Explanatory Circles

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(penultimate version; please cite version in Studies in History and Philosophy of Science)

Abstract

Roughly put, explanatory circles—if any exist—would be propositions such that (i) each explains the next, and (ii) the last explains the first. In this paper, I give two arguments for the view that there are explanatory circles. The first argument appeals to general relativistic worlds in which time is circular. The second argument appeals to special science theories that describe feedback loops. In addition, I show that three standard arguments against explanatory circles are unsuccessful.

1 Introduction

According to orthodoxy, there are no explanatory circles (Audi, 2012; Emery, 2019; Khalifa et al., 2018; Lange, 2013; 2018; Marshall, 2015). There are no sequences of propositions such that the first explains the second, which explains the third, and so on, all the way back to the first. This view—call it the 'orthodox view'—is so common in the literature that it rarely receives explicit discussion. It is often implicitly, uncritically taken for granted.

That is a mistake. As I argue in this paper, explanatory circles exist.[1] One argument for explanatory circles is based on familiar principles about causal circles in general relativistic

[1]Others have also made comments which suggest that they reject the orthodox view. For instance, Barnes argues that there are cases of symmetric metaphysical dependence which might count as circular explanations (2018, pp. 65-66). And Priest argues for symmetric dependence relations—which might be used to support the view that there are symmetric explanations—as well (2018, p. 137).

spacetimes. Another argument for explanatory circles is based on certain empirical models which—though rarely referenced in the philosophical literature—are discussed throughout special sciences like biology, economics, sociology, and more. Together, these arguments show that the orthodox view is unfriendly to scientific practice. The orthodox view contradicts nomologically possible, and even actual, explanations that empirical models support.

In Section 2, I set the stage for the arguments to come. In Section 3, I argue for explanatory circles by appealing to general relativity. In Section 4, I argue for explanatory circles by appealing to various special scientific theories. Finally, in Section 5, I defend explanatory circles against some counterarguments.

Before continuing, a clarificatory remark. In this paper, I focus on an objective, worldly notion of explanation, rather than a notion of explanation which is more subjective and epistemic. There are two reasons why. First, the orthodox view is usually taken to concern the more objective notion of explanation: examples of circular explanations, where the relevant notion of explanation is more subjective and epistemic, are quite common.[2] Second, according to the broadly realist view which I adopt here, scientific models back objective, worldly kinds of explanations; those models can also back more subjective and epistemic kinds of explanations, of course, by tracking objective explanatory relations in the world.

2 Explanatory Circles

In this section, I define explanatory circles more precisely. Then I present two related theses about them. Finally, I explain why philosophers should care about explanatory circles: many debates hinge on whether there are any.

Explanatory circles can be partial or full. A *partial* explanatory circle is a finite sequence

[2] Pragmatic approaches to explanation, which focus on explanations' subjective and epistemic elements, often allow for explanatory circles. For example, see discussions of how non-asymmetric explanations can be generated by shifts in context (De Regt & Dieks, 2005, p. 164; van Fraassen, 1980, p. 130). For a more general introduction to pragmatic approaches, see (Achinstein, 1983; van Fraassen, 1988).

of propositions p_1, p_2, ..., p_n such that p_1 partially explains p_2, p_2 partially explains p_3, ..., p_{n-1} partially explains p_n, and p_n partially explains p_1. A *full* explanatory circle is a finite sequence of propositions p_1, p_2, ..., p_n such that p_1 fully explains p_2, p_2 fully explains p_3, ..., p_{n-1} fully explains p_n, and p_n fully explains p_1. Throughout this paper, I focus on circles of partial explanation: so by 'explanatory circle', I mean 'partial explanatory circle'.

It is worth distinguishing two different theses about explanatory circles. The first is the strongest. It says that there are circles of explanation in the actual world.

Actual Circles

Explanatory circles are actual.

In other words, there are propositions which (i) form an explanatory circle, and (ii) are actually true.

The second thesis is weaker. It says that at least one nomologically possible world features a circle of explanation.

Nomologically Possible Circles

Explanatory circles are nomologically possible.

In other words, there are propositions which (i) form an explanatory circle, and (ii) are jointly compatible with the physical laws. So those propositions may not actually be true. But they are true in some world with the same laws as ours.

Different versions of the orthodox view reject one, or the other, of the above theses. For instance, one version of the orthodox view denies Actual Circles, but remains neutral on Nomologically Possible Circles. Another version of the orthodox view denies Nomologically Possible Circles; given that the actual world is nomologically possible, this amounts to denying Actual Circles too.

In this paper, I offer arguments for both of the above two theses. The first argument is for Nomologically Possible Circles. The second argument is for Actual Circles.

Note that explanatory circles are distinct from circles of other kinds. For instance, explanatory circles are distinct from circular arguments. Not all arguments are explanatory (Bromberger, 1966), and not all explanations are arguments (Craver, 2007). Similarly, explanatory circles are distinct from circular justification. One proposition can explain another even if believing the former does not justify believing the latter,[3] and believing one proposition can justify believing another even if the former does not explain the latter.[4]

Many philosophical debates turn on whether some version of the orthodox view is correct. For instance, take the debate over Humean accounts of laws. According to Humean accounts, the fundamental physical laws partially explain some particular matters of fact,[5] and those particular matters of fact partially explain the fundamental physical laws (Bhogal, 2020; Hicks & van Elswyk, 2015; Loewer, 2012).[6] If the orthodox view is correct, however, then Humean accounts of laws are false: those accounts are committed to explanatory circles, and explanatory circles do not exist (Armstrong, 1983; Lange, 2013; 2018; Shumener, 2019).[7]

[3]For an example, take Scriven's discussion of explanation and low-probability events (1959). To explain why someone developed paresis, it suffices to cite the fact that they have syphilis. But the probability that any given person has paresis, given that they have syphilis, is quite low. So the belief that someone has syphilis does not always justify the belief that they have paresis.

[4]For instance, the belief that the length of a flagpole's shadow is thus-and-so may justify the belief that the height of the flagpole is such-and-such. But the shadow's length does not explain the flagpole's height.

[5]For several reasons, this explanation counts as causal. First, consider an approach to causal explanation proposed by Schnieder: "what makes something a causal explanation...is not that it is itself a fact about causes, but that it is *grounded* in such a fact" (Schnieder, 2010, p. 327). The fact that the physical laws partially explain some particular matters of fact is, plausibly, grounded in causal facts. So given Schnieder's approach, the explanation here is causal. Second, the explanation here—of some particular matters of fact in terms of physical laws—is often described as a certain sort of scientific explanation (Loewer, 2012, p. 116). And that particular sort of scientific explanation is often described, by fans of Humean accounts, as causal (Hicks, 2021, p. 537).

[6]Loewer defends his Humean account by arguing that (i) laws scientifically explain particular facts, (ii) particular facts metaphysically explain laws, and (iii) explanatory structures like this—in which scientific explanation goes in one direction and metaphysical explanation goes in the other—are unproblematic (2012, p. 131). Note that this response, regardless of whether it succeeds, is committed to explanatory circles: for explanatory circles that feature different kinds of explanation are explanatory circles nonetheless. So foes of Humean accounts can reject Loewer's response by adopting the orthodox view.

[7]There is an interesting question about whether (i) the sorts of explanatory circles which Humean accounts of laws endorse, are of the same kind as (ii) the sorts of explanatory circles that I discuss later. One might think that if not, then the examples of explanatory circles in later sections do not really undermine views which reject Humean accounts by endorsing the orthodox view: for those views could endorse a restricted

As another example, take debates over the deductive-nomological account of explanation (Hempel, 1965; Woodward, 2003). That account was ultimately rejected, in large part, because it failed to imply that explanation is acyclic. In other words, one of the main arguments against the deductive-nomological account is based on the orthodox view: the deductive-nomological account allows for symmetric explanations;[8] by the orthodox view, no explanations are symmetric; therefore, the deductive-nomological account is false.[9] Clearly, the soundness of this argument hinges on whether or not the orthodox view is correct.[10]

For yet another example, take debates over probabilistic accounts of causation. Salmon argues for such an account by appealing to the relation of one proposition screening off another: the causal relevance relation inherits its asymmetry from various formal features of the screening-off relation (1998, p. 164). Relatedly, in defending probabilistic accounts of causation against criticisms based on van Fraassen's pragmatist account, Salmon appeals to the asymmetry of causal explanation (1998, p. 269). So whether these arguments succeed depends on whether the orthodox view holds.

One more example: debates over the formal features of grounding. Some claim that

version of the orthodox view—concerning a kind of explanation which differs, significantly, from the kind discussed in this paper—instead. This issue is interesting, and deserves more discussion; for lack of space, however, I do not discuss it here.

[8] A classic example: according to the deductive-nomological account, the flagpole's height deductively implies, and so explains, the length of its shadow; and the length of its shadow deductively implies, and so explains, its height. As argued by Strevens, the former deductive implication "represents a real causal process" (2008, p. 93), the latter deductive implication does not, and so only the former deductive implication corresponds to a legitimate explanation.

[9] Sometimes, this argument is put in causal explanatory terms. Strevens, for instance, explicitly claims that there is an asymmetric relation between the flagpole and its shadow, and that the obvious candidate for this relation is causation: the flagpole causes – and so explains – the shadow's existence, but the shadow does not cause – and so does not explain – the flagpole's existence (2008, p. 24). So Strevens explicitly uses the orthodox view, and in particular the view that there are no circles of causal explanation, to argue against the deductive-nomological account.

[10] For additional arguments in favor of at least some explanatory circles, in the context of deductive-nomological accounts, see (Woodward, 1984). In general, Woodward argues that while non-causal explanations—like certain explanations which appear in general relativity—can be circular and yet still perfectly legitimate, circular causal explanations are objectionable (1984, pp. 436-437). Reutlinger agrees: circular non-causal scientific explanations are sometimes legitimate, but circular causal scientific explanations are not (2017, p. 253). In this paper, I argue that explanatory circles are even more pervasive, in scientific theorizing, than Woodward and Reutlinger suggest. Specifically, I argue that given general relativity, explanatory circles—based on causal loops—are nomologically possible. And I argue that explanatory circles, based on causal interdependencies studied in the special sciences, obtain in the actual world.

grounding is acyclic (Audi, 2012); others claim not (Thompson, 2016).[11] One of the main arguments for the former claim is based on the orthodox view: grounding is often assumed to be sufficient for explanation; the orthodox view implies that explanation is acyclic; therefore, grounding is acyclic too. So this debate, over whether or not grounding is acyclic, turns on the orthodox view.

There are many other examples. For lots of philosophical arguments rely, in one way or another, on the orthodox view. In fact, lots of philosophical arguments—like the ones above—take the following schematic form.

1. If view X is true, then there are explanatory circles.
2. There are no explanatory circles; that is, the orthodox view is true.
3. Therefore, view X is false.[12]

So the results of this paper, if correct, are relevant to many areas of philosophy. If there are explanatory circles, then premise 2 in the above schema fails. A very common style of argument is unsuccessful.

3 The Relativity Argument

In this section, I argue that explanatory circles are nomologically possible; that is, Nomologically Possible Circles holds. Though the argument—call it the 'relativity argument'—appeals to general relativity, it is pretty simple.[13] Basically, general relativity implies that in some nomologically possible worlds, time has the structure of a closed circle. In worlds like

[11]For more work on circles of grounding, which supports the view that metaphysical explanation can be circular as well, see (Billon, forthcoming; Bliss, 2014; 2018; Brenner, forthcoming; Nolan, 2018; Swiderski, 2022).

[12]For still more examples of this style of argument, see (Baron & Norton, 2019, p. 12; Bowers & Wallace, 2018, p. 17).

[13]Another argument for Nomologically Possible Circles appeals to the Copenhagen interpretation of quantum mechanics (Davies, 2006, pp. 223-224). The basic idea: present observations of the universe's past quantum state modify that state, and therefore explain why that state obtains; and that state causally determines, and so explains, why the present state obtains. For lack of space, I do not discuss this here.

that, there are circles of causation; so in those worlds, there are circles of explanation too.[14]

The relativity argument is as follows. General relativity consists of equations which describe the structure of spacetime. Those equations allow for spatiotemporal loops. These loops, which are called 'closed timelike curves', consist of paths through spacetime that circle back upon themselves (Earman, 1995).

Closed timelike curves can contain sequences of events that form a causal circle. In particular, on some closed timelike curves, there are sequences of events c_1, c_2, ..., c_n such that c_1 partially causes c_2, c_2 partially causes c_3, ..., c_{n-1} partially causes c_n, and c_n partially causes c_1. So in general relativity, causal circles are nomologically possible.

Now for the final piece of the relativity argument. Versions of the following principle are frequently endorsed (Lewis, 1986a, p. 217; Schaffer, 2016, p. 58; Skow, 2016, p. 124; Strevens, 2018, p. 3).

Cause-to-Explanation

> If event c partially causes event e, then the occurrence of c partially explains the occurrence of e.

This principle is popular because pre-theoretically, the connection between causation and explanation seems extremely tight. Indeed, philosophical theories often employ the same basic formalisms for both causation and explanation, and take both to be based on certain sorts of counterfactuals (Halpern & Pearl, 2005a; 2005b; Woodward, 2003).

Any nomologically possible causal circle, in conjunction with Cause-to-Explanation, generates a nomologically possible explanatory circle. To see why, take the sequence of events c_1, c_2, ..., c_n from before. Since c_1 partially causes c_2, Cause-to-Explanation implies that the occurrence of c_1 partially explains the occurrence of c_2. Similarly for all the other

[14]Though arguments similar to this one have appeared in the literature, I have not seen any which lay the relevant principles out in the way done here. Also, some arguments which might appear similar to this one—like an argument discussed at the end of this section—are quite different. So it is worth stating this argument in explicit detail.

events in this sequence, up to c_n. And since c_n partially causes c_1, Cause-to-Explanation implies that the occurrence of c_n partially explains the occurrence of c_1. So the causal circle, on this closed timelike curve, generates an explanatory circle. And so explanatory circles are nomologically possible.[15]

A clarificatory aside: though I generally take explanation to relate propositions, nothing hangs on that. In Cause-to-Explanation, for example, the antecedent takes events to stand in the causal relation, and the consequent takes propositions—in particular, propositions about the occurrences of events—to stand in the explanation relation. But Cause-to-Explanation could have been formulated so that events themselves, rather than propositions about those events' occurrences, explain other events. In fact, in the philosophical literature, it is standard to shift back and forth between taking explanation to relate events, propositions, and variables in structural equation models (Franklin-Hall, 2016, p. 557; Lange, 2021, p. 3894; p. 3902). There are ways to translate between event-talk and proposition-talk (Khalifa et al., 2018, p. 6; p. 23). It is also commonplace to use variables—and equations relating variables—to make claims about physical events, and to express propositions about those events occurring or failing to occur: for instance, see Halpern and Pearl—who use variables to describe events and propositions both—writing that "essentially [they] are identifying events with propositions" (Halpern & Pearl, 2005b, p. 895). So in this paper, while I usually take propositions to stand in the explanation relation, there are straightforward ways to translate between explanatory proposition-talk, explanatory event-talk, and explanatory variable-talk.

One might object to the relativity argument by claiming that closed timelike curves cannot support circles of causation. This objection, however, is not very plausible: there are extremely intuitive examples of causal circles on closed timelike curves. For instance, take an

[15] Examples of circular explanations, based on time travel, often strike many as paradoxical: consider the grandfather paradox, for instance (Hawking, 1992; Eldridge-Smith, 2007). And one might take those paradoxes to show that something must be wrong with arguments which, like the relativity argument, use closed timelike curves to conclude that circular explanations are possible. In my view, however, that is not quite right. Paradoxes based on time travel can be resolved, as Lewis argued, by citing commonplace reasons: ordinary events prevent the paradoxical situations from obtaining (1976, pp. 150-151). So the paradoxes of time travel need not be taken to show that arguments for circular explanations, based on loops in spacetime, are misguided.

example due to Maudlin (2012, p. 163). Toni goes back in time by traveling along a closed timelike curve, intent on assassinating her younger self. She raises her gun, aims, and fires. But her hand trembles, and instead of killing her younger self, she merely inflicts a shoulder wound. In fact, the nerve damage caused by that shot affects Toni for her entire life, and in particular, it leads to this very tremble on this fateful day. So Toni's tremble causes the shot to the shoulder, which causes the nerve damage, which in turn causes the tremble.

Instead, one might object to the relativity argument by rejecting Cause-to-Explanation. For certain cases, based on causation across different scales, might seem to suggest that Cause-to-Explanation does not hold in full generality. To illustrate, consider an electrical conductor made of a heterogeneous mixture containing both a good conducting material and a poor conducting material (Batterman, 2013). Presumably, one might claim, the event of the material having a particular microstate causes the event of the material having various conductivity properties at the continuum level: lower-level goings-on are causally responsible for higher-level goings-on. Nevertheless, one might claim, the material's continuum level conductivity behavior is not explained by the material's microstate: its continuum level conductivity behavior is explained by its structural features at the mesoscale level, between the microscale and the continuum scale. And so Cause-to-Explanation is false.

For two reasons, I do not think that this objection succeeds. One reason concerns the distinction between full explanations and partial explanations. Cause-to-Explanation claims that partial causation is sufficient for partial, but not full, explanation. So in order to reject Cause-to-Explanation on the basis of the case just given, the objector must claim that the material's continuum level conductivity behavior is not even partially explained by the material's microstate. And that seems incorrect. It is certainly true that the material's continuum level conductivity behavior is explained, in large part, by its structural features at the mesoscale level. But the material's microstate still plays an explanatory role in accounting for the material's conductivity at the level of the continuum. That microstate partially—not fully, but partially—explains continuum-level conductivity, because that microstate realizes the material's structural features at the mesoscale level. This explanatory contribution is perhaps smaller than the explanatory contribution of the mesoscale facts; but it is an explanatory contribution nevertheless. So while the above case might show that partial causation is insufficient for full explanation, the case does not show that partial causation is insufficient for partial explanation.

Another reason to reject the objection concerns the causal claim which it makes. Causes, according to some theories, must be proportionate to their effects (Franklin-Hall, 2016; Yablo, 1992). The event of the material having a particular microstate, however, is not proportionate to the event of the material having various conductivity properties at the continuum level: for these events occur at different scales.[16] So given this proportionality requirement, the objection is wrong to claim that the event of the material having a particular microstate causes the event of the material having various conductivity properties at the continuum level: for these events are disproportionate.[17]

This argument for explanatory circles is similar to, though importantly different from, other arguments in the literature. For instance, it is superficially similar to an argument given by Meyer (2012). According to Meyer's argument, circles of explanation along closed timelike curves are acceptable because in fact, they reference more than just events within the circle: they reference laws of nature, and perhaps events outside the circle, as well (2012, p. 261). The relativity argument shows, however, that there are circular explanations which do not reference anything apart from the events in the relevant circle. Nomologically possible explanatory circles, which do not reference anything other than the events which the circles contain, derive from general relativistic laws coupled with Cause-to-Explanation.

Note a limitation of the relativity argument: it only establishes the conclusion that

[16] These events are disproportionate in the same way that, for instance, the event of a ball being scarlet is disproportionate to the event of a pigeon pecking. The pigeon has been trained to peck at red targets, so the event of the ball being red—not scarlet—is proportional to the pecking event (Franklin-Hall, 2016, p. 563).

[17] Yet another response to this objection: the relativity argument does not need to assume that Cause-to-Explanation holds in full generality. The following, restricted version of Cause-to-Explanation is sufficient, for the argument to succeed: if event c and event e occur on the same scale, and c partially causes e, then the occurrence of c partially explains the occurrence of e. Since the c_i—in the relativity argument—are events on the same scale, it follows that explanatory circles are nomologically possible.

explanatory circles are nomologically possible. It does not show that the actual world features explanatory circles. And explanatory circles in the actual world would, of course, be a more striking result.

Hence the next section, where I summarize some special science models which deserve more discussion in philosophy. Those models back an argument whose conclusion is that the actual world features explanatory circles. Let us see how.

4 The Special Science Argument

In this section, I argue that there are explanatory circles in the actual world; that is, Actual Circles holds. In Section 4.1, I present the argument itself: it appeals to models that, because of their structure, back circular explanations. In Section 4.2, I defend this argument against three different objections. Finally, in Section 4.3, I make some big-picture remarks about the connection between empirical adequacy and explanation.

4.1 The Argument

The argument for Actual Circles—call it the 'special science argument'—appeals to the special sciences. Many special science models posit feedback loops between two distinct phenomena: one phenomena influences the other, which in turn influences the first. Some of those models use structural equations. And models like that—structural equation models—describe explanatory relationships; it is standard to interpret structural equation models as encoding explanations. So these feedback loops, posited by these models, are partial explanatory circles. These models are highly empirically and explanatorily successful: they account, extremely well, for the relevant phenomena. And so since many successful models posit explanatory circles, we should think that explanatory circles exist.

Before presenting some examples, it is worth briefly describing how structural equation models work. The basic idea is that in structural equation models, explanatory structures[18] are represented by four bits of formalism: variables, values that variables can take, values that variables actually take, and equations relating the variables (Pearl, 2009). For example, there is a structural equation model which represents the causal structure of Susie throwing a rock and so shattering a window. One variable's values represent the occurrence or non-occurrence of the throw; another variable's values represent the occurrence or non-occurrence of the shattering. An equation relates those variables, and in so doing, formally represents the following explanatory fact: the window shattered because Susie threw a rock at it.

Some structural equation models are non-recursive. To a first approximation, these are models in which (i) one variable's values determine another variable's values by means of one equation, and (ii) that other variable's values determine the first variable's values by means of a second equation. In other words, non-recursive structural equation models are structural equation models which feature a loop.

We are now in a position to appreciate how some special science models posit explanatory circles. To start, consider an example from ecology. Folmer et al. propose a structural equation model which accounts for the relationship between (i) the density of seagrass in a particular area, and (ii) the size of sediment grains in that area (2012). As it turns out, the accumulation of smaller grains explains why seagrass density decreases. This decrease in seagrass density, in turn, explains why larger grains accumulate. The accumulation of larger grains explains why seagrass density increases. And the increase in seagrass density explains the accumulation of smaller grains.

Some details will help illuminate this explanatory structure. The average grain size in an area affects the amount of oxygen trapped in that area: smaller grains reduce, and larger grains increase, the amount of oxygen. The amount of oxygen in an area, in turn, affects the density of seagrass in that area: more oxygen increases, and less oxygen decreases, seagrass density. And that is how average grain size affects the density of seagrass. In addition,

[18]Those explanatory structures can be causal (Hitchcock, 2007; Woodward, 2003), metaphysical (Schaffer, 2016; Wilson, 2018), or structures of still other sorts (Wilhelm, 2021a; 2021b).

the seagrass density in an area affects the speed of water currents through that area: higher densities of seagrass generate slower currents, while lower densities of seagrass generate faster currents. The speed of water currents in an area, in turn, affects the average grain size in that area: slower currents facilitate the accumulation of smaller grains, while faster currents facilitate the accumulation of larger grains. And that is how seagrass density affects average grain size.

This model posits an explanatory circle between average grain size and seagrass density. Like all structural equation models, the model proposed by Folmer et al. describes explanatory structures. And their model is non-recursive: it posits a feedback loop between average grain size and seagrass density. So their model posits a circle of explanation: in a given area, average grain size partially explains seagrass density, and seagrass density partially explains average grain size.

Examples like this abound. For instance, in economics, Halilem et al. use non-recursive structural equation models to describe the feedback between innovation – when firms develop new products to sell – and internationalization – when firms expand their markets (2014). So according to Halilem et al.'s model, certain facts about innovation partially explain certain facts about internationalization, and those facts about internationalization partially explain the original facts about innovation. In sociology, Robbins uses a non-recursive structural equation model to capture the mutual relationship between institutional quality – the quality of institutions in a society – and generalized trust – the degree to which people in a society trust one another (2012). That model posits an explanatory circle: the degree of institutional quality in a society partially explains the degree of generalized trust in that society, and the degree of generalized trust in a society partially explains the degree of institutional quality in that society. In urban planning, Gim uses a non-recursive structural equation model to describe a feedback loop between (i) peoples' choices about where to live, and (ii) peoples' attitudes towards different modes of travel (2016). So Gim's model posits an explanatory circle. In circuit theory, Mason uses non-recursive structural equation models to describe complex dynamics among voltages, currents, and other electrical phenomena (1953). Those models posit circles of explanation too.

That concludes the special science argument. Non-recursive models are used throughout the special sciences. They provide the simplest, strongest, most explanatory accounts of many different empirical phenomena. They also posit explanatory circles.[19] So we should too.[20]

4.2 Objections and Replies

Now to defend the special science argument against three objections. The first objection claims that non-recursive models can always be replaced by recursive models which posit no explanatory circles. The second objection claims that non-recursive models fail to describe real causal or explanatory structures at all. The third objection claims that in general, seemingly circular explanations—that the special sciences might appear to endorse—are actually non-circular explanations in disguise. Let us consider each of these in turn.

The first objection to the special science argument—call it the 'recursive counterparts' objection—is as follows. Non-recursive models, one might claim, are merely stand-ins for recursive models, where a recursive structural equation model is a structural equation model in which there are no feedback loops. In particular, one might claim, non-recursive models are stand-ins for recursive models in which all of the relevant phenomena have been indexed to times. Because those recursive models lack feedback loops, those models do not commit us to any explanatory circles. And therefore, one might conclude, their non-recursive counterparts

[19]Since these models are employed in non-fundamental sciences, they are consistent with explanatory circles only ever occurring at the non-fundamental level. They are compatible, in other words, with the view that while there are circles of explanation featuring propositions about non-fundamentalia, there are no circles of explanation featuring propositions about fundamentalia only.

[20]Dynamic structural equation models, such as those studied by Thorson et al. (2024), Hovmand (2003), and McNeish and Hamaker (2020), also posit interesting explanatory structures. None of the models studied in these papers, however, purport to provide empirically or explanatorily adequate replacements for the non-recursive structural equation models I am discussing here. In fact, these authors occasionally suggest that dynamic structural equation models cannot replace non-recursive structural equation models. Hovmand, for instance, writes that such a replacement would generally require sacrificing "a substantial portion of the latent structure representing feedback loops" (2003, p. 212). The loops cannot be eliminated without empirical loss, in other words.

do not commit us to any explanatory circles either.

To illustrate the idea behind the recursive counterparts objection, consider the ecological model due to Folmer et al. again. That model could, one might think, be transformed into an empirically equivalent model that posits no feedback loops at all, if the relevant variables were indexed to times. In particular, that non-recursive model could be transformed into a recursive model which posits the following explanatory structure: average grain size at time t_1 partially explains seagrass density at a later time t_2, seagrass density at t_2 partially explains average grain size at a later time t_3, average grain size at t_3 partially explains seagrass density at a later time t_4, and so on. This other model—call it the 'recursive version' of Folmer et al.'s model—does not commit us to any explanatory circles. Because of that, one might claim, the corresponding non-recursive model does not commit us to any explanatory circles either.

There are at least four problems with the recursive counterparts objection. The first problem: this objection amounts to revising a standard, realist approach to understanding scientific models in general, and structural equation models in particular. According to this approach, when it comes to determining what the world is like, empirically and explanatorily adequate models are reasonably good guides. If a model features in empirically verifiable scientific explanations, and the model says that the world is a certain way, then we have defeasible reasons—not knockdown reasons, but defeasible ones—for thinking that the world is indeed that way. It does not matter if the model can be transformed into a different, empirically equivalent model. If the first model backs explanations, and also says that certain explanatory relations obtain, then plausibly, those relations really do obtain.

The second problem: plausibly, these two models—the original non-recursive one, and the recursive one into which the original was transformed—are not empirically equivalent at all. For they describe different events. The non-recursive model uses fairly general, coarse-grained events like "The size of sediment grains in an area is thus-and-so" to explain similarly general, coarse-grained events like "The seagrass density in that area is such-and-such." The recursive model uses fairly specific, fine-grained events like "The size of sediment grains in an area at earlier time t_1 is thus-and-so" to explain similarly specific, fine-grained events like "The seagrass density in that area at time t_2 is such-and-such." So in these two models, the events being explained—and the events doing the explaining—are numerically distinct.[21] And so these models are not empirically equivalent at all: each model describes a distinct range of empirical phenomena, in a manner consistent with—but not equivalent to—the range of empirical phenomena which the other model describes.

One might worry that the propositions corresponding to coarse-grained events are incomplete, since their truth values cannot be evaluated unless a time is specified: the proposition expressed by "The size of sediment grains in an area is thus-and-so," for instance, cannot be assessed for truth or falsity until supplied with a particular time like t_1. Regardless of whether this is correct, however, it does not pose a problem for the present argument. For explanations can relate both complete propositions and incomplete propositions[22] alike. To see why, it helps to recall standard philosophical theories of the semantics of incomplete propositions more generally. In order to evaluate incomplete propositions' truth values, many additional parameters—contexts, circumstances of evaluation, times, agents, and so on—must be supplied (Kaplan, 1989, pp. 500-501; Recanati, 2006, p. 45). But those additional parameters are not themselves 'part' of the incomplete propositions; they simply feature in standard accounts of how those incomplete propositions end up being true or false. Likewise for the incomplete propositions which figure in explanations. In order to evaluate whether those propositions stand in explanatory relations, many additional parameters—contexts, perhaps, and perhaps times too—may well need to be supplied. But those additional parameters are not themselves 'part' of the incomplete propositions; they simply feature in standard accounts of how those incomplete propositions end up standing in explanatory rela-

[21] Of course, the events being explained seem related: perhaps the fine-grained events are token events, for instance, and the coarse-grained events are corresponding types of events. As I explain later, while discussing another objection, this observation does not help fans of the orthodox view resist the conclusion of the special science argument.

[22] Incomplete propositions are also called 'propositional functions' (Perry, 1993, p. 43).

tions which, relative to any of those parameters, obtain or fail to obtain. In other words, just as an incomplete proposition can be true or false at a time, despite not explicitly invoking times, an explanation featuring an incomplete proposition can obtain or fail to obtain at a time, despite not explicitly invoking times.[23]

Relatedly, one might endorse the view that coarse-grained propositions are tensed rather than tenseless, and that explanation relates propositions both tensed and tenseless alike. For instance, on this view, "The size of sediment grains in an area is thus-and-so" expresses a tensed proposition, in virtue of the tensed verb 'is'. Following Lewis's coarse-grained approach, that tensed proposition can be identified with a particular set of world-time pairs: intuitively, the set of pairs $\langle w, t \rangle$ such that at world w and at time t, the size of sediment grains in the relevant area is indeed thus-and-so (1986b, p. 54). Or following Stalnaker's coarse-grained approach, that tensed proposition can be identified with a certain collection of truth conditions: intuitively, conditions about the truth and falsity of thus-and-so being the size of sediment grains in the relevant area (2012, p. 43). Both approaches allow tensed propositions to explain and to be explained; just as the proposition that Susie throws a rock explains the proposition that the window shatters – and both of these propositions are coarse-grained and tensed in the way just described – so the proposition that the size of sediment grains in an area is thus-and-so explains the proposition that the density of seagrass in that area is such-and-such.

The third problem: the recursive counterparts objection is, plausibly, based on a false claim. It is not obvious that every non-recursive structural equation model, used in the special sciences, is empirically equivalent to some recursive structural equation model. No one has written down a fully rigorous, recursive model to which Folmer et al.'s non-recursive model may be empirically equivalent. Claiming that the relevant variables can be indexed to times, without backing up that claim by actually formulating the model and demonstrating

[23] In order for the arguments in Section 3 to still work, of course, complete propositions must be capable of explaining too. That is why, on the view under consideration here, explanation can relate both complete propositions and incomplete propositions.

its empirical adequacy through various statistical analyses, is armchair science. For this objection to succeed, one would have to actually write down the relevant structural equations, and do the relevant statistical analyses, for all of the non-recursive models mentioned in Section 4.1; and no one has does that. And even that, in fact, would not be enough. For it would still need to be shown that those recursive models are empirically equivalent to the non-recursive models that scientists actually use; one would have to show that there is no empirical loss in the move from non-recursive models to their recursive counterparts. That seems challenging: among other things, the notion of empirical equivalence is notoriously hard to make precise. Merely claiming, on the basis of intuitions, that the imagined—but not yet actually constructed—recursive counterpart models are empirically equivalent to the scientists' non-recursive models, is simply not enough. More arguments are needed here, and the recursive counterparts objection does not provide any.

The fourth problem: the recursive counterparts objection implicitly makes an invalid inference. For the sake of argument, grant that each non-recursive model is empirically equivalent to a recursive model, and grant that these recursive models do not commit us to explanatory circles. It simply does not follow, from that alone, that the corresponding non-recursive model fails to commit us to explanatory circles either.

The following comparison will help illustrate why. Perhaps every biological model is empirically equivalent to some highly complicated model written in terms of fundamental physics. Perhaps the non-recursive version of Folmer et al.'s model, for instance, is empirically equivalent to a model which only mentions subatomic particles and quantum fields. These fundamental physical models do not commit us to biological explanations. Rather, these fundamental physical models only commit us to explanatory structures at the fundamental level. But it does not follow, from that alone, that the corresponding biological models do not commit us to any biological explanations either. The fundamental physical models describe certain explanatory structures; and if we fully accept the models, then we are committed to the explanatory structures which they describe. The corresponding biological models describe other sorts of explanatory structures; and again, if we fully accept the models, then we are committed to the explanatory structures which they describe.

Return to non-recursive models and recursive models. Suppose that each non-recursive model can be transformed into an empirically equivalent, recursive model. That recursive model does not commit us to explanatory circles. But it does not follow, from that alone, that the corresponding non-recursive model does not commit us to explanatory circles either. The recursive model describes an explanatory structure; and if we fully accept the model, then we are committed to the explanatory structure which it describes. The corresponding non-recursive model describes another sort of explanatory structure; and again, if we fully accept the model, then we are committed to the explanatory structure which it describes. So we are committed to both the explanatory structure described by the recursive model and the explanatory structure described by the non-recursive model. And so we are committed to explanatory circles.

Now for the second objection—call it the 'anti-realist' objection—to the special science argument. According to the anti-realist objection, non-recursive models do not accurately describe real causal or explanatory relations at all. Such models are merely useful approximations: they do not actually back explanations. Folmer et al.'s non-recursive model, for instance, is merely a useful approximation of some jumble of facts about how specific densities of seagrass growth in particular areas relate to the specific sizes of sediment grains in those areas.

This objection faces problems entirely analogous to the problems that the first objection faces. For instance, this objection contradicts a standard realist view: scientific models—the ones which scientists actually use—are pretty good guides to the causal and explanatory structures of the empirical world. So if those models posit explanatory circles, then we should not be so quick to endorse the orthodox view: we should be willing to posit explanatory circles as well. The anti-realist objection also implicitly makes an invalid inference. Special science models, like all models, are indeed useful approximations of various empirical phenomena:

but it does not follow, from that alone, that special science models fail to describe causal and explanatory structures.

Yet another problem that the anti-realist objection faces: the most plausible justification for it is, in the present context, question-begging. To see why, just ask: why think that the explanations which non-recursive models purport to posit—those models, in particular, formulated by Folmer et al., Halilem et al., Robbins, and so many others—do not actually obtain? Why is it that of all the posits of all the empirically successful models that special scientists use, the posits of those models in particular—the non-recursive ones—should not be endorsed? Because, the most natural and plausible answer goes, those models are non-recursive; so the explanations which those models purport to posit would be circular explanations; and there are no explanations like that. But in the present dialectical context, this answer begs the question. For this answer simply stipulates that explanations cannot be circular. It is a foot-stomping insistence on the orthodox view. And that is precisely the view under scrutiny.

Now for the third objection—call it the 'disguised token' objection—to the special science argument. One might claim that seemingly circular explanations concerning types of events[24] are actually non-circular explanations, concerning token events, in disguise. So despite appearances, the explanations posited by non-recursive models are not circular at all: for the explanations posited by non-recursive models concern types of events, and so are actually disguised versions of non-circular explanations concerning token events.

There are at least two serious problems with the disguised token objection. First, the existence of some explanations of token events does not, on its own, rule out the existence of any corresponding explanation of any corresponding type of event. For just as token events require explanation, types of events require explanation (Woodward, 2003, p. 40). And just as token events are best explained by other token events, types of events are best explained by other types of events. These different explanations, of different sorts of events, are perfectly

[24]For examples of explanatory claims about event types—or coarse-grained events—in the philosophical literature, see (Woodward, 2003, pp. 17-18; Woodward & Hitchcock, 2003, p. 10).

compatible with one another. So the disguised token objection is wrong to stipulate that explaining token events rules out, precludes, or undermines, explaining types of events.

Second, the disguised token objection is based on a mysterious notion of 'disguise'. What is it for one explanation to be 'disguised' as another explanation? The answer is unclear. Perhaps the thought is: circular explanations are just convenient, codified redescriptions of non-circular explanations. But that seems implausible, for reasons similar to the problems facing the first objection above. Redescriptions of explanations—circular or not—are generally not redescriptions at all. They are genuinely new explanations, since they feature genuinely new propositions: this follows, straightforwardly, from the view that explanations featuring different propositions are themselves different. And that is what happens when explanations of some types of events are 'redescribed' using token events instead. The 'redescription' results in a new explanation, since the resulting explanation features different propositions: whereas the original explanandum proposition is about types of events, the new explanandum proposition is about token events. So the disguised token objection is wrong to claim that the old explanation is just the new explanation in disguise.

To wrap up, here is a succinct way to put the point of this section. Proponents of the above objections—and of the orthodox view more generally—want to posit some sort of explanatory distinction between recursive models and non-recursive models. According to this supposed distinction, recursive models support explanations and non-recursive models do not.

But as the problems for the above objections suggest, there is no good way to draw that distinction. Each objection to the special science argument represents an attempt to do so. But those attempts face serious issues. And there is nothing surprising in that. Successful recursive models are successful scientific models like any other. They are on a par, empirically, with non-recursive models that enjoy empirical success. And philosophers should not be in the business of revising or rejecting what those models tell us, straightforwardly, about the empirical world.

4.3 Empirical Adequacy and Explanation

Before moving on, it is worth making some remarks about the overall state of the dialectic here. In Section 4.1 and Section 4.2, I used the empirical adequacy of certain non-recursive structural equation models to argue for explanatory circles. The basic idea: those models feature feedback loops; since those models are empirically adequate, those feedback loops are explanatory; so there are circles of explanation.

One might take issue with this basic idea's reliance on empirical adequacy. For in order to claim that certain relationships are explanatory, the empirical adequacy of a structural equation model—encoding those relationships—is not always sufficient. A model's empirical adequacy might give us some preliminary reason for thinking that it describes certain explanatory structures in the world. But more work is needed to establish, in any given case, that those explanatory structures really are there.

To illustrate, take Folmer et al.'s model once more. This non-recursive model provides us with some preliminary reason for thinking that explanatory circles exist. But one might worry that the models' variables for average grain size, and for seagrass density, are too coarse-grained to immediately provide us with a knockdown argument for explanatory circles. Such coarse-grained variables are extremely useful, of course: they are what allow Folmer et al. to transform complex goings-on into something tractable. But because of that, we must be careful about the conclusions, concerning explanatory structures, which we draw from Folmer et al.'s model – we must be wary of taking that model's explanatory posits at face value.[25]

I agree with these concerns. The considerations provided in Section 4.1 and Section 4.2 are not knockdown arguments for explanatory circles. They draw on the pervasive use of non-recursive structural equation models in the special sciences, and the standard interpretation

[25]For example, suppose that Susie is throwing rocks at multiple windows, such that (i) her aim improves with each throw, and (ii) she has more fun with each window-shattering throw and therefore the likelihood of her continuing increases with each such throw as well. Then there may well be a feedback loop between the proposition that Susie throws a rock and the proposition that a window shatters. But it does not immediately follow that this feedback loop is an explanatory circle (thanks to an anonymous reviewer for this example).

of those models as encoding explanations, to argue that explanatory circles exist. But in any given case, it is important to look at specific details of the models in question, to see whether any of their variables are too coarse-grained to provide reliable information about circles of explanation.

Many details of Folmer et al.'s model, for example, are relevant to a complete evaluation of the explanatory relationships which that model contains. For instance, in addition to their so-called 'final model' which I have been discussing, Folmer et al. describe five other models as well. All these models describe average grain size and seagrass density in the intertidal mudflats of the Banc d'Arguin, Mauritania. In the initial model, several different parameters facilitate the feedback loop between average grain size and seagrass density: the relevant area's level of exposure to waves, its distance from the sea, its distance from bare mudflats, seagrass cover in the environs, linear and quadratic functions of its organic matter content, and temperature (Folmer et al., 2012, p. 1382). In the final model, a smaller collection of parameters are considered: exposure to waves, seagrass cover, and organic matter content (Folmer et al., 2012, p. 1389). Four other models are discussed as well (Folmer et al., 2012, p. 1388). The models differ in the strengths of the explanatory, causal, and statistical correlations which they attribute to all of these different parameters. But there is still striking convergence, among all six models, in the correlations which they take to feature in the feedback loop between average grain size and seagrass density.

This convergence, in the correlations which feature in that feedback loop, provides additional motivation for thinking that the interdependency between average grain size and seagrass density is indeed explanatory. When multiple mathematical models converge on the same sorts of purportedly explanatory relationships, we have good reason for thinking that those relationships obtain. For in such cases of convergence, we have good reason for thinking that those relationships are not mere mathematical artifacts of one model in particular – those relationships seem to be model-independent. So in the case of Folmer et al.'s models, we have good reason for thinking that there is indeed an explanatory circle between average grain size and seagrass density in intertidal mudflats with certain sorts of environmental conditions.

But even this is not a knockdown argument. One might insist that only some of the relationships among all the variables in Folmer et al.'s models—average grain size, seagrass density, exposure to waves, distance from the sea, and so on—can support explanations. For what it is worth, Folmer et al. describe the relationships between average grain size and seagrass density as instances of causal influence, and so to that extent, as explanatory (2012, p. 1389) – and along with the other arguments presented here, I prefer to take that description seriously. But of course, Folmer et al. might be wrong: that might not be the best interpretation, all things considered, of the relationships which Folmer et al.'s six models encode.

So to summarize: Folmer et al.'s models, and indeed many models in the special sciences, provide reasons for countenancing explanatory circles. Those reasons are defeasible: once any given model is examined more closely, there might be reason to avoid taking its putative explanatory posits at face value. But as was demonstrated by the examination of a few details of Folmer et al.'s models, in some cases, those putative explanatory posits really do seem robust. So dialectically, such models support an argument—not a knockdown argument, but a reasonably good argument nonetheless—for explanatory circles. While we should be careful not to hastily conclude that explanatory circles exist, merely by noticing that special sciences use non-recursive models, we should take such models to support a pretty compelling challenge to the orthodox view.

5 Rebuttals

Arguments against explanatory circles are hard to find. Philosophers usually just assume, without argument, that explanations cannot be circular. The orthodox view tends to be presupposed.[26]

Nevertheless, it is worth exploring the sorts of ideas which might motivate the orthodox view. In this section, I consider three arguments against explanatory circles. The first concerns the link between explanations and informativeness. The second and third concern formal features of the explanation relation.

According to the first argument, explanations must be informative and illuminating. The explanans propositions, in an explanation, tell us why the explanandum proposition occurred. They illuminate the explanandum: they give us insight into it. But for any given circle of purported explanation, the propositions do not illuminate each other. They are neither informative nor illuminating; they do not provide us with insight into why the others obtain. So no such circle is, in fact, explanatory.

My reply: circles of purported explanation *are* often illuminating and informative. We do, often, gain insight from them. For instance, take the explanatory circle—between average grain size and seagrass density—expressed by Folmer et al.'s model. That explanatory circle is extremely illuminating and informative: average grain size affects seagrass density by affecting the amount of oxygen in an area, and seagrass density affects average grain size by affecting the flow of water through an area. There is an informative, illuminating, explanatory dependence that runs both ways between average grain size and seagrass density. So explanatory circles are not always uninformative or unilluminating. The special sciences provide many examples of informative, illuminating circles of explanation.

The second argument against explanatory circles is based on two assumptions. First, partial explanation is transitive: for any propositions a, b, and c, if a partially explains b and b partially explains c, then a partially explains c. Second, partial explanation is irreflexive: for any proposition a, it is not the case that a partially explains a. As a trivial proof shows, these two assumptions imply that partial explanation is asymmetric. So there are no explanatory circles.

[26] For some exceptions, see (Lange, 2018) and (Salmon, 1967). Both make comments which suggest endorsements of the arguments that I discuss here.

This argument is based on a false assumption. As many examples have demonstrated, partial explanation is not transitive. Take a variant of a case proposed by Hitchcock (2001, p. 276): a boulder falls towards a hiker, who ducks, and so survives the ordeal. The boulder's falling partially explains the hiker's ducking, and the hiker's ducking partially explains the hiker's surviving. But the boulder's falling does not partially explain the hiker's surviving.

The third argument picks up where the second left off. For simplicity, in this paper, I adopted a non-contrastive approach to explanation: I assumed that explanatory claims take the form "proposition a partially explains proposition b."[27] The third argument grants that when it comes to non-contrastive partial explanation, transitivity fails. But according to the third argument, partial explanation is best understood contrastively. That is, the relevant explanatory claims take the form "proposition a rather than proposition a' partially explains proposition b rather than proposition b'."[28] And contrastive partial explanation, one might claim, is transitive. That is, one might endorse the principle below.

Contrastive Transitivity

For all propositions a, a', b, b', c, and c', if a rather than a' partially explains b rather than b', and b rather than b' partially explains c rather than c', then a rather than a' partially explains c rather than c'.[29]

In addition, one might claim, contrastive partial explanation is irreflexive: for all propositions a and a', it is not the case that a rather than a' partially explains a rather than a'. And from this, it follows that partial explanation is asymmetric: for all propositions a, a', b, and b', if a rather than a' partially explains b rather than b', then b rather than b' does not partially explain a rather than a'. So there are no explanatory circles.

[27]None of my arguments depended on this assumption, however. They can all be reformulated so that they apply to contrastive approaches to partial explanation.

[28]For discussion of how contrastive approaches generally work—in the case of causation, at least—see (Schaffer, 2005).

[29]Lange endorses a principle like this (2018, pp. 1341-1342).

In reply, I claim that Contrastive Transitivity is false. For a counterexample, consider the falling boulder once more. The boulder's falling rather than not falling partially explains the hiker's ducking rather than not ducking, and the hiker's ducking rather than not ducking partially explains the hiker's surviving rather than not surviving. But the boulder's falling rather than not falling does not partially explain the hiker's surviving rather than not surviving. It is not true that the hiker survived, rather than died, because of the boulder's falling (rather than not). So Contrastive Transitivity fails.

All three arguments against explanatory circles are unsuccessful. Circles of explanation can be informative and illuminating. And partial explanation—in both its non-contrastive and its contrastive form—is not transitive.

6 Conclusion

Philosophical theorizing should break free of the grip which the orthodox view has on it. Philosophers have not always pledged allegiance to anti-circular orthodoxy: historically, for instance, philosophers like Fazang endorsed the circular explanatory interdependence of all things (Hershock, 2013). In this paper, I have argued that similarly circular explanatory interdependencies appear throughout the sciences: in general relativity, biology, ecology, sociology, and more. Philosophers should let this influence their almost automatic and unreflective endorsement of the orthodox view. Explanatory circles are worth countenancing.

Acknowledgements

Thanks to Nina Emery, Barry Loewer, an editor, and two anonymous reviewers, for much helpful feedback and discussion.

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