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SYMPOSIA PAPER

On the Role of Erotetic Constraints in Noncausal Explanations

Daniel Kostić

Institute of Philosophy, University of Leiden, Leiden, The Netherlands
Email: daniel.kostic@gmail.com

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Abstract

In noncausal explanations, some noncausal facts (such as mathematical, modal, or metaphysical) are used to explain some physical facts. However, precisely because these explanations abstract away from causal facts, they face two challenges: (1) it is not clear why one rather than the other noncausal *explanantia* would be relevant for the *explanandum*; and (2) why would standing in a particular explanatory relation (e.g., "counterfactual dependence," "constraint," "entailment," "constitution," and "grounding"), and not in some other, be explanatory. I develop an explanatory relevance account that is based on erotetic constraints and show how it addresses these two challenges.

1. Introduction

The ever-growing interest in noncausal explanations in sciences during the last decade has yielded several philosophical accounts (Batterman and Rice 2014; Pincock 2015; Lange 2017; Reutlinger 2016; Rice 2021). In noncausal explanations, most broadly speaking, some noncausal facts (such as mathematical, modal, or metaphysical) are used to explain some physical facts.

Using Kostić's (2020) account of topological explanations we can outline the shape of many of these explanations. I first present his account and then show how it could be generalized to other noncausal explanations:

a's being *F* topologically explains why *a is G* if and only if:

(T1) *a* is *F* (where *F* is a topological property);

(T2) *a* is *G* (where *G* is a physical property);

(T3) Had *a* been *F'* (rather than *F*), then *a* would have been *G'* (rather than *G*);

(T4) *a is F* is an answer to the question why is *a*, *G*?

The first condition, T1, specifies the type of property cited in the *explanans*, and in that way determines whether an explanation is topological or some other kind. Topological properties are mathematically quantifiable connectivity patterns of network models. T2 ensures that G is a proper scientific *explanandum* (i.e., it is a description of a physical phenomenon), that is, why a disease spreads at a certain rate in a population. The third condition T3, secures explanatoriness, that is, the T3 captures the counterfactual dependence of the *explanandum* on the *explanans* (Bokulich 2011; Reutlinger 2016; Rice 2021; Woodward and Hitchcock 2003). For example, such counterfactual could have the following form:

> *Had the topological properties of contagion relations network in a human population been different, the infection wouldn't have spread as efficiently.*

Finally, the fourth condition T4 provides pragmatic relevance criteria. A putative explanation could satisfy the first three but fail to satisfy this fourth criterion and the resulting explanation would not be a particularly good one because without it is not clear why one rather than the other noncausal *explanans* would be relevant for the *explanandum*, as well as why standing in a particular explanatory relation, and not in some other, would be explanatory.

Because T1 specifies the *explanans*, we could generalize this analysis to other kinds of noncausal explanations by replacing the "topological property" with "a canonical neural computation" (Chirimuuta 2018) for a noncausal computational explanation, "an abstract entity" (Pincock 2015) for an abstract explanation, "an optimality threshold" (Rice 2021) for an optimality explanation, or in general with any mathematical, metaphysical, or modal fact or property for other kinds of noncausal explanations. Furthermore, because the T3 specifies an explanatory relation between T1 and T2, we could also replace "counterfactual dependence" with "constraint," "entailment," "constitution," "grounding," and so on (Andersen 2018; Pincock 2018).

And here we can already see a problem, namely, T1 and T2 tell us what are the *explanantia* and *explananda*, but they don't tell us why this particular *explanans* is relevant for the *explanandum*, and not some other.[1] Even within topological explanations, the same topological property could be a result of very different connectivity patterns, for example, small worldliness can be achieved not only through high clustering coefficient and low average path length but also through presence of network hubs or hierarchical modular topology. Furthermore, the T3 tells us what the explanatory relation between T1 and T2 is. But it does not tell us why that particular explanatory relation is cited in this particular explanation and not some other. Finally, T4 tells us why certain properties and explanatory relations are relevant for the explanation.

My goals in this article are twofold: (1) to spell out in much more detail the explanatory relevance encapsulated in the T4 condition and (2) to show that this pragmatic view of explanatory relevance renders some alternatives, such as ontic backing,[2] superfluous.

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[1] In causal explanations, this could be achieved through interventions (Woodward and Hitchcock 2003).

[2] A requirement that *explanantia* and *explananda* have to correspond to some causal structures in the world, or that the counterfactual dependence needs further backing in terms of its truth makers.

To develop this argument, I proceed as follows: Section 2 provides a philosophical analysis of topological explanation as an instance of noncausal explanation, which has the explanatory relevance criteria already built in T4. In section 3, I unpack those criteria and provide a general account of pragmatics of noncausal explanations. In section 4, I show how this account avoids the ontic backing problem. Finally, in section 5 I discuss some broader lessons that can be drawn from this account of pragmatics of noncausal explanation.

2. An analysis of topological explanations

To appreciate this idea, it is important to provide some background about how the T1–T4 schema is used in actual science and, in this particular example, in neuroscience.

A central issue in network neuroscience is the relationship between structure and function. "Structure" refers to networks of anatomical connections in the brain, also known as structural connectivity models. In structural connectivity models, the connections between nodes are based on physical connections between brain areas. However, "function" refers to various ways in which information is transmitted in the brain. Functional connectivity models define edges based on statistical relations between area activity time series, such as a correlation coefficient, or synchronization index. Both types of connectivity are physically embedded in the 3D volume of the human skull.

Such physical embedding should be guided by some natural constraints on development and evolution of brain networks. The most salient feature of brain networks is unexpectedly short structural edges, also known as "wires." This feature is indicative of wiring minimization in the evolution and dynamics of brain networks (Stiso and Bassett 2018, 256). Presumably, wiring minimization allows for efficient information processing in the system, where efficiency can be understood as low metabolic cost for establishing or maintaining connections. In terms of topological properties, wiring minimization is characterized by fewer long-range wires, which in turn facilitates redundancy and dynamical complexity (ibid., 257). To understand how wiring minimization differs across individuals in healthy brains and in neurodevelopmental disorders such as schizophrenia Stiso and Bassett suggest looking into the volumetric constraints on the wiring minimization. A way to do it is by examining the Rentian scaling properties of the 3D volume of the human skull. Such properties are assessed by calculating Rent's exponent (which quantifies the fractal scaling of the number of connections to or from a region of the brain). In the context of brain networks, the Rent's exponent is computed by placing randomly sized boxes (which capture the volume of the human brain in three geometric dimensions), and then by counting the number of edges crossing the boundary of a given box, as well as the number of nodes contained in the box. Their explanation of how topological structure explains cognitive function describes counterfactual dependence between wiring minimization and Rentian scaling (ibid., 259). In this case, the explanation-seeking question is:

> *Why are characteristic edge lengths short in spatially embedded brain networks in healthy subjects?*

The answer is that the topological volumetric constraints determine the wiring costs in the evolution and development of brain networks, and wiring costs are inversely proportional to the efficiency in both signal processing and establishing new connections. This also bears on understanding the differences in topological properties in health and in neurodevelopmental disease. For example, path length (an average number of edges that need to be traversed in a network) in healthy brains is short (meaning that fewer number of edges need to be traversed to reach any node in a network), which enables very efficient signal processing across brain areas. In contrast, path length is longer in Alzheimer's disease or schizophrenia, which—given the same volumetric constraints of the human skull as in healthy brains—explains why in such disorders signal processing is inefficient or even disrupted.

At this point we can apply the analysis of topological explanations from the preceding section to this example:

(T1) The brain functional connectivity network (*a*) has a Rent's exponent (*F*).

(T2) The brain functional connectivity network (*a*) displays wiring minimization (*G*).

(T3) Had the Rent's exponent been higher (*F'*) the wiring minimization would have been lower (*G'*).

(T4) That the brain functional connectivity network (*a*) has a low Rent's exponent (*F*), is an answer to the question "why is wiring minimization in healthy subjects high (*G*)?"

And here is where the T4 condition provides relevance criteria for both the *explananda* and *explanantia* as well as for the explanatory relation. Unpacking this condition, which is the goal of the next section, effectively provides an account of explanatory relevance for noncausal explanations.

3. Perspectival constraints, why questions, and explanatory relevance

Following van Fraassen's claim that all explanations are answers to why questions (Van Fraassen 1980), topological explanations are such answers, in which *explanantia* and *explananda* stand in a counterfactual dependence relation, that is, the why question "why is wiring minimization in healthy subjects high (rather than low)?" is answered by the counterfactual "had the brain functional connectivity networks in healthy subjects had a Rent's exponent *F* rather than *F'*, it would have displayed wiring minimization *G* rather than *G'*," where *F* and *F'* are topological *explanans* properties and *G* and *G'* are physical *explanandum* properties.

The task of showing how the T4 condition provides explanatory relevance criteria, can be broken down into two more manageable chunks. One is to define what an explanation-seeking question is. And the other is to identify conditions when it is relevant. I take each of these tasks in turn in the following subsections.

3.1 What is an explanation-seeking question?

To date, van Fraassen (1980) has provided the most prominent account of why questions. According to van Fraassen, and applied to the account of topological explanation from section 2, an explanation-seeking question is defined by:

Q1. Its topic, *a is G*.
Q2. Its foil, *a is G'*.
Q3. Its relevance relation *R*.[3]

My account of the pragmatics of explanation puts further constraints on van Fraassen's Q3. The relevance relation can be formally expressed as:

> A proposition "*a* is *F*" stands in relation *R* to the contrast "*a* is *G* rather than *G'*" only if there is some property F' such that the following counterfactual is true:

a. Had *a* been *F'* rather than *F*, then *a* would have been *G'* (rather than *G*), and
b. *F* is a relevant property (e.g., a topological property).

Whenever one of these conditions fails to hold, we do not have a properly formed why question. Now, one might wonder what else is needed to make "a is F" an answer to the why question. This is where the erotetic inference for deriving relevance criteria kicks in, which I discuss in the next subsection.

3.2 Relevance conditions for explanation-seeking questions

A fruitful route to identifying when an explanation-seeking question is relevant, as hinted earlier, is through the T4 condition that states: *a is F* is a topological explanation of why *a is G* only if *a is F* is an answer to the question *why is a, G?* The T4 here provides the explanatory relevance criterion. How the T4 performs this task can be unpacked using the erotetic reasoning (Wisniewski 1996).

Erotetic reasoning relies on the inferential patterns that determine both the questions and the space of possible answers to them. According to this view, questions can be conclusions in arguments that show how a question arises from certain contexts (Hintikka 1981; Khalifa and Millson 2020; Millson 2019; Wiśniewski 1996). We can identify questions with the set of propositions that constitute their possible (direct) answers. As mentioned earlier, this set can be determined by three elements: the topic, contrast class, and relevance relation. On this account, the topic is a proposition, the contrast class is a subset of consequences that follows from the disjunction of propositions that constitute the set of possible direct answers to the why questions, and the relevance relation is the relation in which possible answers stand to the topic. Based on this, the context of why questions entails at least one true direct answer from the disjunction of propositions that constitute a set of possible direct answers to a why question, and also that none of the other elements in the contrast class are true. For example, we can start from a set of propositions and derive questions from those statements:

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[3] Pincock (2018) has extended this analysis to noncausal explanations.

Explanandum: *a* is *G* rather than *G'*.

Example: *Wiring minimization in healthy subjects is high rather than low.*

There are some topological properties *F* and *F'* such that:

E1. *a* is *F* (but not *F'*).

Example: *The brain* functional connectivity network *has a low Rent's exponent, but not high Rent's exponent.*

E2. Had *a* been *F'* (rather than *F*), *a* would have been *G'* (rather than *G*).

Example: *Had the brain functional connectivity network in healthy subjects had a high Rent's exponent rather than low Rent's exponent, it would have displayed decreased efficiency in wiring minimization.*

E3. Why question: Why is *a G* (rather than *G'*)?

Example: *Why are characteristic edge lengths of spatially embedded brain networks in healthy subjects short (rather than long)?*

In this example, the erotetic argument starts with a statement about what it is for a certain arrangement to have a certain topological properties *F* and *F'*. This argument provides a set of *possible direct answers* to the why question, wherein at least one direct answer is true (*F* or *F'*). E1 in this erotetic argument constrains the range of relevant *explanans* properties (*F* or *F'*), and E2 is a proposition encapsulating the explanatory relation between them. Perhaps, it is a platitude that background assumptions determine the relevance of why questions. However, precisely what this means has been vague. My pragmatic account of explanatory relevance regiments that idea: background information determines a why question's relevance just in case that background information erotetically implies that question.

One might object that this account does not rule out silly proposition(s) in E1, for example, *the brain functional connectivity network has a low Rent's exponent, but blue ideas do not sleep furiously*. But one could only derive silly why questions from silly propositions in this way, and so, a relevant answer/explanation would be equally silly. This is as it should be, that is, this account concerns only the explanatory relevance of an answer to a why question. Inquirers' interests, hunches, or tinkering in the lab (Bickle 2021) are reasons why scientists find some propositions more worthwhile than others because science is a grassroot and open endeavor. Hence, scientists' open-ended inquiry uses background assumptions to determine which why questions (and contrast classes) are of interest and then the explanatory relevance criteria specify the range of answers to that why question.

With this, I have accomplished my first goal of providing an account of pragmatics of noncausal explanations. In the next section I apply this account of pragmatics of explanation to the ontic backing problem to accomplish my second goal.

4. Ontic backing, pragmatics, and explanatory relevance criteria

In this section I discuss how the account of pragmatics of explanation developed in the previous sections compares to some alternatives, such as the ontic backing. The ontic backing problem has been formulated in at least two senses. In one sense, it concerns the veridicality of *explanantia* and *explananda*. For example, Craver argues that functional connectivity models cannot be explanatory because they are not modeling the "right" kind of stuff (Craver 2016). This idea can best be understood in terms of Rice's (2019, 181–82) discussion[4] of the mechanistic decomposition strategy, which according to him involves the following assumptions:

(1) Target decomposition, that is, that the real-world system is decomposable into its difference-making component parts as well as its irrelevant parts;
(2) Model decomposition, that is, that a scientific model is decomposable so that the contributions of its accurate parts can be isolated from its inaccurate parts; and
(3) Mapping, that is, the accurate parts of a model can be mapped onto the relevant components of the real-world system and the inaccurate parts distort only the irrelevant parts (ibid.).

However, in functional connectivity models the brain is not decomposed into its difference making parts. The nodes in such a network are blood-oxygen level dependent (BOLD) signals in arbitrary chosen areas of the brain obtained from fMRI data sets and the edges are synchronization likelihoods between BOLD signals (Suárez et al. 2020).[5] As such, BOLD signals do not have distinct causal roles. This bears on the model decomposition as well because all the parts of the network model are inaccurate, that is, nodes and edges are not difference-making components but arbitrary parts. Finally, because there are no target nor model decompositions, that is, no difference making components and the whole network model is inaccurate, there cannot be any mapping between the accurate parts of the model to the relevant parts of the target real-world system either. Furthermore, Rent's exponent determines the wiring costs in any network, not just in spatially embedded brain ones, thus it is neither a difference maker in a system nor accurate part of the model. So, if the decomposition strategy does not even apply to functional connectivity network models, then indeed, what is the relevance of their topological properties to the physical phenomenon we are trying to explain?

A quick answer to this worry is that the conditions T1 and T2 in the general account of noncausal explanation are already veridical. For example, if contagion networks were not small world, then small worldliness (as a topological property F) does not explain why diseases spread as quickly as they do (empirical property G). So, even approximate measures of a topological property F and a physical property G, already suffice for explanation's connection to physical reality. Now, an approximate accuracy of *explanantia* and *explananda* alone does not guaranty explanatoriness, but supplementing it with the counterfactual dependence, as the T3 condition, as well as with the relevance criteria provided by T4, does.

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[4] Rice also argues against it.

[5] BOLD signals and synchronization likelihoods between them are data points in a data set.

However, even this is not the end of the worry, as ontic theorists do ask in virtue of what the counterfactual dependence holds, what are its truth makers?

For example, it has been argued recently that explanations, in which counterfactual dependence serves as an explanatory relation, require some kind of ontic backing to be explanatory (Craver and Povich 2017; Povich 2021). Povich (2021, 24) expresses this worry aptly:

> *In a DME [distinctively mathematical explanations-my clarification], when a natural fact counterfactually depends only on a mathematical fact, why does that dependence hold?*

Povich envisages several reasons due to which counterfactual dependence might hold, for example, when the *explanans* and *explanandum* are identical, the *explanans* constitutes the *explanandum*, the *explanans* causes the *explanandum*, and finally the *explanans* grounds, instantiates or realizes the *explanandum*. It is obvious that identity and causation are not appropriate candidates because causal and noncausal facts by the very definition cannot be identical (if a fact is causal, it cannot also be noncausal and vice versa). Furthermore, causation requires temporal distinctness (causes precede their effects) between the *explanans* and *explanandum*, which our example with Rentian scaling lacks. Hence, we are left with the metaphysical relations such as constitution, grounding, and instantiation/realization. According to this view, we need to appeal to ontic backers to distinguish explanatory models from merely descriptive/predictive models. Here, an "ontic backer" is a truth maker for the counterfactual claim. Povich and Craver set up this problem specifically in terms of directionality and asymmetry problems, that is, that noncausal explanations lacking ontic backing are susceptible to explanatory asymmetry and directionality problems. The directionality problems are germane to asymmetry problems, but instead of using a simple reversal, in directionality problems the reversal is a contraposition. The directionality problem arises when an account of explanation cannot flag instances of contraposition of a purported explanation as nonexplanation (Craver and Povich 2017; Kostić and Khalifa 2021). Kostić and Khalifa (2021, 19) formulate it in the following way:

Directionality Requirement: If X explains Y, then *not*-Y' does not explain *not*-X', where X and Y are highly similar but not identical to X' and Y', respectively.

In response to these specific arguments, Kostić (2020) and Kostić and Khalifa (2021) have developed a so-called ontic irrelevance lesson for solving the asymmetry and directionality problems in topological explanations. On their view, even though one can posit any variety of ontic backing that Povich suggests, it would be superfluous because topological explanations can avoid directionality problems solely based on the property; counterfactual and perspectival directionality/asymmetry, each of which stems from the T1-T4 conditions in Kostić's theory of topological explanations; and from the generalized theory of noncausal explanations developed in this article.

According to Kostić and Khalifa, a topological explanation is property directional when the explanans in an original explanation includes topological properties, but its contraposition does not. Topological explanation is counterfactually directional when in an original explanation counterfactual is true, but in its contraposition it is false. Note that this type of directionality does not concern the truth conditions of a counterfactual, it concerns merely how a counterfactual, and its contraposition are formulated. Finally, a topological explanation is perspectivally directional when an original explanation is an intelligible answer to an explanation seeking question, but its contraposition is not.

These three types of directionalities do not appeal to any kind of ontic backing that Povich requires. This is the core of ontic irrelevance lesson, that is, perhaps in some cases it would be possible to provide some sort of ontic backing, however, it would be superfluous because property, counterfactual, and perspectival conditions already ensure directionality on their own. The question is, could the ontic irrelevance lesson be generalized beyond asymmetry and directionality and apply to the general ontic backing problem?

As hinted earlier, the account of pragmatics of explanation is a fruitful route to answering this worry. One might ask under which conditions would an explanation require ontic backing? Prima facie, it seems plausible to assume that whenever the previously mentioned erotetic argument fails, it would be justified to ask for some alternative reason, such as ontic backing, why the counterfactual holds. However, imagine two situations:

> (S1) in which we can derive the appropriate why questions and relevance criteria, but for some reason the counterfactual dependence has no ontic backer, and
> (S2) in which we do not have relevance criteria, but we do have some kind of ontic backing.

It seems fair to say that in both situations it is not clear in what way the presence or absence of ontic backing contributes to explanatoriness. In S1, we know why the *explanandum* property G counterfactually depends on the *explanans* property F, that is, it is because *F* is erotetically implied direct answer to a properly formed why question. However, in S2, we know what is a truth maker for the counterfactual, but in the absence of relevance criteria we do not know why that particular truth maker and not some other ought to be cited in the explanation. Without explanatory relevance criteria even in situations in which some ontic backing is available, it is not clear why would ontic backing contribute to explanatoriness. Hence, the ontic backing seems like a superfluous requirement for explanatoriness in some noncausal explanations.

5. Conclusion

In this article I argued that some constraints on explanation are pragmatic, that is, by erotetically implying why questions from a set of propositions that encapsulate different epistemic perspectives, the T4 limits a space of possible direct answers to a why question, and, in that way, provides the explanatory relevance criteria. This account of pragmatics of explanation is based on erotetic reasoning that specifies the inferential patterns that determine both the questions and the space of possible answers to them. Finally, I used that account of pragmatics of explanation to argue that ontic backing is a superfluous requirement on some noncausal explanations. This approach then does not require any assumptions about notoriously difficult metaphysical notions such as truth makers either for *explananda* and *explanantia* or for the counterfactual dependence. In this way metaphysical commitments in such explanation are lessened.

Some important issues had to be left for future work because the format of this article does not leave enough room to discuss them properly. For example, given that my account of pragmatics of explanation is thoroughly perspectival, the next obvious issue to discuss is its relation to other accounts of perspectivism (Massimi 2022; Mitchell 2003; Giere 2006). Also, if the ontic backing is a superfluous requirement on noncausal explanations, does that raise a realism problem as it is typically argued in the so-called indispensability arguments (Pincock 2004; Baron et al. 2017; Colyvan 2010; Saatsi 2016; Baker 2005; Bueno and French 2012)? The worry is that if mathematical entities are indispensable to some scientific explanations, then should we have ontological commitment to such entities?

Finally, I see no reason why the same pragmatic account could not be applied to causal explanations as well, given that they too are answers to why questions, that involve *explananda*, *explanantia*, and some explanatory relation between them. I suspect the problem then would be in negotiating extant causal explanatory relevance criteria with the pragmatic ones. All these intricate questions showcase the richness of topological, and more generally noncausal explanations, and a possible applicability of this, or for that matter, any other account of pragmatics of explanation.

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