ANALYSIS OF THE PREVAILING VIEWS REGARDING THE NATURE OF THEORY-CHANGE IN THE FIELD OF SCIENCE

Jonathan Martinez

Abstract: One of the best responses to the controversial 'revolutionary paradigm-shift' theory posited by Thomas Kuhn is the theory, posited by Larry Laudan, that paradigm-shifts occur in the form of piecemeal changes. In this essay, I analyze these two positions and provide an account of why Laudan's response to Kuhn is inadequate; Laudan's response relies on both a limited, erroneous interpretation of historical events and an inductive argument structure that cannot guarantee that future paradigm-shifts will not be revolutionary.

INTRODUCTION

The prevailing philosophical views regarding the nature of theory-change in the field of science fall into two major categories: Kuhnian and non-Kuhnian. In *The Nature and Necessity of Scientific Revolutions* (1970), Thomas Kuhn articulated the Kuhnian perspective and argued that scientific theory-changes occur in a revolutionary fashion (Kuhn 86-88). This process makes individual scientific paradigms only assessable internally because the tools of evaluation (i.e.values) of each paradigm change at the beginning of each successive paradigm (Kuhn 94-96). As such, the practitioners of a previous paradigm cannot evaluate the validity (i.e. its correspondence with reality) of new paradigms because they have no evaluatory tools in common with practitioners of the new paradigm.

This asymmetry has led the philosophical and scientific communities to hold that if Kuhn's theory obtains, theory-changes in science may be nothing but arbitrary changes in the field, as the continuity of the field has been completely disrupted and as all tools of appraisal are rendered useless. In his essay *Dissecting the Holist Picture* (1986), Larry Laudan objects to the view expressed by Kuhn and proposes an alternative view: the possibility of individual, "piecemeal" changes within the elements of a scientific paradigm. While Laudan's non-Kuhnian theory provides a novel account of how theory-changes in science occur in a rational manner, it is ultimately ineffective because 1) the view's reliance on inductive reasoning does not prohibit the possibility of a revolutionary paradigm-shift, even assuming Laudan's interpretation of history to be correct, and 2) there are good reasons for calling Laudan's interpretation of the history of scientific theory-change into question, i.e. historical occurrences that either are unaccounted for or contradict Laudan's assertions.

THE PHILOSOPHICAL LANGUAGE OF SCIENTIFIC THEORY-CHANGE

In this section I will be discussing the meanings of each of the three elements of a paradigm, all of which are terms that must be grasped in order to understand the language of this essay. In addition to this, I will also discuss the "problem of induction," as an understanding of the particulars of the problem will be necessary to understand my critique of Laudan's view in the latter part of the essay.

Kuhn claims that every scientific paradigm consists of three elements: ontology, methodology, and values. "Ontology" refers to the totality of held beliefs (in other words, all things taken to be the case). It may be helpful to think of this term as roughly synonymous with "theory." However, because of the semantic ambiguity that arises when referring either to the individually-held beliefs of a theory vs. "the Theory," which may consist of more than one scientific theory's set of beliefs, ontology is

a far more efficacious term. For example, the theory of gravity contains within it a multitude of assumptions about the world (e.g. that gravity functions in a uniform manner across the cosmos, the gravitational constant is equal to roughly 6.674 x 10^{-11} $m^3kg^{-1}s^{-2}$, etc.). Likewise, the theory of electromagnetism hold a number of beliefs about the nature of the world (e.g. charged particles are subject to the electrostatic force[1]). The totality of these beliefs comprises the paradigm's ontology.

"Methodology" refers to the totality of the methods a paradigm uses to gather data and make observations about the relevant phenomena. These methods include all of the tools of computational analysis (e.g. individual formulas that provide a means of predicting phenomena or computations that prove the existence of non-visible entities/forces), which comprise the way a paradigm goes about its tasks or the way it solves its problems. For example, in Newtonian physics, one of the fundamental computational tools at the disposal of a physicist are the formulas associated with the laws of thermodynamics. These laws provide the practitioners of Newtonian physics a common means of computation, with which they can solve the problems they desire to solve. For example, if one needs to determine the work done by a system,[2] one ought to utilize the first law of thermodynamics.

The term "values," as used by Kuhn in the context of scientific revolutions, refers to what the practitioners of a paradigm would consider the acceptable qualifications for scientific knowledge. In other words, "values" refers to the types of knowledge that a paradigm would deem as *valid*. This term is used in the literature of the philosophy of science

[1] The electrostatic force in the study of electromagnetism is used to determine the force of repulsion or attraction between two charged particles. It can be computed using Coulomb's law.

[2] Note than when I use the example of "work done by a system" I am referring to "work" as the concept articulated in Newtonian physics, i.e. the measurement of energy transferred as some mass is moved over a specified distance by an external force.

interchangeably with the terms "goals," "standards," and "axiological commitments." An example of this term is the acceptance of highly corroborated knowledge as a standard of the practice in science. Currently, science values (accepts as a goal) knowledge that is merely highly corroborated (i.e. science deems highly corroborated knowledge as an acceptable goal). By extension, this valuing of highly corroborated knowledge entails that infallible knowledge is not a value of science (i.e. it is not a goal sought after) due to its being deemed unrealistic.

Finally, inductive reasoning is the style of reasoning in which a person posits the existence of a *universal,* which is a principle that obtains in all states of affairs, based off *particular observations,* which are a *finite set* of observations based on experiences. The problem with this line of reasoning is that it often gives rise to inconsistencies stemming from the fact that particular observations (no matter how numerous) cannot justify a universal statement. Many attempts have been made to resolve this problem, e.g. Reichenbach's appeals to history or Armstrong's use of inference to the best explanation.[3] However, they have all failed due to the fact that to the fact that the only means of justifying the principle of induction are by further use of induction, which yields an infinite regress (Popper 427-428).

The most common example given to illustrate issues with inductive reasoning is the "swan example." Consider the following:

P1) All observed swans have been white.

C1) All swans are white. (Popper 426).

This example is a usage of inductive reasoning in which the observations in P1 are certainly true, but it nonetheless leads to a false conclusion. Non-white swans do exist.

[3] Hans Reichenbach and David Armstrong are both philosophers, well known for their work on metaphysics, who have proposed "solutions" to the problem of induction.

ANALYSIS OF KUHN'S "REVOLUTIONARY" THEORY

Kuhn's major contribution to the philosophical discussion about the nature of scientific theory-change is his claim that, based off his interpretation of history, scientific theories change in the form of revolutionary paradigm-shifts. These paradigm-shifts involve distinct, simultaneous changes in all of the three components of a paradigm (ontology, methodology, and values). Kuhn argues that because all three of these elements undergo changes simultaneously, each paradigm has no means to assess the validity of the next paradigm. As such, each paradigm is only assessable internally (i.e. each paradigm can only assess the validity of its own elements). In this manner, each paradigm will be used to argue in its own defense (Kuhn 88). It is impossible for any paradigm to assess any other paradigm because 1) the individual ontologies have changed, which makes the paradigm seem to be a completely incoherent set of beliefs from the perspective of other paradigms, 2) the ways that they compute their data is entirely different, and 3) what the paradigm takes as being scientifically valid knowledge has changed.

These circumstances surrounding Kuhn's theory led many in the scientific community to proclaim that Kuhn has proven theory-change in science to be an irrational process. Fervent in their belief in the rationality of theory-change in science, many philosophers of science raced to disprove Kuhn's theory and prove that scientific theory change is a rational process. Among the best and more well-known of these theories was made by Larry Laudan in his essay *Dissecting the Holist Picture.*

ANALYSIS OF LAUDAN'S "PIECEMEAL" THEORY

In response of Kuhn's theory, Laudan claims that paradigm-shifts in science are not necessarily revolutionary and posits an alternative view. In contrast to the revolutionary view, Laudan proposes a concept known as "piecemeal change between paradigms," where the elements of a scientific paradigm (ontology, methodology, and values) can change between paradigms on an individual basis (Laudan 145-147). This allows

the adjustment of a single element of a scientific paradigm (such as the accepted ontology of the field) without a change in the other two elements of the field.

Laudan believes this sort of piecemeal theory-change to be historically corroborated in science. That is, he claims that paradigm-shifts that may seem to be revolutionary at first glance are more likely the result of being piecemealed over a period of time. Furthermore, due to the narrow scope of our historical perspective, he says we often mistakenly assume that paradigm-shifts are instantaneous and revolutionary (Laudan 148). The narrow scope of our historical perspective will be of great importance for my critique of Laudan's theory later on, though my critique will deal with issues relating to Laudan's failure to take on a broader historical perspective.

The assumption that what appears to be revolutionary is actually the result of a longer process is common in our evaluation of changes throughout history. For example, it is easy to look at the evolution of hominins, the genealogy comprised of modern humans and their ancestors, throughout the fossil record and assume that the taxonomic features exhibited by modern humans developed rapidly over the course of only a few species. However, upon closer inspection, and upon further archaeological discoveries, it becomes clear that these changes occurred slowly and rarely in more than one adaptive change at a time.

The underlying goal of Laudan's theory is to provide an account of scientific theory-change that is rational in a way that Kuhn's theory is not, through the use of piecemeal changes. Laudan is concerned with ensuring that the process of theory-change in science is understood as a rational and logical process. The necessity of this stems from the fact that, if Kuhn's theory is correct and no compelling alternative account of the nature of theory-change in science can be produced, revolutionary theory-change will stand as the prevailing view of theory-change in science. This would condemn the work of scientists to being merely the product of

circular affirmation and arbitrary theory-changes that do not bring the field closer to the truth.

Laudan proposes a view about the nature of theory-change in which paradigms maintain a degree of resemblance to one another for the purpose of comparison and evaluation of merit. Laudan believes this view not only to be beneficial for preserving our view of science as being guided by rational processes but also to be the correct interpretation of the historical facts of theory-change in science. Because paradigm-shifts can occur as piecemeal changes in Laudan's account, the possibility remains for comparison between the two paradigms. This allows scientists to assess the merit of one theory over the other. Consider following example:

- Paradigm 1: Ontology_1, Methodology_1, Values_1
- Paradigm 1^1: Ontology_2, Methodology_1, Values_1
- Paradigm 2: Ontology_2, Methodology_2, Values_2. (Laudan 143).

In this case, an individual change occurred in the form of a change in ontology while leaving both methodology and values the same. In the next step, the methodology and the values of the paradigm changed, but the ontology remained the same.

Laudan's view accounts for the way paradigm-shifts can be rationally justified by showing that paradigms shift via incremental changes (no more than two of the elements of the paradigm at a time), which allows for rational comparison along each of the changes. That is, the paradigms still possess common features that can be used as tools for evaluation (Laudan 153). Had all of the elements of the paradigm changed at once, the successive paradigm would have been completely dissimilar from its predecessor. A revolutionary change would have ensured that no comparisons could be drawn between the paradigms. This leads to the possibility that the paradigm-shift in question occurred without any sort of rational justification as well as to the impossibility of assessing which theory corresponds more closely with the truth. Laudan claims to have solved these issues through piecemealing theory; however, as we will see

in the next section, his theory retains significant issues because of the way Laudan justifies his claims.

CRITIQUE OF LAUDAN'S THEORY

Laudan's theory offers a fairly robust account of rational theory-change in the field of science, but there are significant shortcomings to the theory. Nothing in Laudan's theory *prohibits* the possibility of concurrent paradigm-changes across all three elements in future scientific theory-changes; it is certainly possible that piecemeal changes could simultaneously occur across all three elements, which would lead to a paradigm-shift that is fundamentally irrational (a Kuhnian revolutionary paradigm-shift). Laudan's theory, despite its best efforts, leaves open the possibility for revolutionary paradigm-shifts (i.e., changes along all three of the elements of scientific theory).

Given his view that what appears to be a revolutionary shift is more likely the result of a longer process of piecemeal change, Laudan would likely attempt to defend his view by claiming that in the history of scientific theory-change, there has never once been a revolutionary paradigm-shift. He may say that we should therefore take such events as either exceedingly rare or simply impossible. The evidence Laudan provides in favor of this claim is that there has only been one value-change in science throughout all of its history: a change from valuing infallible knowledge (knowledge that cannot be doubted) to valuing highly probable knowledge sometime in the late 19th century (Laudan 152-153). If this is true, then, given that there must be change among all three of the elements of the paradigm in order for a revolutionary paradigm-shift to occur, the only opportunity to have a revolutionary paradigm-shift was passed up. Although the values of science changed, the ontology and methodology of the field did not change along with it.

However, this response to my claim that positing the *existence* of piecemeal changes *does not necessitate that changes must occur in a piecemeal fashion* highlights two important issues: 1) the limited scope of

Laudan's concept of values and 2) Laudan's problematic commitment to inductive reasoning. To claim that the singular goal of science is the pursuit of either infallible or highly probable knowledge is a hasty generalization of the field (Laudan 152). Science certainly seeks out knowledge that is as highly corroborated as possible by the available evidence, but to say that this is the only value of science (or at least the only one to have undergone change) is too narrow-minded. Take for example the shift in value from innate/occult properties to mechanical explanations in the aftermath of Einstein's postulations. Science formerly accepted innate properties as a viable means of explaining phenomena (e.g. gravity being an innate quality possessed by all objects composed of matter). However, after Einstein proposed a mechanical explanation for the processes of gravity (i.e. general relativity), scientists abandoned explanations involving innate qualities, judging them invalid, and deemed mechanical explanations as scientifically appropriate. This change is clearly a shift in what the field of science takes to be a scientifically valid explanation (a value), and it is distinct from the example that Laudan provides, which he claimed to be the sole value-change in the field's history. It may be a matter of interpretation what qualifies as a value of science, but more than the single one identified by Laudan exists.

As a result of the fact that the field of science certainly seems to possess multiple values, a significant amount of additional historical work seems necessary in order to ensure that some of the other value-changes in the field science did not also coincide with changes in both ontology and methodology. If this is the case, then philosophers of science would have an even greater reason to fear the shortcomings of Laudan's theory because its validity is contingent upon the fact that revolutionary paradigm-shifts are not corroborated by history.

In addition to the problems associated with Laudan's erroneous interpretations of the history of scientific theory-change, the inductive nature of Laudan's reasoning severely undermines his theory. Even if we take Laudan's interpretations of history to be correct, the fact that

Laudan's reasoning is inductive inadvertently leaves open the possibility for revolutionary paradigm-shifts in the future. Laudan is trying to dispel the possibility of revolutionary paradigm-shifts by appealing to his interpretations of history (a set of particular observations), but this guarantees neither the universal claim that historical trends will remain the case in the future nor the universal claim that all theory-changes have always been non-revolutionary. In other words, because of the problems inherent in using induction to form theories (i.e. it does not offer a compelling account of why universal claims are necessitated by particular observations), Laudan's theory cannot provide an account of how theory-changes in science *necessarily* undergo piecemeal changes. Much like in Popper's analogy where observations of some swans cannot necessitate any universal claim about observations of swans in the future, Laudan cannot use the history of scientific paradigm-shifts to assert that there is any necessary relationship between past paradigm-shifts and what will happen in future paradigm-shifts. If this is the case, then Laudan's perspective merely adds the possibility that piecemeal changes *can* occur in paradigm-shifts, but he does not provide an adequate account that explains why revolutionary paradigm-shifts will not occur.

CONCLUSION

The most grievous problems with Laudan's perspective lie not in his postulation that piecemeal changes lead to paradigm-shifts over time but in his usage of history (and an erroneous view of history at that) as the sole means of justifying this claim. Laudan simply adds another possibility to the question of how theories change in the field of science without fully disproving the occurrence of the revolutionary paradigm-shifts discussed by Kuhn. Laudan's failure to indicate why paradigm-shifts *will* be of the piecemeal variety, coupled with the erroneous nature of Laudan's interpretation of the values that science has held throughout history, leads to the fact that the problems created by revolutionary paradigm-shifts are left wholly unresolved by Laudan. Revolutionary paradigm-shifts remain

a problem in Laudan's theory in spite of the possibility that much theory-change in science may occur in a piecemeal fashion.

Jonathan Martinez
Texas A&M University | 2018
jmartinez100@tamu.edu

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WORK CITED

Kuhn, Thomas. "The Nature and Necessity of Scientific Revolutions." *Philosophy of Science: The Central Issues*, edited by Martin Curd and J.A. Cover, New York: W.W. Norton and Company, Inc., 1998, pp. 86-101.

Laudan, Larry. "Dissecting the Holist Picture." *Philosophy of Science: The Central Issues*, edited by Martin Curd and J.A. Cover, New York: W.W. Norton and Company, Inc., 1998, pp. 139-167.

Popper, Karl. "The Problem of Induction." *Philosophy of Science: The Central Issues*, edited by Martin Curd and J.A. Cover, New York: W.W. Norton and Company, Inc., 1998, pp. 426-431.