UNIVERSALITY, TRUTH, AND POPPERIAN SIMPLICITY

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Abstract

Popper's account of science is an endeavour in establishing the relationship between universality and truth. The idea is that the more an empirical law is universal, by precluding certain realities from obtaining in an evidentially falsifiable way, the more the law is supported by instances of its predictions being evidentially verified. The logical structure of this dynamic is captured by Popper's notion of 'corroboration'. However, this notion is suspect, for, depending on one's interpretation of evidential givenness, the relation between a law's degree of universality and evidential corroborability could instead invert, thereby contradicting Popper. This paper also explores how a conceptualization of universality in terms of necessary simplicity – i.e., a measure of simplicity that is also sensitive to the evidence at hand – can better recontextualize evidential givenness to be about evidential support for a theory's predictive truth conduciveness, against Popper's understanding of evidential support for a theory's veracity concerning the evidence at hand. However, it is argued that employing necessary simplicity to attain truth conduciveness in a theory's predictions must appeal to specific background assumptions concerning the state of affairs the evidence is supposed to be about. When these background assumptions are denied as being necessarily instantiated, then a relation between necessary simplicity and truth conduciveness becomes contingently uncertain.

Keywords: Popper, Universality, Simplicity, Falsification, Truth, Corroboration

1. Introduction

In *The Logic of Scientific Discovery*, Popper details a deductive science that is meant to counteract some of the pressing issues beleaguering sciences based on induction, primarily in regards to inductive justification of empirical theories.[1] An important outcome of Popper's goal for a deductive science is his identification of simpler theories as the more falsifiable ones, and how a theory's falsifiability conditions its extent of evidential support – what he calls a

[1] For a brief overview of his qualms with induction, see, Popper (1992, pp. 28-9, 35). The main source for Popper's thought throughout this essay is his book, *The Logic of Scientific Discovery*, which, through its multiple reprints, corrections, and additions, acts as an up to date version of Popper's general and mature perspective on science.

theory's corroborability. Relatedly, for Popper, a simpler theory is also a more universal one, in that the scope of the world about which it is meant to be is greater than more complex theories. Popper therefore relates universality and falsifiability in this way: the more potential falsifiers a theory has, the more extensive its empirical content is and the more it has to say about the world.

This relation, being one of verisimilitude whereby universality becomes a measure of a theory's truth conduciveness, is problematic due to features of its *deductive structure* concerning how Popper understands the nature of evidential givenness and its probabilistic support for the veracity of empirical laws. To appreciate this problem, we first outline Popper's concept of testability and falsifiability (Section 2), as well as how it is associated with universality (Section 3), before explaining how universality relates to his notion of evidential corroboration (Section 4). Issues surrounding this comprehension of Popper's argument are subsequently brought up (Sections 5 & 6) before discussing how a recent attempt at reviving a workable link between simplicity and truth conduciveness does not fare much better epistemically than Popper's own account (Section 7). We then offer concluding remarks (Section 8).

2. Popper on empirical testability and falsifiability

Popper (1992) reasons that one of the components of a genuine deductive science is "the testing of [a] theory by way of empirical applications of the conclusions which can be derived from it" (pp. 32-33). Empirical testability in theories, for Popper, is closely tied to his understanding of scientific objectivity, for if we regard scientific theories as being composed of 'objective' scientific statements, then Popper would argue that these statements' objectivity "lies in the fact that they can be *inter-subjectively tested*" (p. 44). In other words, scientific statements must be neither so idiosyncratic and esoteric as to be resistant to testing nor regarded as so self-evident that testing would be pointless. According to Popper,

> inter-subjective testability always implies that, from the statements which are to be tested, other testable statements can be deduced. Thus if the basic statements in their turn are to be inter-subjectively testable, *there can be no ultimate statements in science*: there can be no statements in science which cannot be tested, and therefore none which cannot in principle be refuted, by falsifying some of the conclusions which can be deduced from them (p. 47).

In short, "every scientific statement must remain *tentative for ever*" (p. 280).

This conclusion applies even to logical tautologies, which can be regarded as untestable and thus true simply by virtue of meaning. Popper (1992), in this sense, ends up disavowing "the view that there are statements in science which we have, resignedly, to accept as true merely because it does not seem possible, for logical reasons, to test them." (p. 48)[2] This mandate on wholesale testability for science can also be viewed as the reason why Popper insists that scientific laws "cannot be logically reduced to elementary statements of experience . . . [that are also] irrevocably true statements" (pp. 36-37). This is because what is meaningful for science is what allows for experientially testable statements/predictions that are *not* irrevocable, either by experience or meaning, in their truth value (p. 33).[3]

Scientific testability then, for Popper, is a property of statements indicating their falsifiability, since tests can produce negative results that falsify some test statement. This concept of falsifiability is integral for Popper, to the point wherein he takes "not the *verifiability* but the *falsifiability* of a system [of statements] . . . as a criterion of demarcation [for science]" (1992, p. 40). This criterion demarcates non-falsifiable universal statements, along with verifiable although non-falsifiable singular, i.e., non-universal, statements, from falsifiable

[2] Popper (1992) explains that the logical necessity of tautologies can only apply if they are "true in all possible worlds" (p. 432). Furthermore, how we normally justify a tautology's logical necessity is if, at least for Popper, the negation of a tautology would lead "to an obvious contradiction" (p. 429). However, if the concluded contradiction is based on the prior formulation of the tautology in question, then affirming that the tautology is logically necessary would be tantamount to arguing in a circle: a tautology is necessary based on its negation being contradictory, and this contradiction in turn is based on the tautology being necessary. We may instead replace 'necessary' with 'true' to appeal to the fact that a contradiction can simply be based on the establishment of a law as true, not necessarily as necessarily true, but this leads to an obvious problem: if we can replace 'necessary' with 'true' and thereby change the character of a tautology from 'necessarily true' to 'true but not necessarily true', then we have no principled way of certainly knowing that some tautology is necessarily true rather than not. Popper acknowledges this issue and interprets it as indicating that, if necessary truth entails being true in all possible worlds, then any necessarily true statement can never be known as such, because "we cannot search all worlds that differ from ours" (p. 433). In this way, Popper follows Quine (1963) in ascribing to tautologies the feature of falsifiability rather than analytic necessity.

[3] For Popper (1992), "observation is always *observation in the light of theories*, [and] it is the inductivist prejudice which leads people to think that there could be a phenomenal language [that is] free of theories" (p. 59n; *Cf.*, pp. 111, 423). Thus, what is meaningful for science are the empirical observations that are meaningfully conditioned by theory. Now, whatever may be said about the theory-independent *facets* of such observations, Popper merely considers these facets as irrelevant for his brand of science (pp. 99, 107). A helpful distinction between theory-conditioned observation and theory-independent observation can be derived from the discussion of theory-laden phenomenon and non-theory-laden data found in Bogen and Woodward (1988).

universal statements.[4] Said in another way, scientific theories, in Popper's view, deal only with falsifiable universal statements because science is interested in testable *explanation*, not mere *description* (*Cf.*, p. 59n and §85).[5] Moreover, given that from a system of statements other testable statements can be deduced (*Cf.*, pp. 47, 60), we may say that the former statements help explain the latter ones. Popper further justifies why falsifiability, not verifiability, counts for science by noting that "an *asymmetry* between verifiability and falsifiability" of universal statements exists due to their "logical form" (p. 41): universal statements "are never derivable from singular statements, but can be contradicted by singular statements. Consequently it is possible by means of purely deductive inferences to argue from the truth of singular statements to the falsity of universal statements" through the use of *modus tollens* (p. 41), but never from the truth of singular statements to the truth of universal statements (p. 70n*2), as this would entail the fallacy of affirming the consequent. As such, from Popper's argument, if we are committed to a science that deals with *explanation* via universal statements, then falsifiability, not verifiability, is a necessary part of said science, for, among the two, only falsifiability is an obvious property of universal statements.

This is not to say that explanation occurs by way of deduction from *one* universal statement to some prediction, but from an initial *group*, or *system* of statements one can deduce testable predictions. This 'group' consists of the aforementioned universal statements as well as "*singular statements*" acting as the initial conditions that permit the derivation of testable "singular *prediction*[*s*]" (Popper 1992, p. 60; *Cf.*, p. 101n).[6] Popper acknowledges this, which is why, for him, scientific theories, consisting of universal statements, can never be

[4] Popper's conception of universality is explicated in Section 3.

[5] Popper's science thus is a form of falsificationism. For an additonal account of the relevance of falsification for science, see Medawar (1969). Nonetheless, for Popper, although metaphysical systems may help explain phenomena, they are not falsifiable; also, although non-falsifiable singular statements may deal with phenomena, they do not go past them as explanations since they cannot be tested. Consequently, Popper's line between falsifiability and non-falsifiability is not that between synthetic and analytic statements, for while analytic statements are by definition empirically non-falsifiable, some synthetic statements can also be non-falsifiable in a practical way. For example, a non-falsifiable synthetic statement could be of the form, 'X is an experienceable property of Y in possible worlds besides our own.' Here, although X is *in principle* a testable property, since it can be experienced, X is *in practice* untestable if 'possible worlds besides our own' is regarded as 'possible worlds we cannot get to' (*Cf.*, Popper 1992, p. 40n*3).

[6] Indeed, consistent with Popper, one cannot deduce testable predictions from universal statements alone, for the statements that *are* so deducible are hypothetical ones that still need initial conditions fulfilling their antecedent conditions in order to give concrete consequences that can then be tested.

conclusively falsified (p. 50), as there is always the chance for a falsified prediction to be due to the singular statements representing the set of *testable* initial conditions, not to the theory itself.[7] Henceforth, we will disregard the influence that initial conditions have on the falsifiability of deduced predictions, primarily because, as we will see, there are problems even with Popper's understanding of the relationship between a theory's universal statements and their derived singular predictions that have *not* yet been falsified.[8] To prime the discussion on these problems, we must first explore further what Popper means by 'universality'.

3. Popper on the universality of laws

In general, universality for Popper (1992) is meant to express the extent to which a statement's referenced class of entities – i.e., the entities the statement is supposed to be about – can be falsified (p. 141). To understand this concept, we must do some housekeeping.

First, consider that a consequence of science dealing with universal statements and having 'no ultimate statements' is that scientific "theories are tested by deducing from them statements of a lesser level of universality. These statements in their turn, since they are to be inter-subjectively testable, must be testable in like manner – and so *ad infinitum*" (Popper 1992, p. 47). Presumably, for Popper, this infinite testability implies that deduced singular predictions are universal in nature as well, albeit to a lesser extent than those statements from which said predictions had been derived. However, if singular predictions – as in, singular statements derived from more universal statements – are universal in character, then how can they still be

[7] This answers Putnam's claim that Popper does not pay sufficient attention to the interaction between the scientific theories and "auxiliary statements" from which predictions are derived (Putnam 1991, p. 126; *Cf.*, §10).

[8] Additionally, if we consider that scientific theories can be composed of *multiple* universal statements, then the falsification of a derived prediction from one of these statements, in tandem with some set of initial conditions being held as true, would not necessarily falsify the whole theory, but only "some part of it" (Popper 1992, p. 72). Moreover, if the falsified prediction was derived from a combination of universal statements, then "we cannot at first know which among the various [universal] statements . . . we are to blame for the falsity of [said conclusion]; which of these statements we have to alter, and which we should retain" (p. 76n2). Restated, this uncertainty "is possible . . . [only when] the connections between [a theory's] various parts [have] yet [to] be sufficiently clear to enable us to decide which of its [parts] are affected by some particular falsifying observation" (p. 72). In any case, whether a change in initial conditions, the whole theory, or just some part thereof, is warranted, given a falsifying test result, may be decided upon by whichever change, or even combination of changes, arrives at a set-up of increased universality. See, for example, Lakatos (1968, pp. 165-166), as well as Popper (1992, p. 268).

singular? According to Popper, even the most singular of statements can contain universal elements, even statements describing properties of *individual* entities, for insofar as these properties are said to be shared between multiple entities, then these properties would exhibit some universal designation – i.e., based on the logic of universals espoused by Popper, shared properties expressed by a singular statement describing an individual make that statement an inter-subjectively testable one (*Cf.*, p. 425, and §14).

Effectively, if a statement contains universal designations, even for simple sentences like, 'here is a glass of water', then such a statement "cannot be verified by any observational experience . . . [because] the *universals* which appear in it cannot be correlated with any specific sense-experience" (Popper 1992, p. 95). Popper can make this conclusion by appealing to the idea that universal designations in statements never describe individuals but the "universal class of all those individuals to which these [designations] belong" (p. 66). Moreover, if we consider that 'universal class' refers to a potentially infinitely membered class – in general, a universal class is one of *indefinite* size – then Popper would argue that "whether there are any individual things corresponding to [this universal class], and if so how many, must always remain an open question" (p. 66). It is only when a designation in a statement is made to refer to a finite class of individuals that the designation stops being universal in character, but then this would entail that the members of the finite class are therefore already known – the opposite of Popper's argument that the members of an indefinite class cannot be known. This is due to the fact that it is precisely because universals refer to classes whose members are indefinite in extent and thus potentially infinite in size that such classes are not pre-emptively known – once classes are made to correspond to a finite number of individuals, it can only be because a finite number of members are already known in advance to belong to the class.[9]

This fact of the non-verifiability of statements with universal designations by any individual observation can further explain Popper's conception that universal statements can only be falsified by singular statements. Here, a statement with a universal designation can only be confirmed through the potentially infinitely sized classes to which they refer. However, let us consider that the truth of universal and singular statements are validated differently regarding their corresponding referential classes – universal statements require all members of

[9] The case of statements with non-universal designation will not be covered in detail within this paper. For a discussion, see Popper (1992, pp. 95, 111n) and Note 12.

the class for verification while singular statements, specifically observation statements of individual entities, require only one member. Regardless of Popper's qualms concerning how an individual member of a class can be said to be confirmed as a member of that class for verification of an observation statement of that individual, as long as we accept that this member is a part of that class, then its corresponding observation statement can falsify any universal statement precluding membership of the individual to that same class. What is thus entailed by this relation of verifiability and falsifiability between universal and singular statements is that only in principle are such statements both falsifiable and verifiable, as long as an observation statement with the appropriately sized reference class is employed, for in practice they are only falsifiable and not verifiable.

To arrive at Popper's relation between universality and falsifiability, we must introduce statements that are in principle falsifiable yet in practice *unfalsifiable*. Let us begin by comparing two different statement forms that are both principledly falsifiable, yet one is practically unfalsifiable while the other is not: strictly universal and strictly existential statements. Strictly universal (SU) statements are 'all statements', such as, 'all ravens are black', while strictly existential (SE) statements are 'there-is/are statements', such as, 'there are black ravens', or, 'there is at least one black raven' (*Cf.*, Popper 1992, §15). Both SU and SE statements are valid across all possible worlds (§13),[10] and the reason why is clear: none of these statements specify in which world one can find black ravens – even the statement, 'there is at least one black raven' allows for at least one black raven in one of the possible worlds, meaning that in every possible world there is a non-zero probability of finding at least this one black raven. Furthermore, given that every scientific statement is testable, in Popper's view, then both SU and SE statements must be falsifiable – i.e., predictions must be deducible from the combination of some SU or SE statement and a statement expressing a set of initial conditions (§28).[11] Such predictions must in turn be falsifiable themselves if they are, by *modus tollens*, to be capable of falsifying whatever SU or SE statement they derive from. However,

[10] Numerically universal statements on the other hand, which Popper does not regard as of ideal scientific universality, are those statements that are only valid in either some possible worlds or, more restrictedly, a particular spatiotemporal region within our world.

[11] SE statements have the same relation to Popper's 'Basic Statements' that SU statements have to numerically universal statements: basic statements refer to specific spatiotemporal regions while SE statements do not.

while SU statements can be falsified, SE statements are only *principledly* falsifiable, meaning they are *practically* unfalsifiable.[12]

To see how, note that the SU statement, 'all ravens are black' – let us call this, SU-R – can be falsified by a singular statement expressing the observation of a white raven,[13] yet the SE statement, 'there is at least one black raven', cannot – let us call this statement, SE-R. To falsify this SE-R, one would have to apprehend the set of *all* ravens to see if there is not at least one black raven in it – i.e., falsification of SE-R comes about when a *universal* observation statement comprehends the set of all ravens with only non-black ones. Since this set is potentially infinite in size, only one with an infinite experiential capacity can know for sure that they have indeed apprehended the set of all ravens. Consequently, in principle SE statements can be falsifiable, but in practice they are not for beings with finite experiential capacities (*Cf.*, Popper 1992, p. 69).[14] In relation to testable predictions, we can predict, given SU-R, and the statement expressing some set of initial conditions, 'there is a raven at spatiotemporal location *k*', that there are no non-black ravens at *k*. This prediction can therefore be falsified by the observation of some non-black raven at *k*. Importantly, a statement of initial conditions is essential here for the derivation of the prediction. For instance, we cannot immediately derive, from SU-R, SE-R as a prediction, for the latter implies that ravens exist, while the former SU statement does not necessarily. In other words, to derive SE-R, SU-R must

[12] Popper (1992) is sometimes not clear in this regard though, for he claims, in one place, that "universal statements are falsifiable only and existential statements verifiable only" (p. 70n*2). However, this contradicts his latter claim that existential statements are testable, and thus also falsifiable, albeit only in principle (p. 104). To reconcile this seeming contradiction, we can split Popper's use of "existential statements" into two camps: those that are principledly falsifiable yet practically unfalsifiable, and those that are principledly unfalsifiable yet also verifiable. The former case is being discussed here, while the latter case contains those synthetic statements Popper regards as employing non-universal designations. These describe a finitely sized class of referent individuals that are given as verified through immediate connection with a singularly unique experience (p. 95).

[13] However, falsification of SU statements can only occur in a qualified sense. See Note 20. SU statements are moreover principledly verifiable, but practically unverifiable: confirming whether it is the case that all ravens are black would require experientially apprehending the set of *all* ravens, which in principle can be accomplished, but *not in practice* by finite beings, since the set of all ravens is potentially infinite given its indefinite size.

[14] This is what Popper means by the idea that SE statements can only be falsified by universal statements, since these statements comprehend universal sets.

be combined with a statement of an existential initial condition, such as, ‘there exist ravens’.[15] Now, SE-R is still falsifiable, although only in principle, and not in practice, as explained above, meaning that while it is still a prediction, it is one with an exceedingly low level of universality.[16]

To see the differences in universality between SU-R and SE-R, consider what these statements forbid, i.e., what their potential falsifiers are. For SU-R, every iteration of possible colour distribution over the set of all ravens, except the one wherein all members are black, would falsify SU-R. However, for SE-R, every iteration of possible colour distribution over the set of all ravens, except the one wherein all members are black *and* those wherein at least one black raven is a member of the set, would falsify SE-R. In short, the set of potential falsifiers for SU-R is larger than that for SE-R: SU-R “prohibits more” than SE-R (Popper 1992, p. 83), in the sense that “there will be more opportunities for [SU-R] to be refuted by experience [than for SE-R]” (pp. 112-113).[17]

4. Falsifiability, corroboration, and positive empirical attribution

Thus, for Popper, a statement’s universality increases in direct proportion to the size of its set of potential falsifiers. Additionally, more universal theories are more *improbable* than less universal ones, since more universal theories are more readily contradicted by empirical evidence, given that they have more potential falsifiers, than less universal ones.[18] When some first theory contains more potential falsifiers than a second one, Popper (1992) regards this first theory as saying more “about the world of experience than the second theory, for it rules out a

[15] Although one can immediately derive from “all ravens are black” the conditional, “if there are ravens, they would be black”, yet, according to Popper (1992), this conditional is not a testable prediction (p. 101n).

[16] A specific existential statement with a higher degree of universality than SE-R is, ‘there are no non-black ravens’. This statement has the same level of universality as SU-R, because both are compatible with there being no extant ravens at all, while SE-R is not.

[17] In this sense, even the singular statement, ‘there is a black raven here’, can in principle be falsified by whatever observation could constitute the set of potential falsifiers of said singular statement. In other words, it is an open possibility for the set of potential falsifiers for, ‘there is a black raven here’, to include any observation corresponding to, ‘there are *no* black ravens here’. This reasoning is also echoed, for example, in Huemer (2017, pp. 603-604). Interestingly, ‘there is a black raven here’ would not even be practically verifiable due to its use of universal designation by, for example, ‘black raven’, which in this case could only be verified by the experiential apprehension of the potentially infinite set of ‘black ravens’.

[18] From here on, following Popper, we will use improbability, universality, testability, and falsifiability in an interchangeable fashion.

larger class of [potential falsifiers]" (p. 113). In a simplified sense, the more a theory prohibits, the more of a chance one can speak of what the world is *not*. Surprisingly though, Popper does not stop here, for he even argues that the first theory would also convey a greater "amount of *positive* information about the world" and possess more empirical content than the second (p. 41. Italics mine). It is here that a major contention with Popper's thesis emerges: how can a highly improbable theory say anything positive about the empirical world, especially if it is intended to positively say more than less improbable theories? Indeed, according to Popper, the statement, 'all ravens are black', may have a near *zero* logical probability – its sole confirming instance would be when the set of all ravens, a potentially infinite set, contains only black ravens, while every other possible colour constitution for this set would count as a falsifier; if we then consider that a potentially infinite number of ravens can be colour composed in a potentially infinite number of ways, then the effective ratio of confirming to falsifying instances would potentially be one to infinity, entailing a logical probability approaching zero (*Cf.*, p. 264n).[19]

Popper elsewhere makes additional remarks regarding how scientists choose what counts as an instance of falsifying a prediction.[20] Nonetheless, these considerations will not be

[19] This is similar to a criticism in Adolf Grünbaum (2013, pp. 23-30), wherein he argues that any idea of a theory's *positive* empirical content wedded to its logical improbability is bound to fail.

[20] Popper (1992) notes that

> no conclusive disproof of a theory can ever be produced; for it is always possible to say that the experimental results are not reliable, or that the discrepancies which are asserted to exist between the experimental results and the theory are only apparent and that they will disappear with the advance of our understanding (p. 50).

However, Popper still considers that theories can be rejected, but only for *good reasons*, which can range from the "replacement of the [theory] by another which is better testable, [to] the falsification of one of the consequences of the [theory]" (p. 54). Now, since falsification can never be conclusive, then any statement acting as a falsifying instance for a theory and its predictions can only be arrived at via a methodological decision (pp. 108-111). Infinite testability in science does not mean, for Popper, that scientists must not accept basic statements as test reports of observations; it just means that any acceptance can only be *provisional*, i.e., contingent upon a lack of falsification of the accepted statement. It is in this sense that Popper is a conventionalist, ala Carnap (1937; 1956), when the former states that acceptance of basic statements is a matter of practical choice, yet Popper's conventionalism places focus more on the choice of singular statements rather than universal ones (Popper 1992, p. 109). Thus, we can interpret what Popper means with a theory being "better testable" than another: the better testable theory allows for more basic statements to be potentially accepted as falsifying instances of the better outlined in detail, for what interests us is not a practical issue but a structural one: what makes a theory attain greater empirical content than others by mere virtue of their logical structure? In concomitance with his idea that more improbable theories tell us more about the world, Popper introduces his notion of 'corroboration' as a measure of how likely a theory coincides with the truth of the world's state of affairs. Specifically, he calls a theory's value of corroboration a measure of "how far it has been able to prove its fitness to survive by standing up to tests [i.e., attempts at falsification]" (Popper 1992, p. 251).[21] Moreover, "[t]he appraisal" of a theory's corroboration value makes no use of inductive measures, as the appraisal "can be derived [deductively from the structure of] the theory as well as the accepted basic statements . . . [that] do not contradict the theory" (p. 266).[22]

This is not a controversial claim, for all that corroboration is meant to apply to is the assertion "that a certain logical relation holds between a theoretical system and some system of accepted basic statements" (Popper 1992, p. 275). In other words, a theory's value of corroboration is not an absolute judgement, but a relative one, contingent upon an accepted system of basic statements – "a system accepted up to a particular point in time" (p. 275). Whenever basic statements, acting as a report of experimental results – i.e., singular observation statements – go against a theory's singular predictions, that theory's corroboration value decreases, while basic statements that coincide with said predictions help increase the theory's value. Also, given two theories that have passed the same number of tests, the one with the greater universality and degree of testability will attain a higher corroboration value than the other theory (pp. 398-399). Lastly, Popper also makes mention of the *severity* of tests that apply to theories (p. 266), but the details of how a measure of severity ought to be constructed are not discussed in this essay, for what interests us is not how a severe test can potentially affect a theory's corroboration value, but how *any* test that a theory does not fail

theory. See Lakatos (1968, §2(c)) for a discussion. See, also, Persson (2016, p. 468), who explains this movement from one theory to a better testable one in terms of the former being embedded in the more fundamental theory that is the latter.

[21] Carnap (1945) also makes use of a theory's fitness for his arguments of inductive justification in terms of a theory's "*success* in some sense" (p. 96).

[22] Remember, as explained in Note 20, basic statements can only be accepted by convention.

can, in any way, indicate towards that theory's greater empirical content and correspondence to the world's state of affairs.[23]

5. Universality does not guarantee truth

Popper (1992) argues that, by allowing a more restricted field of empirical possibility, the more improbable theory coincides more with the structure of reality, as reality exhibits the most restricted field of empirical possibility possible, that being what is empirically true (*Cf.*, §78).[24] For Popper, the most improbable, and thus the most universal

> theory would describe "our particular world" as precisely as a theory can; for it would single out the world of "our experience" from the class of all logically possible worlds of experience with the greatest precision attainable by theoretical science. All [that] . . . we actually encounter and observe, and only these, would be characterized as "permitted" [by this theory] (p. 113).

However, we can interpret Popper's intention for this argument in two ways. The first is that if it were the most universal theory it would be automatically true; the second is that if it were true it would be the most universal one able to express that truth. These two ways are not identical, for the first guarantees that maximal improbability entails truth, while the second does not. Moreover, the first has some textual grounds: if we interpret universality as a measure of a theory's ability to describe the regularities of experiential reality – the more universal the theory the more it corresponds with reality – then Popper's belief, that "if no regularities were apparent in nature then neither observations nor language could exist" (p. 282),[25] could be interpreted as saying that the fact that we can theorise implies that these apparent regularities exist and are best and most accurately represented through the most universal forms of theorisation, i.e., those that forbid the greatest extent of possible empirical regularities other than our own. Nevertheless, this first interpretation is doomed to fail.

For example, let us consider again the universal hypothesis, 'all ravens are black' (SU-R), and the situation wherein the basic statement, 'there is a black raven here', has been applied to every observation of a raven so far. According to Popper, SU-R's corroboration value will increase with each acceptance of the basic statement for every instance of an observed black

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[23] Popper (1992) at least acknowledges that what counts as a severe test cannot be "completely formalize[d]" (p. 402).

[24] This indicates Popper's determinist bias.

[25] This is just one example of how Kant and Popper share philosophical commitments. For a deeper discussion, see Drieschner (2005).

raven. Nevertheless, given that we can never know the true size of the universal set of ‘raven’, since it is indefinite, we can never know whether, for each subsequent observation of a black raven, the rest of the set of ‘raven’ consists only of black ravens or not. We can also never know the probability of the rest of the ‘raven’ set being only black ravens even *given* the evidence that there have only been observations of black ravens so far, and this is also due to the potentially infinite size of the set – every observation of a black raven still leaves the rest of the ‘raven’ set as potentially infinitely sized, so we would never be able to know just how much *more* probable SU-R is given each observation of a black raven.[26]

Even Bayesian probability formulations require that the distribution of some countable property be given for a set of entities before one can even begin to calculate the probability that any one of those entities has a particular instance of said property;[27] this applies both to the absolute probability of an entity possessing a property instance within the set and to the relative probability of an entity possessing that instance *given* the observation of other entities with specific property instances from the set. Even if we replace ‘entity’ with ‘hypothesis’, as Popper does, since he is interested in the probability of *hypotheses*, not *entities*, given the evidence, we are still faced with the same problem: in the case of SU-R, it is just one hypothesis out of a potential infinitely sized set of hypotheses – let us call this the hypothesis-set – describing the possible colour distributions of the universal set of ‘raven’. As such, the absolute probability of SU-R, along with the relative probability of SU-R given observations only of black ravens, can only be known once the members of the hypothesis-set are known; and this itself can only be known once the size of the universal set of ‘raven’ is known to be finite, for otherwise a potentially infinitely sized ‘raven’ set would entail a potentially infinite number of hypotheses describing the potentially infinite variations of colour combinations of the ‘raven’ set. This would mean that absolute and relative probabilities for SU-R could never be pinned down as certain at the same time.[28]

Popper explores other possibilities of interpreting probabilities for hypotheses, but he seems to conclude that one can only understand relative probabilities – probabilities given the

[26] For a discussion of this issue, see Appendix *IX in Popper (1992).

[27] Popper (1992) even partially bases his own probability systems, and thus corroboration formulations, on Bayesian considerations (*Cf.*, p. 263n*).

[28] Accounts of absolute probabilities, especially Bayesian ones, are notoriously contentious (Huemer 2017; 2019). One could though try and rescue absolute probabilities through an intuitionist approach, but analysing this method is outside the scope of this paper. For a discussion, see Huemer (2009).

evidence – once absolute probabilities – probabilities without consideration of the evidence – are established;[29] but the establishment of, say, the absolute probability of SU-R requires a prior knowledge of the members that constitute the hypothesis-set, which, as we have argued for above, is impossible if the set is meant to be universal, i.e., *indefinite*. Therefore, we can never know just how true a universal hypothesis is given corroborating evidential instances; additionally, the situation is even worse for hypotheses more universal than SU-R, since these more universal hypotheses forbid more from being true than what SU-R does in its corresponding hypothesis-set, which undermines the validity of the first interpretation of Popper's notion of the relation between maximal universality and truth.

6. Truth does not guarantee universality

Now, Popper does de-substantiate the first interpretation in other places. He for instance acknowledges that absolute probabilities for universal hypotheses may never be known (Popper 1992, p. 417), and that any corroborating instance of a hypothesis "can [n]ever seriously reduce, by elimination, the number of the competing [hypotheses against it]" (p. 419). Indeed, Popper regards that in a potentially infinite universe there is no guarantee that experimental tests will ever establish the truth of *any* theory (*Cf.*, p. 424n);[30] yet a theory's *testability* is still relevant for him, especially considering that veritable scientific growth for Popper follows a path of greater theoretical testability/universality (§85). Furthermore, we still have as a possibility the second interpretation of Popper's notion of the relation between maximal universality/improbability and truth: if a hypothesis were true it would be the most universal one capable of expressing that truth. What this interpretation signifies, in combination with Popper's idea of the path of scientific growth, is that, while maximal universality may not guarantee truth, there is still something about a theory's degree of universality that makes a measure of universality our best hope for attaining empirical truth. How Popper argues for this is, again, through his idea of corroboration, wherein a theory's universality is important, for theories with lower probabilities experience greater evidential support – i.e., they are corroborated more with positive non-falsifying tests than theories with higher probabilities, which can be measured via the different probability changes for these theories that occur

[29] See Popper (1992, pp. 415ff.) for a discussion on the relation between absolute and relative probabilities, given by Popper as primary and secondary probabilities, respectively.

[30] Popper (1992) elsewhere even rejects the very belief that lends credence to the first interpretation (pp. 29-30).

between such tests. It becomes clearer that Popper is arguing in this way when we analyse his use of examples showcasing how highly probable theories may still not be well corroborated by the evidence.

One such example is as follows:[31] consider a bag of four differently coloured balls, named either B, G, R, or Y. Consider also two theories, X1 and X2; X1 predicts that B will be picked from the bag, while X2 predicts that some not-R will be picked from the bag (either B or G or Y). Let us also assume that some not-Y (either B or G or R) had been picked from the bag previously, and let this be the evidence, Z. Now, it should be clear that, before Z takes place, $p(X1) = 1/4$, is less than that of $p(X2) = 3/4$. When Z does take place, the relevant probabilities shift, from $p(X1)$ and $p(X2)$ to $p(X1|Z)$ and $p(X2|Z)$, respectively, since now the probability of what colour the picked ball is has to depend on that ball being either B, G, or R;[32] as such, $p(X1|Z) = 1/3$, is less than $p(X2|Z) = 2/3$. However, according to Popper, X1 is *corroborated* by Z, but X2 is *undermined* by Z, because the probability that B will be picked *increases* when not-Y is given – from 1/4 to 1/3 (a change of +1/12) – while the probability that some not-R will be picked *decreases* when not-Y is given – from 3/4 to 2/3 (a change of –1/12). This means that what X1 says pertaining to the empirical reality of the picked ball is supported and substantiated more by the evidence than what X2 says about said reality. Additionally, since X1 is the more universal hypothesis – it is more improbable than X2 – its positive corroboration value, compared to the negative one of X2, given Z, gives weight to the argument that more universal hypotheses – the theories that forbid more possibilities – are supported more than less universal ones by the same evidence set. This allows Popper (1992) to conclude that the ability for *any* theory to be supported by the evidence – its 'corroborability' – "stands . . . in inverse ratio to its logical probability" (p. 270).

However, the above illustration becomes misguided when alternative interpretations are made for what the givenness of evidence entails for theory support. In essence, if a theory is meant to represent the attainment of some property by a set of entities, such as the attainment of some colour by the set of four balls in a bag, then Popper's illustration fails in this regard: X1 and X2 above do not consistently comment on the state of affairs of the bagged balls in the

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[31] See Popper (1992, pp. 395-402) for full details of the example.

[32] P(X1|Z), or, the probability of X1 given Z, can have multiple interpretations (Hájek 2003; Lowe 2008; Schwarz 2018). However, since the important one to focus on here is what Popper uses, at least in this instance in the text, we will have to forego a detailed analysis of alternative interpretations.

above example, for once Z is given, their probabilities only apply to *the not-Y* ball picked from the bag – it is another thing entirely to have X1 and X2 refer to the colour composition of the bagged balls *remaining* once Z is given. Surprisingly, having this referral change occur ends up damaging Popper's conclusion concerning corroboration's relation to universality. To see how, let us make 'X1 given Z' and 'X2 given Z' refer to, after some not-Y ball is picked, a ball picked from the bag being B and some not-R, respectively. p(X1) and p(X2) remain the same – 1/4 and 3/4, respectively – but those for p(X1|Z) and p(X2|Z) change to 2/9 and 7/9, respectively.[33] This entails that the probability change experienced by X1 and X2, once Z is given, is –1/36 and +1/36, respectively, meaning that, with this interpretation of evidential givenness, the more universal hypothesis is actually *undermined* by the same evidence that better *corroborates* the less universal one.

Another example showcases more clearly how 'corroborability' does not necessarily correlate with universality. Take a set of two different entities, both of which have equal probability to attain either one of three states: B, R, or G. Let us have X1 = both entities are B, X2 = one entity is B and the other is G, X3 = both entities are either B or R, and Y = at least one of the entities is B. Logically speaking, X1, X2, and X3 have, respectively, these prior probabilities: 1/9, 2/9, and 4/9. X1 is thus the most universal/improbable hypothesis while X3 is the least. Now, with the given evidence, Y, of one of the entities being B, we have the changed probabilities of X1, X2, and X3, once Y is given, respectively as follows: 1/5, 2/5, and 3/5. (From the evidence that at least one of the entities is B, four different possible descriptions of the state of both entities – R and G; G and R; G and G; R and R – become impossible.) Therefore, the changes in probability for X1, X2, and X3, once Y is given, are +4/45, +8/45, and +7/45, respectively. All that this indicates is that the most corroborated hypothesis – the one most evidentially supported by Y – is X2, and although X2 is indeed a more universal hypothesis than X3, which is corroborated less by Y, the least corroborated hypothesis is the most universal one out of the three, X1.

7. Alternative Approaches

These examples notwithstanding, Popper's notion of testability – i.e., theories that have survived more empirical tests than others are the better supported theories – is not such an

[33] The bagged balls, before Z is given, can be represented as: B,G,R,Y. Once (Z = not-Y = B or G or R) happens, what remains are three equi-possible states: (G,R,Y), (B,R,Y), or (B,G,Y). P(X1|Z) and P(X2|Z) are then both calculated from these three states.

unpalatable idea, for theories whose predictions have stood up to experimental scrutiny have often been valued highly in the sciences. The issue comes about when the idea of testability is wedded to probabilistic constructions of a theory's degree of being true, either in terms of its prior Bayesian probability or in terms of Popper's formulation of corroboration given the evidence.[34] Glymour (1980), for example, may be taken as expressing this sentiment when arguing

> that the body of evidence that distinct theories hold in common . . . may nonetheless provide differing support for the two theories. . . . *Not because one theory is a priori more plausible or probable than the other* but, roughly, because one theory is better tested than the other by the body of evidence in question" (p. 342, italics mine).

This is not to say that there cannot be a way in which one may reasonably argue for a theory's degree of evidential support, just that the precise way in which this support is expressed is highly contingent upon one's prior view of how the world is structured, of that which grants a theory its prior logical probability. This prior view is important, because whether a measure of a theory's testability is considered truth-conducive depends on how complex the world is made out to be (Glymour 1980, p. 377).

The prior probabilities mentioned in the above example of Popper are used to inform his values of a theory's evidential corroboration. However, we had uncovered that whether a more universal theory is better corroborated by the evidence is *not* solely contingent on the theory's universality, given that there are cases wherein more probable theories can experience better evidential support than less probable ones. This result has been a major source of criticism towards Popper's idea of corroboration, leading some, in their attempts at explicating the relation between a theory's universality and its truth, to consider how corroboration may also be based on the *evidence at hand*. The idea is that the extent to which a theory's measure of universality is truth-conducive is in part determined by *a posteriori* considerations, not just on its *a priori* ones (*Cf.*, Sober 1994, p. 141).[35]

[34] For a related critique, see Niiniluoto (1987).

[35] Close approximations to Popper's sense of universality have also employed this idea of truth-conduciveness, for example, in terms of a theory's parametric simplicity (Kelly 2007a, p. 113), theory-ladenness and dimensional simplicity (Rochefort-Maranda 2016, p. 271, §3.1), and explanatory and ontological parsimony (Long 2019, pp. 484-486).

One such attempt is found in Kelly et al. (2016), which can be viewed as elaborating upon Popper's notion of universality by, one, critiquing his relation between simplicity and falsifiability,[36] and two, revising it in terms of a *necessary* simplicity. The basic critique is that a theory's extent of possible falsifiers may be silent on the overall complexity of that theory. For instance,

> if general relativity theory *GRT* is falsifiable, then *GRT* ∩ *P* has at least as many potential falsifiers as *GRT* — but *P* could be hopelessly complex, in which case the conjunction *GRT* ∩ *P* appears to be more complex than *GRT* alone, contrary to Popper's proposal" (Kelly et al. 2016, p. 1207).

GRT ∩ *P* can be interpreted as dealing with at least as many predictions – i.e., potential falsifiers – yet being at least as permissive as *GRT.* Said in another way, a law that predicts *A* ∪ *B* is more complex in its structure and permissive in its predictions than one that predicts *A* ∩ ¬*B*, but *only in relation to those predictions*, because the former law could be less lenient, by having more falsifiers, in its other predictions than the latter one; this would be exemplified in *GRT* ∩ *P* having more potential falsifiers than *GRT* alone.

What then allows for the evaluation between *GRT* ∩ *P* and *GRT* as the better theory must be based on subsequent empirical tests. It is this withholding of judgment until a time wherein one can empirically distinguish between two otherwise equivalent theories that is expressed, by Kelly et al. (2016), as the condition of patience for truth-optimized solutions of empirical problems (p. 1214). Indeed, it is this condition of patience that factors the most prominently in determining the truth conduciveness of a theory's testable predictions for Kelly et al., since taking the condition to its logical conclusion results in a convergence "to the truth with no more reversals or cycles of opinion than are *necessary* for converging to the truth at all" (p. 1201). When convergence is reached, the future is methodologically connected to the past in the sense "that *all* future predictions are correct after convergence" (p. 1202).

Ideally, the above argument is tenable since we can take convergence as the point in which the set of entities that a theory is about is fully in concordance with that set as instantiated in reality. Here, the point of convergence is where, for example, SU-R (all ravens are black) is

[36] Kelly et al. (2016) use the term simplicity, but just keep in mind that whenever this term is used it is meant to express Popper's notion of universality. This is because, for Popper, the less universal theories, being the more probable ones, are so due to their increased complexity allowing less falsifiers and permitting more states of affairs in the world.

in principle verifiable, as convergence would be on the actually instantiated set of ravens, whether it consists of all black ravens or not. The notion that there can be 'no more reversals or cycles of opinion than are necessary for converging to the truth' is meant to portray a methodology – what Kelly et al. (2016) define as constituting a learning method λ (p. 1200) – that is optimally truth conducive by being systematically biased "toward simple answers to an inductive problem", that is, simple empirical theories (p. 1196).[37] This bias towards simple theories is also *patient* in that the importance of a theory's measure of simplicity must always be weighed in tandem with the results of empirical testing in order to avoid theories that are either too simple or too complex *given the evidence at hand* – i.e., not too simple that it predicts less than what is evidentially given and not too complex that it allows for more than what is evidentially given.

We can now understand the abovementioned sense of necessary simplicity, as a relation between a theory's simplicity and its predictive permissibility, in this way: the more permissive the theory, the less simple it is; the less permissive, the less of a chance for *unnecessary* opinion change (not based on evidence) and more of a chance for *necessary* opinion change (based on evidence) – unnecessary opinion changes are potentiated more in more permissive theories because these theories, by permitting more states of affairs in the world, disallow the type of evidence-based opinion shifts capacitated by less permissive theories. Therefore, the simpler the theory, the greater the chance for necessary opinion shifts and the greater any methodological bias to simplicity is in converging to the truth by minimizing unnecessary opinion shifts. In conclusion, given different incompatible theories, wherein the truth of one precludes the truth of the other, the process of rationally choosing between them is optimized in its truth conduciveness by favoring the less permissive theory *given* the evidence at hand. If two theories are equally permissive – e.g., one theory predicts an even number of basic elementary particles while the other predicts an odd number instead – then evaluation must wait for the results of subsequent empirical testing (*Cf.*, Kelly et al. 2016, p. 1207). In short, opinion change must accord with evidential change if *empirical* truth is to be converged at by one's method.

[37] The norm of avoiding unnecessary cycles or reversals of opinion is given more detailed expression in Kelly (2007b, 2011). This norm's relation to simplicity has also been explicated in terms of Ockham's razor by Kelly and Glymour (2004).

Popper's troubles with associating simplicity with falsifiability are curtailed when one associates simplicity with evidence-based permissiveness – or, in other words, when one defines testability in terms of such permissiveness and not of falsifiability – since the amount of potential falsifiers that a theory has, being an evidence-*independent* measure, is a worse measure of evidential support than whether a theory permits more or less than what the evidence shows. Said in another way, a systematic bias towards simple theories optimizes a method's truth conduciveness because all prior iterations of said method are refutable, meaning that, at any stage in the method, looking back at the progress of the method will always find instances of new evidence refuting some prior theory (Kelly et al. 2016, p. 1214). This bias is meant to conclude at a point of convergence with the truth wherein a theory's experimental refutability becomes non-existent while its extent of unfalsifiable predictions is also minimized. The problem that is supposed to be avoided here is when all that is stopping a theory from converging on the truth is its set of predictions that can never be empirically adjudicated on because they are false yet *unfalsifiable*, regardless of how permissive a theory is in predicting the states of affairs for a world.[38]

Nonetheless, there is a problem with this approach by Kelly et al., that being the issue of how one is to know that a prediction will *remain* unfalsifiable or not. Similarly, how can we tell once we have reached convergence? The condition of having 'no more reversals or cycles of opinion than are necessary' is unhelpful here, for how can we tell that we have reached the necessary number of reversals when it is entirely possible (epistemically) for one's opinion to change drastically the next time an observation is made? Of course, having an empirical method follow the evidence as it is observed and be biased towards simple theories that minimize permittance past the evidence may be the best way to represent the evidence, but it does not seem to be any measure of truth *past* the evidence at hand. Here the argument in Kelly et al. (2016) faces similar issues with Popper's, in which a potentially infinite set of entities cannot be exhaustively known concerning some property a universal theory attributes to it. This applies even to theories that are highly falsifiable, simple, whatever, as there is always the

[38] However, a weaker constraint may be allowed, whereby a viable theory can attain some unfalsifiable *a priori* components if these can help explain the empirical evidence at hand. This weaker constraint is derived from French's Viking approach to scientific metaphysics (French 2014), although it is past the scope of this paper to discuss it in detail.

epistemic possibility that a theory will be falsified given future tests, even if that theory is true and can only ever predict veridically.

Now, it can be argued that we can only know that we have arrived at convergence if we can know that the evidence will not be drastically different during future observations thereof. This latter knowledge is expressed, by Kelly et al. (2016, pp. 1193-1194) and Carnap (1945, pp. 96-97), as knowledge of a limit – think mathematical limit – at which convergence takes place. If the limit cannot be epistemically ascertained as instantiated in reality, then the best we can hope for is to presuppose it as a reasonable intuition when constructing our background theories of the world – e.g., the world is simple enough that a limit is possible (*Cf.*, Glymour 1980, p. 377). Sober (2009) even recognizes that the importance we ought to ascribe to structural measures of a theory (simplicity, falsifiability, universality, etc.) towards truth conduciveness "often should be viewed as expressi[ve] of subject-matter-specific background theories" (p. 238). As such, since these background theories are always subject to change because they must remain falsifiable *to us*, then even the background theory that there is a limit on which one can truthfully converge is falsifiable as well.

In short, the fact that evidence *appears* to converge on some value is not any reliable measure that, one, the evidence will not *diverge* in the future, and two, reality is not actually divergent from the evidence at hand. Reliability, as a feature of a theory's predictive capacities, is of value in theory choice often so much so that other structural measures – e.g., interpretive simplicity – may be willingly left by the wayside (*Cf.*, James et al. 2013, p. 25). Moreover, reliability is a primary motivator in Kelly et al. (2016) for their appeal to simplicity bias in one's method for theory choice as a guarantor of predictive truth-conduciveness. Therefore, the sense of reliability often appealed to for the formulation of empirical theories is primarily an ideal that becomes accurate as a descriptor of such theories only when situated within some background theoretical context, such as that specifying the existence of a converge-able limit. Whether these background theories are themselves reliable in their predictive truth conduciveness is another matter entirely.

8. Conclusion

In any case, the foregoing discussion on Popper's espoused relation between universality and truth concludes that the relation is dubious at best. Thus, it seems as if all that Popper can validly say is that more universal theories posit more about what empirical reality is in a *negative* way, not a positive one – i.e., in the sense of what they forbid, as opposed to what is. Indeed, this notion that more universal theories have greater positive empirical content, exhibited through the idea that they are corroborated more by empirical evidence than less universal ones, has motivated interpretations of Popper as optimistic in what he considers a deductive science to be capable of achieving (Veronesi 2014, §2). This optimism in Popper's thought is grounded in his understanding of a theory's corroborability as a function of its universality and falsifiability, but only when a theory is being applied to the evidence at hand, not to what state of affairs the evidence is meant to be about.

However, whether Popper's sense of corroboration – i.e., the greater support given by the evidence to simpler and more universal theories – pans out in the numbers depends on how the theory is being applied; a more falsifiable theory may be made more probable than a less falsifiable one, given the evidence, as a true theory about the evidence at hand, but not necessarily when the theory is made to be about the set of entities from which the evidence is derived, as discovered in Section 6. In effect, Popper constructs an empirical theory's evidential support for what the theory has to say about what has already been evidentially unearthed, not specifically for the theory's *predictive* power past what has been unearthed. Kelly et al.'s remedy of conceiving universality in terms of *necessary* simplicity, in an effort to more effectively conceive of predictive veracity as a function of an empirical method's bias towards theory simplicity, may allow for a better sense of how a theory is justified for what is past the evidence at hand. Nevertheless, what is touted as being where the evidence will eventually lead to when such a method is followed – i.e., the convergence – is not epistemologically given. This implies that the idea of a convergence at which empirical truth is attained suffers from the same type of optimism that characterizes Popper's own account, albeit in a way that is at least more sensitive to the evidence at hand. As a final lesson, we may say this: the justification that a theory attains by the evidence *for the evidence* is different than the justification by the evidence *for the rest of the world* – a difference which may at the end be impossible to spell out unconditionally.

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