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Doubts for Dawid's non-empirical theory assessment

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ABSTRACT

Dawid's account of non-empirical theory assessment is meant to complement traditional theory assessments. I contend that his arguments don't provide support for this account. His three arguments, the no alternatives argument, the unexpected explanatory connections argument, and the meta-inductive argument from prior theories' success, are all problematic, particularly for an assessment of string theory. In particular, I argue that the meta-inductive argument is idle, because it's role in underwriting the future predictive success of a theory is subsumed by the normal accounting of its predecessor's predictions in theory growth and testing. Dawid's arguments are interdependent, so showing that one fails is sufficient to cast doubt on his entire account.

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1. Introduction

In *String Theory and the Scientific Method* Richard Dawid provides an account of non-empirical theory assessment, meant to complement traditional, empirical theory assessment. He provides three interdependent arguments for the continued trust in scientific theories that lack empirical evidence, but which have theoretical virtues and no available alternatives. These arguments are meant to act as sources of non-empirical evidence for the viability of, for instance, the string theory research programme. Non-empirical evidence does not pertain to the phenomena described by a theory, but comes from observations about the research process leading to a theory's formation. Because of the energy scales and the massive number of possible vacuum states involved in string theory,[1] empirical evidence has been, and is likely to remain for the foreseeable future, elusive. Despite string theory proponents' apparent violations of long held standards of empirical theory testing, Dawid argues that string physicists remain warranted in their perception that string theory is a viable research programme that will eventually yield positive experimental results, because it has strong *non-empirical* evidence. In this paper I argue that Dawid does not establish this claim, by showing that his arguments for non-empirical theory assessment are flawed, concentrating on one argument in particular: the meta-inductive argument.

Dawid claims that string theory obtains this non-empirical evidence from the combination of what he calls the *no alternatives argument* (NAA), the *unexpected explanatory coherence argument* (UEA), and the *meta-inductive argument* from the success of other theories in its research programme (MIA). Dawid is not arguing against the notion that decisive empirical evidence should be the ultimate mark of a successful scientific theory, but rather that research programmes like string theory still have a rational, scientific basis through non-empirical theory assessment. Because non-empirical evidence can't be predicted by a theory itself, his supplemental paradigm of theory assessment is meant to explain cases where scientists continue to work on a theory even though empirical evidence is hard to come by.

Although I am sympathetic to Dawid's project, I believe each of his arguments are problematic. I will focus on the MIA, because the scope of my objection is widest against it. I argue that the MIA does not increase the available non-empirical evidence in string theory's favor because the constraints Dawid claims it provides to the conceptual landscape of successor theories are already provided within scientific practice distinct from his line of argument. Only those theories that have the right sort of relationship to the predictions of their successful predecessors are likely to be successful themselves and this relationship supersedes the MIA, leaving it idle. My argument is not specific to string theory, which is Dawid's focus, and so casts doubt on his account of theory assessment generally.

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[1] For example, the Large Hadron Collider (LHC) is capable of reaching energies of about 14 TeV ($\sim 10^4$ GeV). The best estimate of the energy needed to probe matter at the string scale is the Planck energy, or $\sim 10^{19}$ GeV. Likewise, the number of possible vacuum states in string theory is roughly 10^{500}, each representing a different possible physical state of affairs.

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2. Non-empirical theory assessment

Dawid's three arguments are defined in reference to what he calls *scientific underdetermination*. It is a distinct type of underdetermination that he suggests is particularly useful to consider in theory building. Scientific underdetermination, as defined by Dawid, is underdetermination by the currently available evidence (as opposed to all possible evidence) given some general assumptions that are deemed valuable or necessary within a scientifically viable research programme (rather than across all logically possible circumstances). These "ampliative rules of [the] scientific method" include things like a principle of induction, a disregard for ad-hoc explanations, some form of Ockham's razor, and specific rules for scientific practice within a given field. Scientific underdetermination is similar to the "transient underdetermination" described by Larry Sklar and Kyle Stanford (see (Sklar, 1975, 1981) and (Stanford, 2006)), though Dawid notes distinctions in his formulation that make it useful in his account of theory assessment.

Dawid claims that scientific underdetermination is especially useful to understand theory construction, because it allows scientists to follow the generally accepted rules of their field while focusing on presently available evidence. He makes use of unconceived alternatives: rather than highlighting underdetermination between existing theories that account for a phenomenon, Dawid's scientific underdetermination applies across *all possible* theories that explain the phenomenon, even those to which we don't have epistemic access to.[2] Claims of scientific underdetermination in a given context indicate that it could be possible to construct alternative theories which follow the rules and fit the presently available evidence of a scientific field, if only we had the proper epistemic standpoint.[3] Because even these unconceived alternatives are constrained by the evidence available now, our primary method for choosing among all possible theories requires additional criteria.

Dawid's core argument is that we can assess the range of possible alternatives to a given theory, so he proposes methods to constrain the number of possible theories that provide acceptable explanations for the phenomena at hand. Without such constraints, "no correct predictions of new phenomena could ever be expected to occur," because we'd have an infinite number of theories that adequately describe the observed phenomena, with no way to distinguish them besides actively testing their predictions (Dawid, 2013, p. 48). The three arguments that form the core of his account of non-empirical theory assessment act as constraints on scientific underdetermination, shrinking the conceptual space of theories for a given phenomenon.

2.1. The No alternatives argument

The NAA begins with a consideration of the conceptual landscape of possible theories when only one theory actually exists. There are two ways of interpreting the persistent lack of alternatives to a controversial solution to a scientific problem. The first is that there are theoretical avenues left to be discovered, but some contingent factor has barred our epistemic access to them. However, accepting this interpretation fails to provide scientists with any solutions, because the conceptual space under investigation remains the same size, offering too many possibilities and no hint how to find a more promising solution. The other interpretation is more optimistic and the one Dawid prefers. It is to "conjecture a connection between the spectrum of theories scientists come up with and the spectrum of all possible scientific theories that fit the available data" (Dawid, 2013, p. 51). If scientists have problems finding alternatives, it must be because there are few alternatives available to find. If a solution to the problem can be found at all, and only a small number of appropriate solutions can be constructed, we gain confidence in the solution already in hand, even without empirical support. In effect, the NAA raises the subjective degree of belief in a theory's empirical adequacy.[4]

Dawid concedes that the "step from an observation about the present human perspective to a conclusion regarding the overall spectrum of possible scientific thinking is by no means trivial" (Dawid, 2013, p. 51). The NAA may raise the subjective degree of belief for theories like string theory, but it cannot do so without nagging doubts about unconceived alternatives. Further arguments are needed to establish the viability of the project of using constraints on scientific underdetermination for non-empirical theory assessment.

2.2. The unexpected explanatory coherence argument

The UEA constrains scientific underdetermination through examination of the structure of the theory itself as it is constructed. The argument comes into play when explanatory connections that were not purposefully searched for emerge during theory construction. As long as the theorist presupposes another brand of optimism (that there are empirically adequate scientific theories covering each phenomenon in a given domain and that there is at least one theory that covers all of them), a solution that emerges covering more than just the initial phenomenon in question looks more viable than rivals that do not. Scientists could construct a multitude of theories to account for any given phenomenon, but Dawid takes it that there is a smaller logical space for theories that account for diverse phenomena all at once.[5] That these connections in a theory were *unexpected* is relevant, says Dawid, by analogy with the distinction between novel data and data used in constructing a theory. Thus, unsought connections make the theory more attractive, both for being rarer and for having more explanatory power than theories that cover only a single phenomenon.

These connections could be indicative of a more fundamental theory that underlies the one we are assessing however, so we cannot rely solely on the constraints to scientific underdetermination provided by the UEA. The argument *can* be used in conjunction with the no alternatives argument, however. A scientific optimist (or realist) would grant a theory with no actual,

[2] Unconceived alternatives are covered extensively in Stanford (2006). The concept is not without its detractors: see, for example Chakravartty (2008); Godfrey-Smith (2008); Devitt (2011).

[3] A significant difference between Dawid and Stanford's accounts is that Dawid ultimately takes a realist position on string theory, in contrast to Stanford's anti-realism.

[4] A slightly different approach to the NAA is available in Dawid, Hartmann, and Sprenger (2015). Using Bayesian epistemology, they argue that, within the conditions of scientific underdetermination, the NAA can raise the subjective probability of empirical adequacy for a hypothesis without any apparent alternatives, though this increase may be very small. It is in this paper that Dawid's preference for the scientifically optimistic interpretation given above is defended on Bayesian grounds. For the purposes of my analysis, this formulation retains the same functionality in Dawid's overall account. Naturally, anyone who objects to Bayesian confirmation (see Mayo, 1996) will not find this defense of the NAA particularly convincing.

[5] It is not clear that the logical space for such theories *actually is* smaller than that of theories that explain a single phenomenon. One could argue that both logical spaces are in fact infinite, and therefore their sizes could not be differentiated except by cardinality, though Dawid et al. (2015) argue against an infinite number of alternatives under the constraints of scientific underdetermination. On the other hand, it is reasonable to question whether the logical space of possibilities even *has* a size.

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