Inference to the Best Explanation and Disjunctive Explanations

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ABSTRACT: In this paper I will examine Helen Beebee's argument that anti-Humeans are not in a better position to justify induction. I will first argue that her argument proves too much and that it can jeopardize the status of inference to the best explanation as a useful inductive principle. I will then propose a principle that should govern our use of disjunctive explanations in the context of inference to the best explanation and show that Beebee's use of disjunctive explanations violates this principle.

KEYWORDS: David Armstrong – Helen Beebee – Disjunctive explanation – Inference to the best explanation.

1. Explanationist approaches to the problem of induction and Armstrong's argument

By 'explanationist approaches to the problem of induction' I mean the attempts to justify inductive generalizations with inference to the best explanation (hereafter IBE). The overall strategy is as follows.

(1)   All observed Fs are Gs.

(2)   This observed regularity cries out for an explanation.

(3)   The best explanation *or* a consequence of the best explanation of this evidence is the corresponding general regularity that all Fs are Gs.

(4)   By IBE, we are justified to infer 'all Fs are Gs' from 'all observed Fs are Gs.'

Note that (3) is disjunctive, meaning that there are two ways for explanationists to go. Some explanationists think that the best explanation of 'all observed Fs are Gs' is that 'all Fs are Gs' (cf. Harman 1980). I will call them type-A explanationists. Other explanationists think that 'all Fs are Gs' is not the best explanation but a mere consequence of the best explanation (cf. Armstrong 1983; BonJour 1998; Foster 1983; Peacocke 2004). I will call them type-B explanationists.

David Armstrong is a type-B explanationist. He thinks that we can solve the problem of induction in the following way (see Armstrong 1983, 52-53):

(1)   All observed Fs are Gs.

(2)   This observed regularity cries out for an explanation.

(5)   The best explanation of this evidence is N(F,G)

(6)   By IBE, we are justified to infer N(F, G) from 'all observed Fs are Gs.'

(7)   N(F, G) entails 'all Fs are Gs.'

(8)   Therefore, we are justified to infer 'all Fs are Gs' from 'all observed Fs are Gs.'

According to Armstrong, N(F, G) is a necessitation relation and is wholly distinct from 'all Fs are Gs' even though the former entails the latter. Since Armstrong introduces a necessary connection between wholly distinct states of affairs (namely between N(F, G) and 'all Fs are Gs') his view is anti-Humean.

Armstrong's argument has two controversial steps. First, (6) is controversial because IBE itself is extremely controversial. Even though there are many philosophers who are suspicious of IBE, Armstrong does not provide a systemic justification of IBE.[1] So his argument is at best conditional; *if*

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[1]   For criticisms of IBE, see Salmon (2001), van Fraassen (1989). In fact, Armstrong (1983, 59) provides an argument for the rationality of IBE which I find neither systematic nor plausible.

IBE is justified then, unlike the Humean, the anti-Humean can solve the problem of induction. Second, and more importantly, (5) is controversial. Why should we think that N(F, G) is the best explanation of 'all observed Fs are Gs'? Suppose that 'all Fs are Gs' *can* explain 'all observed Fs are Gs'. Then, as type-A explanationists claim, N(F, G) *cannot* be the best explanation. Most philosophers agree that simplicity is an explanatory virtue. Since 'all Fs are Gs' is an ontologically simpler explanation than N(F, G), all other things being equal, we should prefer 'all Fs are Gs' to N(F, G).

Here Armstrong does provide an argument. His basic idea is that a conjunction cannot explain its conjunct(s) – call this 'Armstrong's principle'. We have a strong intuition that a state of affairs cannot explain itself and Armstrong's principle seems to be a natural consequence of this intuition. Once we accept Armstrong's principle, quite trivially we should conclude that 'all Fs are Gs' cannot explain 'all observed Fs are Gs' because 'all Fs are Gs' is logically equivalent to 'all observed Fs are Gs and all unobserved Fs are Gs' (see Armstrong 1983, 40; for a similar argument see Bird 2007, 86-90).

Most critics of Armstrong's argument have focused on Armstrong's principle and tried to prove that it is unjustifiable. Some Humeans argue that this principle simply begs the question against influential theories of explanation, such as the D-N model and unification account. Others, such as Rodger White, claim that Armstrong fails to recognize the important distinction between instance explanation and regularity explanation.[2] I examined these criticisms closely elsewhere and don't want to further discuss them in this paper (see Lee 2013a; 2013b). There is another criticism raised by Helen Beebee in her recent paper (cf. Beebee 2011). She does not focus on Armstrong's principle. Instead, she claims that N(F, G) is not the best *anti-Humean* explanation. So her argument does not lose its credibility even if Armstrong's principle turns out to be true.

In the rest of this paper, I will examine her argument. First, I will explain Beebee's argument in the next section. In section 3, I will show that her argument proves much more than she thinks, which suggests that there must be something wrong with her argument. In section 4, I will argue that Beebee's argument is based on a misconception regarding IBE. In

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[2]   For the former type of criticisms, see Lewis (1994, 478-479); Loewer (1996, 113). For White's criticism, see White (2005).

the last section, I will provide another argument against Beebee, which is closely related to the argument in section 4.

2. Beebee's argument

Beebee does not deny that N(F, G) can explain 'all Fs are Gs'. Instead she argues that N(F, G) is not the best anti-Humean explanation. She argues in Beebee (2011, 510) that the following (anti-Humean) explanation is at least as good as N(F, G).

(SF)   F and G have been necessarily connected so far.[3]

Since (SF) does not entail that 'all Fs are Gs', if (SF) is at least as good as N(F, G), Armstrong's type B approach is hopeless even if Armstrong's principle is true.

One thing we should note is that (SF) is quite different from a time-limited necessitation relation, such as $N_{until-2014}(F, G)$. Beebee acknowledges that N(F, G) is a better explanation than $N_{until-2014}(F, G)$ because only the latter has a temporal parameter. Again, simplicity is an explanatory virtue and additional parameters decrease the degree of simplicity. For this reason, Beebee emphasizes that (SF) does not have temporal-parameter unlike $N_{until-2014}(F, G)$. Based on this fact, she argues that there is no reason to think N(F, G) has the advantage of simplicity over (SF).

Another important issue is whether or not predictive power is an explanatory virtue. (SF) is a disjunctive hypothesis because it is *contextually equivalent* to ($N_{until-2014}(F, G)$ or $N_{until-2015}(F, G)$ or $N_{until-2016}(F, G)$ or $N_{until-2017}(F, G)$ or ... or N(F, G)).[4] Even though most disjuncts of this disjunction have predictive power, there is a disjunct which does *not* have predictive power, namely $N_{until-2014}(F, G)$.[5] Just one disjunct is enough to re-

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[3]   'SF' stands for 'so far'.

[4]   Two comments on this claim are in need. First, the notion of 'contextual equivalence,' and hence that of 'disjunctive hypothesis' (or 'disjunctive explanation') needs to be clarified. I will address this issue in section 4. Second, obviously (SF) is not contextually equivalent to this disjunction. We need much more fine grained disjunction. I believe, however, that my readers will easily catch what I intend here.

[5]   For the sake of argument, let me assume that we are at the last moment of 2014.

move the predictive power of the whole disjunctive hypothesis. Since N(F, G) has predictive power, if predictive power is an explanatory virtue, N(F, G) is a better explanation compared to (SF).

Beebee claims that in the current context predictive power is not an explanatory virtue. First, she argues that in our context we are talking about a *metaphysical* explanation rather than a *scientific* explanation. She says: "Prediction is not part of the point of metaphysics, in either a practical or a theoretical sense" (Beebee 2011, 517). Moreover, since we are talking about the problem of induction, Armstrong's opponent is the inductive skeptic. And "the inductive skeptic holds that, pending a good argument to the contrary, a hypothesis that makes predictions is *eo ipso* a hypothesis that we have no grounds for believing". In short, the simplicity criterion does not discriminate between (SF) and N(F, G), and the predictive power criterion is not applicable in our context. So there is no reason to think N(F, G) is a better explanation than (SF), which means that (5) in Armstrong's argument is not justified.

3. What does Beebee's argument, if good, show?

For the sake of argument, let me assume that Beebee's argument is a good one. Then, as Beebee claims, it shows that Armstrong's type-B approach is hopeless. It also shows many other things, however. First, it shows that the type-A approach is hopeless as well. Suppose that Armstrong's principle is not true. Now type-A explanationists will claim, ignoring Armstrong's argument, that 'all Fs are Gs' is the best explanation of 'all observed Fs are Gs', but compare this explanation with the following Beebee-style hypothesis.

(SF')   All Fs have been Gs so far.

Since (SF') has no temporal parameter, the simplicity criterion does not discriminate between (SF') and 'all Fs are Gs'. Because we are talking about metaphysical explanations, the predictive power criterion is irrelevant. Therefore, there is no reason to think 'all Fs are Gs' is a better explanation compared to (SF').

At this point, one might claim that there is an important difference between these two hypotheses. The worry goes like this. (SF') is a disjunctive

hypothesis because it is contextually equivalent to ('all Fs are Gs until 2013' or 'all Fs are Gs until 2014' or, ..., or 'all Fs are Gs'). Most disjuncts of this disjunctive explanation have temporal parameters and time-limited regularities are not genuine law-like regularities. Only law-like regularities have explanatory power, so (SF') is not considered to be a genuine explanation. I think that this worry is groundless. First, there is no reason to think that only law-like regularities have explanatory power. For example, we can explain why all objects I picked out of this barrel are green with the fact that all objects in this barrel are green.[6] However, 'all objects in this barrel are green' is not a law-like regularity. Second, even if we accept that only law-like regularities can have explanatory power, it does not make much difference. As far as I know, the most powerful Humean theory of law is the Mill-Ramsey-Lewis theory of law, according to which laws are axioms and high-level theorems of best axiomatic deductive system. Imagine a possible world where everything is exactly the same as our world until 2014, and then there is no regularity what so ever after 2014. The Humean must accept this possibility. And the best axiomatic system of this world will contain the following time-limited laws: Boyle's law$_{until\ 2014}$, Charles's law$_{until\ 2014,}$ and etc. Just as Armstrong must accept the *possibility* of time-limited necessitation relation, the Humean must accept the *possibility* of time-limited law.[7] Once we realize that even the Humean must accept this possibility, we can dodge this criticism by converting (SF') to the following (SF'').

(SF'') All Fs have been Gs so far as a nomological fact.

Here, 'nomological facts' means facts that hold as a consequence of law(s) of nature. Since the Humean cannot exclude the possibility of 'all Fs are Gs until 2014''s being a law, (SF'') does not entail 'all Fs are Gs'.

In short, Beebee's argument, if good, undermines the explanationist approach to the problem of induction in general.[8] What makes things worse

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[6]   For a similar idea, see White (2005, 12).

[7]   Beebee nicely explains why Armstrong must accept the possibility of time limited necessitation; see Beebee (2011, 511-513).

[8]   I am not saying that this consequence raises a problem to Beebee. After all, Beebee seems to think that both Humeans and anti-Humeans cannot justify induction. My

is that her argument undermines scientific realism too. Let me assume, following most scientific realists, that IBE is the basic inductive principle for scientific inquiries. So, we justify the existence of such an unobservable entity as atoms with IBE in the following way.

(9)   There are Brownian movements and other observable evidences.

(10)   The best explanation of this empirical evidence is the existence of atoms.

(11)   By IBE, we are justified to believe that there are atoms.

However, (10) is questionable, or so Beebee should think. Compare the explanation, which postulates the existence of atoms – call it '(EA)' – with the following hypothesis '(UM)' for 'unobservable mechanism').

(UM) There is some unobservable mechanism, which produces the observable consequences atoms are supposed to produce.

There is no reason to think (EA) is simpler than (UM). (EA) introduces one additional kind of unobservable entity, namely atoms. (UM) does not exclude the possibility of more than one additional unobservable entity; let's call this hypothesis (TWO). This does not mean that (UM) has commitment to (TWO). (UM) is a disjunctive hypothesis. Just as (SF) has $N_{until-2014}(F, G)$ as its disjunct, (UM) has (TWO) as its disjunct. Just as it is not the case that (SF) is less simple compared to $N(F, G)$ simply because $N_{until-2014}(F, G)$ is (SF)'s disjunct, it is not the case that (UM) is less simple compared to (EA) simply because (TWO) is (UM)'s disjunct. Therefore, as far as the simplicity-criterion is concerned, there is no reason to discriminate between (UM) and (EA).

What about predictive power? Here we are talking about scientific explanation. So predictive power may be an explanatory virtue in our context but this fact does not make a difference. By hypothesis, (UM) has the exact same observable consequences as (EA). Therefore, predictive power criterion does not discriminate between them either.

The problem regarding (10) can be generalized. Whenever scientists introduce a new theoretical entity X to explain the empirical evidences, we

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point is that Beebee's argument, if good, undermines IBE itself. This consequence is just the first step toward my point.

can make an alternative explanation that has the following disjunctive form: there is some unobservable mechanism, which has the same observable consequences as X. This alternative explanation will always block the sort of IBE scientists want to use. This means, if Beebee's argument is good, IBE is useless for the justification of scientific realism.

In fact, this line of argument can be further generalized. Imagine that someone claims that H is the best explanation of our evidence E, then there must be less simple hypotheses which have exactly the same empirical consequences as H. Make a disjunctive hypothesis which has H and those less simple hypotheses as its disjuncts, then argue that this disjunctive hypothesis is at least as good as H. In short, if Beebee's argument is good, then it undermines IBE itself. This means that Beebee's position is not an internally coherent one because she does not question the rationality of IBE.[9] There must be something wrong in Beebee's argument.

4. IBE and disjunctive explanations

One lesson we can learn from the discussion from the previous section seems to be this: when we make IBE, use of disjunctive explanations should be restricted. In this section, I will propose a principle that should govern our use of disjunctive explanations in the context of IBE and defend it.

Let me first define 'disjunctive explanation' and 'disjuncts of a disjunctive explanation.' An explanation (i.e. explanans) will be called a disjunctive explanation in this paper iff it is *contextually equivalent* to a disjunction. And by "disjuncts of a disjunctive explanation" I will mean those disjuncts of a disjunction to which the disjunctive explanation is contextually equivalent. A and B are contextually equivalent iff 'A iff B' is true in all worlds whose possibilities are considered seriously under the context of debate. So if all logical possibilities are seriously considered under the context, contextual equivalence becomes nothing but logical equivalence. Likewise, if all and only metaphysically (or physically) possible worlds are considered under the context, A and B are contextually equivalent iff 'A iff B' is metaphysically (or physically) necessary. So,

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[9]   One might think that my argument does not undermine the rationality of IBE but only shows that it is not very interesting. I think, however, that undermining *interesting* IBE is virtually the same as undermining IBE itself.

(12)   There is some amount of water in this cup

and

(13)   'There is (exactly) one H_2O molecule in this cup' or 'there are (exactly) two H_2O molecules in this cup' or 'there is (exactly) three H_2O molecules in this cup', or .....

are contextually equivalent under the context in which only metaphysically possible worlds are seriously considered because 'water is H_2O' is metaphysically necessary.

Likewise,

(14)   An object is moving

and

(15)   'An object is moving at the speed of 1 m/sec' or 'an object is moving at the speed of 2m/sec' or .... or 'an object is moving at the speed of 299,792,452 m/sec.'

are contextually equivalent under the context in which only physically possible worlds are seriously considered because the speed of light in a vacuum is 299,792,452 m/sec in our world and it is a law that no object can move faster than the speed of light in a vacuum.[10]

My notion of 'contextual equivalence' could be weaker than physical equivalence. Imagine that we are examining an explanatory hypothesis, H, and that under the current context there are only three potential truth-makers of H, namely T_1, T_2, T_3. If there are other physically possible potential truth-makers of H, which can be excluded under the current context, H is contextually equivalent to 'T_1 V T_2 V T_3' even though they are not physically equivalent.[11]

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[10]   Again, strictly speaking, (14) is not physically equivalent to (15) because (15) is not sufficiently fine grained.

[11]   This does not mean that contextual equivalence is necessarily weaker than physical equivalence. As I pointed out, under some context contextual equivalence is nothing but logical equivalence which is much stronger than physical equivalence.

According to my definition, all explanations are quite trivially disjunctive explanations. Let A be our explanation. This is a disjunctive explanation because A is logically equivalent and hence contextually equivalent to (A&B or A&-B). This triviality, however, will turn out to be harmless for the reason I will explain later.

At this point, I must concede that my notion of 'disjunctive explanation' does not fit the ordinary usage of the term. Usually we don't think of $N(F, G)$ as a disjunctive hypothesis simply because it is logically equivalent to a disjunction, say '$(N(F, G)\&P) \lor (N(F, G)\&-P)$'. To the contrary, it is quite natural to think that $N(F, G)$ is a *non*-disjunctive hypothesis because Armstrong thinks that N relation is a second-order universal and believes there is no such thing as disjunctive universals (see Armstron 1978, 19-22). For this reason, one might think that it would be better to replace 'disjunctive explanation' with 'multiply truth makeable explanation' and 'disjunct' with 'potential truth-maker' (I am pretty sure that Beebee would prefer these terms to my terms).[12] For those who are comfortable with truth making talk, I believe that this change of terminology is quite harmless. Main arguments in this paper which use 'disjunctive explanation' and 'disjunct' can be easily converted with minor adjustments to the arguments which use 'multiply truth-makeable explanations' and 'potential truth maker.' After all, it is quite obvious that most examples of 'disjunctive explanations' in this paper are multiply truth makeable explanations. For example, since both $N(F, G)$ and $N_{until-2014}(F, G)$ are potential truth maker of (SF), it is a multiply truth-makeable hypothesis.

Even though I accept that the use of 'disjunctive explanation' could produce some confusion among readers, I don't want to use 'multiply truth makeable explanation' because I think neither 'truth maker principle' nor 'truth making relation' are well-understood concepts. I simply don't want to be involved in truth-making talk. Unlike 'multiply truth makeable explanation,' my notion of 'disjunctive explanation' is quite clear as long as we remember the definition of this term.

Since every explanation is a disjunctive explanation, it *trivially* follows that sometimes we can use disjunctive explanations in the context of IBE. However, there are some non-trivial cases in which we can use disjunctive explanations in the context of IBE. Consider the following explanation.

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[12]   I thank Sung-il Han for this point.

(Lethal-Dose)   A man drank a cup of some kind of liquid. After some time, he died showing typical toxic symptoms of potassium cyanide (KCN). Why did the man die? My explanation: the liquid he drank contained more than the lethal dose of KCN.

The lethal dose for KCN is 200 – 300 mg. For the sake of simplicity, however, let me assume that the lethal dose is 300 mg. My explanation is disjunctive because it is (physically) equivalent to 'the liquid contains 300 mg of KCN' or 'it contains 301 mg of KCN' or 'it contains 302 mg of KCN' or, …'.[13] This disjunctive feature of my explanation is no problem. There is no reason to think that the inference I made in the example is a bad one. Here is another example.

(Informer)   Four bad guys (Adam, Bill, Curt, Dan) conspired to assassinate the president. However, the plot failed because the presidential guards knew the conspiracy. Why did the plot fail? My explanation: at least one of those four guys was a rat.

My explanation is a disjunctive explanation because it is (logically) equivalent to ('Adam was a rat' or 'Bill was a rat' or 'Curt was a rat' or 'Dan was a rat'). Again, this disjunctive feature of my explanation is not a problem. Obviously, we can use this explanation in the context of IBE.

So we need a principled way to restrict our use of disjunctive explanations in the context of IBE. The principle should not be too strict because it should not make (Lethal-Dose) or (Informer) disqualified for IBE-triggering explanations. It should also not be too lenient because, as we saw in the previous section, IBE itself can be undermined if we are allowed to use disjunctive explanations freely.

The principle I propose is very simple: A disjunctive explanation is justified as a complete IBE-triggering explanation only when it is a permissible disjunctive explanation which is better than any other permissible disjunctive explanation that is not its disjunct. When is a disjunctive explanation permissible? There are three principles of permissibility.

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[13]   I am assuming that in the context of (Lethal-Dose), we are considering only physically possible hypotheses.

(P1)   A disjunctive explanation is permissible as a complete IBE-triggering explanation when none of its disjuncts is a genuine explanation.

(P2)   A disjunctive explanation is permissible as a complete IBE-triggering explanation when its disjuncts are all significantly worse than it.

(P3)   A disjunctive explanation is permissible as a complete IBE-triggering explanation when none of its disjuncts is explanatorily salient.

Some comments and explications are in need. First, "permissible" has a very weak sense here. It is not the case that if a disjunctive explanation satisfies at least one of P1 – P3, then we are justified to accept the disjunctive explanation. There might be many permissible disjunctive explanations and in that case we must choose the best out of them. So P1 – P3 should be read in the following way:

A disjunctive explanation is *preferable to its disjuncts* when…

Once we read "permissible" in this way, it is almost self-explanatory that P1 – P3 are justified. An explanation is always better than no explanation, so P1 is justified. A significantly better explanation is always better than a significantly worse explanation, so P2 is justified as well. If two explanations are virtually equal in the explanatory sense, to regard one of them as an IBE triggering explanation is not justified, so P3 is justified. Since P1 – P3 are all self-explanatory, the only question concerning them is whether or not P1 – P3 are exhaustive. Imagine that a disjunctive explanation satisfies none of P1 – P3. Then it would have an explanatorily salient disjunct which is at least as good as the disjunctive explanation. Can this explanation be an IBE-triggering explanation? I don't think so. Remember that IBE is inference to the *best* explanation. If the disjunct is at least as good as the disjunction, the disjunction is not the best explanation. To be sure, according to P3, we can regard some non-best explanations as IBE-triggering explanations,[14] but it is because this is inevitable. We have an independ-

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[14]   This is the reason why my principle contains "it is a permissible disjunctive explanation which is better than any other permissible disjunctive explanation which is not its

ently justifiable principle that if two explanations are equally good, we should not discriminate them in the context of IBE. Unless we find another principle, which can do a similar job, we have good reason to think P1-P3 is exhaustive.

Second, strictly speaking, P1 is redundant. If all its disjuncts are no explanation, they are all worse than the disjunctive explanation. So P1 is an instance of P2. P1 is also an instance of P3 because if all its disjuncts are no explanation, there is no disjunct that is explanatorily salient.

Third, why do we need to insert 'as a complete IBE-triggering explanation?' Consider the following example.

(Short-Circuit) There was a fire last night. The investigators found a typical pattern of soot that is often caused by a short circuit in the fuse box. Why did the fire occur? My explanation: There was a short circuit in the fuse box.

(Short-Circuit) is a disjunctive explanation because it is logically equivalent to 'there was a short circuit in the fuse box and there was sufficient amount of oxygen in the air' or 'there was a short circuit in the fuse box and there was not sufficient amount of oxygen in the air', but this disjunctive explanation is not permissible if we remove 'as a complete IBE-triggering explanation' from P1 – P3. First, the first disjunct is a good explanation, so it does not satisfy P1. Second, the first disjunct is a *better* explanation than the disjunctive explanation itself because the former is relatively close to the complete explanation compared to the latter, so it does not satisfy P2. Lastly, the first disjunct is explanatorily salient because the second disjunct is no explanation, so it does not satisfy P3. These results are unacceptable because intuitively the IBE I used in this example seems to be a good one. If we insert 'as a complete IBE-triggering explanation' in P1 – P3, however, we can handle this problem. In fact, my explanation should not be allowed as a *complete* IBE-triggering explanation because it is at best a partial explanation. This does not mean that my explanation should not be allowed as IBE-triggering explanation. My (partial) explanation seems to come from a perfectly permissible *complete* IBE-triggering explanation.

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disjunct" rather than a simpler expression "it is the best permissible disjunctive explanation."

Fourth, given my definition of 'disjunctive explanation,' virtually all explanations are disjunctive in infinitely many senses. A is equivalent to (A&B or A&-B) and it is equivalent to (A&C or A&-C), and so on. So, my principle should mean this: a disjunctive explanation is permissible as a complete IBE-triggering explanation when all of their possible "disjunctification" satisfies at least one of P1 – P3.

I said that my definition of 'disjunctive explanation' makes all explanation disjunctive in a trivial sense and that this result is harmless. Here is why. Suppose that a hypothesis, H, is a potential explanation of evidence E. Furthermore, suppose that A is an arbitrarily chosen explanatorily irrelevant factor. We can trivially "disjunctify" H using A because H is logically equivalent to (H&A or H&-A). Since A is explanatorily irrelevant to E, -A is irrelevant to E as well. As familiar counterexamples against D-N model show, irrelevancy is fatal to explanation.[15] So, both H&A and H&-A are not explanations, which means that (H&A or H&-A) satisfies P1. In short, we don't have to worry about the possibility of trivial disjunctifications via explanatorily irrelevant factors.

Now let me explain why my principle is neither too strict nor too lenient. First, let me explain why it is not too strict. Consider (Lethal-Dose). It is a disjunctive explanation because it is contextually equivalent to "the liquid contains 300 mg of KCN' or 'it contains 301 mg of KCN' or 'it contains 302 mg of KCN' or, … '. I think (Lethal-Dose) satisfies P1 although it could be slightly controversial. Even if it does not satisfy P1, there is no question that it satisfies P2 and P3, which are weaker than P1. Suppose that the liquid the man drank contained exactly 327 mg of KCN. Can we say that the man died because the liquid he drank contained exactly 327 mg? I don't think so. One reliable test for the existence of explanatory relation is to see whether there is a counterfactual dependence between the alleged explanans and the explanandum. This test is particularly reliable when it is not applied to laws and when there is no worry of backup cause situations, such as preemption, trumping, and overdetermination. Is it true that if the liquid he consumed had not contained exactly 327 mg of KCN, he would not have died? The closest possible world in which the liquid does not contain exactly 327 mg of KCN

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[15]   Probably the most famous counterexample of this category would be the hexed-salt example (originally) by H. Kyburg; see Salmon (1989, 50).

would be the world where it contains, say, 326 or 328 mg of KCN and in this world the man would have died because the lethal dose of KCN is 300 mg. This result can be generalized so that all disjuncts of (Lethal-Dose) turn out to be no explanations. Unlike its disjuncts, (Lethal-Dose) passes the counterfactual dependence test. It is true that if the liquid the man drank had not contained 300 mg or more of KCN, he would not have died. The closest possible world in which the liquid does not contain 300 mg or more of KCN would be the world where it contains 299 mg of KCN and in this world he would not have died. So, (Lethal-Dose) satisfies P1 and it is a permissible disjunctive explanation. I believe that the counterfactual dependence test I used is reliable in this case. It is not applied to laws and there is no worry of a backup cause situation. Even if it is not reliable in our context, I am sure that (Lethal-Dose) satisfies at least P2 and P3. First, compare these two explanations: "The man died because the liquid contained exactly 324 mg of KCN" vs. "The man died because the liquid contained more than lethal dose of KCN". There is no question that the second explanation is much better than the first. Second, compare "The man died because the liquid contained exactly 324 mg of KCN" with "The man died because the liquid contained exactly 325 mg of KCN". There is no reason to think one of them is explanatorily salient, which means that (Lethal-Dose) satisfies P3.

The following example of a red ball by Beebee (2011, 515) is similar to my (Lethal-Dose) example:

> (Red Ball)   There are twenty balls in a bag, all of which (unknown to me) are different shades of red. You pull a ball from the bag, and you want to know why you pulled out a red ball. My answer: all the balls are red.

As Beebee emphasizes, (Red Ball) is a multiply truth makeable explanation and hence it is a disjunctive explanation in my sense because it is contextually equivalent to "all the balls are a shade$_1$ of red' or 'all the balls are a shade$_2$ of red' or ... or 'one of the balls is a shade$_1$ of red and others are all a shade$_2$ of red' or 'one of the balls is a shade$_1$ of red and others are all a shade$_3$ of red' or...'. However, as Beebee emphasizes, (Red Ball) is a permissible disjunctive explanation because it satisfies P1. For example, 'all the balls are a shade$_1$ of red' is not a potential explanation of why the ball I pulled is a red ball. Again, counterfactual dependence test is helpful here

for it is not true that if it had not been the case that all the balls are shade$_1$ of red, then the ball I pulled would not have been a red ball. Probably in the closest world in which the antecedent is true, some balls would be different shades of red and in that world the ball I pulled would be a red ball.[16]

Next, consider (Informer). Unlike (Lethal-Dose), (Informer)'s disjuncts are good potential explanations. Suppose that Adam was the rat. Then it is true that the plot failed because Adam was a rat. In fact, this explanation seems to be better than (Informer) because it is more informative. Therefore, (Informer) does not satisfy P1 and it does not satisfy P2 either, but (Informer) satisfies P3. Compare 'Adam was the rat' with 'Bill was the rat.' Explanatorily speaking, they are perfectly symmetric. There is no reason to think one is better than the other, which means that there is no explanatorily salient disjunct here. So (Informer) is a permissible disjunctive explanation.

Now, let me explain why my principle is not too lenient. My principle does not have the consequences that Beebee's argument has. Consider first (UM). For the sake of argument, let me assume that we are considering seriously all metaphysical possibilities. (UM) is contextually equivalent to "There are atoms' or 'there are *shatoms,* which are different from atoms but produces the same observable consequences atoms are supposed to produce' or 'there is a Cartesian demon who produces Brownian movement and other alleged evidence for atoms' or...'. (UM) cannot satisfy P1. (EA), or 'There are atoms' is a good potential explanation. (UM) cannot satisfy P2 either. There is no reason to think (UM) is much better than (EA). To the contrary, (EA) seems to be better than (UM). (EA) is much more informative than (UM). Lastly, (UM) also cannot satisfy P3. (EA) is significantly salient in the explanatory sense, and that is why scientists believe in atoms.[17] Since (UM) satisfies none of P1 – P3, (UM) is not a permissible

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[16]   Again, even if (Red Ball) does not satisfy P1, quite obviously it does satisfy at least one of P2 and P3.

[17]   One might think we cannot know that (EA) is salient. (UM) is a disjunctive explanation, which has in principle infinitely many disjuncts. We human beings cannot examine those infinitely many disjuncts. In fact, we cannot even know those infinitely many disjuncts! The idea behind this criticism is same as the idea behind the "argument from bad lot" by van Fraassen. For the argument see van Fraassen (1989, 142-143). For Psillos' criticism of this argument, see Psillos (1999, 220). All I want to say here is that

disjunctive explanation. Unlike (UM), there is no reason to think that (EA) is not a permissible disjunctive explanation. So, under the assumption that (EA) is the best permissible disjunctive explanation, we are justified to believe in atoms. My principle allows the defenders of IBE to support scientific realism.

It is quite clear by now that I can reject Beebee's argument with my principle. In short, Beebee's (SF) is not a permissible disjunctive explanation. (SF) is (probably metaphysically) equivalent to the following explanation: ($N_{until-2014}(F, G)$ or $N_{until-2015}(F, G)$ or $N_{until-2016}(F, G)$ or $N_{until-2017}(F, G)$ or ... or $N(F, G)$). Therefore, (SF) cannot satisfy P1. $N(F, G)$ is a perfectly good potential explanation and even Beebee does not deny this. (SF) cannot satisfy P2 either. There is no reason to think (SF) is significantly better than $N(F, G)$. To the contrary, $N(F, G)$ seems to be better than (SF) because it is more informative. Lastly, and most importantly, (SF) also cannot satisfy P3. Compare $N(F, G)$ with $N_{until-2014}(F, G)$. Beebee herself concedes that the first explanation is better than the second one because it, unlike the second one, has no temporal parameters. The question is this: how *significantly* better is $N(F, G)$ compared to $N_{until-2014}(F, G)$? Since saliency is a vague concept, if we want to assert that $N(F, G)$ is the salient disjunct we need to show that $N(F, G)$ is not just better but significantly better than $N_{until-2014}(F, G)$. I believe that $N(F, G)$ is significantly better than $N_{until-2014}(F, G)$. $N_{until-2014}(F, G)$ requires us to radically revise our conception concerning space and time. We don't think that a particular time or space has causal/explanatory power. We do think a particular *length* of time or space can have causal/explanatory power. For example, we can mention a particular half-life to explain radioactive decay, but to say that a particular *length* of time has causal/explanatory power is one thing and to say that such a particular time as 2014 has causal/explanatory power is another. If we accept $N_{until-2014}(F, G)$, we should attribute some kind of causal/explanatory power to a particular time, namely 2014. I am not saying that this is unintelligible; what I am saying is that this is a radical revision of our belief system. Other things being equal, an explanation that does not require such a radical revision is much better

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even if this worry is a genuine worry, this is a criticism of IBE itself. So I don't have to have an answer to this criticism. We (including Beebee) are assuming that IBE is justifiable.

than an explanation that does. So, there is good reason to think N(F, G) is significantly better than $N_{until-2014}$(F, G), which means that (SF) cannot satisfy P3. Since (SF) satisfies none of P1 – P3, it is not a permissible disjunctive explanation. Since there is no reason to think that N(F, G) is not permissible, under the assumption that N(F, G) is the best permissible disjunctive explanation, we are justified to believe in N(F, G).

5. Informativeness as an explanatory virtue

In this last section, I will argue that there is an additional reason to think Beebee's argument fails, which was in fact implicitly suggested in the previous section. Why should we restrict our use of disjunctive explanations in the context of IBE? My explanation in section 3 was that unrestricted use of disjunctive explanations tends to undermine IBE itself because it makes IBE uninteresting. Compare (EA) and (UM) once again. If we allow for the free use of disjunctive explanations in the context of IBE, all we can know is that there is some unobservable mechanism that produces our observable evidence. This knowledge is not particularly exciting. This is not exciting because it is not informative. In other words, it does not exclude many possibilities. So, a lesson we can learn from the discussion in section 3 is that IBE can be a useful inductive principle only if informativeness is an explanatory virtue. The principle I proposed in section 4 can be seen as one way to embody the idea that informativeness is an explanatory virtue.

In fact, the idea that informativeness is an explanatory virtue is a quite familiar one. It is controversial whether Molière's famous dormitive virtue explanation is a genuine explanation. In my opinion, it is a genuine explanation. However, even if it is a genuine explanation, it still does not seem to be a *good* explanation. Behind this intuition is the fact that this explanation is not very informative.

Once we admit that informativeness is an explanatory virtue. The idea that we can make an equally good explanation by disjunctively combining a good explanation with bad explanations seems to be unjustifiable. All we can get by this kind of "disjunctification" is some increase of probability. (This increase in probability should not be very impressive because it is achieved by *bad* explanations.) However, by this disjunctive combining, we

lose all-important informativeness. An inductive inferential principle that does not produce informative conclusions is useless.

To prevent potential misunderstandings, I must emphasize at this point that I am not saying that *any* kind of informativeness can be regarded as an explanatory virtue. One can make a potential explanation more informative in a way that destroys the potential explanatory relation between explanandum and potential explanans. For example, one can make a potential explanation more informative by conjunctively combining it with an explanatorily irrelevant factor; but the increase of informativeness in this sense is no explanatory virtue. Beebee's own example is helpful here. She writes:

> You want to know why Liverpool has failed to score against much weaker teams so far this season. I tell you it's because Torres has been injured and so out of the team. That's an answer that suppresses adjustable parameters in something like the way that (SF) does, in that my answer leaves it open whether or not Torres will be back in the team next week, next month, next season, or never. But again, so what? (Beebee 2011, 516)

Beebee's answer (call it (Torres)) is less informative than 'Torres has been out of the team so far but he will be back next week' but, as Beebee claims, this more informative answer is no better than (Torres). It is because the more informative answer contains an explanatorily irrelevant conjunct, namely 'he will be back next week.' This explanatorily irrelevant factor undermines the alleged explanatory relation between the explanandum and the alleged explanans. Unlike this answer, N(F, G) does not contain any explanatorily irrelevant conjunct and is more informative than (SF). In short, there are two ways we can increase the degree of informativeness of potential explanations: One that destroys the explanatory relation itself and one that does not. (Lethal-Dose), (Red Ball), and (Torres) are all examples of the former, whereas N(F, G) and (EA) are examples of the latter. My claim is that the latter kind of increase in informativeness is always an explanatory virtue. A problem with Beebee is that she seems to conflate these two. Beebee's (Red Ball) and (Torres) does not show that informativeness is not an explanatory virtue.

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