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Transcending Bayesian Self–Credences

John F. DeCarlo*

Abstract: The Quine–Duhem paradox, which highlights the contradiction between the need to isolate known and unknown hypothesis, in order to test a given hypothesis, and the inability to do so, poses complications, both scientific and philosophical. The Bayesian response is the preferred corrective by the scientific community, but one encounters a tradeoff between the positing of meaningful–verifiable experience, and, the type of limiting self–referential implicit in the use of self–credences. In fact, the Bayesian response to the methodological and epistemological issues posed by the Quine/Duhem paradox begs the question of the significant role played by various types of structural creative thought, including: synthesis, blind spots, thin places, inversions, poly–holism, and wild and divergent strands, many of which often stand outside the purview of investigating scientists. In contrast to the Bayesian model, the paper offers a non a priori grounding and/or functional and explanatory set of principles founded in the pattern of historical–interdisciplinary structural creative thought, evident in the history of the physical sciences, at large, and in particular scientific histories of physics, biology and political economy. Via this critical methodology, the self–referential nature of the Bayesian model is significantly tempered and its experimental and theoretical verification process objectively broadened.

Keywords: Quine–Duhem Paradox; Bayesian Self–Credences; Structural Forms of Creative Thought; Historical–Interdisciplinary Methodology; *Non a priori* grounding and/or functional and explanatory set of principles.

1. Statement of Problem: Bayesian Response to Quine–Duhem Paradox

The Quine/Duhem Paradox is fairly straight forward: No hypothesis can be tested in isolation from an indefinite set of auxiliary hypotheses; and in

* Hofstra University and SUNY Farmingdale; john.f.decarlo@hofstra.edu.

order to show that a hypothesis is mistaken, is it necessary to isolate that hypothesis from its set of auxiliary hypotheses; therefore, no hypothesis can be shown to be mistaken. The Bayesian response is to introduce the notion of degrees of belief that an investigator has for a hypothesis, relative to others. Then, as new information emerges, one reevaluates the likelihood of that information being compatible with each original possibility. In other words, the Bayesians solve the Quine/Duhem paradox by rejecting the claim that in order to show that a hypothesis is mistaken it is necessary to isolate that hypothesis from its set of auxiliary hypotheses by asserting that it can be determined whether the set of auxiliary hypotheses should be rejected based on the degree to which those auxiliary hypotheses are believed to be true.

In addition to the problem of confirmation bias, in all its philosophical, sociological, political, professional, even personal aspects, which looms largely over the Bayesian notion of self credences, the dilemma emphasized by Quine–Duhem is that not all of the possible auxiliary hypothesis are completely apparent; in fact, their claim is that no hypothesis can be adequately separated from an — indefinite — set of auxiliary hypotheses, in terms of possible inferences, data, and conditions. By the same token, while evidence should move toward consensus, especially as evidence that favors one alternative automatically disfavors others, what happens to a startling new claim in the absence of a corresponding theoretical explanation at hand? In this respect, Wittgenstein notes in the Tractacus Logico–Philosphicus, probability is a generalization for it is always based on a given circumstance, for while a related proposition is always a complete picture of something, it may well be an incomplete picture of a situation. Whatever we see, whatever we describe, could be other than it is.

Scientists, of the rank of Sean Carroll at Cal–Tech, also acknowledge that the Bayesian Model of scientific inquiry and verification, complete with its notion of prior credences or beliefs, stands on shaky grounds. Carroll also admits that emphasis on priors is subjective, and that some people have certain views that they are just never going to change. Nonetheless, he hopes they will be honest and change their mind as it becomes clear (Carroll 2016: 80–83). However, in April 1900, Lord Kelvin proclaimed that "our understanding of the cosmos was complete except for two "clouds" — minor details to be worked out" (Livio 2013: 131). Those clouds had to do with radiation emissions and the speed of light, and they pointed to two major revolutions in physics: quantum mechanics and the theory of relativity. By the same token, Vera Rubin observed that the stars on the outskirts of galaxies were not slowing down; if anything, they were speeding up. Scorned by authorities in the field that such observations did not have significance, her team observed more galaxies, only to find that the effect persisted, implying that other new types of subatomic particles were left over from the Big Bang and floating around the universe in clouds. Hence, the birth of theories of dark energy, which accounts for some 73% of the known materiality in the universe, that is not only expanding, but at an accelerating rate.

Notwithstanding Carroll's assertion that prior credences need to be subjected to critical scrutiny, he begs his own question/methodology in his recent book: *The Big Picture* (2016). More specifically, for Carroll, the Core Theory, which posits assertions regarding the fundamental nature of reality, is in a sense prior to our particular prior credences, in that, it contains the information that we must use to "update" all other credences. In other words, the Core Theory becomes its own fundamental priority, which by other competing theories are being evaluated, which is contrary to an open–ended science; for example, he rules out the negative analogy, of immaterial entities, and as well as the synthetic proposition, of a world with both material and immaterial entities.

In this respect, Margaret Cunzo notes in her book, *Paradox* (2014), that "to determine when an anomalous result requires that the main hypothesis or some auxiliary hypothesis to be rejected requires more than subjective degrees of belief of the scientist prior to the experiment. What is required is evidence that the auxiliary is the faulty assumption and an account of why this evidence is not mistakenly taken as evidence that the auxiliary is to blame" (ivi: 79). In this regard, Mario Livio, author of *Brilliant Blunders: From Darwin to Einstein — Colossal Mistakes by Great Scientists That Changed Our Understanding of Life and the Universe* (2013), cautions against having faith in one's own beliefs.

It is in relation to this two–fold lacking that the Bayesian Model is being up–graded by using a new historical interdisciplinary approach, whereby the patterns of structural forms of creative thought could improve qualitative methodologies of exploration and analysis, leading to new scientific insight.

2. The Interdisciplinary–Historical Methodology

The history of scientific ideas has demonstrated the provisional nature of even those theories and laws which seemed to be certain and true in a given historical epoch. The pioneers of the great modern sciences, including Newton, Darwin, and Freud, have been moderately falsified (in keeping with Lakatos' revision of Popper theory of falsification), in terms of them subsequently receiving considerable modification based on other conditions, or, changing conditions.

It was Goethe, who first conceived science as the history of science, in that, a hypothesis is always within a historical setting, influenced by needs, interests and circumstances of the time. In these respects, his philosophy of science anticipates Kuhn's notion of paradigm, which addresses and temporarily solves the questions and problems of a particular social–scientific community. By the same token, just as a paradigm is initially refined to accommodate anomalies, but eventually needs to be replaced by a more inclusive theoretical framework, Goethe likens a theory to an old castle which can be "patched up" but eventually becomes "uninhabitable" (Kaufmann 1980: 71).

The philosopher Immanuel Kant also asserted that the sensuous forms of time and space, along with the conceptual categories of substance, causality and reciprocal relationship are human constructs, which can not necessarily be extended beyond known empirical data. It is in keeping with this reasoning that NASA continues to consider the theories of special and general relativity — as theories — and not as laws. Wittgenstein also notes how the whole modern conception of the world is founded on the illusion that the so–called laws of nature are the explanations of natural phenomena, and there is no a priori order of things. As such, the law of causality is not a law, but the form of a law. In fact, what the law of causality is meant to exclude cannot even be described (*Tractatus Logico–Philosophicus*: 6.1 – 6.3). For example, the Newtonian conceptual depiction of space and time, reigned supreme for hundreds of years, and the corresponding formulas are still used, under certain conditions, for their ease and quickness. Yet, they are founded on a fundamental error, regarding the nature of space–time and mass and energy. It is within this epistemological historical context that Cartwright envisions science as a patchwork of domains with various mathematical and theoretical commitments, and their corresponding equations indicating capacities, dispositions, and causal relations to be borne out by local experimental and theoretical contexts: to do otherwise, is to commit a methodological mistake.

While Goethe's conception of science was borne in the pre–specialization period of the sciences, his emphasis on the history of science is echoed by Noam Chomsky, who notes that philosophy of science is best borne out by examining the history of science in terms of: what do the sciences do; what do they do to achieve their accomplishments; what are paths that often lead to errors? Chomsky also cautions that while statistical data is not inherently wrong, more than an error caused by a formal theoretical misconception, is the error caused by just taking in Big Data into a massive computer, and converting it into probabilistic statistical models, and then generating an approximation of what happened. In addition to there being no real explanation, without a theory to guide the data review, there will be a dismissal of the conceptualization of the data / units that are not yet confirmed, or, not even yet in view. Hence, Chomsky advocates a Pre–Galilean state of mind: not knowing what we are looking for, and embracing puzzlement, and moving beyond initial intuitions. Chomsky also notes that historically, the sciences have achieved some of their greatest achievements when they relied on unification or poly holism, as opposed to reductionism (Katz 2012).

3. Prior Literature: Structural Forms of Creative Thought

The project is, in part, in debt to the groundbreaking work of Mary Hesse, which employs the justificatory sense of analogy not to determine whether a scientific hypothesis is theoretically viable, but to establish whether it merits the accolade of even being called scientific at all. A theory has to be able to be put into a formal correspondence with some appropriate model. In fact, Hesse thus employs the justificatory sense of analogy, not to uphold the integrity of science, but to define it (Statile 2008).

However, unlike Hesse's methodology which is limited to positive and negative analogy, related to known areas of experience, and what she called neutral analogy, which explores unknown areas of thought and research, the current project reviews several types of analogy and creative intuition, including: positive and negative analogy, blind spots and thin places, synthesis and inversion, and poly holism and wild and divergent thought, which explore unknown areas of thought and research.

In these respects, the hope is that in our post–post–modern world of science and technology, in which new truths emerge which both transcend our conventional categorical structures of space, time, causality and co–existence, and permanence and substance, and appear to us as being counter–intuitive — as in the cases of curved space, indeterminacy and spooky entanglement, relative time and the lack of material substance — a new set of mental categories associated with various structural types of creativity can both help to guide scientific explorations and evaluate new theories and models and related experimental data.

It should be noted that these structural forms of creativity stand apart from the psychology and sociology of the creative process, which betrays any type of logic of discovery. Take for instance the work of Howard Gardner, who, integrating his theory of multiple intelligence, examines the personal and collective creativity/intelligences of Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi in *Creating Minds: An Anatomy of Creativity. The Rise: Creativity, The Gift of Failure, and The Search for Mastery,* by Sarah Lewis, also examines the creative process in terms of the inherent experience of failure along the way, and actually advocates that the creator surrender to such failures, learning what they can from them (2014). To this effect, Carlo Rovelli characterizes the time leading up to Einstein's theory of general relativity as: "Ten years of frenzied studies, attempts, errors, confusion, mistaken articles, brilliant ideas, mis–conceived ideas" (2015: 5). Richard Feynman also notes that Dirac tried everything before happing onto the 4x4 matrix needed to derive his quantum relativistic theory. In this respect, in *Zig–Zag*, creativity research psychologist Keith Sawyer suggests that one accept the chaotic process of creativity, and do their best to master it by understanding it. Sawyer also comforts the reader: "this book is your personal trainer, coaching you through the eight zig zagging steps of creativity, consisting of asking, learning, looking, playing, thinking, fusing, choosing, and making" (2013: 5–7). And yet, he honestly notes that as psychology and neuroscience are showing, the creative process is far richer than that, and far less rigid, hence even after mastering the eight steps, the need to zig zag between them (ivi: 8).

Instead, the intent of this categorical classification consisting of: positive analogy, negative analogy, the thin place, blind spot, synthesis, poly holism, inversion, and wild and divergent thinking is twofold:

a) to augment, and possibly supplant the traditional modes of verification and proof;
b) in the absence of a logic of discovery, to supplement the Bayesian model of judging the probabilistic reliability of a given hypothesis.

In this respect, the foundational research of this paper is primarily in the modern and post–modern historical development of the physical sciences of physics and biology, with a particular focus and emphasis on the pattern of scientific insight, breakthroughs, and revolutions that have occurred among the various disciplines. These scientific advancements are, in turn, classified relative to the type of creative thought that brought the new idea into existence. Thus, while past, present, and cutting–edge scientific theory and data will be supplied in atomic theory, the theory of special relativity, and Darwinian/Neo–Darwinian biology, the purpose is not to inform the reader of these developments, but rather to present them as categorical illustrations of various types of structural creative insights. The first section, of atomic theory, ranging from initial conceptions to quantum theory and issues of dark matter, will also bear fundamental definitions of the various types of structural creative thought. We also start with the history of atomic theory because its development contains all the types of structural thought, metered out in a nearly perfectly logical format.

It should also be noted that historical–structural analysis has also been done in the Newtonian theory, general relativity, and political economy, but that particular data will be not presented in this paper, due to the constraints of proper length.

4. Results I: The Emergence of Atomic Science

4.1. *Positive Analogy*

Positive analogy can be likened to a grafting process, whereby a model or framework that is similar in nature is applied to an area of exploration. Science is, as noted by both Richard Feynman and Lisa Randall, for the most, conservative in nature. If a straight forward and clear–cut explanation is available that can explain and predict, so be it. The role of positive analogy also plays the role of Falsification in terms of Popper's notion that a theory that can be tested is entitled to be considered a theory; a theory is not a theory if it cannot be tested and falsified. For Popper, this was the case with Freudian theory and Marxist theory. In this respect, N.R. Campbell and E. Negel argue that all scientific theorems require an analogous framework or model. Thus, it is not argued that analogy establishes whether a hypothesis has been proven, but rather that it is necessary in the justification of a theory.

In the case of the scientific narrative of the emergence of the subatomic world view, the heliocentric model was used as a positive analogous approximation in terms of understanding the nature of the atom and its sub–atomic particles. But not everyone was in agreement about this: Lord Kelvin and Maxwell initially thought that the atom could not be divided any further, and ruled out sub–atomic particles (electrons). In all fairness, Kelvin hints at a connection between electricity & magnetism and molecular vortex theory of spherical & concentric rings, which does foreshadow Solar System Analogy (Giles 2008: 98).

With Thompson's discovery of electrons in 1897 (Giles 2008: 102), it was suggested by Lodge that subatomic particles orbit the nucleus like the planets around the sun. Another positive analogy was constructed by Maxwell comparing the electrons to the concentric rings of Saturn; in other words, like the stable satellites, rather than orbits. In terms of Maxwell's suggestion, we see that some positive analogies are better than others. By the same token, take the Wright brothers engineering feat of constructing a viable airplane. Unlike others who relied on the physics of bird flight, often resulting in deadly crashes, they relied on the physics of riding a bicycle in terms of maintaining balance not only in the center relative to left and right, but in terms of front and back. Consequently, it is suggested to start the scientific process with a positive analogy, and then consider when to hold on to that with patience and persistence, and when to move on to the next phase, in this case, a negative analogy; and yet, to caution that the scientific process cannot be turned into any type of formulistic prescription.

4.2. *Negative Analogy*

This is essentially oppositional in nature, comparing the areas of interest to something which is different from what one would expect, and corresponds to the fact that the potential shortcoming of positive analogy is that it is too pact, for it can be too close to an existing truth, offering a false positive. As a result, just as the verification principle cannot be verified, in that, it cannot prove that which cannot be empirically verified does not exist or does not apply under certain conditions, the positive analogy might be working for the wrong reason(s).

While the Hypothetical Deductive is more inclusive than positivism, in that, the latter does not recognize all known auxiliary hypothesis, and rules out unknowns as even less meaningful, the hypothetical–deductive method cannot entertain all possible inferences. Hence, the negative analogy, according to Popper, is one way to falsify a theory by developing a viable negative analogy which the current theory cannot explain. Such a theoretical assertion can then be stronger, although it can also be over–stated. In other words, the negative analogy can open things up to a new conception, but can also stray too far, and will eventually be in need of correction, itself.

Lodge plays with a more opposing analogy: the idea of asteroids, which unlike planets — can strike at any moment; thus, hinting at quantum theory and its unpredictable nature. This, of course, played out with Niels Bohr contra Einstein, with the former emphasizing the erratic quantum leaps of electrons, and Einstein famously noting that God does not play dice with the universe. As it turned out, they were both right, in a sense. We now know that electrons orbit the nucleus, but also jump from one energy level, or ring, from another, depending on their energy level; and as will be noted below, both Schrodinger and Dirac devised models to predict the probability of sub–atomic particles.

4.3. *Synthesis*

Simply put, synthesis is a blending or melding of opposites in keeping with shortcomings and strengths of both positive and negative analogies. In this way, one both eliminates the shortcomings, and elaborates on the strengths. Much of 20th physics is centered on the debates between Einstein and the Copenhagen School regarding: certainty, realism, spooky action at a distance, the nature of time–space, and the measurement problem. Notwithstanding Einstein's assertions that a new and improved mathematics would eliminate uncertainty, and restore Newtonian explanation and prediction, such an assertion is now conceived as a category mistake. Heisenberg's principle of uncertainty, states that in principle, regardless of human procedure or observation, the quantum world is essentially filled with uncertainty: the electron does not have an exact position/momentum. At best, there is a fundamental trade–off between measurements of momentum and location, the probability equal to square of the over–all wave function, as developed by Schrodinger.

4.4. *Synthesis, with Positive and Negative Analogy*

Atomic physics was subject to a second major synthesis, consisting of Dirac's equation of quantum mechanics and relativity, in 1928, which takes into account the speed of motion of electrons according to special relativity. In this regard, attempts to make the old quantum theory compatible with the theory of relativity based on discretizing the angular momentum stored in the electron's possibly non–circular orbit of the atomic nucleus, had failed.

Dirac, who had been working on the foundation of Heisenberg's matrix mechanics, realized how the matrix could be transferred, or positively grafted. In doing so, he also nullified two other theoretical models: Wave function has multiple components, and 4 x 4 matrices, not two as in the Pauli phenomenological theory of spin, or one, as in Schrodinger's. Thus, he explains the behavior of the relativistic moving electron, which is capable of speeds close to the speed of light, allowing the atom to be treated in a manner consistent with relativity. It also offers an explanation of spin ½ massive particles as a consequence of the union of quantum mechanics and relativity.

4.5. *Blind Spots*

The synthesis can be deceptive, for its act of combining and melding of opposites seems to be all in–compassing. However, the histories of the sciences suggest that there is often something that no one even expects or anticipates, and it is usually revealed years after the initial exploration and investigation; it also has lasting implications. In this respect, Bohr was wrong about his rejection of realism: the discovery of cooper pairs and boson pairs in 1970 strongly supported Einstein's claim for realism, contrary to the Copenhagen School's epistemological emphasis on human observation and the collapse of the wave function. To this effect, Schrodinger's meditation of the proverbial Cat (in the box) scenario represents how abstract conceptualization can both represent and potentially solve a vexing theoretical issue. It put to rest two theoretical contentions:

a) unlike the Copenhagen school it indicated that the cat would be dead or alive independent of human observation;

b) unlike Einstein's contention that the quantum world could be integrated into a unified theory, current findings reaffirm the initial postures articulated by Schrodinger, who, unlike the Copenhagen school, not only rejected a subjective interpretation of quantum events, but asserted that such quantum measurements extended to the macro level, would lead to absurd scenarios, such as two dead cats suspended in superposition. Nonetheless, his equation, the analogue of Newton's law is a partial differential equation that describes how the single non–relativistic particle / quantum state of a quantum system changes with time.

Regarding the tension between Einstein and the Copenhagen School, the discovery of the inverted and yet reciprocal nature of fermions and cooper pairs, where the former (which obey Fermi–Dirac stats) cannot occupy the same space, thus preventing mass / the universe from collapsing into itself (as in the case of stars and supernovae), and cooper pairs (which obey Bose–Einstein stats), which can occupy the same space, preventing space–time from breaking into disjointed chucks (Cowen 2015), was not anticipated, and totally altered the discussion regarding atomic physics: there were different types of electrons; they had very different types of behavior and related functions; and cooper pairs might even play a role in gravity.

They also had philosophical implications in that the inverted–reciprocal relationship between cooper pairs and fermions justifies the violation of the Ontological Principle of Indiscernibles (in that, while initially separate, entangled cooper pairs take on all the same properties) on the basis that the functional significance of their inverted physical roles fulfills the principle of sufficient reason.

Frost notes: "There's always something else in my poetry... I'm always saying something that's just the edge of something more". In a similar vein, Dirac did not at first fully appreciate the importance of his results: the explanation of spin as a consequence of the union of quantum mechanics and relativity — and the eventual discovery of the positron — represents one of the great triumphs of theoretical physics. The equation also implied the existence of a new form of matter, antimatter, previously unsuspected and unobserved and which was experimentally confirmed several years later.

4.6. *Inversion*

Beyond a reversal, as found in the negative analogy, inversion involves reversal with a convoluted twist. Such a creative leap usually does not resemble anything, and in this way, can take a big leap, which will either prove to be revolutionary, or misguided. In regard to this cognitive adjustment, Ricoeur's clarification / correction of Aristotle's concept of metaphor is instrumental: dismissing its nature as a noun, just playing the role of substitution, he emphasizing its verbal power to metaphorize and "Bring forth before the eyes..." (Ricoeur 1975: 91). More importantly, it shifts one's perception to a sudden apprehension of similarity. In this regard, Frost aptly notes: No surprise in the writer, no surprise in the reader.

Lodge startlingly and intuitively realized if quantum leaps were the case, related to his negative analogy of electrons being like asteroids, there must be a lot of empty space, anticipating the discovery made by Rutherford, years later, that underling the discovery of a strong atomic center, there exists an empty shell. In other words, in a contrary and yet strangely, and almost absurdly twisted notion the building block of matter is essentially a void.

It would also take decades of development of both science and technology and the super collider at Cern to demonstrate the existence of the Higgs Boson which, in effect, provides the mass of matter; and quantum field theory which suggests that fundamental particles, in the form of energy, become variably excited, thus emerging out the underlying field as particles, only to slip away back into the field.

Also, as early as 1856 Kelvin wondered how could atomic forces be strong and yet the atom is composed of empty space? It turns out that a rather counter–intuitive explanation came into light: as opposed to Newton's law regarding gravity being stronger the closer two objects are in relation to each other, nuclear strong forces are stronger when far apart. Here again, a reversal, with a strange twist.

4.7. *Thin Place*

According to Irish folklore the thin place is that very short and narrow temporal–spatial opening that allows for insight and revelation, and then forever disappears. In the scientific world, it is the subtlest points of theoretical leverage that looms between positive and negative analogy. Various histories of science do suggest a certain pattern in keeping with the scientific temperament of being concrete and reserved, and siding with the positive analogy, and only resorting to more abstract and extreme theoretical speculations of the negative analogy, as need be. In the case of the exploration of the atomic world, the thin place relates both to dark matter and the neutrino.

First, dark matter is thought to comprise 85% of all the gravitational force in the universe. Its name is reflective of the fact that we know very little about it, except that it does not interact with light, hence its double nature of darkness. Then again, this ghostly class of undiscovered particles interacts with matter via gravity, but otherwise interacts with matter or light only weakly, or perhaps, not at all.

In this respect, dark matter is like neutrinos, which were predicted and eventually discovered, even though they interact extremely weakly with ordinary matter. In fact, each night and day, a hundred billion neutrinos pass through each thumbnail patch of your body, every second, without a trace of interaction with your body's atoms — or, more amazingly, they might manifest via forces other than the strong nuclear force, weak nuclear forces, and electromagnetism (Tyson 2017: 76–93). Thus, as in the cases of these two sub–atomic particles, the investigative scientist must generally consider whether one lingers in the camp of the known via positive analogy, or, venture out into the oppositional unknown via the negative analogy.

4.8. *Far–Reaching Poly–Holism*

Whereas synthesis resolves the tension between two competing theories, by melding them together, the reach of poly–holism is even wider. In a sense its role is to pick up all the pieces, including the hidden blind spots and the peculiar types of inversion. In this respect, nearly all physicists admit that the Standard Model is insufficient, and that there might be a fourth generation of fermions, but that no replacement has yet to be devised. In fact, while the Standard Model stands at the best model for the explanation and prediction of things operating in the universe, it does not account for dark matter, or for gravity as described in the general theory of relativity as the curvature of space–time. As a result, it describes a number of fields interacting among themselves with certain forces each determined by certain constants showing certain symmetries, but does not explain why the particular fields, forces, values, and symmetries exist (Rovelli 2015: 34). Thus, the grand unifying field theory, which Einstein felt he was close to, and which he worked toward the latter years of his life at the Institute of Advanced Study, remains an ideal for the physics community, as a whole.

4.9. *Wild and Divergent*

One thinks of a Jackson Pollack painting composed in his quasi–trance like state in which he pours gallons of paint across an open canvas, not knowing nor really controlling how it will manifest itself. By the same token, divergent thinking is the term psychologists use when you generate multiple possibilities because your mind diverges and pushes past the obvious to explore a broad range of options, especially when there is no censor on what to leave in and what to leave out (Sawyer 2013: 133–134).

Similarly, the way in which the equations of the Standard Model make predictions about the world is absurdly convoluted. Used directly, these equations lead to nonsensical predictions where each calculated quantity turns out to be infinitely large, and to get meaningful results, it is necessary to imagine that the parameters entering into them are themselves infinitely large.

Part of the difficulty, if not impossibility of directly measuring fields, is the relationships between various forces and elemental particles in those respective fields. As the old adage goes, the whole is greater than the sum of the parts. However, in field theories different configurations of the unobservable fields such as charges, energies, and velocities, can result in identical observable quantities; and so, a transformation from one such field configuration to another is called a gauge transformation, and the lack of change in measureable quantities is a property called gauge invariance, and is considered a gauge symmetry. In this respect, the potential importance of gauge theory is its ability to provide a unified framework to describe the quantum–mechanical behavior of electromagnetism, the weak force and the strong force. As such, gauge symmetry makes quantum electrodynamics a renormalizable theory, one in which the calculated predictions of all physically measureable quantities are finite. However, while the procedure of "renormalization" is relatively effective, as Paul Dirac, the first and principle designer of the Standard Model, noted: "we have not yet solved the problem" — implying that theory had not yet be married to the wild and divergent nature of reality (Rovelli 2015: 35).

5. Results II: Biology (Darwin to Epi–Genetics)

Not unlike the study of history and astronomy, where it is difficult to construct realistic experimental labs, it is difficult to see Darwinian evolution in action, no less to repeat it for verification. For this reason, both fruit flies and bacteria, which move from generation to generation in short amounts of time, are favorite study populations. The emergence of biology as a science was also haunted by the specter of the Judeo–Christian mythology, with its representative creation myths in both Genesis I and II. In this respect, the development of Darwinism is inherently filled with negative and positive analogies, from the outset.

5.1. *Negative Analogy*

Not unlike Copernicus and Galileo in relation to the Roman Catholic Church, the stakes were quite high: Divine creation versus Darwinian evolution. In his *Dialogues Concerning Natural Religion* David Hume strongly suggested that there is a substantial difference between a designer and our traditional notion of God, but he did not yet have a plausible explanation for the emergence of the diverse world of nature in terms of an efficient and correspondingly material set of causes.

5.2. *Positive Analogy*

While not generally known, or discussed, Goethe's first discovery is made in the field of comparative anatomy. In that day is was established that the inter–maxillary bone, which is located between the bones of the maxilla, and unites them, is found in animals including monkeys, but not at all in man. But his research leads to the insight that man does have a rudimentary form of the inter–maxillary bone, fused with the adjacent parts of his facial structure.

Others had written about the plan and order of nature, the fitness of plants and animals to meet the challenges of the natural world. For example, Charles Lyell discussed and addressed how the movement of water had carved out major geological modifications, over great periods of time. It was also a family interest in that Darwin's grandfather theorized that all varieties of living things evolved from an original type.

5.3. *Inversion*

Darwin not only nullifies or reverses the metaphysical notion that God is the designer, but also proposes the concept of design without a designer. It is a theory about ends being served by variation but not contrived by some providential super–intelligence. In contrast, Darwin carefully observes and classifies the creative natural process, minus, the creator. Variations do not consciously strive to reach any future goals, and neither can individual organisms influence them by their actions. Variations that fortuitously improve an organism's chances of passing on its genetic heritage will be more likely to survive than those that are harmful or neutral.

Darwin also nullifies the notion that homo sapiens have some type of superior and privileged position and status in the larger scheme of things. Not only is this reversed, but man is associated with the primates, the two being in close biological relationship. It is now known that some 97 % of the human genome is in common with the genome of the primates, which can be interpreted two different ways: we are very, very similar, and, 3 percent makes a big difference. In any case our commonalities are underscored in a way that Victorian Society found to be both disturbing and insulting.

5.4. *Negative Analogy*

To some degree, it can be assumed that the Judeo–Christian myth implies that the changes due to the hand of god, are relatively immediate, whereas Darwin addressed the slow and gradual evolutionary changes that take place over multiple generations, if not eons. However, as developed by Gould, the dynamics of punctuated equilibrium, whereby long–term evolutionary trends are understood as the distinctive and relatively sudden success of some species (or members of a species) versus others, rather than as a gradual accumulation of adaptations of a continuing evolving population, seems to be highly relevant. In other words, change occurs not in terms of evolutionary time, but ecological time, putting extreme pressure on species to progressively adapt, or die away. This is especially true considering that there have been 4 major extinctions on the planet, with 17 to 54 percent of the species being eliminated during each event. One can easily imagine losses within species as well, so that fitness is determined both between species, and across a given species.

5.5. *Synthesis*

Darwin didn't know about DNA or RNA, or even of genes. In fact, Mario Livio notes how he relied on the widely–held belief of his day that the characteristics of the two parents became physically blended, not unlike colors of paint, in their offspring (2013: 149). The development of Darwinian biology would be reliant on Mendel who established the basic rules of heredity through a set of experiments crossing different varieties of pea plants. In the early mid–period of the 20th century biologists developed the modern synthesis, combining natural selection with Mendelian genetics. The synthesis includes the difference between evolution and natural selection, the former referring to the change in the complete set of genetic information contained in the genome, and the latter to specific cases where changes in the genome are supported by different amounts of reproductive success.

5.6. *Positive Analogy and Hypothetical Deduction*

Schrodinger postulated that a collection of atoms could fit together in a reproducible way, with the capacity for carrying substantial amounts of information. Likewise, Crick and Watson deduced the double–helix form of DNA, the molecule that essentially all known living organisms use to store the genetic information that guides their functioning. Not surprisingly each strand contains the same information, as the nucleotides in one strand are paired up with the complimentary ones in the other, which allows for a possible copying mechanism for the genetic material (Carroll 2016: 265–266). The two strands of DNA can unzip from each other and then act as templates, with free nucleotides fitting into the appropriate places on each separate strand.

5.7. *Blind Spots*

The passing on of specific genes for specific behaviors and physical traits is not as simple as it was initially conceived. Rather than having one particular string of nucleotides as an agent, there is actually an interplay between different factors working simultaneously. Consequently, selective pressure acting on one trait may end up affecting another one, if they depend on common sets of DNA sequences. Such secondary adaptations as coined by Gould and Lewontin consist of traits that arise for one reason and then end up being used for something quite different.

The concept of Genetic Drift has also been introduced as forces that do not directly relate to adaptation: mutations that neither increase nor decrease the fitness of an organism. In fact, a single trait can be brought to life by multiple, separate mutations, which may not individually have much noticeable impact; the randomness in sexual reproduction; and unpredictable features of the environment.

5.8. *Inversion*

Epi–Genetics involves genes being passed on to the offspring other than through reproduction. There are cases where the chemical structure of inherited DNA is modified during development by influences such as the nutritional intake of an organism and the maternal environment in which the embryo develops. Since there is not an actual change in the inherited gene structure, but rather in its gene expression (if the gene gets expressed, when, and to what degree), it is currently unclear how much such changes can be inherited by subsequent generations. However, research by Azim Surani at Cambridge University and colleagues, has recently shown that some epigenetic tags escape the cleaning process at fertilization, slipping through the net. More specifically, in the cases where traits that are not contained genetically in the fertilized egg, that are still passed on to the offspring, research examines the germ cell, of either the sperm or egg, which might have a tag or marker attached to it. In the case where the marker is attached to either the sperm or egg, but not both, the cleansing process that takes place shortly after fertilization might be circumvented.

There are also cases, where environmental pressures exerted on the offspring effect if and when a gene gets turned on or off, but this does not exactly entail a modification of the genetic code. This is especially true with respect to epi–genetic tags, where "cultural scars" of the parents seem to be passed down, chemically, to their children both in terms of hormonal disposition and traumatic memories. This has also complicated, if not thwarted the efforts toward gene therapy, for it is not always clear how a gene relates to later development, as the development is mediated by the phenotype, just as it is affected by the genotype.

5.9. *Wild and Divergent*

With the initial discovery of the DNA molecule, it was believed that the DNA replication process by which the entire gene pool is essentially copied was the major force of mutations. This stemmed from the fact that despite proofreading chemical actions, designed to stabilize the genetic inheritance, errors occur in the replication process. Contrary to the prevalent view for much of the 20th century, that genes were a stable entity arranged in an orderly linear pattern on chromosomes, in 1950 Barbara McClintock's observational studies of chromosome breakage in maize led to her discovery of a chromosome–breaking locus that could change position with a chromosome. Moreover, transposons revealed that these mobile elements could reversibly alter the expression of other genes. In fact, more operative than mutational change, is the process of transposition, or, jumping genes, by which the gene structure is not directly altered, but significantly re–arraigned in terms of how genes are associated with each other.

5.10. *Inversion*

Another theoretical reversal has occurred, but this is more radical. Whereas Gould's concept of ecological time, still contains the notion of evolutionary pressure, the microscopic marine bacteria called *Prochlorococcus*, which is one of the tiniest organisms on Earth, and also one of the most abundant, can add one more superlative to its list of attributes: It evolves new kinds of metabolites called lanthipeptides, more abundantly and rapidly than any other known organism. Moreover, while most evolution takes place through tiny incremental changes, while preserving the vast majority of the genetic structure, the genes that enable *Prochlorococcus* to produce these lanthipeptides do just the opposite. They somehow undergo dramatic, wholesale changes all at once, resulting in the production of thousands of new varieties of these metabolites (Chandler 2017).

6. Results III: Special Relativity

6.1. *Positive Analogy*

Galileo's principle of relativity is based on the example of seamen below deck who can't discern whether the ship set in smooth waters is in motion, or, stationary relative to the movement of the water. Two inertial frames are related by a Galilean transformation, which involves the addition or subtraction of velocities relative to some absolute reference frame. Thus, it preserves 3 dimensional Euclidean distances, in that, distance is purely spatial and time differences are preserved.

6.2. *Positive and negative analogy*

By the late 19th century the effects of the not yet formulated theory of special relativity had been noted: FitzGerald — bodily contraction 1887, Lorentz — same idea elaborated, 1892, Lorentz & Larmor — time contraction, too, 1900. Hence, in 1905, the Poincare Group via rotation of the coordinates of Euclidean geometry develops transformations that preserve a space–time interval, with time as an imaginary fourth unit or coordinate. More specifically, they restate the Maxwell electro–magnetic equations in four dimensions, showing directly their invariance under the Lorentz–Fitzgerald transformation equations. In doing so, when dealing with non–simultaneity they resorted to depicting space and time as fictional variables, thus insuring proper time and length contraction.

6.3. *Negative Analogy*

Whereas Poincare is not prepared to make a complete commitment to a space–time metric, Minkowski, via hyperbolic rotation, develops a single metric with the Poincare transformation. In this respect, he relies on the Euclidean three dimensional spaces, and melds it with a fourth dimension of time. But this too, does not have a complete realism about it. It will take Einstein's boldness to declare it as an actual reality.

6.4. *Synthesis & Hypothetical Deduction*

Einstein is still wrestling with the scientific findings of Michelson and Morley (in 1887): light has the same velocity, regardless of its directional movement around the earth, and whether its source or the observers are in motion. In other words, the speed of light is a universal constant, regardless of one's speed of movement. Hence, the relative velocity between 2 inertia frames is bound by the speed of light, which is different from Maxwell's electro–magnetic current. Thus, instead of universal time, each inertia frame has its own temporal measurement: time and space are relative to a particular observer. He deduces that the temporal duration of an event is dependent of the state of motion of the system of reference in which the duration is measured.

6.5. *Inversion*

Special relativity: (a2 — b2 = C2); Based on the Cartesian coordinates contained in c–squared factor of the Pythagorean equation, Einstein, in a sense, simply inverts a plus sign to a minus sign: a2 — b2 = c2/D2 —T2 = S2, and in doing so, introduces the absolute parameter of space–time in that length is no longer measured in terms of a straight line, but rather as a curved line by which the length is measured by time; consequently, the curved line which is actually longer than the straight line, measures time as shorter than the straight line. Imagine a merry go round: people seated near the center have a shorter distance to transverse compared to those who are seated at the outer edge, but both complete a full circle in the same amount of time. Why? Those on the outer edge must travel faster, slowing down the relative passage of time. While this represents a basic reversal of the Pythagorean equation, it is also a radical inversion of the notions of space and time. The notion that time is relative to the motion of one's frame of reference is a revolutionary idea.

6.6. *Negative Analogy*

In 1908, Minkowski posits a real time coordinate within an absolute four–dimensional space–time continuum based on experimental physics, which confirmed Einstein's theory. Minkowski space–time is a combination of Euclidean space and time into a four–dimensional manifold where the space–time interval between any two events is independent of the inertial frame of reference in which they are recorded. While the individual components in Euclidean space and time will often differ due to length contraction and time dilation relative to one's frame of reference, in Minkowski space–time, all frames of reference will agree on an invariant: the total distance in space–time between events.

6.7. *Inversion*

Notwithstanding Einstein's revolutionary theory of special relativity, current data in quantum mechanics conceives of space–time to be an emergent quality, not an inherent geometric structure. More specifically, due to the lack of differential between time dilation between constant motion and acceleration, the arrow of explanation has been conceptually reversed by Harvey Brown in terms of the geometric structure of Minkowski's space–time being the result of the dynamic–emergent quality of certain key aspects of the behavior of particles, and on the conceptual notion that a curved line is a series of short straight lines (2007). But more radically it calls the very notion of space time into question: rather than being a fundamental geometry, inherent to reality, it is an emergent quality.

6.8. *Blind Spot*

The Equivalency principle, known as Einstein's fondest thought in 1907, represents analogy as a structural similarity, namely that: Limits of Special Relativity, it did not consider acceleration. A basic postulate of general relativity is that at any point of space–time the effects of a gravitational field cannot be experimentally distinguished from those due to an accelerated frame of reference.

6.9. *Holistic and Extended Analogy*

Special relativity and gravitational forces affect time. Hence, even before he develops the concept of curved space–time, Einstein combined the equivalence principle with special relativity in 1911 to predict that clocks run at different rates in a gravitational potential, and light rays bend in a gravitational field.

7. Discussion

As a seeker of certain, universal, and verifiable truths, science is inherently a slow and cautious process; hence, it is not surprising that positive analogy is often the first step toward new insight, and eventual breakthroughs, and even revolutionary visions. In terms of negative analogy, Popper seems to be right that the history of science/the sciences is the history of falsification, in that, prior myths, beliefs, and even solid theoretical frameworks are often refined, if not, overhauled. In this respect, for Popper, echoing Hume's critique of the inductive method, no theory can be proven, for there is always a particular case that can be raised that can undermine the theory; therefore, all one can do is falsify an existing theory.

Moreover, just as positive and negative analogies, as well as synthesis, and even inversion and holism, have been regular and essential parts of the scientific process, blind spots, along with wild and divergent elements seem to be part of the accepted expectations. In fact, as in the case of atomic science, notwithstanding the synthetic integration of various theoretical assertions, not one but two blind spots emerge in biological theory. All these histories also include revolutionary inversions, which required a radical re–imagining. In these respects, the limitation of the Bayesian response to the Quine–Duhem paradox is noteworthy, for such aspects of nature have not yet been tapped, by the natural sciences, at large; intricate and dynamic puzzles have probably not yet been fully discerned, and challenges remain.

The results of three–fold analysis of atomic theory, biology, and special relativity, are two tiered: on one level, while the structures of creative thought do not identify specific causal–mechanical dynamics, the structures are explanatory, in that, a diverse group of historical scientific systems have consistently displayed the same large–scale developmental pattern. More specifically, while the history of atomic theory includes all eight of the creative structural forms, biological history includes seven, and special relativity, which stands as a more particular strain, contains five of them. This continuity implies that the patterns demonstrate how the structural forms of creative thought can be used as grounding and/or functional principles to explain and predict data driven systems.

Close examination of the particular scientific histories, relative to their particular observed data, indicates that the structural creative schema correlate with the nature of the system that is being examined, and its connection(s) with other systems of data. For example, the history of atomic theory, which aims to plummet the basic parts and connections of the physical world, has exhibited the logical sequence of: positive and negative analogy, culminating in synthesis, and yet followed by blind spots and inversions, culminating in a quasi–holism, with remaining wild and divergent strands. In contrast, owing to the presiding theological assumptions about the creation of the natural world, the history of biological science is prompted by negative or oppositional analogies. Moreover, owing to the dynamic and creative nature of biological organisms, which required the cleansing of mind–sets to fully understand, two inversions precede the major synthesis. But as in the case of atomic theory, there are blind spots, and wild and divergent strands linger, and there is even a third inversion, after synthesis. Lastly, the history of the theory of special relativity, more closely follows the logical structure of atomic theory of: positive and negative analogies, culminating in synthesis, but rather than the blind spot immediately following, this does not emerge until two inversions have placed things in proper perspective. In these respects, the three respective histories and their corresponding creative structural forms, represent logical axioms and rules that pertain to the given historical science and its respective data.

Hence, on both levels, the patterns of the structure of creative thought could guide current and future scientific explorations and evaluate new theories and models and related experimental data. For example, in light of the series of radical inversions in biological theory, which calls into question the conceptual borders of a gene, cell, organ, organism, and environment, a unifying holism is in order. By the same token, considering the limitations of the Standard Model in physics, relative to dark matter, gravity, and theory of special relativity, the grand unifying field theory which Einstein felt he was close to, remains an ideal for the physics community, as a whole. Moreover, it might require prior points of synthesis between two sets of strange bedfellows, such as general relativity and quantum theory, and high energy physics and condensed matter physics.

Looping back to the initially stated tradeoff between meaningful–verifiable experience being posited, and, the type of limiting self–referential implicit in the Bayesian model and its instrumental use of self–credences, the pattern(s) of creative structural thought in both the broad history of the sciences, as well as the histories of particular sciences, allows the practicing scientist to transcend and objectify, to some degree, the limitations of the their Bayesian approach, with its use of self–referencing prior credences. By the same token, the awareness of the dual pattern of blind spots, thin places, and inversions, even after substantial cases of theoretical synthesis, guards against the exclusion of currently vague and unknown parameters.

8. Implications

The structural categories which have been introduced and examined in the contexts of atomic, biological, and special relativity science, in a somewhat logical fashion, seem to represent a phenomenological structure of scientific pursuit. Hence, it seems incumbent upon scientists to be aware of these creative structural forms, as well as how and when they have manifested in the course of their particular scientific history. For example, chemists working on the extraction of hydrogen from water seem to be at an impasse: there are two schools of thought, which basically contradict each other, with each deriving limited results (although one has better results, but with less understanding of the process). In such a case, it would seem that a synthesis of the two approaches is ripe, if not begging for implementation. A similar state exists in the science of political economy (which has been closely examined, but excluded from this study due to publications constraints), where the field is still attempting to reconcile the competing assertions of Colbert and Adam Smith, whose seminal works are still being extended and fully developed, exposing contradictions and shortcomings in both theoretical camps. Hence, it is hoped that such awareness can both help to guide scientific explorations, and evaluate new theories and models and related experimental data.

9. Conclusion: Limitations and Future Research

In order to provide a fuller and more representative account of the history of the sciences, and their general and particular pattern(s) of structural creative thought, further publication will include: Newtonian physics, general relativity, and political economy, for the histories of these sciences seem to manifest similar patterns, supporting the assertion that future scientific insights and breakthroughs could be pursued and monitored, accordingly.

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