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and Philosophy of Science

Shyam Wuppuluri

A. C. Grayling *Editors*

Metaphors and Analogies in Sciences and Humanities

Words and Worlds



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and Philosophy of Science

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Shyam Wuppuluri • A. C. Grayling
Editors

Metaphors and Analogies in Sciences and Humanities

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Preface

It is a great thing, indeed, to make proper use of the poetic forms . . . But the greatest thing by far is to be a master of metaphor . . . ordinary words convey only what we know already; it is from metaphor that we can best get hold of something fresh – Aristotle

*The fish trap exists because of the fish. Once you've gotten the fish you can forget the trap. The rabbit snare exists because of the rabbit. Once you've gotten the rabbit, you can forget the snare. Words exist because of meaning. Once you've gotten the meaning, you can forget the words. Where can I find a man who has forgotten words so I can talk with him?
– Zhuangzi*

Metaphors and analogies occupy a prominent place in our scientific discourses as they do in literature, humanities and at the very level of our thinking itself. They shape our mind, our experiences and our interpersonal/intrapersonal behaviour. Etymology of the word 'metaphor' can be traced to the Greek word μεταφορά (*metapherō*), which is derived from μετά (meta) 'across' and φέρω (pherō) 'to carry'. In our final analysis of things, given the structure of language and cognition, we can always find similarities between dissimilar things and vice versa – and metaphors and analogies that dwell in that space between can either help us shape our understanding of the world in beautiful ways using familiar objects and ideas to convey the concrete graspable aspects of the underlying abstractions or forever derail our understanding of the concepts due to their ambiguities and incongruities and can even bring about socio-political ramifications when one doesn't whet them appropriately. Despite the baggage that comes along with them, metaphors and analogies are (and continue to be) indispensable to our scientific practices and outreach. They promote interdisciplinary thinking and collaboration across domains. Also, metaphors by their nature aren't precise, and one has to add bells and whistles and tinker around with them before fully grasping their contextual meaning. So, the task is to employ and decode them skilfully: being mindful of the dividing line between their use and abuse.

How do metaphors shape the study and practice of science? What role metaphors and analogies play at the level of our cognition and linguistic discourses? How do they help us understand and skilfully deal with our complex socio-political scenarios? Through this highly interdisciplinary volume, we would like to systematically

study the role of metaphors and analogies in (mis)shaping our understanding of the world. Articles within that are systematically categorised into various disciplines not only deal with the notion of metaphors and analogies from a scientifico-philosophical perspective but also from a pragmatic and humanities viewpoint. All authors have attempted to make their articles as readable as possible so that a passionate layperson can easily skim through the book and understand a good deal of it. The book does not claim to address everything there is to the subject, but we hope it will at least open up avenues for readers to further explore the deeper and subtler interrelationships between the role metaphors and analogies play in our daily life.

This book wouldn't have been possible without the collective and kind efforts of authors and those who assisted behind the scenes in producing it: given the unprecedented times at the time of assembling this volume. I can't help but resort to metaphors to thank their kindness chronologically. When I first approached Prof A. C. Grayling with an outline of the volume and set of authors, he not only responded positively but has been there all through: encouraging me and enabling me to happily undertake and successfully complete this otherwise strenuous task. His immense kindness, warmth and optimism are acknowledged herewith. I would also like to thank Prof Otavio Bueno for his support and feedback in the initial stages of the volume. I would also like to thank Prof Edward Witherspoon and Prof Nana Last for their willingness to work on another volume of mine - it has been a pleasure collaborating with them. I am very thankful to Alice Major, Prof Brigitte Nerlich and Prof Claus Emmeche for their kindness and support. In the context of typesetting, I would like to acknowledge the efforts of the typesetting staff for their wonderful editorial support. Much of this work has been done during my Albert-Einstein fellowship, and in that context, I would like to acknowledge the perennial kindness of Prof Susan Neiman, Prof David Shulman and the entire board and staff of Einstein Forum who made my stay very memorable. Last but not the least, I am forever indebted to Thích Nhất Hạnh and Tâm Liên Đài for teaching me how to smile and live in the present moment. Smile is a cloud that rains happiness on the garden of our face. May it continue to do so!

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Introduction

The chapters in this volume explore the different roles that metaphor plays in enquiry and in making sense of the domains over which thought and enquiry range. It is clear from them that metaphor is not just a matter of utility, but sometimes – indeed, often – indispensable to these practices. It can be the heuristic that opens a path of enquiry, and it can sometimes be the only handle we have on phenomena under scrutiny. When employed well it is instructive, explanatory and insight-bearing. It is remarkable how widely used it is as a tool of intellectual endeavour; it is present in, and is sometimes constitutive of, insights and understanding across the whole range of what human curiosity explores and creativity brings, from fundamental physics to art, mathematics and the social sciences.

At the same time, it carries risks of misdirection. If metaphor is – to employ a metaphor – a light that illuminates, it can also be an *ignus fatuus*, a will o' the wisp that leads astray across difficult terrains of thought. The question of how the misleading possibilities of metaphor are controlled is one that lies close to the most fundamental concerns of epistemology.

In the paragraphs to follow, I make some brief comments on the nature of metaphor, in particular focusing on the logical character of the copula employed in metaphorical assertions. This demarcates metaphor from its close cousins simile and analogy, explains in part how metaphor can be – for all its illuminating power otherwise – a sometimes risky resource in enquiry, and suggests that there is an interesting task to be undertaken in understanding the cognitive mechanisms that make metaphor and the allied rhetorical device of metonymy work, mechanisms deeper than and different from those at work in similes and analogies.

Central to the cognitive processes of mind are pattern-seeking and sense-making, both interpretative acts. In both activities, closely linked as they are, the application of metaphors and similes has a significance close in importance to memory; one might have met with a thing or situation before, or with an instance of the kind of thing or situation, and memory will underwrite recognition, as this term itself implies: *recognition*. But if one has not met with this thing or situation before, the next resource is to ask: what is it like? What can it be represented as, so that I can make sense of it? The first question seeks a simile as an answer, the second

a metaphor. The resource of memory is present here too, in the case of simile recalling resembling features, in the case of metaphor summoning what can serve as an interpretative blueprint by means of a conceptual transfer of an interestingly deep kind. Calling these devices of thought ‘figures of speech’ is not inaccurate, but underplays the importance of their cognitive role; for standardly they are constitutive of the act of ‘making sense’ itself.

By conceptually revisualising something unfamiliar in terms of something familiar one domesticates it, so to speak; one provides a conceptual house-room for it. It is heuristic in function, though whereas heuristics might provide a path into something further, metaphor is sometimes the end point of the sense-making enterprise; it is what our best current understanding of a domain consists in. This is the case with quantum theory which, at time of writing, admits of competing interpretations, some irreducibly metaphorical given the seeming impossibility of translating quantum theoretical descriptions into a classical framework.

‘Making sense’ is the key idea in play. Using the terms ‘target’ and ‘source’ now familiar in conceptual metaphor theory – themselves metaphorical – to denote respectively the domain to be understood and the domain from which a means of making sense is drawn (so in ‘all the world’s a stage’ the stage is the source, the world the target), one can list the functions of the source as: *describing, illuminating, illustrating, picturing, analogising, likening, revealing*, and by these means *informing*. In this list appear functions also, and sometimes more directly, performed by similes and analogies, but the cognitive purpose of all three rhetorical devices is very close; compare ‘My love is like a red, red rose’ and ‘Mary is the rose of Tralee’. In achieving the functions just listed, metaphor exploits the power of cognitive assimilation to transfer (consider the etymology of *metaphor* itself) from source to target what is to a sufficient *but figurative* degree *cognate, comparable, correspondent, homologous* or *parallel*. The qualifier *but figurative* is essential: there is no invariable suggestion that the source resembles (is ‘like’) the target in any literal respect. Rather, it is specifically intended that the source present the target under a description that is itself comprehensible and by its means makes the target comprehensible, or more so.

At the same time, employment of a metaphor is *not* an assertion that source and target are *related, kin, agnate, congeneric, allied* or *approximative*, or that the nature of the source is a *property* or *component* of the target. It is (or once was: it is now a cliché) illuminating and rhetorically effective to say, ‘Life is a battle’, but it is unilluminating and rhetorically clumsy to say ‘A battle is a struggle’ or ‘War is a battle’, which is what choice of something related, agnate, kin, and the rest would give us. This point suggests that it might be part of the definition of metaphor that it expressly trades on *not* asserting likeness between target and source in any of *these* ways – the ways of surface similarity. For that, simile is precisely the tool.

If one puts together the insight that employment of a metaphor is intended to transfer intelligibility to the target from antecedent grasp of the source by using the relevant suggestive aspect of the source’s illumination of the target, along with express recognition of the fact that literal identification is not intended, one sees that the copula ‘is’ in metaphorical statements has a unique logical character.

It is neither the 'is' of identity nor the 'is' of predication. The 'is' in similes is, by contrast, a straightforward 'is' of predication. This is a logical difference between metaphors and similes which makes no logical difference, though they are rhetorically different, and though the asserted content trades empirically on literal resemblance in the one case and expressly not so in the other. To explain this more fully, compare the identity-asserting and predicative cases, as follows.

The 'is' of identity asserts that what are putatively two or more are in fact one. In the case of a reduction of certain phenomena (say, intentional phenomena of psychology such as remembering and fearing) to another class (say, activation of structures in the brain) without remainder, a strong claim might be intended to the effect that the identity is eliminative, or more weakly that the terms of the reduced and reducing classes can be intersubstituted *salva veritate* in extensional contexts (so they are coreferential, courtesy of the identity, even if differing in sense, as with 'the morning star' and the 'evening star' as designations of the planet Venus). Either way, the 'is' of identity says at least that if X and Y are identical all and only the properties of X are the properties of Y and vice versa. Obviously, that is not intended by employment of a metaphor.

The 'is' of predication states that the subject of a proposition has a certain property, or if the proposition has multiple subjects that they all have that property or stand in a specified relation to each other. 'Napoleon is short, Napoleon is a Corsican, Napoleon is a clever general' all tell us about properties of Napoleon. 'Napoleon is a whirlwind', said of him during his years of triumph, tells us about him (illuminates, reveals, informs) by doing something different: not by directly imputing a property to him, but by imputing *by implication* a property or properties that would make a man informatively describable as a whirlwind, and doing so by exploiting, in the proposition's logical form, the analogy with the 'is' of identity. Contrast this with 'Napoleon is like a whirlwind'; in this case – using a simile – the 'is' is indeed the 'is' of predication; the property of 'being like a whirlwind' is predicated of Napoleon. In the case of metaphor – 'Napoleon is a whirlwind' – what is explicitly at work is the non-literal use of the 'is' of identity, constituting for metaphor a logical category of the copula for itself and in this way defining 'metaphor' and distinguishing it from simile and analogy.

Similes and analogies differ too, in that whereas the former assert a likeness, an analogy asserts a comparison that is explicitly intended to be explanatory of its target. Thus, Janus-faced, it borrows something from both simile and metaphor. Some similes are analogies if they have expressly explanatory and not merely illustrative intent; some have just the latter. From the point of view of logical form, analogies may not be expressed predicatively; Schrodinger's dead-and-alive cat is an analogy for superposed states, but the sense in which a cat's being both dead and alive is *like* superposed quantum states is not the same as the sense in which my love is *like* a red red rose. The cat illustrates uncertainty, but is not *like* the psi-function of the system (cat, box, Geiger counter, gunpowder, etc.), whereas my love really is like a red red rose in respect of her efflorescent beauty. To capture the sense in which not all analogies are expressed in the form of similes, one notes that 'likeness' in a simile is always literal, the 'likeness' in an analogy is not always so

and when not so is, in fact, metaphorical – it is not, note, the analogy itself which is metaphorical, but the imputation of ‘likeness’ between the analogy and its target. A toy cat is ‘like’ (looks like, resembles) a real cat; a cat that is both dead and alive simultaneously is ‘like’ (is an analogy for) a pre-interaction quantum state; the ‘like’ in the second case is a metaphorical ‘like’ that implies not actual resemblance but illustrative comparison.

It is worth repeating that the distinction between metaphor and the other two rhetorical devices is not cognitively significant, only rhetorically so, in case one thought that either a loss or a misdirection might follow, in relation to substantive content, from a choice of which figure to employ. All three devices have the primary sense-making, illuminative or illustrative function, but the question of which to use might be decided by any number of considerations – for example, Robert Burns chose a simile to achieve an iambic tetrameter (first beat on the second word) in ‘*My love is like a red, red rose*’ but had he wished to write that poem in trochaic tetrameter (first beat on the first word) he would have written ‘*My love is a red, red rose*’, thus choosing a metaphor. The *poetic* significance of the choice of metre makes the choice between simile and metaphor non-arbitrary, but one can think of many cases where using a simile in place of a metaphor or vice versa does not matter.

But the choice of rhetorical device is also of course non-arbitrary beyond poetry. To make sense of the quantum realm by means of conceptions belonging to the classical realm, analogy is sometimes the only option, as in explaining superposition of quantum states by the figure of a cat in a box which is simultaneously both dead and alive until an interaction occurs. Here analogy is the choice for purposes of illustration. Sometimes it is not clear whether a description is intended literally or metaphorically: does the collapse of the wave function consist in a bifurcation of the universe’s forward history, as in many-worlds theory, or choice of a unique forward history? There are those who take bifurcation literally, and those who say that although there are possible alternatives, the one and only real universe is whichever is realised by ‘choice’ of one the alternative futures. In the former case talk of bifurcating universes is literal, in the latter case, talk of ‘choice’ of one possible future is metaphorical. There are reformulations of the latter view available that would obviate the need for metaphor.

It might be asked what importance attaches to getting a clear conception of the nature of metaphor. The answer has already been given in the opening paragraphs above, in regard to taking the metaphor of metaphor as illumination. There is much less risk of a simile or an analogy, when understood as such, being an *ignus fatuus* leading one astray. How metaphor is controlled in the process of theorising, how the disanalogies by definition present in the relationship between source and target are discounted and the interpretative power of the metaphorical illumination allowed to do its work are questions for case by case uses of the device, most especially where there is no alternative means of expressing a conceptual insight. History presents us with familiar examples of metaphors taken as so close to being literal identifications that they seemed indeed literal: nature as clockwork, the nervous system as a telephone exchange, God as an astronaut, the brain as a computer. One

can readily see how they can seem so given cases where the identification is indeed literal – ‘the heart is a pump’ – *looking* like metaphors without being so.

The same danger does not occur with the other two figures. To say *X is like Y* is not to mislead anyone into thinking that X is very close to being Y, or is *very* like Y in some ontologically suggestive way, or even perhaps *is* Y. The potential for slippage lies in the mimicking by the ‘is’ of metaphor of the ‘is’ of identity. This suggests a further thought, and perhaps a research project: that whereas the cognitive outcomes of uses of metaphors and similes is the same, the underlying mechanisms at work are different. The cognitive act involved in understanding *that* a metaphor has illuminated its target and *how* it has done so is something richer and deeper than, and different from, the cognitive act of comparison *simpliciter*. In this respect, understanding metaphor is like understanding metonymy (the speech-act of using ‘the White House’ to mean the US government, or ‘the crown’ to mean the monarchy). Arguably, metonymy is a form of metaphor, or at least exploits the same kind mechanism, this mechanism consisting in a transitive power of cross-applying conceptual content. In the case of metonymy, this is used for the lesser (though hardly unimportant) task of fixing reference rather than illuminating some terrain of thought or theory, but with the same process of *semantic assignment by substitution* at work. As this indicates, the difference here is that there is much more to the uses of metaphor than the use of metonymy, and something cognitively different going on in both these cases from simile and analogy recognised as such.

This relates to the question of what it is one knows, or knows how to do, when one grasps a conceptual content, obviously a key factor in the cross-application of content for achieving metaphor’s purposes. A simple case is given by a dog knowing that he is about to be taken for a walk; when he sees his master putting on his hat – this being the signal that a walk is in immediate prospect – he makes the association (draws the inference?) and thus illustrates how one thing ‘means’ another. This is what is at issue in the case of metonymy, and in part, but only in part, what is at issue in the case of metaphor.

This in turn suggests a distinction between complete and incomplete metaphor. The target in ‘Napoleon is a whirlwind’ is Napoleon’s military career, of which a complete account can be given if someone asks for a justification for the metaphor’s application, but the target in metaphors offered to make sense of quantum phenomena is something for which the metaphor is a rough guide merely, nothing more being sayable. In this kind of case, the metaphor is *essentially* incomplete; it is this case which shows that the cross-application of conceptual content at work, here viewing the metaphor as a signal or cue that picks out and illuminates the target content, is only partial and *at best* only so. A taxonomy of metaphors would have its roots in this distinction, but it would not be a taxonomy of function, nor of effectiveness; it would mainly show which metaphors could be substituted by an analogy or even a simile, and which are irreducible.

These thoughts are schematic merely, but they suggest that there is a matrix of connections, in the cognitive architecture that instantiates concepts, along which resources of sense-making travel. There is no doubt that new knowledge offers new possibilities for illumination by metaphor, as history abundantly shows: the

computer metaphor for the brain was not possible before the computer, and the productive power of metaphor is equally well illustrated by a metaphorical move in the opposite direction, yielding the idea of neural networks. One could proliferate examples. In cognitive psychology, in epistemology, and in the intrinsic interest of metaphor in literary and linguistic respects, there is much to explore; the chapters to follow wonderfully bear this out.

In conclusion, I wish to express my thanks and admiration to Shyam Wuppuluri for his editorial labours. With this, and his previous volumes, he has built a remarkable edifice of contributions to human knowledge, bringing together scholars and thinkers from across the span of intellectual endeavour to reflect on the processes of enquiry. It is a great achievement. I am sure that when he, so modest and unassuming a man, happens to see on his bookshelf the volumes that have hitherto appeared as a result of his efforts, he is thinking only of his next project; most others would be congratulating themselves on the very palpable evidence of what they have done. But his achievement emphatically merits applause, not least for the current volume. As its co-editor, I can tell you that the work for it has been done by Shyam, to whom therefore my thanks and that of the contributors are wholly due. And I add my thanks to Shyam and the authors of the chapters here; they have all made deeply appreciated contributions.

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A. C. Grayling

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Part I
Philosophy and Sciences: Philosophy and
Foundations of Sciences

Chapter 1

Syntactically Recharacterizing Analogies, Assessing Theories of Assessing Analogies (And Making Some Observations About Induction Too)



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Abstract The home of analogy is semantics; its aim is understanding and inference. An analogy—e.g. “the body politic”—grafts our understanding of a kind of thing (via our grasp of one or more truths about it) onto another kind of thing. Proponents of the “semantic conception of scientific theories” often describe scientific models in terms of purported analogies drawn between them and realities. The philosophical take on analogies from a semantic point of view—in terms of *things* being analogized to other things—is misguided. The value of analogies isn’t to be seen by regarding them as drawn between kinds of objects; it’s that the analogies drawn enable the invention of new hypotheses about things; they motivate moving tractable syntactic objects—sentences, and groups of them (i.e. theories)—from successful applications to the hopes of new ones. The genuine role of analogy in scientific practice is as ways of *stating* hypotheses: the discovery of potentially applicable and tractable scientific theories. In old-fashioned philosophical language, the drawing of analogies lives (fully) in the context of discovery, not in the context of justification. Because of this, analogies are not amenable to a systematic general theory of justification; there are only background-specific justifications of particular groups of analogies in particular situations coupled with the after-the-fact testing of one or another hypothesis (one or another hypothesis that’s been, say, creatively invented via an analogy)—a testing that’s typical of scientific hypotheses, generally.

Keywords Ampliative reasoning · Analogous reasoning · Analogy · Induction · Inference to the best explanation · Mathematical applications · Ontology · Scientific models · Scientific theories · Syntax

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1.1 Some Introductory Remarks and an Outline of the Paper

“Analogy” is an impressionistic notion covering an extremely wide territory; equally loose is how we ordinarily recognize analogies as in play. My aim in this paper isn’t to tighten up a characterization of “analogy”: I’ll be taking it for granted that we often have strong intuitions about when we think analogies are good ones, and my discussion will rely on a standard characterization of analogies. One thing I’ll disagree with, however, is the typical treatment of analogies as between objects (or kinds of objects), a focus that many philosophers of science more generally have claimed is central to understanding the successful application of scientific theories. Consider the phrase, “characterizations of phenomena”; the target of these philosophers of science—proponents of the semantic conception of scientific theories—is on what these characterizations are *of*: models on the one hand, and what’s being modeled on the other.

One aim of this paper is to show that this focus on *things* as opposed to *language* is badly misplaced.¹ As so often happens when the philosophical lens is semantic, directed for example, to the *targets* of words—referents, extensions and the like—there is a failure to realize that what *we humans* have to work with (and all *we* have to work with) are, as it were, only the words themselves, and the sentences that these words appear in.² If “models,” in particular, are scientifically valuable, that value can’t be characterized in terms of how purported objects in the model are similar (or not similar) to whatever they’re being used to model (realities or the objects in other models). Their value can only be in what sorts of *characterizations* (e.g. descriptions and theorems) that these models codify—more accurately, that are the linguistic structures that we use to characterize these models themselves—and what relationships those characterizations have to the characterizations of the phenomena being modeled.

The outline of the paper is this. In Sect. 1.2, I briefly discuss analogy and “analogical reasoning”—what these things (purportedly) are. On my view, analogies are tools for imaginatively generating hypotheses whose applications to phenomena can then be tested. In Sect. 1.3, I discuss what’s often narrowly called the problem of induction, and I there sketch the idea that this “problem” is actually a special case of the general one of discovering useful hypotheses—what’s come to be called “inference to the best explanation.” Unlike the case of deductive reasoning, for which—leaving aside debates about alternative logics—there are single unified methods (extensionally equivalent ones) for recognizing validity, available are only specific, limited, subject-driven families of recipes for generating hypotheses

¹ Because it’s misguided in this way (and because there’s a lot to say about how it, as a result, obscures philosophical insight into scientific practice), I’ve twice argued against the “semantic conception” in previous papers: Azzouni (2014, [Forthcoming-a](#)).

² We also have iconic-looking tools, of course: diagrams and the like. These also involve “syntax,” in the sense I’m using it. Nothing I say against “models” excludes the importance or the availability of these iconic tools for scientific purposes. See Azzouni ([Forthcoming-b](#)).

(usually from other hypotheses), ones that aren't, in particular, very successful—before testing—at sifting the good ones from the bad ones: analogies—which are kinds of recipes for doing this—group into, therefore, large, open-ended, and only sloppily-definable collections. “Analogy” is a label for perceived resemblances which as a group have only the slightest of commonalities.

In Sect. 1.4, I contrast unified-recognition-procedure situations, that of first-order logic for example, or deductive axiom systems, with recipe-situations, the ones we're in with respect to families of attempts to establish good hypotheses. Families of recipes, which are all we have for analogy-design, are essentially local in their reach. One reason for this, which I take up in Sect. 1.5, is that analogies, unlike standard cases of induction, are often ontologically ampliative; this means that the vocabulary of an hypothesis generated by an analogy often sprints far beyond the given vocabulary already in place in the target area of study. Another reason for this, one that's true both of analogies and induction generally, is that any theory of such always involves substantial worldly assumptions that are specific (and specifically nonlogical), ones about causation, distributions of properties among the targeted things, relevance of characteristics, as well as ones about our epistemic access to distributions of properties (e.g. that it's random), and so on.

In Sect. 1.6, I analogize the open-ended families of recipes for analogies and the open-ended family of techniques for solving differential equations. The lesson is the same one: a rich subject area of *various* tools and techniques of all (unexpected) sorts is the result of an epistemic failure, of there not existing a *single* tool for recognizing a desired kind of thing (a good analogy on the one hand, a function in closed form, on the other). Section 1.7 turns to evaluating Bartha's project of developing (Bartha (2010, 3) a “substantive normative theory of analogical arguments,” one which has “both depth and generality.” Such a theory, were it possible, would provide us with a theory of justification for analogies (at least, in one sense of the word “justification”³). It would enable us to evaluate the qualities of those analogies used to generate hypotheses *before* having to test the hypotheses: it would enable us both to sort hypotheses generated by analogies into provisional “good and bad” ones, and to be justified in so sorting them. In light of the preceding discussion of the paper, I show that this sorting, provisional at best, can only take place with substantial presuppositions (background knowledge) in place. This is also the case with inductions, and indeed, generally with ampliative reasoning. I further show in Sect. 1.8, and specifically with respect to Bartha's characterization of *prima facie* plausibility, that the theory in question provides nothing epistemically substantial much beyond our ordinary intuitions about good and bad analogies. Section 1.9 takes up what Steiner (1989) calls “Pythagorean analogies” and discusses Bartha's analysis of them. Here it becomes clear that Bartha's theory fails to be appropriately *general*; this is because the two general

³ Bartha (2010, 290–291) writes: “I believe that analogical arguments framed in accordance with [my] theory have more than heuristic value: they provide a measure of justification for their conclusion.”

principles he offers insufficiently constrain the many kinds of analogies—many kinds of *models* of analogies—that he characterizes. Section 1.10 concludes the paper by describing the sensitivity that the quality of an analogy has to background knowledge—something that’s true of ampliative inference generally; and second, by describing some rough-and-ready desiderata had by good general theories of subject areas, ones (that is) that go beyond the mere placing of a collection of things under a single label.

1.2 Characterizing Analogy

What are analogies? *Oxford Languages* tells us this (retrieved from the web November 12, 2020):

a comparison between two things, typically for the purpose of explanation or clarification.
“an analogy between the workings of nature and those of human societies”

a correspondence or partial similarity
“the syndrome is called deep dysgraphia because of its analogy to deep dyslexia”

a thing which is comparable to something else in significant respects
“works of art were seen as an analogy for works of nature”

Only the second item above is at all helpful because “comparable” doesn’t mean much (anything, after all, can be “compared” to anything else, right?) Perhaps this is the idea—and perhaps this is a good characterization of analogies: Consider two things or two kinds of things, C and D. We draw an analogous comparison between C and D by either noting some significant set of properties P_i that C and D have in common, where the more significant and/or the more numerous the properties in question are, the “deeper” the analogy (and correspondingly, insignificant or fewer properties in common make the analogy “weaker”). Or, given a set of properties of C, P_1, \dots, P_n , and a second set of properties Q_1, \dots, Q_n , of D, we describe the properties themselves in these sets as resembling one another closely. This second characterization is a rough and ready first stab because, surely, more has to be said about what it means to say that properties can “resemble” one another. This, alas, is something I can’t discuss much more in this paper—although I will say that it’s a major reason why analogies, as a class, are so unruly and wide-ranging in their qualities. This characterization also has a drawback, shared by many approaches to analogy, of describing the analogies in question as drawn between kinds of *objects*. But analogies may be drawn between events, fictions of various sorts, or sheer descriptions of phenomena (e.g. patterns in sets of measurements). These last sorts of items, interestingly, will be revealed to be significant vis-à-vis analogous applications of mathematics (see Sect. 1.9). In the meantime, and indeed, throughout most of this paper, I’ll acquiesce in speaking of analogies as drawn between kinds of objects—doing so facilitates my discussion of semantic approaches to analogy, in which this way of speaking is rampant.

As Hesse (1966, 8) stresses, when we evaluate an analogy we need to focus not only on what the elements in the respective sets have in common (what she calls “the positive analogy”) but also on what they don’t have in common (the “negative analogy”). The aim of the analogy, on the other hand—what we’re hoping to illuminate about the target items of the analogy—are among what she calls the “neutral analogy.”⁴

What, on the other hand, is *analogical reasoning*? Here I borrow a characterization from Bartha (2010, 13, 2019), one that I modify along certain lines that he subsequently mentions. He (2019) describes this characterization as fairly standard, and found in many “elementary critical thinking texts”:

1. *S* is similar to *T* in certain known respects (and not similar in certain other known respects).
2. *S* has some further feature *Q*.
3. Therefore, *T* also has the feature *Q*, or some feature *Q** similar to *Q*.

As (3) is stated here, it’s baldly asserted; but as Bartha notes, the argument is “ampliative”; that is, it’s nondeductive. What this means (among other things) is that the conclusion (3) about *Q* or *Q** isn’t stated simply as a conclusion; rather (Bartha, 2010, 15), the conclusion contains *Q** occurring within the scope of a sentence operator (italics mine):

It is plausible that Q or Q holds in the target because of certain known (or accepted) similarities with the source domain, despite certain known (or accepted) differences.*

As Bartha further describes analogical arguments (“quasi-formally”), they’re semantic, and he ultimately characterizes them model-theoretically. He defines *S* and *T* as, respectively, the “source” and “target domains,” where a “domain” is a set of objects, properties, relations and functions. (He adds: “More formally, a domain consists of a set of objects and an interpreted set of statements about them.”) In turn (italics his):

an analogy between S and T is a one-to-one mapping between objects, properties, relations and functions in S and those in T,

where not all the items in *S* and *T* need be in the mapping function.

This characterization, being purely model-theoretic, doesn’t explain exactly how *reasoning*, ampliative or otherwise, or propositions themselves, come into the picture; and Bartha (2019) simply presumes on the connections.⁵ What’s needed is something else:

Let L_1 and L_2 , respectively, be the languages of *S* and *T*; and let *M* be the mapping of the nonlogical *terminology* of L_1 (the constants and *n*-place predicates) to the nonlogical terminology of L_2 that’s induced by the analogy that maps one-to-one the objects, properties, relations and functions defined on *S* to those defined on *T*. Let D_S be a family

⁴ These distinctions are originally due to Keynes (1921, chapter XVIII).

⁵ He (2010, 13) does write: “Informally, the analogy mapping is extended to propositions by replacing terms pertaining to one domain with the corresponding terms that pertain to the other.”

of generalizations and/or descriptions of items in S ; that is, the sentences of D_S are true in S . Then, on the basis of the analogy between S and T , we hypothesize D_T to be true of T , where D_T results from D_S by substituting for the constants and n -place predicates of L_1 the constants and n -place predicates of L_2 that the constants and predicates of L_1 are mapped to by M .

In the above, the analogy between S and T that's fueling the hypothesis that D_T is true of T isn't well-captured by only mentioning the semantic properties of the one-to-one mapping. Crucial are facts about sets of propositions, corresponding to the earlier-mentioned positive and negative analogies, namely that there are families of propositions, P_S and N_S , that hold of S ; and although P_T holds of T , N_T doesn't.

1.3 Ampliative Reasoning; Illusions of Inference

In translating, as I just have, semantic characterizations of analogies into syntactic characterizations, I'm not merely claiming that doing so shows that a semantic perspective provides no insight over and above a syntactic one: I'm further claiming that semantic characterizations (despite completeness results and the like) mislead us by giving the impression of resources beyond syntactic ones (semantic ones, as it were) for capturing aspects of the world we try to describe.

Related to this is the hope that our analyzing talk of analogy and analogous reasoning will provide methodological tools for making progress with the following question: How do we discover good characterizations of phenomena we're scientifically studying? It should be pointed out (so that we don't overlook the range of what's needed) that good characterizations aren't, for example, *only* exceptionless generalizations. Exceptionlessness is neither necessary nor sufficient for something to be a good generalization in a science. It isn't sufficient because some (in fact, many) exceptionless generalizations are trivial. But characterizing when a generalization isn't trivial isn't trivial (sorry for the joke). On the other hand, it isn't necessary because exceptions don't render a generalization useless (and, why and what kinds of exceptions don't do this, again, isn't trivial).⁶ Indeed, thinking of generalizations, for example, as falsified when they're subsequently discovered to have exceptions is mistaken; Newton's laws of motion (along with his gravitational force law) weren't falsified because there were discovered to be some exceptions to them—that's entirely the wrong picture of how Newton's laws were supplanted.

It's all too easy (in part because of training) for even those philosophers otherwise quite knowledgeable about the sciences to think that needed (and desired) scientific generalizations are in the ballpark of things of the form of $(x)(Px \rightarrow Qx)$.⁷ Often accompanying this idea is another one: that scientific *laws*—items with

⁶ I'll try to say *something* about this in Sect. 1.10.

⁷ One terrible tendency, that I can't pursue in this paper, is that focusing on examples like these as paradigmatic of scientific laws inadvertently depicts those laws (implicitly) as purely qualitative.

the *modal* property of necessity—are the targeted items we’re trying to establish.⁸ But, actually, statements of *any form at all* are relevant to scientific theorizing; and (and the following corollary is a fairly dramatic claim I won’t try to establish within the confines of this paper): lawlikeness isn’t a requirement of an hypothetical scientific characterization of a phenomenon.⁹ Even relatively weak existential-quantifier statements (where, say, each describes a kind of thing that’s taken to exist) are among the sorts of hypotheses that one may need to discover (and subsequently confirm/test—to the extent that that’s ever possible). The scientific power of such hypotheses will be in their implications, of course; some of these are implications that they have jointly with other hypotheses in what we may as well call a scientific theory.

Putting the matter this way, treats existential-quantifier statements, $(\exists x)Px$, along the same lines as generalizations, $(x)Px$, since the instances, Pa_1, Pa_2, \dots are simply implications of the generalization, $(x)Px$. Focusing on generalizations (of this form), however, misleads us in a second way, by offering illusions of inference that strike us, for psychological reasons, as similar to genuinely deductive ones.

Consider the old example, “All ravens are black.” The (Hempelian) thought¹⁰ is that this is confirmed by a single black raven. (It’s also confirmed by single glass of white milk—but let’s leave aside that annoying point.) The hope is that some sort of inference is being licensed by additional black-raven sightings (and, of course, there being no sightings of ravens of other colors).

The idea is intuitively compelling. It really does look like there is something happening, something *inferential*, as we boringly see black raven after black raven—something that *inferentially* brings us closer to “All ravens are black,” something excitingly different about a sequence of black-raven sightings that distinguishes that sequence of sightings from our very first black-raven one. The hope is that some

That many of them aren’t is very important—although I won’t be able to discuss that importance in this paper.

⁸ These ideas, exceptionlessness and necessity, are already present in Hume and are certainly full-blown in Kant. They result (I hypothesize) from centuries-long inertial effects due to thinking of reasoning as paradigmatically syllogistic. By “necessary” I mean only that laws are (intuitively) taken to sustain counterfactuals, and nonlawlike statements are taken not to. The old examples: *All the coins in my pocket are quarters; if this penny were in my pocket, therefore, it would be a quarter. All copper conducts electricity; if this wood splinter were copper, it would conduct electricity.

⁹ It looks to me, for example, that Chomsky’s (1995) minimal theory isn’t to be characterized in terms of “laws” at all: what look like linguistic “laws” are superficial characterizations that only work up to a point. Rather, a mental “organ” is being postulated, a “thing,” as it were, with dispositional properties. Notice also that the perspective I’m urging, if it can be made to work, erases what otherwise looks like a sharp methodological difference between physics—at least certain aspects of it (the “laws,” not the “parameters” or “standing conditions”)—and other scientific subject-areas, such as geology, or even history. That doesn’t mean that other methodological differences between these sciences may remain, e.g. applications of different sorts of mathematics.

¹⁰ Hempel (1965).

sort of numericalizable inference is operative, that we're engaging in a form of ampliative reasoning that accords stronger "warrant" (or whatever) on "All ravens are black," the more sightings of black ravens that we endure.

The sad story, alas, is one every undergraduate should know (whether in philosophy or not). Yes, we're *psychologically impelled* (by "custom") to experience "All ravens are black" as more likely (or more likely to be true) the more black ravens we experience (along with nonexperiences of other-colored ravens). But, as Hume the philosopher pointed out some centuries ago, there is nothing we know after seventeen raven-sighting, or a *million* of them, *inferentially speaking*, than we knew after one such sighting, except that we've now seen seventeen black ravens (or a million of them). I'm stressing the *logical point*. With additional premises about temporal succession, we get results about induction and the like. We also get results about generalizations about the past, and so on. And with other *worldly* assumptions, e.g. that ravens are finite in number, that our sightings are suitably randomized, we get probabilistic results about likelihoods of black ravens—for example, by applying what's called the straight rule for enumerative induction.¹¹ *Without* these or similar worldly assumptions, we don't get anything—this is Hume's point. Hume's important observation generalizes, of course, to inductive logics or confirmation theories (of whatever sort); i.e. we need something like Carnap's chance-universe assumption or some cleaned-up version of the principle of indifference (see Keynes, 1921, chapter IV), or the like (various conditions on *priors*, for example, in Bayesian approaches).¹²

The core fact that I'm stressing here is the tense-neutral one that there is no bare inferential connection—semantic or otherwise—between collections of single raven-truths, however sized, and *any* generalization about ravens, except the dull ones that deductively follow.¹³ That there is any inference at work here to be

¹¹ See Hawthorne (2020) on this.

¹² A nod to Harman (1973, chapter 8, section 4) is surely called for; so I'm so nodding. He urges the replacement of a notion of statistical inference with an inference-to-the-best-explanation approach. This is the right way to go (although I deplore his insistence on using the muddy notion of "explanation"). Now isn't the time to get further into my agreements and disagreements with Harman on this.

¹³ Here is Hume (1739, 136):

It may be thought, that what we learn not from one object, we can never learn from a hundred, which are all of the same kind, and are perfectly resembling in every circumstance. . . . From the mere repetition of any past impression, even to infinity, there never will arise any new original idea, such as that of a necessary connexion; and the number of impressions has in this case no more effect than if we confin'd ourselves to one only.

And here is Hume (1777, 37)—this is one succinct version of the point that he endeavors to get across in several ways, with several simple examples, billiard balls, changes in weather, bread, etc. in Section IV:

Now where is that process of reasoning which, from one instance, draws a conclusion, so different from that which it infers from a hundred instances that are nowise different from that single one?

formally codified is a psychological illusion. Once we have a hypothesis—*however* we’ve gotten it—we can test it, of course. But there is no *purely* inferential mechanism of any sort for generating (i.e. listing) these desired hypotheses, and distinguishing the good ones from the bad ones. Hume’s observation shouldn’t be understood narrowly: as only a point about syntactically-restricted generalizations, that is, about inductions. It applies to *any* form of “ampliative reasoning”—where the connection between the premises and the conclusion isn’t truth-preserving (e.g. what’s sometimes called “inference to the best explanation”). We only have one “method” available to bridge ampliative gaps—of *any* sort: this is to supply *nonlogical* tissue, examples are what I earlier called “worldly assumptions” in the last paragraph, which together with our background logic yields a deductive connection between these premises and conclusion (a probabilistic conclusion, say, or one about the plausibility of a statement falling within the scope of a plausibility operator). But there is no general approach to finding such nonlogical tissue: our methods, for example, for establishing “inferences to the best explanation,” to the extent that the ways we come upon these hypotheses deserve to be called “methods” at all, are always local and context-specific. I’ll turn to developing this point directly in a more general setting.¹⁴

But first I want to recast this important point in another way. One might hope to supplement (or generalize) deductive reasoning by embedding it in a larger class of reasonings: probabilistic reasonings or plausibility reasonings. The idea is that just as there is truth-preserving reasoning, reasoning where a valid argument provides

That is: there is no *unadorned* inference to be made beyond one sighting of a black raven (there having been seventeen, a thousand . . .) to anything else about black ravens except of course what follows deductively from the specific number of these particular sightings.

¹⁴ Bartha mistakenly assimilates the unified proof-methodology of formal logic to that of one or another set of inductive principles in one or another “inductive logic”; this goes some distance towards explaining why he thinks analogy is susceptible to a general characterization, one that goes beyond local descriptions of the values of some set of analogies (in some narrow context of application). He writes (2010, 21): “[T]here are no widely acknowledged commonsense inference rules for analogical arguments . . . This contrasts sharply with the situation in deductive logic, where we have plenty of unimpeachable inference rules, and with enumerative induction, where we have candidates such as the familiar ‘straight rule.’” The context makes clear that this is a defect he intends to set right with respect to analogical arguments. His tone later in the book is quite a bit different. Bartha (2010, 241–242) revisits a list of commonsense criteria for good analogies that he first gives in Sect. 1.6 in order to show that his “theory developed in Chaps. 4, 5, and 6 both summarizes and improves upon these criteria.” He also writes late in the book (Bartha, 2010, 236) that “my objective is to develop a model for analogical arguments at a level of detail intermediate between an elementary “commonsense” description of analogical arguments and a meticulous case study.” And he adds, one sentence later, “Inevitably, a sophisticated analysis of a particular analogical argument will be more illuminating than the criteria that I have proposed.” One can ask, therefore, what exactly his (Bartha, 2010, 2, 3) “substantive normative theory of analogical arguments” that’s “general” is distinctly offering here. I discuss that in Sect. 1.8. In the interim, I think we can draw the conclusion that Bartha is genuinely conflicted about what the supposed generality he’s offering via his new theory of analogy comes to. This isn’t his fault: what makes a general theory good, and not speciously general, is none-too-easy to see. I discuss this a little in Sect. 1.10.

“total support” for a conclusion, there is also “inductive logic,” where (Hawthorne, 2020):

the truth of the premises provides some degree of support for the truth of the conclusion, where this degree-of-support might be measured via some numerical scale.¹⁵

In a mathematical setting, say that of number theory, *topic-specific* mathematical content can be tucked into the inferential structure of arguments (so that they supplement logical principles); one *infers* via a mathematical-induction rule, for example, from $P(0)$, jointly with $(n)(P(n) \supset P(n + 1))$, that $(n)P(n)$. That is, we treat “numerical inference” as including mathematical-induction inferences along with the inferences licensed by pure logic. Of course, any such construal of topic-specific mathematical content can always be transformed into a standard-looking case where nonlogical assumptions—in particular, Peano’s axioms (which include mathematical induction)—are entirely axiomatized, and where the inferences are restricted to being purely logical ones.

My suggestion is that in treating “support” as a legitimate generalization of truth-preservation, we’re doing exactly the same thing: we’re tucking mathematical content (in this case, content about probabilities or the like) into inferential structure. The only problem with this otherwise purely technical (i.e. philosophically innocent) maneuver is that by thinking of “support” as a legitimate generalization of truth-preservation, we’re in danger of overlooking Hume’s insight—that nothing follows from a set of statements except what follows deductively. We can only “plausibly infer” or “probabilistically infer” B from A if, in reality, we’re relying on additional nonlogical tissue (which amounts to the axiomatizations of notions like “. . . Plausible X” or “Probability (n, X)”) so that we’re using this axiomatized material to deduce “Plausible B” or “Probability (n, B),” where $0 \leq n \leq 1$, from A. That is, what must be in place is a substantial mathematical theory of probability, one which we’re *hypothesizing* can be applied (to whatever scientific domain we’re choosing to apply it to).

It might be feared that I’m illegitimately treating logic—first-order logic—in an epistemically-special way by doing this. Some logical pluralists (see footnote 17) will argue that worldly assumptions of one sort or another are surely at work in the choice of a logic *too*. My argument, here, yields no conclusions that conflict with that. The point is only to frontline the fact that substantial worldly assumptions—*above and beyond* whatever assumptions are in place once one has settled on (or, more accurately, inherited) a logic—are at work when one or another inductive logic is contemplated. Further, that these worldly assumptions go far beyond what’s contemplated in standard logic (which amounts to a purely syntactic characterization of inference) is made visible by grue phenomena (see footnote 29); this shows not only that no syntactic characterization of an induction logic is likely possible, but that substantial answers to serious questions about what additional content is required must be presupposed as well (that is, answers are presupposed to

¹⁵ See also Keynes (1921), especially his chapter IV, section 12, 57, on “partially follows from.”