Contrastive Causal Explanation and the Explanatoriness of Deterministic and Probabilistic Hypotheses Theories

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Abstract: Carl Hempel (1965) argued that probabilistic hypotheses are limited in what they can explain. He contended that a hypothesis cannot explain why E is true if the hypothesis says that E has a probability less than 0.5. Wesley Salmon (1971, 1984, 1990, 1998) and Richard Jeffrey (1969) argued to the contrary, contending that P can explain why E is true even when P says that E's probability is very low. This debate concerned noncontrastive *explananda*. Here, a view of contrastive causal explanation is described and defended. It provides a new limit on what probabilistic hypotheses can explain; the limitation is that P cannot explain why E is true rather than A if P assign E a probability that is less than or equal to the probability that P assigns to A. The view entails that a true deterministic theory and a true probabilistic theory that apply to the same *explanandum* partition are such that the deterministic theory explains all the true contrastive propositions constructable from that partition, whereas the probabilistic theory often fails to do so.

keywords: contrastivism, determinism, explanation, explanatoriness, probability.

1 Introduction

Hempel (1965) argued that if hypothesis H explains why E is true, then H must confer on E a probability that is greater than 0.5. Salmon (1971, 1984, 1990, 1998) and Jeffrey (1969) argued to the contrary by appealing to persuasive examples like the following. In Mendelian genetics, if an offspring is an AA homozygote, this would be explained if its parents are both AB heterozygotes, even though the probability that that parental pair will produce an AA offspring is only 0.25. The process of haploid gamete formation and the coming together of sperm and egg in reproduction to form a diploid embryo is doing the explaining. I think that Salmon and Jeffrey were right and Hempel was wrong here, and I will assume that that is true in what follows.

The question concerning what a probabilistic theory can explain is different from a second question: if probabilistic theory P and deterministic theory D both explain why E is true, does the deterministic theory provide the better explanation? Jeffrey (1969) and Salmon (1971, 1984, 1990, 1998) took a stand on this second question as well. They were "egalitarians," claiming that a theory that says that a given *explanandum* has a low probability can be just as explanatory as a theory that says that that *explanandum* has a high probability. Strevens (2000, 2008) argues for the contrary position (i.e., for "elitism") by presenting historical case studies. Clatterbuck (forthcoming) rightly criticizes Strevens's argument. The main problem discussed in what follows is neutral on the starting question of this paragraph, which assumes that D and P each explain E and asks which explanation is better. I'll touch on it briefly, but my main task is to describe a type of proposition that true deterministic theories *always* explain, but which true probabilistic theories often cannot explain *at all*.

The propositions I have in mind are contrastive; they assert that E is true rather than A. Dretske (1972), Van Fraassen (1980), and Garfinkel (1981) argued that all explanations are contrastive. Their idea can be conveyed, well enough, by an example from Garfinkel. To explain why *Willy Sutton robbed banks*, you need to explain why that proposition, rather than an alternative proposition, is true. There are multiple options for that alternative from which to choose. For example, you might seek to explain why

Willy robbed *banks* rather than candy stores,

or why

Willy *robbed* banks rather than painting them pink,

or why

Willy rather than Sue robbed banks.

Each of these propositions is contrastive; each contrasts a proposition said to be true with a proposition said to be false. The thesis that explanation is contrastive says this: if E is a noncontrastive proposition, an explanation of why E is true must explain why E is true rather than some contrasting alternative A, and there are multiple choices for what that contrasting alternative might be.[1] Different choices of alternative constitute different explanatory problems. As the Willy Sutton examples suggest, asking why a proposition rather than its negation is true often fails to identify a definite question; typically, E and A are contraries, not contradictories.[2] In what follows, I'll focus on causal explanations that address contrastive *explananda*; I will not assume that all explanations are contrastive, nor that all explanations are causal.

Although Salmon and Jeffrey put probabilistic and deterministic explanations on a par, a difference in their explanatoriness can be found in connection with contrastive causal explanations. My main thesis is this:

> When a true deterministic causal hypothesis D and a true probability hypothesis P both apply to the same *explanandum* partition, D explains every true contrastive proposition constructed from that partition, whereas P often does not.

The concept of an *explanandum* partition and the concept of a hypothesis's applying to a partition will be clarified in due course.

Some groundwork is needed before I can argue for this main thesis. In Section 2, I discuss the conflict that several philosophers have seen between contrastivism and the thesis that P can explain E even though P says that E was very improbable. In Section 3, I criticize three proposals concerning what it is to explain why E is true rather than A. In Section 4, I present and defend a view of what a contrastive causal explanation amounts to, which I call CON. In Section 5, I use CON to defend my main thesis. I discuss that thesis in Section 6, and offer some concluding comments in Section 7.

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[1] There is a second contrastive thesis about explanation; it concerns the *explanans*, not the *explanandum*: Is the question of whether hypothesis H explains why E is true rather than A incomplete until H is contrasted with an alternative hypothesis? I'm inclined to think that the answer is *no*, but will not discuss this issue here.

[2] Existence claims are exceptions; the question of why there are some tigers rather than none at all is well-posed (Sober 1986).

2 Does Contrastivism conflict with Egalitarianism?

Although Salmon (1984, 1990, 1998) contends that an explanation of E can say that E was very improbable, he opposes the view that all explanations must have contrastive *explananda*. Here's the sort of example that moves him: You sample from an urn with the result that the ball you draw is green. What explains this result? Salmon thinks this outcome is explained by the fact (if it is a fact) that you drew at random from an urn in which 20% of the balls are green and the rest are red. He thinks, in addition, that the composition of the urn does not explain why you drew a green ball rather than a red one. I agree with both these judgments, but I think they pose no threat to contrastivism. To explain why the ball you drew was green, contrastivism requires that a contrasting alternative be supplied, but it is no commitment of that *ism* that the alternative must be the drawing of a red ball. A different contrast to consider is drawing a ball that is purple. This allows you to conclude that the 20%Green−80%Red composition of the urn explains why the ball you drew was green rather than purple.[3]

One might object that it isn't legitimate to consider the possibility that the ball is purple because the hypothesis that 20% of the balls are Green and 80% are Red doesn't call the purple possibility to mind. My reply is that the hypothesis *entails* that the probability is zero that the ball is purple, and that what comes to mind is a psychological matter that has no place in an "ontic" approach to explanation of the sort that Salmon (1990) embraced, and which I am assuming in this paper.

3 Three interpretations of what it takes to explain why E is true rather than A

Before comparing how a deterministic and a probabilistic theory answer the question "Why is E true rather than A?" we need to get clear on what this why-question means. A good place to begin is the following thesis:

(DEF) X explains why E is true rather than A precisely when X explains why E&notA is true.

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[3] Hitchcock (1999) presents textual evidence that Lewis (1986), Railton (1981), and Salmon (1984) believed that contrastivism about explanation entails that explanations must be deterministic. Hitchcock argues that this does not follow, as does Ylikoski (2001).

DEF is deflationary, in that it equates explaining a contrastive proposition with explaining a noncontrastive conjunction. Even so, DEF seems to preserve the contrastivist idea that the explanation of why E is true rather than A can differ from the explanation of why E is true rather than B; DEF says that these explanations are distinct when E&notA and E&notB are not equivalent.

That said, DEF is defective when E, A, and B form a partition (meaning that the three propositions are pair-wise incompatible and jointly exhaustive). If explaining why E is true rather than A is equivalent to explaining why E&notA, and given that this conjunction is equivalent to E&(EvB), it follows from DEF that you can explain why E is true rather A just by explaining E. Similarly, if explaining why E is true rather than B is equivalent to explaining why E&notB, and given that this conjunction is equivalent to E&(EvA), it follows from DEF that you can explain why E is true rather than B just by explaining E. Two problems for DEF thereby arise. First, if E is noncontrastive, "explaining why E is true" is often an incompletely specified task. Secondly, the propositions that explain why E is true rather than A often need to differ from the propositions that explain why E is true rather than B. For example, the explanation of why Willy robbed the bank rather than the candy store may be that the bank had more money on hand than the candy store did, while the explanation of why Willy robbed the bank rather than the bar may be that bar owners have weapons at hand that they are willing to use, whereas bank tellers do not. The task of explaining why E is true rather than A does not reduce to the task of explaining why E&notA, so long as E and A are exclusive but not exhaustive.

Lipton's (1993) approach to understanding the question "Why is E true rather than A?" is more satisfactory. He begins with a simple example (p. 76) − the question of why Jones rather than Smith has paresis. Lipton's answer is that only Jones had tertiary syphilis.[4] Lipton uses

[4] Lipton's example is inspired by Scriven's (1959) introduction of paresis and syphilis into philosophical discussion of explanation. Only a minority of people with tertiary syphilis develop paresis, but only those suffering from tertiary syphilis can develop paresis. Scriven does not discuss the contrastive task of explaining why E is true rather than A.

this example to motivate a general thesis, which he formulates as follows (I've adjusted his notation):

(L) To explain why E rather than A, you need to find a causal difference between E and not-A, consisting of a cause of E and the absence of a corresponding event in the history of notA.

Lipton's L thesis looks good when it is applied to his Jones/Smith example, but matters change when other examples are considered. For example, consider the question of why a coin landed heads rather than tails. If the coin is heavily biased in favor of heads, you have an answer. The bias of the coin explains both why the coin landed heads and why it failed to land tails. And one explanation for why Willy robbed the bank rather than the candy store is that he believed that the bank had more money than the candy store, and he wanted to maximize his cash flow.

In the paresis example, the explanation that Lipton constructs cites two separate and causally independent histories for Jones and Smith. In the coin-tossing example and the example about Willy's choice of bank over candy store, a common cause does the explaining. So L's separate-cause pattern is right for some why-questions, but wrong for others. Which pattern is right depends on facts specific to the problem at hand. For example, why did Willy rather than Sue rob the bank? The answer may be that they were members of the same gang and they tossed a coin, with heads meaning that Willy would rob the bank and tails meaning that Sue would do the deed, and the coin landed heads. Here we have the common cause pattern. But now consider an alternative story. Willy and Sue never knew each other, Willy decided to rob the bank, but Sue never even considered robbing a bank. Here we have the separate cause pattern described by L. Since background information is *always* relevant to deciding whether the question of why E is true rather than A should be answered by citing separate causes or by invoking a common cause, it follows that the contrastive why-question by itself does not settle which pattern is right.

Lipton's principle L proposes a necessary condition for answering a contrastive why-question, and I have tried to show that the condition isn't necessary. Sober (1986, p. 145) makes the complementary mistake, claiming that "Why is E true rather than A?" presupposes that E and notA have a common cause. Lipton's Jones/Smith example shows that that is wrong too. For all I've said, Lipton's condition and Sober's may each be sufficient. If so, maybe a necessary *and* sufficient condition can be described that subsumes the separate cause and the common cause patterns as special cases. I'll explore that possibility in the next section.

The third account I want to discuss of what explaining why E is true rather than A amounts to is developed by Hitchcock (1999). He says that "X is explanatorily relevant to the contrastive question 'Why E rather than A?' when $Pr(E \mid X \& B \& (EvA)) \neq Pr_b(E \mid B \& (EvA))$ (p. 587)."[5] Hitchcock (p. 601) says that the "v" in this expression represents the exclusive *or*. B represents background assumptions. Hitchcock's probability condition can be simplified by baking B into the probability function and writing

(H) $Pr_B(E \mid X \& (EvA)) \neq Pr_B(E \mid (EvA))$.

Notice Hitchcock's wording; he states a sufficient condition for X's being relevant to a *question*, not a sufficient condition for X's *explaining why E rather than A*. Hitchcock (1999) thinks these are equivalent (as does Humphreys 1989), but I disagree. Hitchcock's H is equivalent to:

(H′) $Pr_B(A \mid X \& (EvA)) \neq Pr_B(A \mid (EvA))$.

Putting H and H′ side-by-side shows that Hitchcock's account does not require an explanation of why E is true rather than A to describe a respect in which E differs from A that goes beyond the fact that E is true and A is false. Rather, H and H′ describe how E and A are the same; under the assumption that EvA is true, E and A each have their probabilities changed by X. However, explaining why E is true rather than A requires you to cite a factor that distinguishes E from A, other than the mere fact that E is true and A is false (Sober 1986, Ylikoski 2001). Even if Hitchcock is right about explanatory *relevance*, the explanatory relevance of X to the question of why E is true rather than A is not enough for X to explain why E is true rather than A.

Although Hitchcock's use of "when" rather than "precisely when" in the quoted passage indicates that he is offering only a sufficient condition, he later summarizes his view like this: "To provide a contrastive explanation is to provide information that is explanatorily relevant to the *explanandum*, given the presupposition that is expressed by the contrast (p. 608)." As

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[5] Whenever I use a probability function, the arguments of that function should be understood as elements of an algebra on some exhaustive set of possibilities, and all conditional probabilities are calculated via the ratio formula.

before, Hitchcock is glossing explanatory relevance in terms of probabilistic relevance, but here he is proposing a necessary and sufficient condition.

Why does Hitchcock think that the explanatory relevance of X to the question "Why is E true rather than A?" should be decided by comparing probabilities that both conditionalize on EvA? Hitchcock (p. 602) says that EvA is the presupposition that is "relevant" to the explanatory question. But why is it and it alone the right presupposition on which to conditionalize? H might be the right criterion if the proposed *explanans* included the assertion that X is true and E and A are the only possible outcomes of the process described by X. However, if there are more possibilities than just E and A, the H criterion is inappropriate and one then might want to conditionalize on a disjunction that is logically weaker than EvA.[6] The more general point is that the choice of propositions one should conditionalize on in deciding about the explanatory relevance of X to the question of why E is true rather than A depends on the details of what X says. The why-question by itself doesn't settle this. You can *ask* why Willy robbed banks rather than candy stores without assuming that those were his only two possibilities concerning what to rob. Ditto for *answering* the question. Notice that "Willy robbed banks rather than candy stores" is compatible with "Willy robbed banks rather than candy stores, and he robbed banks rather than bars."[7]

My suggestion − that statement S's presupposing T does not entail that T must be part of the explanation of why S is true – gains further credence from a Strawsonian view of presupposition.[8] Strawson (1952) maintained that statement S presupposes T precisely when T

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[6] There are nontrivial probability distributions on which "$Pr_B(E \mid X \& (EvA)) \neq Pr_B(E \mid (EvA))$" and $Pr_B(E \mid X \& (EvAvF)) \neq Pr(E \mid EvAvF)$" have different truth values. My thanks to William Roche for finding examples on *Mathematica*.

[7] Here I disagree with the claim made in Sober (1986, p. 144) that the disjunction EvA is "insertable" into an explanation of why is E true rather than A, where "insertable" is a term of permission, not obligation. I think there is no such blanket permission.

[8] I bring this up even though Hitchcock does not reference Strawson and says that his ideas on presupposition are broadly consonant with those of Stalnaker (1973) and Lewis (1983). Hitchcock also says that his ideas about presupposition are neutral on the question of whether

must be true if S is to be either true or false. This idea does not say anything about what it takes for a question to presuppose that T is true, but that deficiency is easily remedied by the following proposal:

(Q) The question "why is E true rather than A?" presupposes the same propositions that the statement "E is true rather than A" presupposes.

When a presupposition of a question is false, the question has no answer, and the question should be rejected; the question might then be said "to not arise" or "to not be in order" (Bromberger 1966; Van Fraassen 1980).

Strawson's theory of presupposition entails the following principle:

(PRESUP) If S presupposes T, and T entails C, then S presupposes C.[9]

The statement "E is true rather than A" presupposes that E&notA is true, so PRESUP indicates that the quoted statement also presupposes all consequences of E&notA. This means that the contrastive statement presupposes E, notA, EvA, EvnotA, notEvA, EvF, EvAvF, and so on. Given the Q proposal and the Strawsonian picture of presupposition, Hitchcock was right to say that the question "why is E true rather than A?" presupposes that EvA is true. His mistake was in thinking that the EvA presupposition must be conditionalized on in deciding whether X answers the why-question.

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presupposition is a semantic or a pragmatic concept. Indeed he seems to like both approaches; he talks about what a *question* presupposes and also about what a *person* presupposes when he or she asks a question of someone else. However, the work that Hitchcock does with the concept of presupposition is resolutely centered on the semantics. His theory describes what a why-question presupposes, and he proposes a test for whether a given proposition answers a why-question.

9 This principle holds for nonStrawsonian accounts of presupposition, provided that they say that S presupposes P precisely when something "bad" happens to S if P is false. It is up to a theory of presupposition to say what that bad outcome is; one option is to say that "bad" means that S is false; another is to say that "bad" means that S is nonsensical.

5 CON

The previous discussion of the deflationary theory DEF, Lipton's L, and Hitchcock's H sets the stage for the following proposal:

(CON) X provides a causal explanation of why E is true rather than A if and only if X, E, and notA are all true, X adequately describes events or processes that cause E to be true and also cause notA to be true, and $Pr_X(E) > Pr_X(A)$.[10,11]

X may itself be a contrastive statement, but my interest in what follows concerns contrasts in the *explanandum*, not in the *explanans*. X may describe a common cause or a pair of separate causes (or both). CON leaves open whether E is a deterministic or a probabilistic outcome of the events or processes that X describes. However, for X to explain why E is true rather than A, X must entail that E is a *possible* outcome of the event or process that X describes. In contrast, X need not say that A is possible; indeed, X may say that it is not. I take the probabilities mentioned in CON to be objective (in keeping with the broadly "ontic" view of explanation I mentioned earlier), but this leaves open whether a reductive interpretation of objective probability is possible.[12] I put "adequately" in CON to mark the fact that not just any description of the

[10] Here I write "$Pr_X(E)$" rather than "$Pr(E|X)$" because the standard definition of conditional probability says that $Pr(E|X) = Pr(E\&X)/Pr(X)$ if $Pr(X) > 0$. I want to be able to talk about the probabilities that hypotheses confer on *explanandum* propositions without having to assign probabilities to the hypotheses themselves. The subscript notation is used by Royall (1997) for the same reason.

[11] Strictly speaking, causation is a relationship between events (or facts), not between propositions, so my talk of causation as a relationship between propositions should be understood to indicate a causal relationship between the events (or facts) described by those propositions.

[12] And since CON will soon be applied to a true deterministic theory and to a true probabilistic theory that address the same *explanandum* partition, I'm assuming that objective probabilities

causing events or processes will do.[13] Finally, I note that CON does not say that all explanations are contrastive or that all explanations are causal; it merely describes what contrastive causal explanation involves.

I offer no reductive account of what the causal relation amounts to, but I find useful the nonreductive idea that an event c causes an event e precisely when manipulating the system so that it changes from some event c′ to c (where c′ ≠ c) would raise the probability of e; see Woodward (2003) for discussion.[14] Here "causes" and "prevents" are opposites; causes raise probabilities while preventors lower. The former are "positive causal factors" while the latter are "negative causal factors."[15]

To keep my account simple, I'll limit myself to causal variables that have just two states. The argument I'll make will apply to the fact that smoking tobacco rather than not smoking tobacco causes lung cancer, but not to how non-smoking, moderate smoking, and heavy smoking affect lung cancer. Extending the story told here to discrete n-state (n>2) and continuous causal

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that are strictly between 0 and 1 are compatible with an underlying determinism. See Sober (2011, Section 5.3) for discussion.

[13] Philosophers disagree about what a causal explanation is; for example, see Lewis (1986), Sober (1983, 2011), Skow (2014), Elgin and Sober (2015), Lange and Rosenberg (2011), and Lange (2017). Some of the insights from this literature may require CON to be fine-tuned. I hope those insights won't upset the apple-cart that I am pushing here.

[14] In order not to multiply notations beyond necessity, I will usually treat X, E, and A as propositions, but sometimes I'll treat them as events or states of a variable. I could introduce lower-case, x, e, and a for events (or states) and reserve capital letters X, E, A for the proposition that this or that event (or state) has occurred (or is instantiated), but that seems to me to be unnecessary since context indicates which of these I am talking about.

[15] A lot of current philosophical discussion of causation focuses on causal variables, and authors who think along those lines sometimes see no point in distinguishing events that causally promote from events that tend to causally prevent. It's interesting that contrastive explanations force one to consider distinct states of a single effect variable; variable-talk is not enough.

variables is a project for the future. However, I place no such restriction on the finite number of alternative states an effect variable may have, for reasons that will become clear.

If D is deterministic and true, then the event to which it assigns a probability of 1 must happen, and events to which D assigns a probability of 0 cannot (where the number of conceivable outcomes is finite). When this D explains why one event rather than another happened, it automatically obeys the probabilistic constraint described in CON. The nontrivial question about CON concerns whether a true probabilistic theory must obey it. I think that $Pr_X(E) > Pr_X(A)$ is a necessary condition for X to provide a causal explanation of why E is true rather than A, regardless of whether X is deterministic or probabilistic. X must "favor" E over A if X is going to explain why E *rather than* A is true.[16] The fact that a coin is fair does not explain why it landed heads rather than tails. And the fact that a coin is biased in favor of tails does not explain why the coin landed heads rather than tails.[17]

What does CON say about Lipton's example of paresis and syphilis? It entails what Lipton says: the fact that Jones rather than Smith has paresis is explained by the fact that Jones had tertiary syphilis while Smith did not. Tertiary syphilis causally promotes paresis, so the absence of tertiary syphilis promotes the avoidance of paresis. But now let's consider a slightly different example. Does tertiary syphilis explains why Jones contracted paresis rather than avoiding that ailment? CON says *no*; tertiary syphilis causally promotes paresis, but the syphilis does not favor paresis over non-paresis. Does tertiary syphilis explain why someone avoided paresis rather than getting that disease? CON says *no* here too; tertiary syphilis favors avoiding

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[16] The favoring described here differs from the favoring described in the law of likelihood, on which see Hacking (1965) and Sober (2015).

[17] These claims about the two coins, if true, show why X's raising the probability of E and lowering the probability of A isn't sufficient for X to explain why E is true rather than A. Suppose you toss a fair coin and it lands heads. Suppose, further, that if you hadn't tossed a fair coin, you would have tossed a coin that is biased in favor of tails. This means that tossing the fair coin raised the probability of heads (and lowered the probability of tails), but the fact remains that your tossing the fair coin doesn't explain why it landed heads rather than tails.

paresis over contracting that disease, but syphilis doesn't causally promote the avoidance of paresis. I think these consequences are as they should be.

CON, I submit, avoids the mistakes that undermine the accounts described in the previous section of what it takes to explain why E is true rather than A. The deflationary theory DEF has an implausible consequence; it entails that you can explain why E is true rather than A just by explaining E, when E, A, and B form a partition. CON does not make that mistake. CON also avoids Lipton's (1993) error of demanding that the explanation of why E is true rather than A must describe separate causal histories for E and notA, and it also avoids the complementary mistake that Sober (1986) makes when he says that the explanation of why E is true rather than A must postulate a common cause of E and notA. Hitchcock's account, I've argued, errs when it asserts that an explanation of why E is true rather than A need only describe a way in which E and A are the same, and CON avoids that mistake as well. In addition, CON avoids a second mistake in Hitchcock's account, namely his claim that whether X answers the question "why is E true rather than A?" must be addressed by conditionalizing on EvA.

A fuller exploration of CON is worth undertaking, but at this point I'm going to assume that CON is true, and use that criterion to argue for my main thesis.

6 The Main Thesis

My main thesis is restricted to a comparison of a true probabilistic theory P and a true deterministic theory D that apply to the same finite *explanandum* partition $\mathbf{C} = (C_1, C_2, \ldots, C_n)$. For the probabilistic theory P, its applying to that partition means that P says that the n members of **C** are pair-wise incompatible, P assigns a probability to each member of **C**, at least two of those probabilities are positive, and the n probabilities sum to 1. For the deterministic theory D, its applying to the partition means that D says that the members of **C** are pair-wise incompatible, D entails one member of **C**, and D also entails that all the others are false.

The contrastive explanatoriness that a true theory T has, relative to an n-membered *explanandum* partition to which T applies, is to be understood as follows. Suppose C_t, a member of the partition, is true and the other $n-1$ members are false. There therefore are $n-1$ true contrastive propositions constructable from this partition, each of the form "C_t is true rather than C_i" (where $i \neq t$). The contrastive explanatoriness that a theory has, relative to this partition, goes up as the number of true contrastive propositions that the theory explains goes up. I don't want to say that the theory's contrastive explanatoriness is *proportional* to the percentage of true contrastive propositions it explains. That would mean that a theory that explains 6 out 10 contrastive propositions is twice as explanatory as a theory that explains just 3. And I don't want to compare the contrastive explanatoriness of two theories that apply to different *explanandum* partitions, nor do I want to compare the contrastiveness that a single theory has relative to one partition with the explanatoriness it has relative to another. If one theory is more explanatory than another relative to a shared partition in the sense just defined, it does a more "thorough" or "complete" job of explaining the true contrastive propositions constructable from that partition. This is different from a theory's scope or generality, which are often understood in terms of the number or variety of real-world systems to which a theory applies.

I'll now use CON to argue that a true deterministic theory often explains more contrastive facts than a true probabilistic theory does, relative to a shared finite *explanandum* partition. In developing this argument, I'll assume, in agreement with Salmon and Jeffrey, that a hypothesis H can explain why E is true rather than A even when H says that E was very improbable. My argument is made simpler by using this idea, but the argument can be reformulated without it, as I'll explain in the next section.

First, let's nail down the straightforward picture of how a true deterministic theory D bears on a finite *explanandum* partition to which it applies. Here applicability means that there exists a member of the **C** partition, C_i, such that

$$Pr_D(C_i) = 1 > Pr_D(C_j) = 0, \text{ for all } j \neq i.$$

If D is true, and D entails C_i, then C_i must be true. Given this, CON entails that the deterministic theory D explains $n-1$ contrastive facts, each of the form "C_i is true rather than C_j" (where $j \neq i$). Theory D thus explains *all* of the true contrastive propositions constructable from the **C** partition; D thus has *maximal* contrastive explanatoriness, relative to the partition. No true probability theory P can do better.

A true probabilistic theory P that applies to the **C** partition will either explain all $n-1$ contrastive facts, or it will explain fewer. Indeed, it's possible that P explains *none* of those contrastive facts. If so, P has *minimal* contrastive explanatoriness, relative to **C**.

It's easy to see what it takes for a probabilistic theory P to achieve maximal contrastive explanatoriness relative to partition **C**. If the probability that P assigns to C_i is greater than the probability it assigns to C_j (for all $j \neq i$) and C_i is true, then (according to CON) P achieves maximal contrastive explanatorinesss; P explains all $n-1$ of the true contrastive propositions constructable from **C**. However if P assigns to C_i a probability that is less than or equal to the probability it assigns to C_j (for all $j \neq i$) and C_i is true, then P has no contrastive explanatoriness with respect to **C**. An example of this worst-case scenario arises when the probability distribution that P assigns to the members of the **C** partition is flat.

Having just described best- and worst-case scenarios for the probabilistic theory P, I want to describe a simple situation in which P's degree of contrastive explanatoriness is in between. Suppose that the probabilities that theory P assigns to the members of **C** are *all positive* and *all different*; this theory is APAD, for short. The APAD property means that we can arrange the propositions in **C** in order of the increasing probability they have, according to theory P. In this arrangement, $Pr_P(C_j) < Pr_P(C_{j+1})$, for all $1 \leq j < n$. Now there are several cases to consider:

- First, suppose that C_n is true. Then, according to CON, P explains why C_n rather than C_j is true, for all $j < n$. So P explains $n-1$ contrastive facts.

- Second, suppose that C_{n-1} is true. Then, according to CON, P explains why C_{n-1} rather than C_j is true, for all $j < n-1$, but P does not explain why C_{n-1} is true rather than C_n. So P explains $n-2$ contrastive facts.

- Third, suppose that C_{n-2} is true. Then, according to CON, P explains why C_{n-2} rather than C_j is true, for all $j < n-2$, but P does not explain why C_{n-2} is true rather than C_n, nor does P explain why C_{n-2} is true rather than C_{n-1}. So P explains $n-3$ contrastive facts.

And so on down the line. At the bottom of the list, C_1 is true, so CON entails that P fails to explain why C_1 is true rather than C_j, for each j such that $1 < j \leq n$. Thus, if **C** is a partition, relative to both a true deterministic theory D and a true probabilistic theory P, then D explains every true contrastive proposition constructable from that partition, whereas P, if it is APAD, will fail to do so if the true proposition in the partition isn't the one that P says is most probable.

In addition, the explanatory gap between the two theories widens as the true proposition in the partition gets lower and lower in the probability ordering that P entails.

What if the probabilistic theory P is not APAD? There are two types of probabilistic theory to consider here. There are probabilistic theories that assign probabilities to the members of **C** that are all *positive* though some are *equal*, and there are probabilistic theories that assign probabilities that sometimes are equal to zero. Delving into this space of possible theories may be worthwhile, but this detail need not detain us, since the main result is now in place: *a true probabilistic theory* P *can't have greater contrastive explanatoriness than a true deterministic theory* D*, relative to partition* **C**. *The only way that* P *can have the same degree of contrastive explanatoriness is if* P *assigns to* C_i *a probability that is greater than the probability P assigns to* C_j *(for all* $j \neq i$*) and* C_i *is true.* This result is a consequence of the probabilistic inequality described in CON.

7 Discussion

The explanatory gap between deterministic and probabilistic theories widens if you apply Hempel's (1965) idea that probabilistic theory P can't explain C_i unless $Pr_P(C_i) > 0.5$ to contrastive explanations. The Hempelian formulation that results is that P can't explain why E is true rather than A unless $Pr_P(E) > 0.5$. This means that when you observe which member of the **C** partition is true, there are two possibilities. The first is that the partition has a member to which P assigns a probability greater than 0.5 and that proposition is true. In this case, there are $n-1$ contrastive propositions that the probabilistic theory P explains. The second possibility is that P doesn't assign a probability greater than 0.5 to any member of **C**, or it does but that's not the one that is true. In this case, the Hempelian idea entails that P can't explain any of the true contrastive facts constructable from the partition. Not surprisingly, the Hempelian idea entails that probabilistic theories often have less contrastive explanatoriness than the Jeffrey/Salmon idea says they have.

If you think of the propositions in the **C** partition as observation claims, the story told in the previous section involves a single observation. If you observe that C_i is true, and you know that C_i is a member of partition **C**, then you know that $n-1$ contrastive propositions are true; these several contrastive propositions derive from a single observation. Even so, the argument given in the previous section generalizes to the case in which there are numerous observations to which a deterministic theory D and a probabilistic theory P each apply. The previous example about the urn illustrates this point. Suppose you sample 1000 times (with replacement) from this urn, each time drawing a single ball, and you happen to obtain 205 green balls and 795 red ones. For each of the 795 red outcomes, the probabilistic hypothesis (that the sampling was random and the urn contains 20% green balls and 80% red) explains why the ball you drew was red rather than green, but for the 205 green outcomes, the hypothesis fails to explain why the ball was green rather than red. A true deterministic model would do much better.

A deterministic explanation for this data set will need to discern physical differences that the probabilistic explanation does not recognize. For example, the physical details of the sampling process that led to your drawing a red ball will have to differ from the physical details that led to your drawing a green one. And even among the red draws, the physical details may well differ, and the same is true for the green draws. The deterministic explanation may need to be a 1000-fold conjunction, with each conjunct telling a unique physical story that applies to a single outcome in your data set. This deterministic explanation disunifies the observations, whereas the probabilistic explanation unifies them. I don't conclude from this that the deterministic model isn't an explanation or that it's a terrible explanation (despite what Putnam 1975 maintains). The deterministic explanation is more detailed but less unifying, whereas the probabilistic explanation is less detailed but more unifying. Unification and detail are both explanatory virtues (Jackson and Petit 1992; Sober 1999, 2015).

The concept of a theory's contrastive explanatoriness that I have described in this paper is relative to an *explanandum* partition. Given this, there is a mistake that I want to identify. Suppose a deterministic theory D applies to only 50 real-world systems whereas a probabilistic theory P applies to those 50 and to 50 others. The greater generality of P is nice, but when D and P both explain what happens in a given system, you can't conclude that P provides the better explanation of what happens *there* from the fact that P explains what happens in *other* systems about which D says nothing. How generally applicable a theory is and how well it explains the contrastive propositions constructable from a single partition are different questions.

A referee has suggested that I consider contrastive propositions that take up more than two members of the n-membered *explanandum* partition **C**. For example, instead of looking exclusively at contrastive propositions that have the form "C_t is true rather than C_i," one could also consider propositions of the form "C_t is true rather than C_i or C_j" and propositions of the form "C_t or C_k is true rather than C_i or C_j." Happily, widening the problem in this way does not dislodge my main thesis.

I have compared deterministic theory D and probabilistic theory P relative to an explanation partition **C**, so the question may be raised as to how **C** should be constructed. For example, when I introduced the urn example, I described a probabilistic hypothesis that says that 20% of the balls in the urn are green and 80% are red, so there are only two possible outcomes of your drawing a single ball. These two outcomes form a partition, but so does the three-member partition that includes the ball's being purple. Does introducing this zero probability outcome to the partition open the floodgates? If the ball's being purple is added to the partition, what about the sundry other colors that one could mention? Where does the adding stop? The answer is that one should introduce these extra items only if there is a point in doing so. Adding purple makes sense because it shows that the probabilistic explanation of the sampling outcome has contrastive explanation would have been invisible if you had considered only the two-membered partition. However, putting lots more outcomes into a partition *may* be pointless. Indeed, it *is* pointless if the task at hand is to compare the contrastive explanatoriness of a true deterministic theory with the contrastive explanatoriness of a true probabilistic theory. You can add those extras if you want, but you are wasting ink in doing so.[18,19]

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[18] For those who are reluctant to include "additional" propositions in the *explanandum* partition to which probabilistic theory P assigns zero probability, I note that depriving the partition of those propositions further reduces the contrastive explanatory power of the probabilistic theory, and thus strengthens the main thesis of this paper.

[19] A partition that theory T says is exclusive and exhaustive can be expanded *ad infinitum* by adding new members to which T assigns zero probability. In doing so, T seems to achieve a degree of contrastive explanatoriness that approaches infinity, and that may seem to be an objection to the argument advanced here. My reply is that I never defined a measure of the absolute explanatoriness a theory. My exclusive focus was on comparing the contrastive explanatoriness of two theories, relative to a shared finite partition.

My comparison of a true probabilistic and a true deterministic theory that apply to the same *explanandum* partition has involved counting the number of true contrastive propositions that each theory explains, but I have not discussed the project of measuring how well the two theories explain a single contrastive proposition. This is where a theory of explanatory power would come in handy. Several measures of explanatory power[20] and of causal strength[21] have been proposed in the literature,[22] but these measures were constructed with noncontrastive *explananda* in mind. When it comes to contrastive explanatory power, CON provides some guidance. If a necessary condition for H to explain why E is true rather than A is that $Pr_H(E) > Pr_H(A)$, a natural suggestion for measuring H's contrastive explanatory power is the difference measure, $Pr_H(E) - Pr_H(A)$.[23] When a true deterministic theory D and a true probabilistic theory both explain why E is true rather than A (as judged by CON), D has the *higher* degree of explanatory power (as judged by the difference measure). Indeed D has the *highest* degree of explanatory power possible, since $Pr_D(E) – Pr_D(A) = 1$. However, a word of caution is in order here, which applies to both contrastive and noncontrastive explanatory power: if explanatory power is multi-dimensional (Ylikoski and Kuorikoski 2010), it may be impossible to represent explanatory power as a single number.

8 Concluding Comment

Hempel argued that a hypothesis that explains E must assign E a probability greater than 0.5; Jeffrey and Salmon replied that E can be explained by a theory that assigns E a very low probability. I think that Jeffrey and Salmon were right and Hempel was wrong, and it may seem to follow that probabilistic theories are just as explanatory as deterministic theories. I have argued that this picture comes to grief when contrastive explanations are considered. Whether or not all explanations are contrastive, many of them are, and a plausible characterization of

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[20] See, for example, Schupbach and Sprenger (2011) and Crupi and Tentori (2012).

[21] See, for example, Cheng (1997), Ay and Polani (2008), Fitelson and Hitchcock (2011), Korb *et al.* (2011), Janzing *et al.* (2013), Gerstenberg *et al.* (2015), and Sprenger (2018).

[22] Glymour (2015) criticizes these measures for the Bayesian framework they adopt.

[23] If the literature on measuring degree of Bayesian confirmation is any guide, there are many other measures of contrastive explanatory power to consider as well.

contrastive causal explanation includes the requirement that H explains why E is true rather than A only if $Pr_H(E) > Pr_H(A)$, or so I have argued. This probabilistic constraint is different from Hempel's, but it is a constraint nonetheless. It is in this context that one finds an asymmetry between deterministic and probabilistic explanations. A true deterministic theory often has greater contrastive explanatoriness than a true probabilistic theory (relative to a shared *explanandum* partition), but a true probabilistic theory never has greater contrastive explanatoriness than a true deterministic theory (relative to a shared partition).

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References

Ay, N. and Polani, D. (2008). "Information Flows In Causal Networks." *Advances in Complex Systems* (*ACS*) 11(01): 17-41.

Bromberger, S. (1966). "Why-Questions." In R. Colodny (ed.), *Mind and Cosmos*. Pittsburgh: University of Pittsburgh Press, pp. 86-108.

Cheng, P. (1997). "From Covariation to Causation - a Causal Power Theory." *Psychological Review* 104(2): 367-405.

Clatterbuck. H. (forthcoming). "A Defense of Low Probability Scientific Explanations," *Philosophy of Science*.

Crupi, V. and Tentori, K. (2012). "A Second Look at the Logic of Explanatory Power (with Two Novel Representation Theorems)." *Philosophy of Science* 79: 365–85.

Dretske, F. (1972). "Contrastive Statements." *Philosophical Review* 81: 411-437

Elgin, M. and Sober, E. (2015). "Causal, *A Priori* True, and Explanatory − A Reply to Lange and Rosenberg." *Australasian Journal of Philosophy* 93: 167-171.

Fitelson, B. and Hitchcock, C. (2011). "Probabilistic measures of causal strength." In P. McKay-Illari, F. Russo, and J. Williamson (eds.), *Causality in the Sciences.* Oxford, pp. 600-628.

Gerstenberg, T., Goodman, N., Lagnado, D., & Tenenbaum, J. (2015). "How, Whether, Why - Causal Judgments as Counterfactual Contrasts." *Proceedings of the 37th Annual Conference of the Cognitive Science Society*, Austin, TX, pp. 782-787.

Hempel, C. (1965). "Aspects of Scientific Explanation." In *Aspects of Scientific Explanation and Other Essays in Philosophy of Science.* Basic Books.

Janzing, D., Balduzzi, D., Grosse-Wentrup, M., Schölkopf, B. (2013). "Quantifying causal influences." *Annals of Statistics* 41(5): 2324-2358.

Korb, K., Nyberg, E., and Hope, L. (2011). "A New Causal Power Theory." In P. McKay-Illari, F. Russo, and J. Williamson (eds.), *Causality in the Sciences*, Oxford, pp. 628-653.

Kyburg, H. (1965). "Comment." *Philosophy of Science* 32:147-151.

Garfinkel, A. (1981). *Forms of Explanation − Rethinking the Questions of Social Theory.* New Haven: Yale University Press.

Glymour, C. (2015). "Probability and the Explanatory Virtues." *British Journal of the Philosophy of Science* 66: 591–604.

Hacking, I. (1965). *The Logic of Statistical Inference.* Cambridge: Cambridge University Press.

Hempel, C. (1962). "Deductive-Nomological vs. Statistical Explanation." *Minnesota Studies in the Philosophy of Science*, 3: 98-169.

Hitchcock, C. (1996). "The Role of Contrast in Causal and Explanatory Claims." *Synthese* 107: 395–419.

Hitchcock, C. (1999). "Contrastive Explanation and the Demons of Determinism." *British Journal for the Philosophy of Science* 50: 585–612.

Hitchcock, C. (2013). Contrastive Explanation." In M. Blaauw (ed.), *Contrastivism in Philosophy − New Perspectives*. Routledge, pp. 11-34.

Humphreys, P. (1989). *The Chances of Explanation.* Princeton: Princeton University Press.

Jackson, F. and Pettit, P. (1992). "In Defense of Explanatory Ecumenism." *Economics and Philosophy* 8(1): 1-21.

Jeffrey, R. (1969). "Statistical Explanation vs. Statistical Inference." In N. Rescher (ed.), *Essays in Honor of Carl G. Hempel.* Dordrecht, D. Reidel, pp. 104-113.

Lange, M. (2017). *Because without Cause − Non-Causal Explanations in Science and Mathematics*. Oxford: Oxford University Press.

Lange, M. and Rosenberg, A. (2011). "Can There Be *A Priori* Causal Models of Natural Selection?" *Australasian Journal of Philosophy* 89(4): 591-599.

Lewis, D. (1983). "Keeping Score in a Language Game." in *Philosophical Papers − Volume I.* Oxford: Oxford University Press, pp. 243–249.

Lewis, D. (1986). "Causal Explanation." In *Philosophical Papers − Volume 2*. Oxford: Oxford University Press, pp. 214-240.

Lipton, P. (1993). *Inference to the Best Explanation.* London: Routledge.

Putnam, H. (1975). "Philosophy and our Mental Life." In *Mind, Language, and Realty.* Cambridge University Press.

Railton, P. (1981). "'Probability, Explanation, and Information." *Synthese* 48: 233–256.

Royall, R. (1997): *Statistical Evidence – a Likelihood Paradigm*. Boca Raton, FL: Chapman and Hall.

Salmon, W. (1971). "Statistical Explanation." in *Statistical Explanation and Statistical Relevance.* In W. Salmon (ed.), Pittsburgh: University of Pittsburgh Press, pp. 29–87.

Salmon, W. (1984). *Scientific Explanation and the Causal Structure of the World.* Princeton: Princeton University Press.

Salmon, W. (1990). *Four Decades of Scientific Explanation.* Pittsburgh: University of Pittsburgh Press.

Salmon, W. (1998). *Causality and Explanation.* Oxford: Oxford University Press.

Schupbach, J. and Sprenger, J. (2011). "The Logic of Explanatory Power." *Philosophy of Science* 78(1): 105-127.

Scriven, M. (1959). "Explanation and Prediction in Evolutionary Theory." *Science* 130: 477–82.

Skow, R. (2014). "Are There Non-Causal Explanations (of Particular Events)?" *British Journal for the Philosophy of Science* 65: 445-67.

Sober, E. (1983). "Equilibrium Explanation." *Philosophical Studies* 43: 201-210.

Sober, E. (1986). "Explanatory Presupposition." *Australasian Journal of Philosophy* 64: 143-149.

Sober, E. (1999). "The Multiple Realizability Argument Against Reductionism." *Philosophy of Science* 66: 542-564.

Sober, E. (2011). *Did Darwin Write the Origin Backwards?* Amherst, New York: Prometheus Books.

Sober, E. (2015). *Ockham's Razors – a User's Manual*. Cambridge: Cambridge University Press.

Sprenger, J. (2018). "Foundations of a Probabilistic Theory of Causal Strength." *Philosophical Review* 27(3): 371-398.

Stalnaker, R. (1973).: "Presuppositions." *Journal of Philosophical Logic,* 2: 447–457.

Strawson, P. (1952). *Introduction to Logical Theory.* London: Methuen.

Strevens, M. (2000). "Do Large Probabilities Explain Better?" *Philosophy of Science* 67: 366-90.

Strevens, M. (2008). *Depth − An Account of Scientific Explanation.* Cambridge, MA: Harvard University Press.

Van Fraassen, B. (1980). *The Scientific Image.* Oxford: Oxford University Press.

Woodward, J. (2003). *Making Things Happen.* Oxford: Oxford University Press.

Ylikoski, P. (2001). "Indeterminism and the Contrastive Theory of Explanation." In M. Kiikeri and P. Ylikoski (eds.), *Explanatory Connections – Electronic Essays Dedicated to Matti Sintonen.* url = *http://www.helsinki.fi/tint/matti/*.

Ylikoski, P. and, Kuorikoski, J. (2010). "Dissecting explanatory power." *Philosophical Studies* 148: 201-219.