Abstract

This paper challenges premises regarding the 'Kuhn vs Popper debate' which is often introduced to students at a university level. Though I acknowledge the disagreements between Kuhn and Popper, I argue that their models of science are greatly similar.

To begin, some preliminary context is given to point out conceptual and terminological barriers within this debate. The remainder of paper illuminates consistencies between the influential books *The Logic of Scientific Discoveries* (by Popper, abbreviated as *Logic*) and *The Structure of Scientific Revolutions* (by Kuhn, abbreviated as *Structure*). The central purpose of this comparison is to synthesize a shared model of scientific change. The broader implication of this approach is appreciating common ground in discussions that are defined by their disagreements (particularly in philosophy of science).

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Models of Scientific Change

Bridging the gap: Popper vs Kuhn Debate

"When you turn to scientific inquiry, again, so little is known about how it proceeds - how discoveries are made - that we are reduced to speculation and review of historical examples."

~ Noam Chomsky, 2016

Philosophy of science discourse tends to regard Karl Popper and Thomas Kuhn as great opponents. There is some reason for this, as they have come to embody particular attitudes within the field. Popper was stringent about method and continuously advocated for skepticism. On the other hand, Kuhn was far less prescriptive, often defending the long periods of paradigmatic stagnation observed throughout scientific history. That being said, these attitudes tend to overshadow similarities between their models of scientific change.

Despite their disagreements, I argue that Popper's methodology in *The Logic of Scientific Discovery* is mostly compatible with the paradigm model introduced in Kuhn's *The Structure of Scientific Revolutions*. In my interpretation, parallels between these books suggest fundamental agreements worth considering. Sharing common ground, *Logic* and *Structure* should exist as complementary perspectives for understanding the nature of science.

The Professor of Logic vs. The Professor of History

Understanding the career objectives of Popper and Kuhn is key to interpreting their texts. *Logic* and *Structure* were clearly written for different reasons; so different in fact that their focuses and language create the illusion of great disagreement. In reality, as will be addressed later, many of these differences are due to perspective (rather than structural disagreements), coated with additional layers of subjectivity from the authors' personalities.

Karl Popper was primarily an academic philosopher who wrestled with "verbal problems" [1]. He spent much of his career as a professor of logic, which was his academic focus. As a witness to the revolutions of Sigmund Freud, Karl Marx, and Albert Einstein, Popper was determined to characterize theories. As a philosopher, his central contribution of 'falsificationism' served to distinguish science from pseudoscience [2]. Consequently, his book *Logic* proposes methodology meant to provide science with a superior claim to fact. As the full title suggests, *The Logic of Scientific Discovery* is mostly concerned with logically evaluating 'discoveries' that redefine fields of inquiry. The methods in *Logic* are in many ways ideals - how proper science should aspire to operate [3].

Thomas Kuhn, on the other hand, was a historian with a background as a physicist. The most progressive ideas in his book *Structure* result from observing large historical trends. His historical perspective provides a birds eye view that outlines distinct phases and sociocultural patterns. *Structure* captures how discovery has evolved under the ever changing definition of 'science', as well as how it has not. Unlike the prescription in *Logic*, *Structure* can be read as a more descriptive account of scientific development. The model in this book is explained in

relation to time, which is not the case with Popper's logical postulations. This aspect of *Structure* may be partly responsible for scientific processes seeming longer and more resistant to change.

Any comparison of these two intellectuals ought to be done within the aforementioned context. Most importantly, the methods of conceptualization in *Logic* and *Structure* are very different. As a consequence, a certain generosity is required for mending the gaps in translation [4]. With that in mind, Popper's methodology can be fairly juxtaposed with Kuhn's paradigm model. Looking beyond approach and diction, there are clear consistencies between these two books.

Normal Science

The most dividing concept between these two is undoubtedly Kuhn's 'normal science'. Normal science is research that adheres to a 'paradigm' [5] and consists of: a. extending the knowledge of paradigm facts, b. increasing a match between facts and model predictions, and c. further articulation of the paradigm. Many have argued that the existence of this research alone defies Popper's whole methodology. British philosopher John Watkins wrote that "the condition which Kuhn regards as the normal and proper condition of science is a condition which, if it actually obtained, Popper would regard as unscientific, a state of affairs in which critical science had contracted into defensive metaphysics" [6]. It should be noted that Popper himself did eventually acknowledge the existence of normal science, though rather disdainfully.

Regardless, the large role Kuhn gives to normal science in *Structure* is seen to challenge Popper. Two main contentions for this are the following: 1. Unlike the falsification in Logic,

anomalies do not cause revolutions & 2. Normal science is an example of science not characterized by falsificationism and skepticism. Although these are understandable concerns, they can be addressed.

1. "Anomalies do not cause revolutions"

In order to respond to this, it needs to be clarified that Kuhn's normal science 'anomaly' and Popper's 'falsification' are not synonymous. In fact, adequately distinguishing these two terms may do as much as to completely resolve this issue. In brief, anomalies are any unprecedented observations which contradict a theory (i.e. outlier data) , whereas falsifications are conclusive cases for replacing a theory [7]. This distinction becomes evident when by examining the entirety of these texts.

In *Structure*, 'anomalies' are vaguely introduced as any "recognition that nature has somehow violated the paradigm induced expectations" [8]. This "recognition" is only the *perceived* recognition, since many Kuhnian anomalies are resolved or corrected within their paradigm. For example, anomalies in the orbit of Uranus did not lead to the abandonment of Newton's principles or Kepler's laws. Rightfully so, as suspended postulations later led to the discovery of a new planet, Neptune - explaining results perfectly under the current paradigm. Countless anomalies also turn out to be errors, and some are explained with minor adjustments to a theory. Sometimes, solutions may lie just beyond the available technology, in which case problems are rightfully shelved for further analysis. One way or another, the emergence of an

anomaly is often short of suggesting a serious dilemma on its own; hence it does not produce an immediate revolution.

On the other hand, Popper's 'falsification' is a much more deliberate process of testing and building upon anomalous evidence. The term was never meant to refer to a single observation, despite it's singular conjugation. According to Popper, potentially falsifying evidence must be thoroughly replicated (among other requirements) before even being considered. In *Logic*'s section entitled 'Falsifiability and Falsification', Popper writes that "a few stray basic statements contradicting a theory will hardly induce us to reject it as falsified. We shall take it only as falsified if we discover a *reproducible* effect" [my emphasis - 9]. This alone greatly distinguishes falsificationism from the 'anomaly', a term Kuhn used to refer to individual examples and minimally investigated results.

This justification may seem insignificant however next to Kuhn's stating that "even severe and prolonged anomalies" are not treated as "counter instances". This is soon followed by, "No process… of scientific development at all resembles the methodological stereotype of falsification by direct comparison with nature" [10]. In these words, it could appear that Kuhn directly rejects the epistemological foundation of *Logic*. Jumping to this conclusion however would be to overlook the intended point of this passage, which is to identify the factor which *is* responsible for theory replacement: a counter theory. Kuhn explains that comparing predictions to nature (falsification) *is* part of rejecting a theory, but that ultimately a "theory is only declared invalid if an alternative candidate is available to take its place" [11]. This is to say that what

Kuhn rejected was naive falsificationism [12], which (as shown below) is not the methodology in *Logic.*

In addition to replication, Popperian falsification requires a corroborated [13] 'falsifying hypothesis'. This hypothesis serves to replace or upgrade the theory being challenged. Popper writes, "we only accept the falsification if a low-level empirical hypothesis which describes such an effect is proposed and corroborated" [14]. This is vastly different from Kuhn's anomalies, which can exist without a supporting thesis (or even an explanation). In many of *Structure*'s examples, an anomaly is considered legitimate as long as it is accepted as data by the scientific community. Popper has also stated that "[a corroborated hypothesis] may not be allowed to drop out without 'good reason'. A 'good reason' may be, for instance: replacement of the hypothesis by another which is better testable" [15]. This remark is almost exactly the same as that given by Kuhn. Here again, *Logic* recognizes that theories are not instantly discarded amidst controversy, essentially outlining the proceedings of *Structure*.

The process of corroborating 'falsifying hypotheses' also further bridges the gap between each book's scientific revolution timeline [16]. Although bundled into one term, the time consuming parts of 'falsification' (i.e. replication and a corroborated falsifying hypothesis) essentially mirror stages in *Structure*, such as 'insecurity' and 'crisis'. In both examples, a theory's authority is first called into question by persisting anomalies, and eventually faces competition from strong contending theories. Kuhn lays out his stages more proportionally to their duration however, drawing attention to slower phases of development and bureaucracy.

The Anomaly, The Discovery, and The Falsification

In *Structure*, there is a chapter dedicated to "Anomaly and the Emergence of Scientific Discoveries". Here, the 'anomaly' is introduced side by side with the 'discovery' - a term usually ignored in the Kuhn vs. Popper debate (perhaps because it was not original to the texts). The neglect of the discovery is unfortunate, given that it's more similar to the falsification than anomalies are. Like falsifications, discoveries in *Structure* "are not isolated events but extended episodes with a regularly recurrent structure" that blossom from anomalies [17]. Both falsifications and discoveries develop from anomalies, but, once again, are not *solely* anomalies.

Incidentally, these discoveries (essentially described as the successful investigation of persistent anomalies) produce significant shifts in theory, or in Kuhn's words, they "only close when the paradigm theory has been adjusted so that the anomalous has become expected" [18]. This seems to reaffirm that valid, replicable anomalies play a significant role. Once again, when accompanied with a 'falsifying hypothesis' of sorts, these discoveries also lead to more major revolutions.

Logic also refers to discoveries as being a focal point in scientific change. Popper defines the term similarly, requiring a regularly recurring effect. He expresses that "Every experimental physicist knows those surprising and inexplicable apparent 'effects' which can perhaps even be reproduced in his laboratory for some time, but which finally disappear without a trace. Of course, no physicist would say in such a case that he has made a scientific discovery"[19].

Popper insists here that effects must be "regularly reproduced by anyone" for them to carry any significance and therefore suggest a discovery - which would include a falsifying one.

This emphasis on replicability proves that Popper reserved substantial caution and patience towards anomalous data, contrary to his reputation. Despite how instantaneous Popper's systems may read in theory, *Logic* actually accounts for the time consuming realities of accepting novel information (including falsifications)- despite them being more thoroughly addressed in *Structure.*

In sum, the 'anomaly vs falsification' confusion is a prime example of how these books emphasize different areas of a similar model. The haziness of these terms has additionally contributed to the misconception that *Logic* is unrealistic in retrospect.

The basic models for scientific revolution in *Logic* and *Structure* can be illustrated side by side; boiled down into a unifying equation. This "equation" is highly simplified, but it lays out the major parallels between *Structure* and *Logic* proportionally (unlike the books themselves). It should also be noted that the following illustrations are not mathematical or formal logic.

Comparing the Models of Popper and Kuhn

The letters *X*, *Y*, and *Z* represent concepts that are essentially synonymous between Popper and Kuhn. As the product of the equation, the letter *A* will represent significant change to an overarching theory (i.e. the paradigm). The addition symbol "+" is placed between concrete

requirements for change, while the multiplication symbol “x” is used to signify processes being applied to those more concrete elements.

Popper’s Model

(Outlier Results {X} + Falsifying Hypothesis {Y}) x Replication/corroboration {Z} = Falsification*

Falsification* → Change to Theory {A}

(X + Y) x Z → A

Kuhn’s Model

(Anomalies {X} + Alternative Theory {Y}) x Replication/persistence{Z} = Discovery*

Discovery* → Change to Theory {A}

(X + Y) x Z → A

** essentially a ‘Falsifying Discovery’*

2. Normal Science lacks (a.) falsificationism as a function

& (b.) skepticism as an attitude

2a. Unlike more dogmatic theories of understanding (such as religion and political ideology), science has the ability to prove itself wrong, at least in principle. Incidentally, this is perhaps the core principle to Popper's methodology. Considering this, normal science is inherently Popperian given potential to produce falsifying evidence. Normal science experiments correct their paradigm because there exist underlying expectations from which results can deviate. Of course to be aptly compared to the methodology in Logic, this would be under the assumption that most experiments are performed with accuracy and integrity.

In the book *Kuhn vs Popper,* author Steve Fuller writes, "For Popperians, deduction is mainly a tool for compelling scientists to test the consequences of their general knowledge claims in particular cases by issuing predictions that can be contradicted by the findings of empirical research. This is falsifiability in a nutshell"[20]. Similarly, the deductive approach of normal science experiments (specific expectations from fundamental assumptions) lays the groundwork for falsification. Under this premise, normal science allows theories to progress in further detail while adhering to Popperian falsifiability. This was a goal of Popper's, who endeavoured to 'make the mesh [of theories, described as "nets"]... finer and finer" [21].

A sound objection here is that the *purpose* of normal science is still not falsification, but rather the verification of paradigm assumptions (which Popper rejected as a means of conducting science). After all, Kuhn writes that normal science works by "actualizing" the proposals of a

theory “by increasing the extent of the match between those facts and the paradigm’s predictions, and by further articulation of the paradigm itself” [22].

Although this sounds like the process of verifying something, confirming evidence is more of an aesthetic byproduct of dealing with already corroborated theories: they are not supposed to serve a functional purpose or protect paradigms. Kuhn actually writes that the vast majority of normal scientists *aim* to complete “mop up work”. This is not the verification, but "the articulation" of the paradigm’s main theories through more specific hypotheses. Elsewhere, he confirms that the aim of normal science as a whole is “the steady extension of the scope and precision of scientific knowledge” [23]. In other words, normal science’s purpose is to further develop theories, not fact-check them.

Turning to *Logic*, a normal science under this definition does not affect theory assessment whatsoever. To preface, it should be established that Popper’s concept of an ‘axiomized system’ is essentially his equivalent to Kuhn’s ‘paradigm’; both being the accepted assumptions and statements based on unifying theories and principles. The fundamental postulates of the axiomized systems are called ‘axioms’ and all other hypotheses must extend from them. Popper writes that, “all the other statements belonging to the theoretical system can be derived from the axioms by purely logical or mathematical transformations” [24].

Founded in its axioms, Popper’s system mirrors Kuhn’s paradigm in its relationship with elaborative hypotheses (the inquiries of normal science). Popper states that a “system [of

theories] must be formulated sufficiently clearly and definitely to make every new assumption easily recognizable for what it is: a modification and therefore revision to the theory" [25].

Rationally, the articulative hypotheses and expansive experiments of normal science (i.e. "mop up work") can be interpreted as Popperian modifications and revisions. This is because the purpose of normal science is neither to falsify *or* verify its theories; it is to depthen them through further testing. After all, hypotheses only increase the detail of theory predictions and improve testability (and therefore falsifiability). To reiterate, developments of the sort are not involved in theory assessment and therefore have no responsibility to make falsification their purpose according to *Logic*. Even so, normal science seems to provide an adequate platform for falsification to occur. Either way, Popper's methodological standards stay intact, leaving the big picture of falsifiability unscathed - at least within a reasonably skeptical and ethical scientific environment.

2b. *Skepticism (ie. 'critical attitude')*

Skepticism is undoubtedly more challenging to identify, but nonetheless still observable in normal science. Much to the credit of Popper's influence, critical attitude has become a cornerstone of the scientific approach. Although understandably reduced for the corroborated theories of a paradigm, this attitude plays an essential role in modern normal science: maintaining integrity. Corrective processes such as peer review and experiment replication are examples of critical attitude in action, their purpose being to preserve scientific standards.

A counterargument to this reasoning is that many structures designed to hold science responsible are corrupted and fail their purposes. In a presentation entitled *Science vs. Politics: The Battle for Integrity*, speaker Heather Douglas remarked "What we do and do not know is deeply influenced by the distribution of effort among scientists, and this distribution can be distorted by power and money"[26]. More concerning yet, she gave examples of esteemed scientists who had successfully published manipulated data used to help verify certain agendas; all within the critical guidelines of normal science.

Although these problems exist, corrupted research cannot serve as examples of unpopperian science - as they are not examples of true science to begin with. Douglas also acknowledges this distinction, clarifying that "deceptive research" which violates scientific integrity "just has the *appearance* of actual scientific research"[My emphasis-27]. The only time these practices are mislabeled as valid normal science is when they fail to be properly exposed. Regardless of their disguise, they are still intrinsically 'pseudoscientific'. After all, *Logic* aims to define proper methods, so as to separate pseudoscientific claims from actual science. In the rare case of clearly unfounded claims passing scientific standards, the standards should be corrected.

Kuhn is by all means justified in recognizing mistakes for the sake of history, considering their observable influence. Yet, because these are examples of *improper* scientific procedure (at least by modern standards), they should not contradict Popper's methodology which serves to improve standards. All malpractice strays away from the qualities that ought to define science,

and therefore must be considered sub-scientific or incomplete. If the skepticism meant to uphold this ideal fails to exist entirely, then so does science itself.

Skepticism is also closely tied to the previously mentioned phenomenon of normal science creating its own falsification. Although the aim of normal science is not to scrutinize its paradigm, skeptics arise by default under strict expectations. Kuhn admits that paradigmatic research is particularly effective for inducing change; counter evidence being "produced inadvertently by a game played under one set of rules, [its] assimilation requires the elaboration of another set" [28]. Examples of self manifesting skepticism in *Structure* include the discovery of oxygen. It is emphasized that long before helping to discover the revolutionary gas, scientists like Lavoisier were motivated by suspicions that something was wrong with current theories. The experiential outcomes that followed later gave form to what was previously only skeptical intuition from a select few. This form invited skeptics to turn up in greater numbers, building a competitive landscape between theories.

Skepticism can be seen here as a gradual process, one that hesitates but that ultimately performs its Popperian function - discovering truth through falsificationism. Many normal scientists may lack a constant critical attitude on an individual level, but skepticism always exists where it is warranted. Otherwise, normal science would be the only state of science. To quote professor Darrell P. Rowbottom in an essay on *Kuhn vs Popper*, "it is possible for science to perform a critical function with wide scope even when none of its participants have (completely) critical attitudes" [29].

Further Reflections

In sum, anomalies that repeat themselves and are supported by corroborated counter theories are essentially Popperian falsifications. This equivalence debunks the myth that *Logic*'s falsificationism is too impractical and skeptical next to *Structure*. Popper has in fact remarked that scientists becoming overly "objective and rational" will make "the revolutionary progress of science barred by an impenetrable obstacle" [30].

Kuhn's attitude has also been exaggerated - yet in the opposite direction. In Kuhn's case, normal scientists are interpreted as being unreasonably resistant to change. In reality, Kuhn's paradigm model relies on a similar falsificationism to that in *Logic.* Put succinctly, Kuhn remarks that "insecurity [of a paradigm] is generated by the persistent failure of the puzzles of normal science to come out as they should. Failure of existing rules is the prelude to a search for new ones" [31]. This understanding appears consistent throughout both books, although *Structure* does more to emphasize the hesitations around abandoning corroborated theories.

It is worth considering as well that perhaps normal scientists aren't protecting their paradigm due to a lack of skepticism, but as Popper speculates, because of a "skeptical attitude as to the reliability of the experimenter whose observations, which threaten our system… are insufficiently supported" [32]. If this is the case, *Logic* seems to once again account for the dynamics detailed in *Structure.*

Beyond these mentions, there are additional connections worth considering between these books. In the meantime, those included seem to reflect the most intelligible aspects of scientific nature- fundamentals which both Popperians and Kuhnians can agree on.

Concluding Statement

Understanding approach is crucial for comparing the ideas of intellectuals, especially Thomas Kuhn and Karl Popper. The push and pull nature of their opinions provides a healthy range for science to evolve within, depending on the circumstances it finds itself in. Despite obvious differences in *Logic* and *Structure*, the underlying models of scientific change have striking similarities. Hopefully by acknowledging these parallels, future philosophers will have a more complete and unified picture of science.

"There is only a perspective seeing, only a perspective 'knowing'; and the more affects we allow to speak about one thing, the more eyes, different eyes, we can use to observe one thing, the more complete our 'concept' of this thing, our 'objectivity', be."

~ Friedrich Nietzsche, 1887

Notes

[1] Albert B. Stewart. “Pertinent Popper.” *The Antioch Review*, vol. 41, no. 4, 1983, pp. 488–494.

[2] Or served to “demarcate” science, in Popper’s words.

[3] See *Kuhn vs Popper: The Struggle for the Soul of Science* by Steve Fuller.

[4] Quite literally sometimes. Popper and Kuhn both use a number of terms that were more or less born from their publications, some of which are very vaguely defined or float under a number of possible definitions (for example, Kuhn’s ‘Paradigm’, which received criticism for its lack of concreteness).

[5] Definition of term varies by interpretation.

[6] Imre Lakatos, Alan Musgrave, and John Watkins, “Against Normal Science,” in *Criticism and the Growth of Knowledge* (Cambridge: University Press, 1970), p. 28.

[7] I do not mean to suggest that Popper believed in conclusive falsificationism, as he certainly did not. However, Popper’s methodology relies on falsifications being thoroughly convincing and having direction (they must be relatively conclusive).

[8] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, IL: The University of Chicago Press, 2015), p. 53.

[9] Karl Raimund Popper, “Falsifiability and Falsification,” in *The Logic of Scientific Discovery* (Mansfield Centre, CT: Martino Publishing, 2014), p. 86.

[10] Kuhn, *Structure*, p.77.

[11] Ibid.

[12] A scientific philosophy in which refuting examples falsify entire claims on their own.

[13] Corroboration is the process of a theory or statement “proving its mettle” by withstanding vigorous testing and scrutiny. This is not related to probability theory.

[14] Popper, *Logic*, p. 86.

[15] Popper, *Logic*, pp. 53-54.

[16] Or rather, helps illustrate time in relation to Popper's methodology, which is often difficult to judge in *Logic.*

[17] Kuhn, *Structure*, p. 53.

[18] Ibid.

[19] Popper, *Logic*, p. 45.

[20] Fuller, Steve. *Kuhn vs. Popper: the Struggle for the Soul of Science*, p. 16 New York City, NY: Columbia University, 2004.

[21] Popper, *Logic*, p. 59.

[22] Kuhn, *Structure*, p. 24.

[23] Kuhn, *Structure*, p. 52.

[24] Popper, *Logic*, p. 71.

[25] Ibid.

[26] Heather E. Douglas, in *Science vs. Politics: The Battle for Integrity* (Dallas, TX, 2012).

[27] Ibid.

[28] Kuhn, *Structure*, p. 55-56.

[29]. Darrell P. Rowbottom, "Kuhn vs. Popper on Criticism and Dogmatism in Science: a Resolution at the Group Level," *Studies in History and Philosophy of Science Part A* 42, no. 1 (2011): pp. 117-124, https://doi.org/https://doi.org/10.1016/j.shpsa.2010.11.031, pp. 23-24.

[30] Fuller, *Kuhn vs Popper,* p. 96.

[31] Kuhn, *Structure*, p. 68.

[32] Popper, *Logic*, p. 81.