

## The Usefulness of Popper: A Scientist's Response to Professor Charlotte Sleigh

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### Introduction

In “The Abuses of Popper,” (*Aeon*, February, 2021; *hps&st*, April 2021) historian Charlotte Sleigh comprehensively dismantles the philosophy of Karl Popper. She sees Popper’s foundational principle of “falsification” as a relic of a long-discredited philosophy; less than worthless, a net negative within philosophy of science, the scientific community, and in politics.

As a scientist and a Popperian, I write in response to Professor Sleigh. I argue that Sleigh’s premise is flawed and hence much of her argument is misguided. I also go over some serious negative consequences that would follow if science abandoned Popper’s pragmatic philosophy.

Her argument has four stages: first, the premise: long ago, Popper’s principle of falsification was “quickly demolished by philosophers”. This creates a mystery: how to understand its lasting popularity among scientists? Second, the “solution” of the mystery: a small cohort of influential scient-

ists and economists made anxious by unfavourable perceptions of their fields, craved public and professional respect. Popperianism was ideally suited to image rehabilitation, and they embraced the man and his program. Third, linkage of scientific and ethical concerns: the men in the cohort identified scientific practice in general with Popperian procedures. Thus, Sleigh infers, if science goes wrong, Popper is wrong: ‘falsification offers moral non-accountability to its adherents’. And science goes wrong when it associates with eugenics, nuclear weapons, and especially, the collection of doctrines called *neoliberalism*. Hence, Popper is guilty of providing an intellectual smokescreen for these undesirable moral doctrines. Fourth and finally, Sleigh pinpoints falsification as the Popperian doctrine that is responsible for maiming the public’s ability to understand crucial societal debates related to, e.g., social inequality, poverty, the abuse of labor, and the dangers of tobacco smoking and global climate change. These are sins for which Popperians must answer.

Professor Sleigh implies that bad societal outcomes inevitably result from Popper’s scientific methodology. However, defending his scientific philosophy, as I will do, does not imply defence of the social and political movements, which I can’t comment on. I will show that in her zeal to condemn neoliberalism, she condemns Popper’s useful approach for conducting science. This skews her account and undermines the very causes she is most passionate about.

As everyone may not be familiar with Popper’s thought, I’ll briefly review two key concepts. The first is the *scientific hypothesis* (not the statistical one, which is an entirely different thing; “hypothesis,” as used here, always means “scientific hypothesis”). The second is fallibilism. “Fallibilism tells us that there is no conclusive justifica-

tion and no rational certainty for any of our beliefs or theses” (The Internet Encyclopedia of Philosophy).

A hypothesis is a proposed explanation for some aspect of nature (I won’t distinguish among *hypotheses*, *theories*, and *laws* as they share many properties). The fundamental goal of science is to understand nature, and hypotheses are key to achieving it. A hypothesis is proposed as a true account of why things are the way they are. It must also be testable and *falsifiable*, i.e., there must be, in principle, at least one experiment or observation that would, if the results came out a certain way, imply that the hypothesis is false.

What about fallibilism? Probably all scientists and most philosophers are fallibilists. They understand that there is residual doubt about any explanation for an empirical phenomenon at some level of analysis. We can’t be 100% certain that any scientific hypothesis is correct in every detail. Even cursory reflection on the many historical scientific “facts” that eventually turned out to be false conveys the fallibilistic world view. Sleigh appears to dismiss fallibilism but doesn’t engage directly with it and says little about how science works.

### **Popperian scientific methodology – some basics**

Anyone who accepts fallibilism and believes that science is intent on discovering truths about the world must say how science can make progress if everything it learns is uncertain to some degree. According to Sleigh, the Popperians’ view of science “doesn’t presume to provide the final answer to any question, but contents itself with trying to disprove things. Science, so the Popperians claim, is an implacable machine for destroying

falsehoods.”

The first and last parts of this claim (no “final answers” and “destroying falsehoods”) are accurate, but the middle—“contents itself with trying to disprove things”—is flagrantly misleading. What does it mean, exactly? That Popperians believe that disproof is all there is to science? That Popperian science is “content” with a collection of falsified hypotheses? Simply incorrect.

The Popperian approach is simple: if empirical results and a complex theoretical system, including our scientific hypothesis, contradict one another, something must be wrong, and it is the scientist’s duty to locate the error; if everything remains consistent, then we could be right, but we can never know. Ordinarily, scientists deduce and empirically test predictions from a hypothesis. Disagreement between predicted and observed results suggests the hypothesis is false, whereas agreement between them means the hypothesis could be correct. This is progress and is the essence of his falsification strategy. Popperians are vitally interested in getting to the truth about nature, they want to explain and understand it and will not be content with anything less. They accept that the best that basic scientists can do is to avoid believing in falsehoods. But their process produces much more than destroyed falsehoods.

Recall that a hypothesis is proposed as a *true explanation*. A tested-and-not-falsified hypothesis then is, by supposition, true – as far as we know, and it remains a viable avenue for exploration and inquiry– and we use it to make further discoveries. Moreover, when action is called for (e.g., we must build a bridge), Popper recommends basing our actions on the most severely tested-and-not-falsified (he calls them *corroborated*) hypotheses that we have. There is a distinction between the

ideal goal of ultimate truths about nature, and the functional goal of guiding real-world actions. Basic science seeks ultimate truths; applied science settles for the best hypotheses available—and we are to understand ‘best’ as ‘surviving our most rigorous attempts to show it is false’. Thus, falsification, the acid test of all hypotheses, has both theoretical and practical applications.

Of course, science is not only about generating or testing formal hypotheses. Scientists have always gathered information and made inferences without hypotheses and Popper saw these activities as normal aspects of science. Psychological or cognitive processes, such as induction or generalisation, were outside his interests. And he recognised that the scientific community collectively judges scientific claims. None of these features contradicts or supersedes his thinking. Only when observations need explanations, when the question, “why?” must be answered, does the falsification program kick in.

Plainly, there are major differences between the goals of Popperian hypothesis-testing and its *methods* (determinedly filtering out falsehood). Failure to recognise this is a mistake. Science is possible though “proof” is impossible. It is *the fantasy of attaining certainty that must be abandoned*.

### Was Popper vanquished by “philosophy?”

When Professor Sleight says that philosophers demolished Popper’s falsification program, she alludes to the argument advanced by Pierre Duhem and W.V.O. Quine (cf. Harding, ed.). The gist of the Duhem-Quine Thesis (sometimes called “holism”) is that all hypotheses depend on other auxiliary hypotheses, which in turn depend on others,

etc. As each hypothesis is entangled in a web of other hypotheses, we cannot test any one of them in isolation, let alone falsify it. Here's an example: a biologist who uses a microscope to test her biological hypothesis about a tiny organism implicitly accepts all hypotheses that make up the science of optics. These are "auxiliary" hypotheses. If an auxiliary hypothesis about how light interacted with her biological material were incorrect, then she could misinterpret what the results meant for her biological hypothesis. This very argument was made when Galileo first reported observing the moons of Jupiter – skeptics said they were artefacts of the strange new device, the telescope, that he used. In fact, any observation might have explanations not involving the original hypothesis. This means, so the argument goes, that Popperian falsification cannot work.

But the conclusion is false. First, practically speaking, it must be possible for scientists to falsify scientific hypotheses in principle since scientists have already tested and falsified countless hypotheses in practice: Galileo's observations of Jupiter's moons falsified major facets of Aristotelian cosmology, the famous Michelson-Morley experiment effectively falsified the hypothesis that light traveled through a luminiferous ether, tests of Einstein's theory of General Relativity falsified Newton's theory of gravity, etc. And these are just a few historically noteworthy cases. Every day, scientists in laboratories around the world test and falsify more mundane hypotheses. How do they do that given Duhem's insight (which is undisputed, even by Popper)?

## Philosophers re-evaluate; falsification actually can work

Popper was a Duhemian holist. In fact, the first time Popper sets out his criterion for demarcation in *The Logic of Scientific Discovery*, he says, '...it must be possible for an *empirical scientific system* to be refuted by experience' (Popper 1959, p. 18, emphasis added).

Even critical philosophers came to agree that the principle of falsification has merit. By 1969 Quine had modified his earlier opinion that the Duhem-Quine thesis implied that "the unit of empirical significance is the whole of science" and arrived at the same position as Popper: a sufficiently tight-knit system of theoretical statements on its own can contract experience. While he still agreed with Duhem that hypotheses were inextricably embedded in webs, he now proclaimed that "theories" were valid units of empirical significance that could be tested. As Quine (1991, 286) said, focusing on the "whole of science",

This [statement] is true enough in a legalistic sort of way, but it diverts attention from what is more to the point: the varying degrees of proximity to observation...I have invoked not the whole of science but chunks of it, clusters of sentences just inclusive enough to have critical semantic mass. But this I mean a cluster sufficient to imply an observable effect of an observable experimental condition.

A theory, one form of "cluster of sentences", is also a web of hypotheses, but the component hypotheses are taken together as a single conceptual entity. A theory makes predictions about the world, and we can test it by seeing if its predictions work out. Thus, says Quine, while no single component hypothesis can be tested in isolation, a theory can be tested and falsified wholesale (his rationale

is somewhat involved and not strictly germane). Naturally, if the theory is falsified, we won't know which of its component hypotheses to blame, as both Quine and Popper readily recognised. Nevertheless, Quine's acknowledgement that falsification is possible is a significant development that Professor Sleight's account omits.

Next, note that Quine's revised view presupposes a sharp distinction between hypotheses and theories. Yet, the Duhem-Quine Thesis blurred the distinction. The Thesis states that a hypothesis is not a simple, unitary statement but a web of hypotheses; a central hypothesis plus auxiliary hypotheses. Thus the hypothesis, as a complex entity makes predictions and can be tested and potentially falsified if its predictions fail. As always, if the hypothesis is falsified, we won't know whether the central hypothesis or an auxiliary hypothesis is to blame. A hypothesis, in other words, is equivalent to a "mini-theory." The important point is that re-interpretation of hypothesis as suggested by the Duhem-Quine Thesis shows how to understand Popperian hypothesis-testing in a rational way.

### **How science deals with the problems caused by the Duhem-Quine Thesis**

Although few scientists know about the Duhem-Quine Thesis, an appreciation for the difficulties it creates is baked into their bones. Their strategies for coping with it include:

1. "calibration experiments" to ensure that their instruments do what they're supposed to (Galileo's telescope worked fine when trained on familiar earthbound objects),
2. "control experiments" where experimental variables that could provide alternative explanations

are systematically manipulated while the one of interest is held constant;

3. multiple kinds of experiments to test separate predictions of a given hypothesis – different instruments, chemicals, subjects, etc. Finally,
4. replication; the strength of a finding is amplified when it is independently confirmed in several laboratories.

Each technique enmeshes the central hypothesis in a different web of hypotheses. Because the central hypothesis alone remains constant, experimental conclusions that converge across varying conditions are probably attributable to it, rather than to any auxiliary hypothesis. Consistency of results justifies placing greater confidence in a central hypothesis, whether for practical or theoretical purposes.

In summary, hypothesis-testing by falsification is more complex and nuanced than we might naïvely have expected. The principle of falsification has not been demolished and remains a useful tool. Scientists understand that alternative explanations are conceivable and that "falsification is never final." Science, in Popper's world view, is a process; not a vault loaded with incontestable facts.

### **Are some hypotheses off-limits?**

Professor Sleight claims that the existence of "protected" hypotheses that are supposedly off-limits to questioning is another flaw in Popper's program. But there are no such hypotheses. Popper's "supreme" methodological rule (Popper, 1959, 33) is that no genuine scientific statement can be protected against falsification. Scientists do frequently find it convenient to assume, temporarily,

ily, that a well-corroborated hypothesis is true to foster progress in both the laboratory and the real world. Nonetheless, all hypotheses are open to challenge.

Indeed, testing and rejecting firmly established hypotheses can lead to extraordinary advances and career rewards. Here's an example from neuroscience. Since the late 1800's, an elemental hypothesis has been that the nerve cell (neuron) alone carries out the brain's information-processing activity. All the textbooks said so. We now know this hypothesis is false. It appears that glia cells, non-neuronal cells, are vital partners in brain signalling. The neuron hypothesis was a good-enough approximation to allow many discoveries that did not hinge on recognising glial cell involvement to be made. Like Newton's law of gravity, the old idea continued to be useful even as its deeper inadequacies emerged. No matter how useful, however, the neuron hypothesis was doomed as new methods and instruments permitted it to be tested in ever finer ways. Popper would have applauded.

## Scientists and their support for Popper

Sleigh associates Popper and some of his admirers with reactionary intellectual and political movements. I cannot critique her account (Shearmer, HPS&ST, May 2021, rebuts her charge of Popper's neoliberalism) beyond noting that she doesn't make a compelling case that the association between Popperianism and the movements is necessary or causal, i.e., that Popper's ideas must lead to evil societal outcomes. Her characterisation of the scientists who supported Popper is certainly misleading. Despite its including John Eccles and Peter Medawar (both Nobel Prize winners), and Herman Bondi, Sleigh sums

up the group as primarily scientists whose work "could least easily be potted in an attempted laboratory disproof," and therefore "turned to Popper for vindication." In fact, Medawar's Prize was for work that critically tested, and corroborated, an important hypothesis in immunology. Similarly, Eccles was well known for having, early-on, leaned toward the electrical ("spark") hypothesis of neuronal communication, against the competing, chemical ("soup") hypothesis. When refinement of experimental techniques allowed, he directly tested his electrical hypothesis and decisively showed that it was false. He instantly abandoned the idea, joined the "soup boys," and did the research on neuronal signalling that led to his Prize. Bondi (knighted for his work) was a mathematician and theoretical physicist who advanced several testable cosmological hypotheses (the most famous of which, the Steady State Model of the universe, was falsified by evidence that led to the Big Bang Theory). Perhaps because Professor Sleigh's premise is that Popper's principle of falsification is worthless, she doesn't raise the possibility that these scientists and others found it genuinely useful and advocated Popper's program for that reason.

## Does the principle of falsifiability have a moral dimension?

A major theme in Sleigh's essay is that science (and technology) and ethics are intertwined. Scientists are responsible for the societal impact of their work. In particular, they are culpable not only if they actively support immoral causes, but also if their work is used by others who do. She cites Naomi Oreskes's and Eric Conway's book, *Merchants of Doubt*, that documents the craven behaviour of a few scientific luminaries who carried water

for the fossil-fuel industry, often grossly distorting Popper's program in the process. This, she implies, proves its moral bankruptcy. I can't excuse these scientists' behaviour, but I disagree that Popper is responsible if his program is mis-applied for evil purposes.

If scientists hide behind Popperian falsification to do evil, then they're evil. But does adopting the principle automatically lead to evil deeds? On the contrary, staunch proponents of the anthropogenic hypothesis of global climate change cite Popper too (Mercer, 2016); evidence that his ideas are neither evil nor intrinsically prone to fostering evil.

Furthermore, rather than targeting Popper's fallibilism or falsifiability *per se*, Sleigh is underscoring the real dangers of simultaneously maintaining an unusually high degree of skepticism towards highly-corroborated hypotheses and credulity towards repeatedly falsified hypotheses for specific politically motivated reasons, an inversion of the entire Popperian project.

### Creativity in science

Sleigh scoffs at Popper's view that scientists arrive at hypotheses through "conjecture" (guesswork), an act of creativity. To her, this was a transparent and shoddy attempt by scientists to piggyback on the respect accorded to high culture – the humanities and the arts – at a time when the public increasingly feared science as a potentially dangerous scourge. She evokes Stanley Kubrick's comically demented and malevolent "Dr. Strangelove" as the archetypal mad scientist from which the academic scientists wanted to distance themselves.

Even if Sleigh were right that science needed and

sought the image-polishing it got from publicly associating itself with Popper's vision of science as a creative endeavour, that would not mean his vision was wrong. Besides, "creativity" is a term that often masks our ignorance of how our minds work. It refers to a mental or cognitive process that we don't know much about. Popper (and Richard Feynman among others) acknowledges ignorance of how scientists formulate hypotheses by calling it guesswork. It is hard to read anything sinister into this usage.

### What would science be like in Professor Sleigh's world?

This is a tricky question. She disparages Popper and his program without offering specific suggestions for improvement. For example, she casts aspersions on the concept that all scientific facts are tested-and-not-falsified hypotheses. What is the alternative? That some facts are established beyond conceivable doubt? That confirmed truths make up the body of science? This insidious misconception contributes to public misunderstanding and mistrust of science, but she doesn't refute it.

What about the process of falsification? Should it be entirely off-limits, as Sleigh seems to imply, or only when mis-interpreted? In *Why Trust Science*, Naomi Oreskes vigorously rejects falsification as the "one true scientific method," while implicitly acknowledging its influence in science. Oreskes's overarching message is that consensus of opinion among scientific experts who have no vested interest in the matters in question is the primary basis for justified trust in science. She doesn't deny that scientists take falsifying evidence into account in arriving at consensus.

Professor Sleigh implies that doing away with Popperian thinking will be an unalloyed plus for science and society. To the contrary, taking a wrecking ball to Popper's scientific methodology would leave the public with a more inaccurate, less valid picture of science than it has. Greater public misinformation, mistrust, and skepticism about science may well lead to or exacerbate a range of societal ills.

To achieve Professor Sleigh's aims, it would seem more sensible to foster a realistic public understanding of science – its goals, methods, achievements, and weaknesses. Informed citizens are better able to appreciate and support effective, socially sensitive, and desirable actions. Science is inherently complicated and educating the public about it is no trivial task. It is also extremely important. Science will, after all, be done, whether under Popperian auspices or not.

### Unanticipated negative consequences of Professor Sleigh's Approach

Although Sleigh focuses on climate change deniers' co-optation of Popper for their own ends, as noted, committed climate change believers also cite Popper. They argue that the anthropogenic climate change hypothesis is testable and has been corroborated by severe tests. Thus, presently, our best hypothesis is that the climate crisis is real, man-made, and gravely serious. It therefore can, and should, be (provisionally) accepted as true. Popper would agree that we are fully justified in taking appropriate actions even if "all the data are not in." Doing away with Popperianism would undercut these supporting arguments.

Moreover, it is climate change deniers who push the false notion of perfect, certain knowledge

when "all the data are in," as the goal of science. This mis-representation is fundamental to their arguments for delaying action to mitigate climate change. Furthermore, when the hoped-for perfect knowledge is not forthcoming, its absence fosters cynicism and distrust in the whole scientific enterprise. The deniers get away with this in part because Popper's critics don't distinguish between Popperian goals – ultimate truth versus practical guidance – and between these goals and the method of falsification.

Sleigh reports that "anti-science skeptics seize upon a single anomalous piece of data to claim to have disproved the entire edifice of combined research..." Their claim is an absurd disfigurement of Popper's thinking. A single piece of anomalous data is never sufficient to disprove an edifice of research. Anti-science skeptics make such claims because they are unaware of, or assume the public is unaware of, the facts about Popper's methodology and its immense usefulness in everyday science.

In 1959, C.P. Snow presciently laid out the dangers that arise when large portions of a society are ignorant of the science and technology on which the society depends. In failing to make clear the differences between the aims of basic and applied science, in ridiculing and misrepresenting the principle and value of falsification, in appearing to deny the reality of fallibilism, Popper's critics create a knowledge vacuum that true believers and unscrupulous scientists fill with dangerous nonsense that misleads many and betrays everyone. We can and must do better.

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