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EPISTEMOLOGICAL FRONTIERS: EXAMINING KUHN'S PARADIGMS AND POPPER'S FALSIFICATIONISM IN THE ARENA OF IDEAS

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Abstract

This comparative examination intends to directly explore the approaches of two cornerstones of the philosophy of science in understanding the nature of research and scientific progress. On the one hand, Kuhn's paradigms that follow one another are understood as frameworks that incorporate a set of beliefs, methods, and results shared by the scientific community in a specific time frame. The humus for scientific progress is represented by normal science characterized by the resolution of theoretical and practical problems that arise within a paradigm. This is just one of the different phases that accompany the scientific revolutions, to which are added the pre-paradigmatic and paradigm acceptance ones, emphasizing the role played by the anomalies that generate a crisis in the existing paradigm revealed gradually insufficient. On the other hand, in Popper's Epistemology, the focus is on the open, dynamic, and provisional nature of knowledge which does not remain caged within the confines of paradigms. Key elements are falsificationism as a scientific method and the proactive and ongoing work carried out by scientists in generating problem-solving hypotheses by subjecting them to rigorous examinations, seeking evidence and theories that contradict them rather than selecting those in favor, and barricading themselves behind their own conceptions (confirmation bias). Which of the two positions will be the most solid?

Keywords: falsification; paradigm; Popper; revolution; science; scientific;

1. INTRODUCTION

To know something about any subject, studying at least ten texts is necessary. In this case, the starting point could not but be *The Structure of Scientific Revolutions* (1962), the milestone in the philosophy of science to which Thomas S. Kuhn has dedicated about fifteen years, with the fundamental question that intends to clarify how it moves science.

Whenever there is a lively debate around scientific revolutions, it reflects particularly around the Newtonian revolution but it has not remained isolated since, over the centuries, there have been and there will be others ready to undermine the set of methods and beliefs, involving a qualitative and quantitative leap. These changes do not add up to the past and do not occur horizontally or gradually but mark a significant breaking point with the previous scientific system, becoming irreconcilable with subsequent scientific systems. It is not repudiated, as each has its internal effectiveness and efficiency, accepted and shared by the scientific community up to a given moment, until it gives way to the next which will, in turn, become incompatible with the scientific system that will follow it.

The enduring reference to Popper's epistemology and the perpetual warnings about Russell's evergreen metaphor of the *inductivist turkey* represent essential compasses both for those who encounter the *hard sciences* and for those who approach the *soft sciences*. Knowledge, and with it scientific progress, are understood by the Austrian epistemologist as evolving, rejecting the concept of untouchable truths since, even those that seem most sturdy, must be continuously subjected to criticism, future revisions, and continuous improvements, in other words, empirically verified. An innovative scientific approach based on critical analysis, the criterion of *falsifiability*, and the search for contrary evidence allows us to move beyond obsolete theories in favor of new hypotheses that are never dogmatic but available to be tested.

In a historical moment in which modern hyper-globalized and liquid societies struggle to recover lost balances, the Popperian approach confirms itself as a beacon that traces the route of scholars, distancing them from inductivism and the accumulation of observations to fortify the theses formulated. They must, therefore, be open to doubt and creativity as well as constructive criticism to review their contributions and verify their scientific nature. If one confines oneself within a set of beliefs or convictions, one loses sight of the ultimate goal of science, and there is the risk of a (con)fusion between what is scientific and what is not scientific, like religion(s), Freudian psychoanalysis or Marxism in all their multiple declinations.

2. THE ANATOMY OF SCIENTIFIC CHANGE: FROM ANOMALIES TO REVOLUTION(S)

It is clear that science is not an end in itself, immutable or static, and does not proceed linearly but goes through various phases among which the so-called *normal science*[1]. The adjective *normal* indicates it's being based on a precise paradigm, on concrete scientific results, achieved, accepted, and shared in a given period. But what does paradigm mean? A term as widely widespread as it is abused, understood as the set of all results, ideas, knowledge, methodological rules, and guidelines recognized as valid by the scientific community, accepted, and used for a while[2]. They are enclosed in reference works, in immortal study manuals that allow not only the sharing of these indications but, above all, their maximum application. The scientific results are clarified by two key features:

1. scientific results must be qualified as *sufficiently new* to attract an ever-increasing number of *followers*. Scientists will, therefore, neither go to re-investigate the principles nor will they re-start from the fundamentals - already - established but will concentrate on much more circumscribed aspects, giving life to increasingly refined and complex specializations;
2. the scientific results cannot fail to qualify as *sufficiently open* to allow the resolution of the problems (*brain teasers*[3]) that one intends to investigate within them.

It is so reductive to consider the paradigm as a mere example, as a scheme to be reproduced slavishly rather it allows more and more specific articulations that take into account the details, the indications, or even the instructions contained therein to arrive at certain solutions, without the claim of

[1] Three elements of absolute cruciality emerge at this point: the relevant facts, the facts that come forth from the necessary comparison between the paradigm and the world of nature, commitment, and empirical practice.

[2] Kuhn Samuel Thomas (1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.

[3] Di Berardino Elena, Lucchetti Roberto, Schiaffonati Viola (2011), *Temi filosofici dell'Ingegneria e della Scienza*, Maggioli, Santarcangelo di Romagna (RN), pp. 50-52.

definitively solving all the problems globally[4]. What is learned from the examination of the manuals such as formulas or theorems is not confined to a theoretical level but is applied every day to solve the brain teasers. In other words, in normal science, the paradigms hold a prominent position concerning the rules understood as:

> […] Examples of more general epistemic values; precisely because values such as simplicity or predictive power are open to different interpretations, they are compatible with different rules: some will establish the validity of a theory based on the novelty and success of its predictions, others will be satisfied with the fact that the theory explains already known phenomena; these differences, however, do not question the importance that both attribute to empirical validity [...] Methodological differences do not necessarily reflect deeper theoretical conflicts [...][5].

If science is not only made up of rules in the most austere sense of the term, they regain relevance when there is a paradigm shift[6]: the scientific foundations are questioned only during *extraordinary science* but not in normal science. The latter (phase 2), it should be noted, is preceded both by the pre-paradigmatic (phase 0) and by the acceptance and normalization of the paradigm (phase 1) but the watershed lies in the birth of *anomalies* (phase 3) which will not necessarily lead at the definitive fracture of the paradigm, on the contrary, it could even get strengthened. However, when it proves no longer adequate to solve current problems or its techniques and instruments are so obsolete concerning the new needs - sometimes due to discoveries or new theories - then it will be necessary to face to the crisis that has arisen (phase 4). Scientists will begin to think hard about the fundamentals of why anomalies are so recurrent and brain teasers so difficult to solve with a paradigm turned anachronistic, no longer suitable for the emerged needs. They continue to reflect on whether and to what extent it is still possible to have faith in that paradigm that has provided guarantees for a long time but is now beginning to waver in the face of such incurable anomalies. → Here the scientific revolution (phase 5) will bring with it a change of paradigm that will not in any way add up to the previous one but will be irreconcilable: from the recognition/acceptance of the new paradigm (not immediate, not without resistance, and with a certain degree of persuasion), a normal science will restart with its concepts, theorems, definitions, and methodologies. Without falling into error, it can be said that it is a new and different system of thought that will answer questions that the previous paradigm was no longer able to address despite its reliability, having been used as a reference for a long time.

Given that the paradigm provides a vision of the world and that each represents the field of action of scientists for many decades, centuries, or even millennia (as shown, for example, by the Ptolemaic theory), it would be a mistake to think that "true"/more "authentic" science resides exclusively in the extraordinary science. The scientific revolution comes with assiduous study, with the daily research that takes place in normal science, which although necessarily perimeter, goes deep into the questions allowing new frontiers of examination, and applications that are gradually more and more particular and targeted. In normal science, there is science, science is made, and progress is pursued: the scientific revolution cannot ignore normal science because it is precisely from here that the conditions that will lead to the scientific revolution may develop.

Furthermore, another blunder is to think that once the new paradigm has been accepted and becomes a reference, the previous one must be condemned, as if it were a beacon with a light so blinding that it has hidden the best way to go. Indeed, what criterion can or must be used to qualify one paradigm as "better" than another? Kuhn argues there is no need for any standardized or impartial criteria, supporting his thesis by introducing *incommensurability*, as each paradigm intrinsically carries its unrepeatable vision and perception of the world

[4] Maxwell Nicholas (2017), *Karl Popper, Science and Enlightenment*, UCL Press, London, p. 77.
[5] Bicchieri Cristina (1988), *Ragioni per credere, ragioni per fare. Convenzioni e vincoli nel metodo scientifico*, Feltrinelli, Milano, p. 37. [All quotes have been translated by the authors from Italian to English, faithfully reporting the extrapolated passages].
[6] Sfetcu Nicolae, *Epistemology of Experimental Gravity – Scientific Rationality*, Multimedia Publishing, Bucharest, p. 167.

> Along with the problems, quite often the standards imposed upon scientifically admissible solutions change. […] After a revolution, many of the older concepts and methods are still used, but in modified ways. […] scientists belonging to different paradigms conduct their research in *different worlds*[7].

Worrall explored another core idea to understand Kuhn's paradigms, namely that scientific conversion, while not taking place through the coercive use of force, will take place in a profound way (and could, but not necessarily coincide, with a generational change) but it will not be, at least in the short time, a mass conversion. It must be considered a positive signal since the resistances that emerge will serve to further test the emerging paradigm

> […] successive theories are not comparable but instead 'incommensurable'; the switch to the newer paradigm is a 'conversion experience' rather than a process governed by general rules of theory superiority; 'hold-outs' for older paradigms who do not accept the superiority of the revolutionary new paradigm are 'neither illogical nor unscientific'[8].

3. SCIENCE IN FLUX: EMBRACING FALSIFIABILITY AND REJECTING DOGMA

Taking up the assertion "all swans are white"[9] one fully understands his thought: it seems a trivial statement, taken for granted, and what appears to be an indisputable truth is valid until proven otherwise. This means that when a black swan or any other color appears before our eyes the castle of certainties on which we had relied, collapses[10]. In this path, knowledge cannot and must not be immutable, on the contrary, it is by allowing the opening of new horizons that the error correction becomes possible, and in so doing they can be assiduously subject to refutation. One has a scientific theory to the extent that it can be refuted, and the more ways are there to refute a theory, the greater will be its hallmark of scientificity.

Let's pay attention: falsifiability is not synonymous with verifiability or justifications (typical of logical empiricists)[11]. Verifiability will lead scientists to defend their positions, to cling to their lucubrations: they must always rely on the uninterrupted research of verification and support. On the contrary, falsification allows the scientist to learn from mistakes by subjecting hypotheses[12] to rigorous criticism, not to consider them as indisputable truth despite their reliability; these can be considered valid conjectures as long as evidence to the contrary emerges ready to refute the assertion previously made. Future, and perhaps more complete considerations, must be weighed valuable as they can both corroborate conjectures and be supplanted by stating the exact opposite, showing a permeability and not closing like a hedgehog towards falsifications.

It is natural to wonder how the "diligent scientist" or "good scientist" will move, which are the main stages and how they combine each other. Without transcending into simplification, the three pillars of the Popperian scientific perspective can be summarized in this model:

[7] Kaldis Byron (2013), *Encyclopedia of Philosophy and the Social Sciences*, SAGE, Los Angeles, p. 525.
[8] Worrall John (2003), *Normal Science and Dogmatism, Paradigms and Progress: Kuhn 'versus' Popper and Lakatos*, in Nickles Thomas (edited by), *Thomas Kuhn*, Cambridge University Press, Cambridge, p. 83.
[9] Popper Raimund Karl (1997), *La ricerca non ha fine. Autobiografia intellettuale*, edited by Antiseri Dario, Armando, Roma, p. 56.
[10] Gorman Jonathan (1992), *Understanding History. An Introduction to Analytical Philosophy of History*, Ottawa Press, Ottawa, pp. 107-108.
[11] Maxwell Nicholas (2017), *op. cit.*, p. 14.
[12] Popper Raimund Karl (1970), *Logica della scoperta scientifica*, Einaudi, Torino, p. 308.

In contrast to the inductive method[13], what does the scientist do[14]? He "stumbles" into a problem and elaborates hypotheses to be subjected to the scrutiny under criticism and falsificationist's methodology. Science consists of solving problems that arise from the dyscrasia between the wealth of knowledge acquired and the events, making those certainties - seemingly unscratchable - falter that is unceasingly called into question. The diligent scientist puts himself in a daily process, and by adopting this approach, he may consider the research as open and susceptible to falsification. He follows the opposite path, a severe one full of pitfalls rejecting the scaffolding to support his thesis, instead in search of all those refutations able to highlight the weak points on which to improve. It categorically rejects the vision of science that leads to a certain truth (do not forget its warning of the stratagem of *ad hoc* hypotheses) because science, being open, must have an evolving character, and even if a theory resists falsification and controls it cannot be excluded that one day a contrary proof will emerge[15]. Falsifications are to be understood as shock waves compared to hypothetical explanations: the more they will be able to resist the strong blows of refutation, the closer they will be to the truth, but not in an absolute sense (→ provisionally corroborated).

The Popperian perspective has been openly anti-inductivist since its origins, and the criticisms to logical empiricists have not remained isolated (induction does not exist and cannot be considered as a criterion of demarcation, indeed it is not possible to draw a universal law from the observation of a series, albeit accurate and repeated, of particular cases). They are added to the famous Freudian psychoanalysis and Marxism theory (have been defined as pseudo-sciences in disguise), are considered extremely dispersive and generic escaping from falsifications, kept alive by fraudulent adjustments. In both, Popper tracked down that fearsome recurring explanatory omnipotence difficult to eradicate and if for psychoanalysis there is the almost obsessive reference to the unconscious for the justification of the most powerful anomalies, in the Marxist doctrine, he questioned historicism, collectivism, and the totalizing centrality of the economic structure but, above all, the vague outcomes of a utopian future communist society that would be formed after the proletarian dictatorship as a transitional phase to reach a society without classes, marked by the socialization of the means of production, the total dissolution of the State and exploitation in all its forms. He identified, again in both, a visceral link with the myth and defined them as dogmatic, unfalsifiable, and without any scientific character, especially in their definitive formulations. It is clear how the criterion to be used is falsification to mark off what science is from all that is not science; even the "basic statements" should not be regarded as unshakeable blocks but should be prepared to accept any attempt at rebuttal[16].

4. KUHN VS. POPPER: AN OPEN DISCUSSION

At this point, the differences that emerge with the backward comparison with Kuhn[17] become clearer as the initial questions are more or less similar but they change the answers to which they arrived, creating one of the most heated debates of the last century. The different academic formations that have influenced the analyses carried out should not be overlooked, even though they both reached the field of the philosophy of science.

The Viennese epistemologist considered science as permanently in revolution while Kuhn the exact opposite: the scientific revolution is the exception but not the rule, they are rare compared to long periods of *normal science* where there is in no way a scientific impasse[18]. Within normal science, one

[13] Corradini Antonella (2005), *Epistemologia delle scienze umane. Un'introduzione al corso*, EDUCatt, Milano, p. 67 ss.
[14] Antiseri Dario (2002), *Karl Popper. Protagonista del secolo XX*, Rubbettino, Soveria Mannelli (CZ), p. 10 ss.
[15] Popper Raimund Karl (1963), *Conjectures and Refutations*, Routledge and Keagan Paul, London, p. 33 ss.
[16] Mitra Suddhachit (2020), *An Analysis of the Falsification Criterion of Karl Popper: A Critical Review*, *Tattva-Journal of Philosophy*, vol. 12, n. 1, pp. 2-3.
[17] For a critical and provocative comparison please refer to the reading of Fuller Steve (2004), *Kuhn vs. Popper. The Struggle for the Soul of Science*, Columbia University Press, New York.
[18] Bird Alexander (2014), *Thomas Kuhn*, Routledge, New York, p. 24.

cannot ignore the paradigm of reference that leads the research to become increasingly more and more meticulous. The founding principles are not questioned at this stage but only in the *extraordinary* one. For Popper, every error is relevant, not only the scientist but also students must be educated from tender age to analyze them critically, not to take them for granted, but letting teaching derive from them.

Error after error allows an increasingly adequate description of reality without tending to a printed truth; for Kuhn instead, the *anomalies* can also be reabsorbed by the current paradigm and not necessarily lead to its prompt collapse. The rationalistic criticism accused all that long series of subjective or irrational[19] elements to which the Kuhnian scientist is subjected when he would "act" caged in a paradigm that limits and consequently circumscribes the field of action or, even worse, his investigation. The socio-cultural context, formation, and influences of the scientific community are factors that Kuhn does not consider secondarily, giving importance to both the individual and the collective component. This does not mean that for Popper they are not relevant, but the falsificationist methodology rises to a role of primary importance regardless of the context of reference.

The scientist, rather than remaining confined in a "paradigm-shaped" comfort zone, proceeds by conjectures and subsequent refutations, by trial and error[20], modifying how he approaches the problem. There is, therefore, a Popperian asymmetry between the verification of a theory and the definitive proof of its scientific correctness. The progressive adjustment deviates from the rigidity of Kuhnian paradigms, promoting a science that does not proceed by leaps but circularly: the initial observations/considerations give life to theories and new observations, which in turn enter existing theories, gradually modifying them only in the extent to which the experimental protocols for the falsifiability of new hypotheses allow it.

5. CONCLUSIONS

The complex insights provided by Thomas S. Kuhn's philosophy of science continue to chart the path of scientific progress even today. He overturned the traditionally understood conception of science as an exclusively linear, rational, and cumulative process by emphasizing scientific revolutions and paradigm shifts. A break with logical positivism and the gradual accumulation of knowledge or observed facts. Both the historical and contingent dimensions of science acquire relevance, attributing weight to social and cultural influences or pressures as well as to the historical context, bringing it back to a "more human" level made by men and for men not as a distinct entity and far from the human being. Science is dynamic and discontinuous, and the truth is never objective. Still, it must always be placed in the paradigm from which it emerged since when the paradigm changes, the perspectives, and conceptual frameworks do the same: we do not move from a "wrong" paradigm to a "right" one.

Any comparison is useful to the extent that it is contextualized. The falsificationist method, as appealing as it may be and as agreeable in many aspects, finds procedural resistances, as well as Kuhn's explanatory plant, especially in the social sciences. The demystification of human fallibility, praise for error, and science no longer put on a pedestal are the most attractive cores to which are added the hints for reflection on a policy focused on pluralism and on an open society to be understood as a product of individuals and never vice versa. Many contemporary socio-political events can be read thanks to Popper's interpretations, demonstrating the immortality of his work not limited to a philosophy of science's reflection. Is it still correct to continue to reflect on an irreconcilable contrast between the authors, or are their conciliation and integration possible? Is it right to remain on opposing sides of *apocalyptic* and *integrated*, or will it be possible to amalgamate them in favor of a richer perspective on scientific research?

[19] In this perspective, it is useful De Stefano Edoardo (2012), *Il logos in Popper, Kuhn, Feyerabend: dal razionalismo all'anarchismo epistemologico*, in Carderi Flavia, Mantovani Mauro, Perillo Graziano (edited by), *Momenti del Logos. Ricerche del* "*Progetto LERS*" (*Logos*, *Episteme*, *Ratio*, *Scientia*), Nuova Cultura, Roma, p. 539.

[20] Borghini Andrea (2000), *Karl Popper. Politica e società*, FrancoAngeli, Milano, p. 27.

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