes its broad role,

> the analogy comes close to the idea of a scientific "paradigm" as elaborated by Kuhn in *The Structure of Scientific Revolutions*; indeed Kuhn himself sometimes writes of

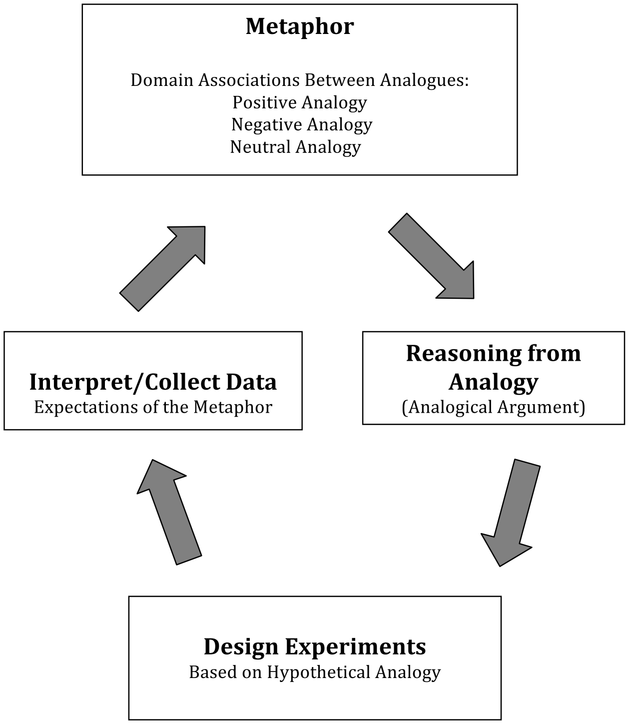

Diagram 1. The Iterative Process of Metaphor Guided Science

Throughout scientific practice, the "metaphors and analogies direct the investigators' attention to some aspects of reality and not others" (Stepan 1986, p. 274). While this may provide researchers with insight, Stepan notes the broad and narrow roles of analogical reasoning "generate a considerable amount of new information about the world that confirms metaphoric expectations and directs attention away from those aspects of reality that challenge those expectations" (Stepan 1986, p. 274).

Not only does a metaphor draw attention to certain features and downplay others, the positive and negative analogies may contain misinformation, such as correspondences of similarity that society assumes are shared by both the

paradigms as though they are extended metaphors and has proposed that "the same interactive, similarity-creating process which Black has isolated in the functioning of metaphor is vital also in the function of models in science." (See Kuhn 1962, 35–42 and Kuhn 1993, 415). (Stepan 1986, p. 272).

source and target even though they are not. Once a metaphor is established within the community, scientists understand the phenomenon in terms of the correspondences of the metaphor; they design their experiments and collect the data with reference to the analogies suggested by the metaphor. Given the possibility of error associated with the correspondences suggested by a metaphor, it is easy to see how a metaphor can not only mislead, but also entrench itself within a community. Scientists use the language of the metaphor to describe reality, and without the critical resources to challenge the assumptions of the metaphor, it is likely the members of a community will "confuse the devices of procedure with the actual process of nature, and thus unknowingly insinuate metaphysics" (Turbayne 1971, p. 50).

The problem of ingrained analogy not only poses a worry for knowledge generating practices, it also has implications for society and those who create political policies that are informed by science. As Stepan notes, nineteenth century race science contributed to the social policies of unjust treatment of "women and the 'lower races'" (Stepan 1986, p. 275).[14] The issue of how to prevent scientists and their communities from being misled by metaphor and analogy has not only an epistemic component, but it takes on a moral one as well. Thus, as Stepan points out, how to critique a metaphor, or how communities change from one metaphor to another, is critical (Stepan 1986, p. 276).

Dealing with the Problem of Ingrained Analogy

In *The Myth of Metaphor*, Colin Turbayne describes the problem of ingrained analogy as scientists being "victimized" by their metaphors (Turbayne 1971, p. 50). According to Turbayne, when scientists uncritically use metaphor, they run the risk of confusing "the model for the thing, and the metaphor for the literal truth" (Turbayne 1971, p. 4). This shift in thought is dangerous because it is done unconsciously. When the metaphor becomes commonplace to the point that its use is no longer recognized as metaphorical, those acting under the influence of the metaphor are being misled, or in Turbayne's terms are "victimized" (Turbayne 1971, p. 5).

Stepan's research supports Turbayne's claim; scientists researching human variation "saw" the world in a particular way, which affected key features of their scientific practice, such as the development of methods for measurement, design of experiments, and the interpretation of data. Scientists of human difference failed to distinguish reality from their

14. According to Stepan, the reasons given for preventing "social change" in the interests of women and people of color was "that inequality was a 'fact' of nature and not a function of the power relations in a society" (Stepan 1986, p. 275).

metaphorical descriptions. Instead of generating knowledge about the actual world, these scientists "insinuate[ed] metaphysics" (Turbayne 1971, p. 4). When scientists treat the analogies associated with a metaphor as literal comparisons, they ascribe the non-existent features and relations of the analogy to the phenomenon. In doing so, "The victim not only has a special view of the world but regards it as the only view, or rather, he confuses a special view of the world with the world" (Turbayne 1971, p. 27).

Simply recognizing that a metaphor can misdirect scientific practice, however, is not sufficient to prevent being misled by it. As Turbayne explains, we cannot simply re-allocate the "facts" to the proper metaphysical categories because "we never know exactly what the facts are. We are always victims of adding some interpretation" (Turbayne 1971, pp. 64–5). Without the benefit of a view from nowhere, "we cannot help but allocate, sort, or bundle the facts in some way or another" (Turbayne 1971, pp. 64–5). Thus, instead of trying to fix the existing metaphor, Turbayne suggests scientific communities "show that [the metaphor] is expendable" (Turbayne 1971, p. 65).

Turbayne proposes testing the analogies of a community's metaphor by contrasting it with those of a competitor. In doing so, the community initiates an active "search for the best possible metaphor" (Turbayne 1971, p. 65). A competing metaphor provides a different filter for looking at the world, giving the community an opportunity to select the better metaphor by employing unique methods for evaluation that can only be discovered in the context of competition (Turbayne 1971, p. 70).

Turbayne's account offers a solution that addresses my sketch of scientific practice. Yet, there are costs associated with his approach that communities may find too steep. For one, using this approach may prompt communities to discharge their metaphors before the fruitful implications have been fully explored. If only one feature of the metaphor is discovered to be problematic, it is reasonable to expect that the community may be able to correct their assumption. For example, researchers relying on a metaphor that posits planetary motion as a model for electrons orbiting a nucleus may adjust their understanding from that of a predictable trajectory to one of orbital shells around a nucleus.

A second reason, which is more detrimental to Turbayne's account, is the possibility that a community may introduce a competing metaphor that shares the same problematic features as the incumbent. Members of a scientific community—having been indoctrinated into the discipline—may lack the epistemic diversity necessary for developing a metaphor with the needed novel correspondences. Metaphors, and the analogies underpinning them, are products of a particular historically situated community, seeking to explain a specific phenomenon. As such, scientists may rely on similar assumptions to select a competitor. An additional worry is that, unlike metaphors in literature, scientists cannot use any source analogue; they depend on ones that fulfill the "constraints of similarity, structure, and purpose" of the phenomena (Holyoak and Thagard 1995, p. 7). Best case, the new metaphor may be liable to the same inaccuracies as the first, and worst case, the metaphors may be mutually inconsistent, like the particle-wave metaphor in optics.

Recker, like Turbayne, maintains that once a metaphor is taken for granted within a community, re-inserting "like" back into the metaphorical expression does not solve the problem (Recker 2004, p. 217).[15] For Recker, this strategy fails to overcome the human psychological tendency to equate the figurative correspondences posited by a metaphor with the way the world actually is (Recker 2004, p. 217).[16] Insofar as metaphorical explanations are intelligible and "fit experience adequately, there is no reason to look more closely" (Recker 2010, p. 660). Thus, metaphors that conform to experience—like *nature as machine* or *human races as distinct species*—are easily accepted within a community and less likely to be challenged. As Recker concludes, "if there is no motivation to look more closely at something that seems to be adequate, there will be no reason to abandon the default mode of reasoning" (Recker 2010, p. 661).

To deal with the problem of ingrained analogy, Recker considers a strategy that seeks to weaken the analogy between the source and target analogues, even though he is not fully convinced that it can motivate people to look at a metaphor differently (Recker 2010, p. 662).[17] To counter the problem of an ingrained analogy, Recker suggests an active search for the dissimilarities between the source and target strategy; this is similar to that originally put forth by David Hume (Recker 2004, p. 217).[18]

An active search for the dissimilarities between analogues mobilizes the critique of the metaphor in two ways: first, it serves to heighten

15. Interestingly, Recker points out that some individuals reject the claim that the relation between two analogues is metaphorical, emphasizing the identity (or taking the analogy for granted) in support for their position (Recker 2004, p. 213). For example, Recker cites Bishop William Paley's insistence that animals are "*identical to,* not merely analogous to machines" (Recker 2004, p. 213).

16. Recker states "part of the problem [of being misled by an analogy] is *psychological* rather than logical, concerned with how we do think as opposed to how we *should* think" (Recker 2004, p. 217).

17. Recker uses the optical illusion of the Müeller-Lyer arrows as an example of default thinking that "*can* be superseded by training or cueing" (Recker 2010, p. 657). In the absence of such cues, overcoming the default mode of thinking is unlikely.

18. Hume offers an analysis in his Treatise 1.3.12 (see Hume 1896). According to Hume, "in the probability deriv'd from analogy, 'tis the resemblance only, which is affected. Without some degree of resemblance, as well as union, 'tis impossible there be any reasoning" (Hume 1896, p. 142).

the community's awareness of the non-literal content of the metaphor and second, it may yield a relevant difference, a feature that has the potential to reject the analogy altogether. The difficulty, according to Recker, is overcoming the psychological influence exerted by an ingrained analogy (Recker 2004, p. 217). For example, Recker notes that even though the metaphor, *nature as a machine,* was scientifically refuted, it continues to influence public opinion, and those under the sway of the metaphor will not abandon it unless given good reason to do so (Recker 2010, pp. 660–62). [19]

While focusing on the differences between the source and target analogues provides opportunities to break the hold that a metaphor exerts, it may not be able to provide the dissonance needed for an individual to reject their default reasoning (Recker 2010, pp. 660–62). If members of the community are so taken by their metaphor that they cannot conceive of differences between the source and target, they will fail to provide a robust critique. A community that fails to challenge its metaphors is not difficult to imagine. Analogies supporting a metaphor are comfortable and the members of a scientific community are often raised on the same metaphors and supporting analogies as part of their professional education. Without sufficient critique, however, the metaphor guiding their practice will likely remain "entrenched" (Recker 2010, p. 661).

Communities that are homogeneous—ones whose members have similar backgrounds and practical experiences—will lack the resources to achieve a robust critique capable of destabilizing an ingrained analogy because individual members may have little to offer in critiquing the assumptions that ground a community-endorsed metaphor. Thus, any account dedicated to solving the problem of ingrained analogy should not only include cultivating a community's awareness of the non-literal nature of metaphor, as suggested by Turbayne and Recker, but it should also promote the community's critical discourse.

Toward a Robust Critique of Metaphor

Contributions from socially defined situated knowers (those who increase the epistemic diversity of the community) have proven to be pivotal in opening the lines of critical discourse. In fields like—primatology, biology, and archaeology—feminist scientists made positive contributions to the critical discourse of community's nonliteral language by challenging the

19. As Recker notes, "Like those who have no reason to measure the arrows in the Müeller-Lyer illusion, [...] they will not experience the cognitive dissonance necessary to move to a more rule-based approach" (Recker 2010, p. 657).

gendered assumptions of the dominant metaphors.[20] Even so, diversifying the membership within a community does not guarantee that the background experience and knowledge of those members will be what is needed to effectively critique a particular metaphor. As Kristen Intemann cautions "the mere presence of a member of an oppressed group will not be sufficient to achieve the sort of conscious, critical reflection that is required for achieving a standpoint" (Intemann 2010, p. 789). It is reasonable, therefore, to consider what types of experience or background information should be maintained or promoted within a community.

Given the variety of disciplines and research questions in science, articulating the specific experience and background knowledge that the members of a community will need in order to generate a robust critique of their metaphors is difficult. In general, I expect effective criticism to come from individuals who have diverse practical experience or knowledge regarding the source and target analogues (the objects standing in comparison) and/or the correspondences of similarity and difference in the positive and negative analogies of the metaphor. Not only will this type of background knowledge and experience will prove most useful in critically appraising the aptness of the metaphor, it will also serve to assess the merit of any analogical arguments generated by scientists who reference a metaphor.

Any solution to the problem of ingrained analogy should generate a robust critique of metaphor, and by robust, I suggest introducing into the community the epistemic novelty and diversity necessary for maximizing the critical interactions within a scientific community. Since scientific communities will not be in a position to know whether its membership can serve as effective critics, I propose that they admit the critical contributions of individuals from outside of the community whenever they rely on metaphor to guide their practice. Of course, not every individual will be an effective critic, and not every critic will have the relevant expertise. However, the diagram of scientific practice that I provided earlier can inform the community in the selection of outsiders to participate in the critical discourse of their practice.

The problem of ingrained analogy arises when the correspondences of the metaphor are taken as fact and, in turn, figure as premises of subsequent analogical arguments. Consider the following tabular representation of an analogical argument.[21]

20. For specific examples in primatology see Haraway (1989) and for examples in biology see Martin (1991) and Okruhlik (1994). For examples in archaeology, see Wylie (2002), particularly the types of contributions she distinguishes as "content critiques." For more on the feminist contribution to the critique of science in general, see Wylie (2012).

21. The tabular representation of an analogical argument contains all the standard information of the argument in premise-conclusion form. The columns list the analogues and

Diagram 2. Tabular Representation of an Analogical Argument

Source	Target
P1	P1*
P2	P2*
P3	P3*
P4	P4*
Conclusion	Hypothetical Analogy

Suppose the horizontal correspondence of Diagram 2., that between P2 and P2*, posits a correspondence of similarity where there is none.[22] For example, a popular, yet incorrect correspondence found in the arguments supporting nineteenth century research on human variation was the belief that human races, like distinct species, could not yield viable offspring.[23] According to Samuel George Morton, "a law of infertility [among people of different races in the Americas] demonstrated that mixed-race crossings would result in feeble and/or sterile individuals (Nott and Gliddon 1854, p. 398).

The analogical arguments that contained this particular correspondence, of course, are ill-formed. Contrary to the belief that offspring of parents from distinct races were sickly or sterile—mixed-race children live, and thrive. However, scientists relying on the putative similarity to design their experiments and interpret data will be misled, and as a result, they posit incorrect

the features ascribed to them. The horizontal rows are premises that contain correspondences of similarity and difference between the two analogues.

22. I am limiting the effect of the ingrained analogy to only one horizontal relation for simplicity's sake. It is possible that misleading correspondences could appear in multiple horizontal lines on the tabular representation.

23. Samuel George Morton pointed to the reduced ability of mixed-race slaves (Creole peoples) to give birth to viable offspring. According to Morton,

> As respects crosses between Negroes, Indians, and white persons, on the Panama isthmus; a passage was indicated to me by Mr. Conrad: —"The character of the half-castes is, if possible, worse than the Negroes. These people have all the vices and none of the virtues of their parents. They are weak in body, and more liable to disease than either the whites or other races. It seems that as long as pure blood is added to the half-castes proper, when they only intermarry with their own colour, they have many children, but these do not live to grow up…" (Nott and Gliddon 1854, p. 726n548).

information to the analogies of the metaphor, which will affect how other scientists design their experiments and collect their data.

As a solution to the problem of ingrained analogy, I suggest that outsiders to a discipline may have the critical resources to not only challenge the correspondences of similarity and difference, but to also challenge whether those correspondences are relevant to the conclusion of the analogical arguments used to design experiments and inform the collection of data. For example, Frederick Douglass in his 1854 address "The Claims of the Negro Ethnologically Considered," issued multiple objections to the metaphors used by nineteenth century researchers on human variation. Douglass challenged the assumption of polygenesis held by Morton and his followers. For Morton, human races originated in different areas around the world, which gave rise to their physical and behavioral differences (Baker 2008, p. 93). Douglass points out the motivations behind the assumptions, noting

> The evils most fostered by slavery and oppression, are precisely those which slaveholders and oppressors would transfer from their system to the inherent character of their victims [...] For, let it be once granted that the human race are of multitudinous origin, naturally different in their moral, physical, and intellectual capacities, and at once you make plausible a demand for classes, grades and conditions, for different methods of culture, different moral, political, and religious institutions, and a chance is left for slavery, as a necessary institution [...] There is no doubt that Messrs. Nott, Gliddon, Morton, Smith, and Agassiz were duly consulted by our slavery propagating statesmen. (Douglass 1999, p. 287)

In his speech, Douglass directly challenged the research of Samuel George Morton and his followers by objecting to Morton's attempt to classify Egyptians as non-Negro. Previously, Morton argued that the Sphinx, in spite of its facial appearance, was not patterned after the Egyptians (Morton 1839, p. 29).[24] Instead, Morton claimed that a civilization capable of such architectural feats must be Caucasian and not Negro (1839, p. 31). Even though Douglass "contributed considerably to the exposure of these pseudo-scientific theories," his objections received little uptake by Morton or the other researchers who relied on the assumptions of the same metaphor (Douglass 1999, p. 282).

Douglass' challenge to Morton's theory illustrates with particular clarity how criticism and its uptake are vital to challenging entrenched assumptions

24. Morton suggests that the Sphinx was a shrine created for the Negro populations in Egypt (Morton 1839, p. 29).

of scientific metaphors. Although Douglass possessed the relevant experience and background knowledge to critically engage the community's metaphor—as a member of a marginalized race, his contributions to the critical discourse did not receive uptake. Stepan notes that "The confusion of metaphor for reality in science would be less important if metaphors did not have social and moral consequences in addition to intellectual ones" (Stepan 1986, p. 275). Not only were nineteenth century scientists on human variation misled by the metaphors they used, members of the non-Caucasian racial categories were deeply affected by social policies informed by the science of the day. The metaphor, *human races are distinct species*, implied a social hierarchy used to justify social polices like slavery and Indian Removal (Baker 2008, p. 93).[25] Regrettably, the effects of these policies are still felt today.

Conclusion

Members of a scientific community enact a myriad of decisions, such as pursuing a particular research program, designing specific experiments, adopting measurement standards, and interpreting data—all of which are informed by the framework assumptions of the guiding metaphor. Given the implicit influence of the metaphor, even the best-intentioned critic may not be critical enough, or critical in the right ways, to escape the influence of the metaphor. Scientific communities should avail themselves of individuals who have the background knowledge to challenge assumptions cloaked in metaphor.

Of course, that is not to say that scientific communities should be vulnerable to all forms of external critique. To prevent abuses, I suggest the selection of these individuals be informed by the roles of analogical reasoning in scientific practice. Individuals likely to have the necessary critical experience will possess knowledge regarding the analogues, the correspondences, and whether those correspondences are relevant to the conclusions posited by scientists in their analogical arguments. Douglass' critiques of Morton's metaphor were based on his practical experience with the phenomenon and challenged the fundamental assumptions supporting a hierarchy of race. His writings and speeches, despite the lack of formal education, served as a counter to Morton's claims. The community, however, clung to its metaphor. Unfortunately, they were not the only group to fall victim to being misled by metaphor.

25. Baker notes that Morton "did not hesitate to provide evidence of Negro 'inferiority' to John C. Calhoun, the prominent proslavery secretary of state, to help him negotiate the annexation of Texas as a slave state" (Baker 2008, p. 94).

References

Arber, A. 1947. *Analogy in the History of Science: Studies and Essays in the History of Science and Learning Offered in Homage to George Sarton on the Occasion of His Sixtieth Birthday*. New York: Henry Schuman.

Baker, L. D. 2008. History of Anthropology. Pp. 93–94 in *Encyclopedia of Race and Racism*. Edited by J. H. Moore. Detroit: Macmillan Reference USA/Thomson Gale.

Bailer-Jones, D. M. 2008. Models, Metaphors, and Analogies. Pp. 108–127 in *The Blackwell Guide to the Philosophy of Science*. Edited by Cambridge: Blackwell.

Bartha, P. F. A. 2010. *By Parallel Reasoning: The Construction and Evaluation of Analogical Arguments*. New York, NY: Oxford University Press.

Black, M. 1962. *Models and Metaphors: Studies in Language and Philosophy*. Ithaca, N.Y.: Cornell University Press.

Boyd, Richard N. 1993. "Metaphor and Theory Change." Pp. 481–532 in *Metaphor and Thought*. Edited by A. Ortony. Cambridge: Cambridge University Press.

Carloye, J. C. 1971. "An Interpretation of Scientific Models Involving Analogies." *Philosophy of Science* 3 (4): 420–471.

Cat, Jordi. 2001. "On Understanding: Maxwell on the Methods of Illustration and Scientific Metaphor." *Studies in History and Philosophy of Modern Physics* 32 (3): 395–441.

Darden, L. 1982. "Artificial Intelligence and Philosophy of Science: Reasoning by Analogy in Theory Construction." *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2: 147–165.

Douglass, F. [1854] 1999. *The Life and Writings of Frederick Douglass*. Edited by Philip Foner. New York: International Publishers.

Dunbar, K. 2000. "How Scientists Think in the Real World: Implications for Science Education." *Journal of Applied Developmental Psychology* 21 (1): 49–58.

Garfield, E. 1986. "The Metaphor-Science Connection." *Essays of an Information Scientist* 9 (42): 3–10.

Haraway, D. 1989. *Primate Visions: Gender, Race, and Nature in the World of Modern Science*. New York: Routledge.

Harré, R. 1988. "Where Models and Analogies Really Count." *International Studies in the Philosophy of Science* 2 (2): 118–133.

Hesse, M. 1966. *Models and Analogies in Science*. South Bend, Ind.: University of Notre Dame Press.

Holyoak, K. J. and P. Thagard. 1995. *Mental Leaps: Analogy in Creative Thought*. Cambridge, Mass.: MIT Press.

Hume, D. 1896. *A Treatise of Human Nature by David Hume*. Oxford: Clarendon Press.

Intemann, K. 2010. "25 Years of Feminist Empiricism and Standpoint Theory: Where Are We Now?" *Hypatia* 25 (4): 778–796.

Jordan-Young, R. 2010. *Brainstorm*. Cambridge, Mass.: Harvard University Press.

Kay, L. E. 2000. *Who Wrote the Book of Life?* Stanford, CA: Stanford University Press.

Keynes, J. M. 1921. *A Treatise on Probability*. London: Macmillan and Company.

Kuhn, T. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Kuhn, T. [1979] 1993. "Metaphor in Science." Pp. 409–419 in *Metaphor and Thought*. Edited by A. Ortony Cambridge: Cambridge University Press.

Leatherdale, W. H. 1974. *The Role of Analogy, Model, and Metaphor in Science*. New York: American Elsevier Pub. Co.

Librizzi, L., Biella, G., Cimino, C., and M. De Curtis. 1999. "Arterial Supply of Limbic Structures in the Guinea Pig." *Journal of Comparative Neurology* (411): 674–682.

Martin, E. 1991. "The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male-Female Roles." *Signs* 16 (3): 485–501.

Maxwell, J. 2011. *The Scientific Papers of James Clerk Maxwell*. (Cambridge Library Collection-Physical Sciences). Edited by W. Niven. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511710377

Morton, S. G. 1839. *Crania Americana; or, A Comparative View of the Skulls of Various Aboriginal Nations of North and South America: To which is Prefixed an Essay on the Varieties of the Human Species*. Philadelpia: J. Dobson.

Nott, J. C. and G. R. Gliddon. 1854. *The Indigenous Races of the World*. Philadelphia, PA: J. B. Lippincott & Co.

Phoenix, C. H., R. W. Goy, A. A. Gerall, and W. C. Young. 1959. "Organizing Action of Prenatally Administered Testosterone Propionate on the Tissues Mediating Mating Behavior in the Female Guinea Pig." *Endocrinology* 65 (3): 369–382.

Recker, D. 2004. "Machine Metaphors and Design Arguments." *Southwest Philosophy Review* 20 (1): 211–220.

Recker, D. 2010. "How to Confuse Organisms with Mousetraps: Machine Metaphors and Intelligent Design." *Zygon* 45 (3): 647–664.

Ruse, M. 1973. "The Value of Analogical Models in Science." *Dialogue* (12): 246–253.

Stepan, N. L. 1986. "Race and Gender: The Role of Analogy in Science." *Isis* 77: 261–277.

Terril L. A. and D. J. Clemons. 1998. "The Laboratory Guinea Pig." In *The Laboratory Animal Pocket Reference Series*. Edited by M. A. Suckow. CRC Press.
Turbayne, C. 1971. *The Myth of Metaphor*. New Haven, CT: Yale University Press.
Vanderlip, S. 2003. *The Guinea Pig Handbook*. UK: Barron's Education Series Inc.
Wagner, J. E., and P. J. Manning. 1976. *The Biology of the Guinea Pig*. Academic Press.
Wylie, A. 2002. *Thinking from Things: Essays in the Philosophy of Archaeology*. Berkeley: University of California Press.
Wylie, A. 2012. *Feminist Philosophy of Science; Standpoint Matters: 2012 Presidential Address*. Paper presented at the Pacific Division APA (April 2012), Seattle, WA.
Young, W. C., R. W. Goy, and C. H. Phoenix. 1965. Hormones and Sexual Behavior. Pp. in *Sex Research: New Developments*. Edited by J. Money. New York, NY: Holt, Rinehart, and Winston.