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Articulating Invariantism

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Abstract

Building on Nozick's (2001) work, I provided a novel invariantist account of scientific objectivity: the *Counterfactual Independence Account* (Reutlinger 2024). Despite its virtues, this account needs to be articulated in a more nuanced manner – regarding its scope, content, and consequences. My goal in this paper is to develop such a more articulated and improved version of the *Counterfactual Independence Account* in two steps. First, I will discuss two instructive dissonances between Nozick's version of invariantism and the *Counterfactual Independence Account* – dissonances concerning what concept of objectivity is addressed and how the key notion of invariance is characterized. Second, I will develop an argument for the claim that (epistemic) objectivity plays a productive role in scientific inference or, more precisely, that objective evidence is, in a sense to be specified, more evidence.

Keywords: Scientific objectivity; epistemic objectivity; objective evidence; invariance; invariantism; confirmation; scientific inference; Bayesian confirmation theory; testimony; likelihoodism

1. Introduction

Invariantism is the attempt to define a philosophically relevant concept by drawing on the notion of invariance. In Reutlinger (2024), I provide a novel invariantist approach to the concept of scientific objectivity: the *Counterfactual Independence Account*. According to this version of invariantism, the key notion of invariance is spelled out as a specific sort of counterfactual independence – which is, in turn, a notion imported from the research literature on causation, laws of nature, and scientific explanation in order to shed new light on scientific objectivity.

The *Counterfactual Independence Account* is intended to improve Nozick's invariantism about objectivity (Reutlinger 2024: 119–121). According to Nozick's view, “[a]n objective fact is one that is invariant under all admissible transformations” (Nozick 2001: 82). While I do think that the *Counterfactual Independence Account* succeeds in overcoming several shortcomings of Nozick's invariantism, the account needs to be articulated in a more nuanced manner – regarding its scope, content, and consequences – to be fully convincing.

In this paper, my approach will be entirely constructive: my goal is to provide a more articulated and improved version of the *Counterfactual Independence Account*. My focus will be on this account and on how it relates to Nozick's invariantism. To be sure, there are other invariantist accounts of objectivity besides the two mentioned ones.¹ There are even more numerous alternative, non-invariantist accounts of objectivity in philosophy of science and adjacent areas of philosophy. Analyzing the advantages of the *Counterfactual Independence Account* in comparison to alternative (invariantist and non-invariantist) theories of objectivity would be a worthwhile undertaking, but I leave this demanding task for another occasion.

In this paper, I will proceed and argue as follows. In Section 2, I will provide a brief reconstruction of the *Counterfactual Independence Account*. In Section 3, I will develop a more precise articulation of the scope and content of the *Counterfactual Independence Account* resulting in the conclusion that it should be read as a monist account of epistemic objectivity (or, equivalently, of objective evidence). I will suggest that this articulation is prompted by two instructive dissonances between Nozick's version of invariantism and the *Counterfactual Independence Account* (dissonances concerning what concept of objectivity is addressed and how the key notion of invariance is characterized). In Section 4, I will address a claim that I present, in the concluding section of Reutlinger (2024), as a potentially "advantageous and fruitful consequence" of the *Counterfactual Independence Account*: namely, the claim that "valuing objectivity is simply a plea for more evidence, for more evidence from different sources (from different scientists and/or methods)" (Reutlinger 2024: 125). I will argue that this claim can be made precise (in the form of different interpretations) and supported by applying Bayesian confirmation theory (and further assumptions) and by at least one other theory of scientific inference, likelihoodism. I will treat Bayesian confirmation theory and likelihoodism as premises (or tools) – that is, I will apply, but not attempt to defend or improve these approaches. In Section 5, I will provide a conclusion of my arguments and raise open questions for the *Counterfactual Independence Account* (and, at least potentially, also for other invariantist approaches to objectivity) to emphasize the philosophical promises of invariantism.

2. Reconstructing the *Counterfactual Independence Account*

According to the *Counterfactual Independence Account*, objectivity is defined as follows:

Evidence E is scientifically objective in relation to a given contrast class of scientists and methods if and only if: (1) *Independence Condition*: E is counterfactually independent of the scientists, or of the methods they use. (2) *Absence Condition*: There is no evidence of defeaters. (Reutlinger 2024: 120)

To render my discussion of the *Counterfactual Independence Account* in Sections 3 and 4 accessible, I will briefly reconstruct a few crucial aspects of the account: how the key concept of counterfactual independence is defined (figuring in the first necessary condition of the *Counterfactual Independence Account*) and what its contrastive

¹Nozick firmly places himself in the invariantist tradition and explicitly claims to be influenced by Paul Dirac, Albert Einstein, Felix Klein, and Eugene Wigner (Nozick 2001: 76, 78, 82, 85–86, 328, 330–331). For surveys to this tradition, see Daston and Galison (2007: chapter 5) and Debs and Redhead (2007: chapter 3) and the references therein.

character consists in, what the intended explicandum is (the concept of epistemic objectivity or, equivalently, of objective evidence), and how the *Counterfactual Independence Account* captures one instructive kind of epistemic objectivity (namely, epistemic objectivity as replication).²

On counterfactual independence. The central notion of invariance is undefined in Nozick's version of invariantism, or so I claimed (Reutlinger 2024: 119). In response to this shortcoming, I propose to define invariance in terms of counterfactual independence as follows. Fact A is counterfactually independent of fact B if and only if the following counterfactual conditionals are true: (1) if B were the case, then A would be the case, and (2) if B were not the case, then A would (still) be the case (Reutlinger 2024: 121). This explication of invariance is imported from other debates in philosophy of science³ and applied in a novel context: to define objectivity and to, thereby, improve an invariantist account of objectivity.

On the contrastive character of independence. If one defines objectivity via invariance and invariance itself in terms of counterfactual independence, then objectivity inherits specific features from counterfactual independence.⁴ Let me highlight one of these features, the contrastive character of counterfactual independence, because it is helpful for understanding the *Counterfactual Independence Account*. Counterfactual independence holds relative to a contrast class: fact A is independent of fact B relative to a contrast class specifying the “possible alternatives to B, or possible variations of B” (Reutlinger 2024: 121). A contrast class “indicates which antecedents matter for the counterfactual conditionals if we want to assert that A is independent of B” (ibid.). I will provide a more concrete illustration of a contrast class below when reconstructing how the *Counterfactual Independence Account* captures “objectivity as replication.”

On epistemic objectivity. I focus on an epistemic concept of scientific objectivity; this concept is the target of explication (Reutlinger 2024: 120, 122). The concept of epistemic objectivity characterizes empirical evidence and, relatedly, evidential support relationships holding between the evidence and some hypothesis (I will discuss such evidential support relationships in Section 4). Indeed, the focus on objectivity as an epistemic concept is also openly displayed in the definiendum of the *Counterfactual Independence Account*: objective (scientific) evidence. In what follows I will use “epistemic objectivity” and “objective evidence” interchangeably.⁵

²For present purposes, I will entirely set aside the *Absence Condition*.

³The notion of counterfactual independence is inspired by the notion of counterfactual dependence that is familiar from various counterfactual theories of causation and explanation, including Lewis (1973a, 2004), Woodward (2003, 2021), and also Reutlinger (2016, 2018). Moreover, I also explicitly refer to notions of independence used by Skyrms (1980) and Lange (2009) in their accounts of laws (Reutlinger 2024: 122). I would also explicitly add Hitchcock and Woodward (2003), Woodward (2003: chapter 6, 2021: chapter 5), and Woodward and Hitchcock (2003) to this group of approaches to laws of nature.

⁴Besides being contrastive, such features include the modal, relational, and comparative (or gradual) character of counterfactual independence (Reutlinger 2024: 121–122). These features are also described by other invariantists: for instance, Woodward (2003: 241, 243), Hüttemann (2021: 30), and Sher (2021: 3947) on the relational aspect, Woodward (2003: 243 and section 6.4) and Sher (2021: 3959) on the comparative or gradual aspect, and Woodward (2003: 250, 281), Hüttemann (2021: 24–26), and Sher (2021: 3950) on the modal character of invariance.

⁵The *Counterfactual Independence Account* is intended to remain neutral with respect to different philosophical accounts of what scientific evidence is, be it protocol sentences or data models (see Boyd and Bogen 2025 for a survey).

On applications to kinds of epistemic objectivity. Countering Nozick's focus on examples of objectivity from physics, I analyze three kinds of epistemic objectivity that I take to be pervasive kinds of epistemic objectivity in many (experimental) sciences: objectivity as replication, as robustness, and as Mertonian universalism.⁶ I argue that the *Counterfactual Independence Account* captures the mentioned three kinds of epistemic objectivity (Reutlinger 2024: section 3).

To pave the way for Sections 3 and 4, it is useful to sketch how the *Counterfactual Independence Account* is intended to apply to one of the mentioned kinds of epistemic objectivity. Objectivity as replication – in a simplified version involving only two scientists – consists in the fact that scientist S_2 successfully replicates the experimental result E of another scientist S_1 by using the same (experimental) method M that S_1 applied previously.⁷ In this simplified scenario, the relevant contrast class is assumed to have only two members: S_1 and S_2 who apply the same method M . According to the *Counterfactual Independence Account*, objectivity as replication should be described as follows: evidence E , obtained by using (experimental) method M , is objective relative to the contrast class {scientist S_1 ; scientist S_2 } only if obtaining E is counterfactually independent of whether scientist S_1 or scientist S_2 applies method M (Reutlinger 2024: 123). Given the definition of counterfactual independence, the following two counterfactual conditionals have to be true: (1) if S_1 used experimental method M , then E would be the experimental result, and (2) if S_2 used experimental method M , then E would also be the experimental result.

3. Learning from dissonances

Authors contributing to the debate on scientific objectivity differ significantly in what they attempt to analyze and how. This also holds for philosophers who advocate an invariantist approach to objectivity, or so I will argue in this section. For this reason, it is an achievement to be more precise about the *scope* of an account of objectivity (i.e., about what concept of objectivity is the definiendum, or explicandum, and which applications of the concept count as paradigmatic examples) and about the account's *content* (i.e., about the concrete proposal of a definiens or explicans).

In Reutlinger (2024), I argued that the *Counterfactual Independence Account* improves Nozick's invariantism. While I still take this to be true in some respects, the *Counterfactual Independence Account* is, on closer inspection, not simply an improved version of Nozick's invariantism, as the former differs significantly from the latter. To articulate the *Counterfactual Independence Account* and to make explicit its scope and content, it is helpful to understand these differences. In particular, one can learn from two informative dissonances in my earlier reading of Nozick, in Reutlinger (2024), or so I will suggest.

The first dissonance concerns the notions of objectivity that Nozick and I analyze (Section 3.1). While the *Counterfactual Independence Account* is intended to explicate different kinds of epistemic objectivity (or, equivalently, of objective evidence), Nozick's invariantism is concerned with "objective facts" (mostly regarding law statements or

⁶Woodward (2006: 233–235) presents the second kind of epistemic objectivity as "measurement robustness."

⁷I assume that the *Counterfactual Independence Account*, as an account of objectivity, is neutral with respect to different philosophical accounts of replication and of what it means that scientists obtain the same result in the context of a successful replication. Fidler and Wilcox (2025) provide a survey to the debate on replication.

monic facts). The second dissonance regards the definition of invariance (Section 3.2). I will argue that the *Counterfactual Independence Account* should be read as relying on a monist understanding of invariance (in the context of epistemic objectivity), while Nozick's invariantism should be read as adopting a pluralist view of invariance (with respect to "objective facts"). The dissonances do not point to flaws but instead constitute instructive information about the scope and content of the *Counterfactual Independence Account*: unlike Nozick's invariantism, it is best understood as being a monist theory of epistemic objectivity.

3.1. Learning from dissonances regarding examples

Nozick appeals to examples from physics to illustrate "objective facts." Consider two of his representative examples:

That invariance is importantly connected to something's being an objective fact is suggested by the practice of physicists [. . .]. Einstein taught us that spatial distance and temporal distance are relative to an observer; their magnitudes will be measured differently by different inertial observers, and spatial and temporal intervals are not invariant under Lorentz transformations. However, inertial observers will agree about another, more complicated interval between events, involving not just spatial separations alone or temporal separations alone but a particular mixture of the two, namely, the square root of the square of the time separation minus the square of the spatial separation. This more complicated interval is invariant under Lorentz transformations. The principle of relativity of Einstein's Special Theory holds that all laws of physics are the same for all inertial observers; they are the same in every inertial reference frame, and so are invariant under Lorentz transformations. (Nozick 2001: 76; original emphasis)

Amalie Emmy Noether showed that for each symmetry/invariance that satisfies a Lie group, there is some quantity that is conserved. Corresponding to invariance under translation in space, momentum is conserved; to invariance under translation in time, energy is conserved; and to invariance of the law under the addition of an arbitrary constant to the phase of the wave function, apparently electrical charge is conserved. So it is not surprising that laws that are invariant under various transformations are held to be more objective. (Nozick 2001: 81)

The trouble with Nozick's examples is that they are too physics-specific: "Such a one-sided diet is dissatisfying if one is after a general explication of scientific objectivity, as opposed to objectivity in physics only" (Reutlinger 2024: 120). To enrich the "diet" of examples, I substituted Nozick's examples of objectivity from physics with the three mentioned kinds of epistemic objectivity (objectivity as replication, as robustness, and as Mertonian universalism), because the latter "occur frequently in the (experimental) sciences, not just in physics" (Reutlinger 2024: 122).

Now, even if one agrees with this worry about Nozick's choice of examples and on the need for discussing examples of objectivity beyond physics, one might still want to ask how the examples I use to motivate the *Counterfactual Independence Account* relate to Nozick's own examples. Did I succeed in merely replacing Nozick's examples of objectivity from physics by examples of the *same kind* differing from Nozick's stock of examples only in that they generalize to more sciences? I believe this is not the case.

When I turned away from Nozick's original examples, I failed to notice that his examples illustrate a rather different concept of objectivity. Nozick's examples are not about objective evidence (or epistemic objectivity), instead they are shining examples of "objective facts" in physics: particularly, of the objectivity of nomic facts or law statements (and symmetry principles).⁸

Does the *Counterfactual Independence Account* capture Nozick's examples of objective (nomic) facts? Or do they amount to potential counterexamples challenging the *Counterfactual Independence Account*? The short answer simply consists in being explicit about the intended scope and the definiendum (or explicandum) of the *Counterfactual Independence Account*. The account, as articulated in Reutlinger (2024), is only intended to define the concept of *epistemic objectivity* and to capture paradigmatic examples or applications of this concept. If so, Nozick's examples of "objective facts" as such do not pose counterexamples to the *Counterfactual Independence Account*. Hence, a seeming dissonance between the *Counterfactual Independence Account* and Nozick's invariantism vanishes, as these accounts are concerned with explicating (or characterizing) different concepts of objectivity.⁹

Of course, one might still wish to settle the question whether the notion of counterfactual independence can be used to capture "objective facts" and the related plentitude of invariances associated with law statements in physics (such as invariance under Lorentz transformations) and, at the same time, with law statements in other natural and social sciences (such as, invariance under interventions).¹⁰ A positive answer – as suggested by, for instance, Woodward (2003: 242) and Hüttemann (2021: 34) – might be fruitful for several reasons, including that it would unify separately conducted debates in philosophy of physics and in general philosophy of science. However, whether one can provide such a positive answer is immaterial for my present concern: that is, for removing the dissonance regarding examples of objectivity in Nozick's version of invariantism and the *Counterfactual Independence Account*.

3.2. Learning from dissonances regarding invariance

A shortcoming of Nozick's invariantism can be described as follows: "Nozick does not provide an explication of the central modal notion of invariance. He merely illustrates the notion of invariance by way of example [...]" (Reutlinger 2024: 119). According to the *Counterfactual Independence Account*, invariance is explicated in terms of counterfactual independence (Reutlinger 2024: 121). However, on a closer reading of Nozick's book, it is not the case that Nozick characterizes the central concept of invariance *only* "by way of example." Indeed, Nozick provides three conceptual

⁸Nozick (2001: 85–87) discusses some of these examples in the context of proposing a revised "Humean" definition of law statements. What is more, Nozick's "objective facts" are also discussed under the label of "structural objectivity" (Daston and Galison 2007: chapter 5). However, I would like to avoid Daston and Galison's label, because it suggests a structuralist or structural realist position. I prefer Nozick's philosophically more neutral label.

⁹"Scientific objectivity" should not automatically be equated with epistemic objectivity. Scientific objectivity may not be a single concept, but at least two concepts (epistemic objectivity and "objective facts"). The nature of their relationship is an open question for me.

¹⁰On kinds of invariances shared by the laws of physics and by the laws of other natural and social sciences, see, for instance, Woodward (2003: chapter 6, 2021: chapter 5), Hitchcock and Woodward (2003), and Woodward and Hitchcock (2003).

characterizations. The first characterization of invariance is situated in a group-theoretic approach¹¹ to symmetry as invariance under a specified group of transformations:

A transformation can be a *mapping*, a function from one set to another set (possibly the same one). (This is the notion used in mathematics.) To say that something is invariant under a transformation, in this sense, is just to say that when certain things have a property, other things also have this property. (Nozick 2001: 79; original emphasis)

Nozick distinguishes this (group-theoretic) mapping characterization from another characterization of invariance under transformations:

Second, a transformation can be an actual dynamical *change* or alteration of things through time, so that the very same things, though present, are changed in some way (which is compatible with the continued existence of those things). Properties invariant under such dynamical transformations, however, are not changed; they still apply to the entity. (ibid.; original emphasis)

Moreover, in a footnote attached to the paragraph quoted above, Nozick considers a third characterization that is closely related to the proposal to characterize invariance via counterfactual independence (as advocated by proponents of the *Counterfactual Independence Account*):

Perhaps also a transformation can be a *subjunctive difference*, such that if the members of the domain *were* different in some way, some properties or relations would still hold true of them, and hence be invariant under that subjunctive difference. (Nozick 2001: 329; original emphases)

Commenting on the three characterizations of invariance, Nozick claims that they “might be appropriately used for different subject matters” (2001: 79).

Does this more careful reading of Nozick’s book amount to an objection to the *Counterfactual Independence Account*? On the one hand, it is not correct to claim that Nozick does not provide any conceptual characterization of invariance at all. On the other hand, I would still insist that, given the central status of invariance in Nozick’s theory of objectivity, he does surprisingly little to shed light on this concept and does in fact not provide an explicit definition of invariance.

To my mind, the lesson from a closer reading of Nozick should *not* give rise to an objection to the *Counterfactual Independence Account* – ultimately, the charge of having overlooked a passage and a footnote in Nozick’s book. Instead, drawing on a distinction between pluralism and monism (developed in Reutlinger 2017: section 3, 2018: section 2), the true lesson should be this: Nozick should be interpreted as being a pluralist regarding the concept of invariance, while the *Counterfactual Independence Account* should be understood as relying on a monist approach to invariance.¹²

¹¹Brading and Castellani (2003: section 2.1, 2007: sections 2–4) provide a general survey to the group-theoretic account of invariance.

¹²Originally, I introduced this distinction with respect to theories of causal and non-causal scientific explanations. Here, I suggest that one can also apply the distinction to accounts of invariance in the debate on objectivity.

However, when using the labels of pluralism and monism, one should bear in mind that Nozick and I do not address the same concept and the same paradigmatic examples (as pointed out in Section 3.1). Nozick's pluralism concerns the notion of invariance used in (or applicable to) the context of paradigmatic examples of "objective facts," while the monism I advocate (via the *Counterfactual Independence Account*) is intended to capture the notion of invariance used in (or applicable to) the context of paradigmatic examples of epistemic objectivity.

According to Nozick's pluralism, one needs at least three different characterizations of invariance (see above) to capture the notion of invariance used in relation to paradigmatic examples of "objective facts" and no single characterization by itself suffices to accomplish this task. According to the monism built into the *Counterfactual Independence Account*, the notion of invariance – relevant in the context of paradigmatic examples of epistemic objectivity – is defined explicitly in terms of counterfactual independence. In other words, all relevant examples of invariance (in the intended domain) can be captured in terms of a single characterization: counterfactual independence. This monist reading coheres with the "unificationist spirit" attributed to the *Counterfactual Independence Account* (Reutlinger 2024: 121).¹³

Realizing that Nozick's invariantism and the *Counterfactual Independence Account* differ in the way just described is instructive. It highlights a feature of each account, not necessarily a bug. In what follows, I will refrain from discussing the merits of Nozick's characterization of invariance and my own. For the purposes of this paper, I will simply work with the monist assumption that invariance can be defined in terms of counterfactual independence.

In sum, the *Counterfactual Independence Account* should be understood as a monist theory of epistemic objectivity – that is, as an invariantist approach with different scope and content than Nozick's invariantism.

4. Epistemic objectivity and its confirmatory role

Articulating the *Counterfactual Independence Account* goes beyond making precise its scope and content. Articulation also includes elaborating potentially fruitful *consequences* of the account. Indeed, there is at least one promising candidate of such a consequence:

valuing objectivity is simply a plea for more evidence, for more evidence from different sources (from different scientists and/or methods). Hence, if scientists care about empirical evidence, it is not surprising that they value objectivity. It might be fruitful to elaborate this idea on the basis of extant accounts of empirical confirmation (such as Bayesian confirmation theory, frequentist hypothesis testing and likelihoodism). (Reutlinger 2024: 125)

One interpretation of this claim is that, according to the *Counterfactual Independence Account*, objective evidence plays (or, at least, can play) a twofold confirmatory role: (1)

¹³Another possible interpretation of Nozick's three characterizations of invariance is that he intends his invariantist account of objectivity to remain neutral with respect to different (explicit) definitions of invariance. In this case, the *Counterfactual Independence Account* (at least in its monist version) still differs from Nozick's version by giving up such a neutral stance, favoring a definition that invokes counterfactual independence.

objective evidence confirms a hypothesis of interest, and (2) objective evidence provides, in a sense to be specified, “more evidence” for a hypothesis.¹⁴ I will refer to this interpretation as the *Confirmatory Role Claim*. This interpretation is particularly useful, if one adopts Bayesian confirmation theory, or so I will argue in Section 4.2.¹⁵ In Sections 4.2 and 4.3, I will refer to (1) as the first component and to (2) as the second component of the *Confirmatory Role Claim*.

In Reutlinger (2024: 125), the *Confirmatory Role Claim* has the character of an open issue for future research and, hence, it is not argued for. I believe that it is a crucial task for articulating the *Counterfactual Independence Account* to make the *Confirmatory Role Claim* more precise and to develop an argument in support of it. My goal in the present section is to do just that.¹⁶

As a helpful starting point for pursuing this task, consider a toy example to illustrate the *Confirmatory Role Claim*. Let’s use, once more, a simplified replication scenario involving only two scientists who apply the same method. Suppose that two scientists wish to test the hypothesis that water boils at 100 degrees Celsius. In their laboratories, each scientist heats water, uses a mercury thermometer, and each of them measures that water boils at about 100 degrees Celsius. According to the *Confirmatory Role Claim*, the two results taken together (1) confirm the hypothesis of interest and (2) constitute more (confirming) evidence for the hypothesis than each result just by itself.¹⁷

If the *Confirmatory Role Claim* is true in the context of epistemic objectivity (the definiendum of the *Counterfactual Independence Account*), then this claim highlights an interesting contrast to the non-confirmatory role typically attributed to “objective facts” (Nozick’s target). This non-confirmatory role might take different forms. For instance, Nozick (2001: 79–83) advocates a “reflective equilibrium” view concerning “objective facts.” According to this view, scientists learn *a posteriori* which invariances to rely on by determining which empirically successful theories “entail” these invariances; and, in turn, invariances are used to “modify,” “alter,” and constrain the content of theories to be tested empirically.¹⁸ However, although Nozick provides his readers with little information in terms of describing the latter usage in more detail, invariances are not supposed to play a confirmatory role.¹⁹ Other scholars hold that

¹⁴See also Nozick (2001: 108–109).

¹⁵In Section 4.3, I will discuss an alternative, likelihoodist interpretation: the *Favoring Role Claim*.

¹⁶I was too hasty to endorse (or to suggest) the unnecessarily strong claim that the *Confirmatory Role Claim* is a “consequence” of the *Counterfactual Independence Account* alone. At least, I do not wish to defend this strong claim now. Instead, I will argue for a weaker claim: namely, that the *Confirmatory Role Claim* holds, if one adopts (a) the *Counterfactual Independence Account*, (b) specific assumptions regarding testimonial evidence (described Section 4.1) and (c) a Bayesian approach to confirmation (presented in Section 4.2).

¹⁷Such (toyish) replication scenarios seem to presuppose that the reliability of the method is a given and it is the hypothesis that is being tested and (sometimes) confirmed. However, this is not necessarily so: the *Confirmatory Role Claim* is also applicable to situations in which the reliability of a *method* is being tested and the hypothesis is not.

¹⁸Indeed, Nozick emphasizes that the question which invariances to accept (and, thereby, which transformations to deem “admissible”) is ultimately a question of empirically confirming the theory that entails the invariances in question: “If well-confirmed theories that are our only explanation of certain phenomena fail to be invariant under certain transformation, these transformations will be dropped from the list of admissible ones.” (Nozick 2001: 80).

¹⁹Nozick (2001: 94) does claim that the objectivity of *belief* is connected to truth-conduciveness (supposing that truth is a goal of inquiry) and, I presume, thereby, to confirmation. However, my focus is on Nozick’s discussion of “objective facts”. I will not discuss his account of objective belief; instead, I treat it as a topic for future research (see Section 5).

(at least certain kinds of) Nozickian “objective facts” play a *heuristic role* in developing or constructing new law statements (or, depending on the terminology being used, new theories or models).²⁰

In what follows, I will draw on major theories of confirmation – or, more generally put, on theories of scientific inference – to argue for the *Confirmatory Role Claim* (as envisaged in Reutlinger 2024: 125). To be able to make use of theories of confirmation, I will introduce a couple of assumptions in Section 4.1 to frame the *Confirmatory Role Claim*. In Section 4.2, my focus will be confined to Bayesian confirmation theory. My rather modest goal is to argue that there is a Bayesian defense of the *Confirmatory Role Claim*.²¹ In Section 4.3, I will argue that, although Bayesianism is an attractive option for supporting the *Confirmatory Role Claim*, a revised interpretation of the claim that “valuing objectivity is simply a plea for more evidence” (Reutlinger 2024: 125) is available, if one happens to prefer another theory of scientific inference: likelihoodism. However, I will leave the considerably more complex task of comparing and discussing various other theories of confirmation or of scientific inference for another occasion.

4.1. Preliminary assumptions: counterfactuals and testimonies

Recall from Section 2 how the *Counterfactual Independence Account* describes one prominent instance of epistemic objectivity, objectivity as replication: evidence E, obtained by using (experimental) method M, is objective relative to the contrast class {scientist S₁; scientist S₂} only if obtaining E is counterfactually independent of whether scientist S₁ or scientist S₂ applies method M (Reutlinger 2024: 123). According to the assumed notion of counterfactual independence, the following two counterfactuals have to be true:

1. If S₁ used experimental method M, then E would be the experimental result.
2. If S₂ used experimental method M, then E would also be the experimental result.

To get a Bayesian analysis off the ground, I will make the following two assumptions regarding the relevant counterfactuals above.

First, I assume that the *Counterfactual Independence Account* allows for, what I choose to call, *actual* objective evidence. That is, I assume that, according to the *Counterfactual Independence Account*, the following kind of situation is possible: the two scientists (referred to in the relevant counterfactuals above) *actually* – that is, in the actual world in which the two counterfactuals are evaluated – both apply the same method M (for instance, using a mercury thermometer) and both obtain the same result E (for instance, that water boils at about 100 degrees Celsius in each of their laboratories). To make room for actual objective evidence, I have to permit that counterfactual

²⁰Different versions of this claim are presented and analyzed by, for instance, Brading and Castellani (2007: 1347), Debs and Redhead (2007: 53–55, 66–68), and Woodward (2021: 259–261, 265–270). See also Daston and Galison (2007: 302–306) on a related discussion of Einstein’s “theory-specific, holistic” invariantism about scientific objectivity.

²¹In Section 4.2, I will draw on and reuse material from Reutlinger (2026: section 3.2), in some passages *verbatim*, to develop a Bayesian approach that I will use to make precise and to argue in favor of the *Confirmatory Role Claim*.

(or, for that matter, subjunctive) conditionals may have a true antecedent and, if they do, that they have a non-trivial truth value.²²

Second, I will assume that the consequent of the counterfactuals above can be interpreted as being about a scientist's report (or testimony): the report of a scientist that the result of using method M was E.²³ Drawing once more on the toy example I used above, such a report could have the following content: "In my laboratory, I heated water, used a mercury thermometer, and measured that the water boiled at about 100 degrees Celsius." In a case of successful replication, both scientists report the same proposition. Relying on the reports of scientists is useful for defending the *Confirmatory Role Claim*, since it enables me to draw on existing Bayesian accounts of the social epistemology of testimony – or so I will suggest in the next subsection.

4.2. Bayesian confirmation theory and the confirmatory role claim

Bayesian confirmation theory provides one possible and fruitful way to make the *Confirmatory Role Claim* more precise.²⁴ I will begin with the exposition of a general Bayesian approach covering multiple (i.e., more than two) scientists and their reports. Then, I will illustrate the relevant results by appealing to the sort of two-scientist replication scenario sketched in Section 4.1.

Let's take the following Bayesian definition of when the reports of multiple scientists confirm a hypothesis as a useful starting point for articulating the *Confirmatory Role Claim*:

The reports of multiple scientists that proposition E is true confirm a hypothesis H if and only if the following condition holds: when an epistemic agent learns about the total testimonial evidence (the entirety of reports), then the agent should have greater confidence in the truth of H.

Bayesians interpret the vague notion of an epistemic agent having *greater confidence in the truth of a hypothesis* in terms of subjective probabilities: the agent assigns a posterior probability to H being true, $P^*(H)$, that is greater than the prior probability the agent assigned to H, $P(H)$. In the context of multiple reports, the prior probability is the probability the agent assigned to H before receiving the reports, whereas the posterior probability is the probability the agent assigns to H after having received the reports.

²²In this paper, I will not defend any specific claims about how this permission has to be reflected in a semantics of counterfactuals, for instance, in the form of the strong centering axiom as a logical truth (Lewis 1973b: section 1.7) or as an "approximation" of the strong centering axiom (Leitgeb 2012: section 1). All I would like to commit to in this paper is that the *Counterfactual Independence Account* requires a semantics for counterfactuals that is compatible with counterfactuals having a true antecedent and, if they do, that they have a non-trivial truth value. This minimal commitment expresses my intention to frame the *Counterfactual Independence Account* as neutrally as possible with respect to the semantics for counterfactuals (Reutlinger 2024: 121).

²³This testimonial perspective on replication is inspired by Robert Boyle's description of replication as the "multiplication of witnesses" (based on the analysis by Shapin and Schaffer 1985: 59–60), or, in my terminology, as multiple scientists reporting the same proposition. For an elaboration, see also Reutlinger (2026: section 3.1).

²⁴I build on seminal statements of Bayesian confirmation theory including Jeffrey (1992: 109–110), Goldman (1999: 223), Bovens and Hartmann (2003: section 3.3), and Sober (2008: 42–43). However, my main point of reference will be Earman (2000: 55–58).

If we use “ $S_i(E)$ ” to express that one of n scientists, scientist i , reports that proposition E is true and K to express background knowledge, then Bayesians express the fact that the reports of multiple scientists $S_1, \dots, S_n$ confirm a hypothesis via the following inequality (for $i = 1, \dots, n$):

$$P^*(H) = P[H|S_1(E), \dots, S_n(E), K] > P(H|K)$$

This Bayesian approach, as I present it here, rests on two basic assumptions.

First, I adopt Earman’s proposal to state the Bayesian approach explicitly as being conditional on the background knowledge K of an epistemic agent (Earman 1992: 33–34, 2000: 26–27, 55). I take such background knowledge to include previously acquired empirical knowledge (i.e., previously obtained research results, including empirical evidence) as well as methodological and conceptual knowledge, shared and accepted in a field of scientific inquiry.

Second, I assume for simplicity’s sake that an epistemic agent obtains the posterior probability of H via the updating rule of strict conditionalization, according to which (testimonial) evidence is believed with certainty.²⁵ In other words, appealing to Bayes’ theorem, the posterior probability $P^*(H)$ is determined as follows²⁶:

$$P^*(H) = P[H|S_1(E), \dots, S_n(E), K]$$

$$= \frac{1}{1 + \left(\frac{P(\neg H|K)}{P(H|K)} \right) \times \left(\frac{P[S_1(E)|\neg H, K]}{P[S_1(E)|H, K]} \times \dots \times \frac{P[S_n(E)|\neg H, K]}{P[S_n(E)|H, K]} \right)}$$

Now, to see how the Bayesian approach works, it is helpful to assume that two conditions hold: the *Minimal Reliability Condition* and the *Conditional Independence Condition*.²⁷ In what follows, my entire focus will be on the minimal reliability of scientists.

The second condition is strictly speaking not a necessary one, if one would like to adopt a Bayesian approach. However, in this paper, I will work with the assumption that the *Conditional Independence Condition* is satisfied. I make this assumption to keep the exposition of the Bayesian approach as simple as possible. This (simplifying or idealized) condition of independence is itself the subject of a philosophical debate (including questions as to how the condition should be stated, how it can be motivated, and how it is applicable in scientific contexts).²⁸ In this paper, I will sidestep this debate by assuming

²⁵On the rule of strict conditionalization (also known as Bayesian conditionalization or Bayes’ rule), see, for instance, Earman (1992: 34) and Sprenger and Hartmann (2019: 22). However, other updating rules are available that allow for uncertain evidence, perhaps most importantly Jeffrey conditionalization (Jeffrey 1983: chapter 11, 2004: chapter 3). It will be a task for future research to explore whether such alternative updating rules hold an advantage over the rule of strict conditionalization if applied to the *Confirmatory Role Claim*.

²⁶For informal and formal proofs, see Earman (2000: 55) and Bovens and Hartmann (2003: Appendix E.1).

²⁷I present the two conditions in a way tailored to Bayesian confirmation theory. However, the conditions as such (and the intuitions motivating them) need not be defined in a Bayesian framework, nor in any probabilistic or even formal way at all.

²⁸Indeed, there are various proposals of how to define the notion of conditional independence to render it plausible in scientific contexts (i.e., contexts involving collaboration and exchange between scientists) and an advocate of the Bayesian approach might – at least, in principle – appeal to them. Such work includes Bovens and Hartmann (2003: section 3.5), Dietrich and List (2004: 180–184), and Dietrich and Spiekermann (2013: 98, 104–107). Dietrich and Spiekermann (2020) provide an instructive survey to the research literature in point. However, it is not my goal to assess the merit of these proposals here.

that the *Conditional Independence Condition* is met in instances of objectivity as replication (and in instances of other kinds of epistemic objectivity).²⁹

According to the *Minimal Reliability Condition*, it is more probable that a scientist S_i reports E , if the conjunction of H and, as already indicated above, background knowledge K is true rather than if $\neg H$ and K is true. This condition expresses the intuition that, for a reliable scientist, the content of a report E depends sensitively on the truth of H and K . Mathematically, we can express the *Minimal Reliability Condition* regarding S_i 's reporting of E as follows in terms of likelihoods:

$$P[S_i(E)|H, K] > P[S_i(E)|\neg H, K]$$

The assumption that a scientist is minimally reliable can also usefully and equivalently be expressed as a likelihood ratio that is greater than 1:

$$\frac{P[S_i(E)|H, K]}{P[S_i(E)|\neg H, K]} > 1$$

The *Conditional Independence Condition* requires that the reports of multiple scientists asserting that E is true be probabilistically independent, *conditional on* whether H and K is true. The intuition expressed by this condition is that the report of one scientist is not affected by what other scientists report.³⁰ The *Conditional Independence Condition* with respect to reporting E can be stated as follows in formal terms (for $i = 1, \dots, n$):

$$P[S_1(E), \dots, S_n(E)|H, K] = P[S_1(E)|H, K] \times \dots \times P[S_n(E)|H, K]$$

Let me add a cautionary note at this point to avoid a potential misunderstanding. It is crucial not to conflate the probabilistic notion of conditional independence figuring in the *Conditional Independence Condition* (that is a part of the Bayesian approach) with the notion of counterfactual independence (figuring in the *Independence Condition* of the *Counterfactual Independence Account*). In this paper, I assume that the two independence conditions are logically and conceptually distinct.

To simplify matters, I will talk straightforwardly about likelihood ratios and not about posterior probabilities. In doing so, I will appeal to, what I will call, the *Confirmation-Likelihood-Principle*, according to which multiple reports confirm H if and only if the likelihood ratio (regarding all relevant reports) is greater than 1. Formally, we can express this principle as follows (for $i = 1, \dots, n$):

$$P[H|S_1(E), \dots, S_n(E), K] > P(H|K) \Leftrightarrow \frac{P[S_1(E), \dots, S_n(E)|H, K]}{P[S_1(E), \dots, S_n(E)|\neg H, K]} =: x > 1$$

With this principle in place, let me turn to an illustration of how the Bayesian approach works. From this illustration, it will be a small step to explaining how the Bayesian approach helps to articulate the *Confirmatory Role Claim*.

Recall the toy example of objectivity as replication involving only two scientists, S_1 and S_2 , and suppose that two scientists both actually report E , expressed as " $S_1(E)$ " and " $S_2(E)$ ". These reports constitute the total actual objective evidence in the

²⁹I also make this simplifying assumption, because it is not my goal in this paper to motivate or defend Bayesian confirmation theory but to treat it as a premise or tool (as already stated in Section 1). I do not mean to suggest in any way that it is not a crucial task to define and to motivate the conditions underlying the Bayesian approach. But it is not a topic I will address in this paper.

³⁰In the context of discussing the confirmatory impact of successful replications, Nozick (2001: 109) also appeals to an informal expression of independence.

situation. Given that the two scientists are minimally reliable and report independently, their individual likelihood ratios can be multiplied (licensed by the definition of conditional independence above) and the product of their individual likelihood ratios is greater than 1.³¹ This can be stated – regarding the minimally reliable and conditionally independent reporting of E – by the following inequality in which each fraction expresses the likelihood ratio for a single scientist (for $i = 1, 2$):

$$\frac{P[S_1(E)|H, K]}{P[S_1(E)|\neg H, K]} \times \frac{P[S_2(E)|H, K]}{P[S_2(E)|\neg H, K]} > 1$$

If this inequality holds, then, according to the *Confirmation-Likelihood-Principle*, the reports of the scientists S_1 and S_2 (the total actual objective evidence) confirm H – that is, then the posterior probability $P[H|S_1(E), S_2(E), K]$ is greater than the prior probability $P(H|K)$.

Now, given this illustration, what does the Bayesian approach imply for articulating the *Confirmatory Role Claim*? First, the Bayesian approach allows us to say straightforwardly that the reports of the two scientists – constituting the total actual objective evidence in the imagined situation – do indeed confirm the hypothesis of interest, provided that the scientists report reliably and independently. This captures the first component of the *Confirmatory Role Claim*.

Moreover, recall that, according to the second component of the *Confirmatory Role Claim*, objective evidence is – in a sense to be specified – supposed to be “more evidence.” The Bayesian approach provides the desired specification by comparing the confirmatory power of multiple reports with that of a single report. To see how, consider the illustration with two reporting scientists once more. Although each single report considered in isolation constitutes confirming evidence for H, the product of the two individual likelihood ratios is greater than the individual likelihood ratio of each scientist considered in isolation (for $i = 1, 2$):

$$\frac{P[S_1(E)|H, K]}{P[S_1(E)|\neg H, K]} \times \frac{P[S_2(E)|H, K]}{P[S_2(E)|\neg H, K]} > \frac{P[S_i(E)|H, K]}{P[S_i(E)|\neg H, K]} > 1$$

Hence, given *Confirmation-Likelihood-Principle*, the posterior probability taking into account the total actual objective evidence – that is, $P[H|S_1(E), S_2(E), K]$ – is not only greater than the prior probability $P(H|K)$; it is also greater than the posterior probability resulting from conditionalizing on only one of the two reports in isolation – that is, $P(H|S_i(E), K)$. For this reason, the reports of the two scientists provide *more evidence* for the truth of H, *more* than the report of either S_1 or S_2 considered in isolation. Hence, the Bayesian approach also provides a way to articulate and to support the second component of the *Confirmatory Role Claim*.³²

³¹I assume that the scientists are minimally reliable. In general, Bayesian confirmation theory is applicable even if witnesses fail to be minimally reliable – see, for instance, Earman (2000: 55–56), Bovens and Hartmann (2003: 14–15), and Reutlinger (2026: section 4).

³²It is an additional advantage of the Bayesian approach that it is applicable to situations in which scientists disagree in their reports – see, for instance, Jeffrey (1992: 110–114), Bovens and Hartmann (2003: section 3.6), and Reutlinger (2026: section 5).

4.3. What depends on Bayesian confirmation theory?

Is the *Confirmatory Role Claim* – in combination with the Bayesian approach (developed in Section 4.2) – the only possible interpretation of the claim that objective evidence is “more evidence”? Or are there other possible interpretations?

To answer this question, let’s consider a prominent alternative to Bayesian confirmation theory: likelihoodism as an account of scientific inference.³³ Likelihoodists reject central Bayesian concepts, such as the concepts of the prior probability and the posterior probability of a hypothesis, as well as of the notion of confirmation. Making use solely of the notion of likelihoods, likelihoodists replace the mentioned Bayesian notions by the less demanding notion of “favoring” to characterize scientific inference (Sober 2008: 32–35).³⁴ Sober expresses likelihoodism in terms of the “law of likelihood”:

The observations O favor hypothesis H_1 over hypothesis H_2 if and only if $\Pr(O|H_1) > \Pr(O|H_2)$. And the degree to which O favors H_1 over H_2 is given by the likelihood ratio $\Pr(O|H_1)/\Pr(O|H_2)$. (Sober 2008: 32)

Let’s adapt this statement of likelihoodism to our notation and to the discussion of what multiple scientists $S_1, \dots, S_n$ report. Then, the total actual objective evidence – consisting in the entirety of the reports $S_1(E), \dots, S_n(E)$ – favors H_1 over H_2 (relative to K) if and only if $\mathbf{P}[S_1(E), \dots, S_n(E)|H_1, K] > \mathbf{P}[S_1(E), \dots, S_n(E)|H_2, K]$. Moreover, the degree to which the total actual objective evidence favors H_1 over H_2 (relative to K) is given by the following likelihood ratio:

$$\frac{\mathbf{P}[S_1(E), \dots, S_n(E)|H_1, K]}{\mathbf{P}[S_1(E), \dots, S_n(E)|H_2, K]} > 1$$

Likelihoodists cannot accept the *Confirmatory Role Claim* as it stands, because they reject the notion of confirmation. However, a proponent of likelihoodism could happily agree to a slightly revised interpretation of the claim that “valuing objectivity is simply a plea for more evidence, for more evidence from different sources (from different scientists and/or methods)” (Reutlinger 2024: 125). Let’s call this revised interpretation the *Favoring Role Claim*. According to this interpretation, actual objective evidence can play an epistemic or evidential role in the following sense: (I) the reports of multiple scientists (that E) favor H_1 over H_2 , and (II) these reports (that E) also favor H_1 *more strongly* over H_2 than a single report (that E) considered in isolation. Here, I treat (I) and (II) as the likelihoodist analogs of the two components of the *Confirmatory Role Claim*.

So, where does this leave us? The task of articulating the claim that objective evidence is “more evidence” is neutral with respect to at least two interpretations: the *Confirmatory Role Claim* (in a Bayesian version) and the *Favoring Role Claim* (based on likelihoodism). Hence, the articulation is not committed to Bayesian confirmation theory and I take this to be an advantage.

³³It will be a rewarding task for future work to discuss further theories of confirmation or, more generally, of scientific inference: particularly, various frequentist theories (for a survey, see Sober 2008: chapter 1) as well as approaches in social choice theory based on the Condorcet jury theorem (see Dietrich and Spiekermann 2020 for a survey).

³⁴Sober (2008: 32) presents likelihoodism as a “fallback position” available to Bayesians when there are, for instance, no convincing empirical reasons for assigning prior probabilities.

5. Conclusion

In Sections 1 and 2, I reconstructed the *Counterfactual Independence Account* and suggested the need for a more precise articulation of its scope, content, and consequences. In Section 3, I discussed two dissonances between Nozick's invariantism and the *Counterfactual Independence Account*: one concerning the examples illustrating the sort of objectivity both accounts aim to capture, and the other concerning their characterizations of invariance. I argued that identifying these dissonances is helpful to articulating the scope and content of the *Counterfactual Independence Account*: it should be understood as a monist account of epistemic objectivity. In Section 4, I addressed the claim that objective evidence is "more evidence." I argued that Bayesian confirmation theory provides one precise articulation of this claim and that likelihoodism, an alternative account of scientific inference, allows for another, slightly revised articulation of the claim. In sum, the arguments presented in Sections 3 and 4 give rise to a more articulated and improved version of the *Counterfactual Independence Account*.

Moreover, the articulated *Counterfactual Independence Account* is fruitful, since it raises additional questions for future work, including the following three ones.

First, I adopt a broadly counterfactual approach to defining invariance that is inspired by the work of Lewis and Woodward. But this is perhaps not the only way to elaborate such a counterfactual approach. Could one, as an advocate of the *Counterfactual Independence Account*, define invariance differently? For instance, could one – remaining close to the account as it is presently stated – draw on alternative counterfactual approaches to invariance, such as Lange's (2000, 2009) notion of (counterfactual) stability? Or, more radically, is it possible to define invariance (or independence) via a purely group-theoretic concept of invariance (along the lines of Nozick's "mapping characterization" presented in Section 3.2), via other kinds of conditionals that are not counterfactual conditionals, or via conditional probabilities? These more radical options might take inspiration from, for instance, Leitgeb (2017), Sher (1991, 2016, 2021), or Skyrms (1980, 1984). If one explored the more radical options, it would, of course, no longer be sensible to speak of a *Counterfactual Independence Account*, but simply of an *Independence Account* of objectivity instead.

Second, some philosophers propose to define different kinds of necessity in terms of invariance, understood as counterfactual independence (including Lange 2005, 2009; Lewis 1973b; Sher 2021; Williamson 2005; see also the discussion in Nozick 2001: chapter 3). Suppose that one accepts such definitions of necessity and that objectivity can be defined in terms of invariance. Does this imply that objectivity is a specific sort of (restricted) necessity?

Third, Nozick analyzes two concepts of objectivity: "objective facts" and "objective belief" (Nozick 2001: 94–96). In this paper, I have focused entirely on his discussion of objective facts. However, it might be interesting to explore whether one can also define the concept of objective belief in terms of counterfactual independence. In what way would such a definition diverge from other broadly invariantist approaches to belief (for instance, Leitgeb 2017)? Furthermore, what would such a novel invariantist account of objective belief imply for Nozick's theory of knowledge (as presented in Nozick 1981: chapter 3, 2001: 78)?

I hope that these open questions, in conjunction with the arguments presented in this paper, suggest that the *Counterfactual Independence Account* and invariantism about objectivity more generally deserve more attention in the debate on objectivity – and even beyond the topic of objectivity, since invariantism is entertained with respect to diverse

subjects such as necessity, logical truth, lawhood, belief, probability, and more. Indeed, I agree with Earman (2004: 1239–1240) and Sher (2021: 3968) that the notion of invariance (as a philosophical concept) and invariantism (as a philosophical position) are particularly exciting and potentially fruitful, because they cut across various fields of philosophy including philosophy of science, epistemology, metaphysics, and philosophy of mathematics and logic.

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