AIPS

JUSTIFICATION, CREATIVITY, AND DISCOVERABILITY IN SCIENCE

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Prof. Luca Fonnesu, Director of the Philosophy Section
Prof. Jure Zovko, President of AIPS

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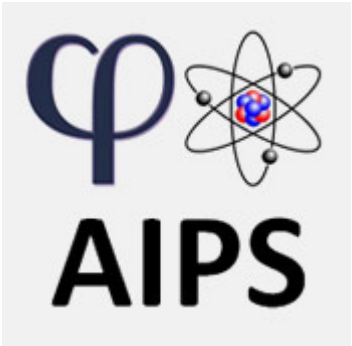

Alai, Mario

Can we Recognize Future-proof Science, and How?

According to the pessimistic meta-induction, none of our current theories, hypotheses or assumptions are true and will be preserved in the future. For some hyper-optimistic outlooks (Doppelt 2007, 2011), unlike past science practically all current science is true and (save minor adjustments) it will stay forever. A much more plausible view is that not all, but some (perhaps many) of our scientific claims are at least approximately true and "future-proof", in the sense that they will never be rejected.

The problem, however, is telling *which ones*. On the one hand, it seems that in order to identify them we should be able to anticipate future scientific progress, which is impossible. On the other hand, this question is becoming crucial today, not only for philosophers or historians of science, but also for policymakers and the general public: the Covid-19 pandemic has shown how important it is that even individual laypersons become able to distinguish between mere scientific *opinions* and established scientific *facts*.

In a forthcoming book (*Identifying Future-Proof Science*, Oxford University Press) Peter Vickers maintains that due to the current level of specialization and the interdisciplinary nature of many issues, not only philosophers or laypersons, but even no individual scientist can possibly examine all the relevant first-level evidence, in order to identify future-proof claims. However, he argues that they can be identified by a second-level criterion:

If the relevant scientific community is sufficiently large and diverse, and at least 95% of its members believe that a claim C *describes an established scientific fact,* C *is future-proof.*

This, of course, runs against the current wisdom that consensus may be due to purely sociological reasons, and much science unanimously accepted in

the past was subsequently rejected by the "scientific revolutions" (Kuhn, 1962). However, Vickers holds this criterion is borne out by the history of science: no claim fulfilling this requirement has ever been rejected. Yet, in spite of many interesting and insightful observations and arguments, he falls short of giving a full principled explanation of how scientists may reach such a 95% consensus, and why it should be so reliable.

Here I suggest some further steps toward answering these questions, starting from on the "no miracle argument" from novel predictions. While the probability of a hypothesis *H* given old evidence *e* is given by Bayes' theorem, the probability that by chance a false hypothesis implies a true prediction *ne* is equal to the logical probability *lp*(*ne*). Hence, the probability that *H* is true given *ne* is $p(H/ne) = 1\text{-}lp(ne)$.

Thus, in the ideal case a future-proof statement might be recognized by just one piece of evidence. For less risky predictions (with higher *lp*) this will not be the case, but typically H licenses various independent novel predictions $e_1...e_n$, whose conjunctive probability diminishes with their number. Thus, $p(H/ e_1...e_n)$, i.e., $1\text{-}lp(e_1...e_n)$, may still be quite high.

Even old evidence confers to H some probability, which grows with the number of empirical data $e_1...e_k$ accounted for by H, the number of the auxiliary hypotheses required to entail them, and therefore the number of theories with which H must be consistent. In fact, when these numbers raise, it may become improbable that H was found just by puzzle-solving skill, and more probable that (first and foremost) the theoretician searched for a *true* hypothesis (which as such entails true consequences), and actually found one. This might account for the confirmatory power of the convergence of independent theories, or of measurements based on independent theories, of non-*ad hoc* explanations, etc. (Alai 2014b). Yet, I argue that in this way we may be confident that a claim is future-proof only in the weaker sense that *some of its parts* are going to be preserved forever (Alai 2021).

Buzzoni, Marco

Method, Creativity, and Serendipity in Scientific Research

The paradox of discovery already foreshadowed by Heraclitus and resolved by Plato with the theory of anamnesis has recently been taken up again in the discussion around serendipity, i.e. the phenomenon in which a fortuitous and unexpected experience turns out to be an essential element leading to a discovery or invention. If one does not want to accept the Platonic theory of ideas (or any of its many variants), it is necessary to rethink the root of the problem of the relationship between creativity and method. Method and creativity seem to be, at least at first sight, opposing concepts, and as such are often used in everyday language, where, for example, the originality and lack of rules typical of a creatively oriented mind is contrasted with the order and regularity with which a methodically oriented mind proceeds. To resolve this tension, it is necessary to critically rethink both the acceptance of the (e.g. neo-Positivist and Popperian) distinction between discovery and justification and its more recent rejection within the epistemological tradition. The solution we intend to propose is based on a distinction between two senses - one transcendental, the other empirical - of the distinction between discovery and justification. This distinction makes it possible, in general, to reconcile the at first sight contradictory concepts of creativity and method and, in particular, to lead to a better solution of the paradox of control formulated and discussed in the debate around serendipity.

Cordero, Alberto

Ontological Commitment, Creativity, and Justification in Science

Selectivist science and philosophy take novel empirical success and fecundity of a theory as indicators that at least some of its distinct theoretical claims are approximately true. On this view, we should take the most successful scientific theories as ontologically committing, as we do with successful descriptions at the ordinary observational level.

An influential argument revived by Kyle Stanford (2015, 2019) rejects this "conservative" interpretation of scientific success as intellectually pernicious based on two alleged premises. The first is that ontologically committing to successful theories makes scientists skeptical of radically new proposals. This charge applies especially to novelty incompatible with the ontological commitments in place. The second claim is that, by contrast, not ontologically committing to theories makes scientists systematically more open-minded to radical theoretical novelty, ultimately more creative, their beliefs more modest but better justified.

My presentation will discuss the issues involved and suggest that the noted case against ontological commitment is misguided and, in any case, unsound. However, the case provides an opportunity to clarify some connections between ontological commitment and the pursuit of creativity and justification in science.

I begin with the second premise of the noted argument against ontological committing. The case for it is very poor for old reasons pointed out by critics of radical empiricism in the last century. There is a strong case for claiming that systematic skepticism against ontological committing to theoretical content leads to scientific stagnation. It does not systematically foster creativity and discoverability. More recent experience with calls for systematic ontological restraint is no better. A case in point is the empiricist exaltation of empirical adequacy. There is no case for claiming that

ontologically restrained science aimed at empirical adequacy systematically leads to more creative theorizing and better-justified narratives.

The first premise is also dubious. Does ontological commitment disincentivize criticism and hinder progress? In numerous areas of inquiry, taking a selective realist stance fosters radical novel theorizing (Big Bang cosmology, Darwinian evolution, evolutionary psychology, and many other areas). I will concentrate on ontic theories in quantum mechanics that started in the 1950s with the explicit aim to look for alternative quantum theories to the one presented in textbooks. Their deviant efforts have continued ever more creatively since, exemplified by such projects as Bohmian mechanics, many-worlds quantum mechanics, and spontaneous collapse approaches. These are developments committed to the idea that the quantum state represents a physical aspect of reality. The intellectual efforts behind all these approaches may be regarded as "conservative" in their determination to take the quantum state ontically. However, especially from the 1990s, these ontic proposals have articulated radically alternative categories of understanding in physics. They do this while improving the quality of theoretical justification—especially intra-theoretically, advancing the integration of descriptive domains across initially incompatible disciplines (notably, classical and quantum physics), opening the scientific mind beyond what was imagined possible. In these ways, the noted theories arguably advance justification, creativity, and discoverability in contemporary science, even if nothing else.

So, the two premises reviewed against ontological commitment ring false. I, therefore, suggest that Stanford's and similar critiques of selective ontological commitment are unsound.

We need to end with a disclaimer, however. The conclusion reached above is not that engaging in ontological commitment "systematically" fosters justification and creativity. Nor is it that avoiding ontological commitment systematically hinders those features. What is rejected here is the suggested allegation of *systematic connections*. Scientific creativity and justification navigate in a sea of contingencies. There is no systematic impoverishment of either features caused by ontological commitment.

Descles, Jean-Pierre

Plausible hypothesis constructed by abduction: some examples of discovery in sciences

The notion of abduction (with the meaning given by Ch. S. Peirce) is essential for the formation of a new knowledge. However, it has not received enough attention from the philosophers of sciences. The inference by abduction (or retroduction) constructs a plausible hypothesis 'plausible (p)' from a general implication [p=>q] and an observed fact 'q' ; in this case, 'p' is only a plausible explanation of the occurrence of 'q' , whose it is necessary to find an explanation ; 'q' is an "indice" in favor of the plausibility of the hypothesis 'p'. The plausibility of an hypothesis 'p' increases when exist different "indices" { q1, ..., qn } in favor of 'p'. For a set of observed facts { q1, ..., qn }, it is possible to propose, by an abductive process, different concurrent plausible hypotheses. When we do not observe some fact 'q', according to the implication [p => q], the explanation of the plausible hypothesis 'p' must be rejected. A plausible hypothesis inferred by abduction is not "the best explanation" of observed facts, since, sometimes, another plausible hypothesis may be also proposed. The plausibility of an hypothesis 'p' (from the implication [p =>q] and 'q') must be not confused with the probable consequence 'probable (p)' deduced from a fact 'q' and the implication [q => probable (p)].

The abductive process runs in different domains of sciences. For instance, in linguistics, it is by abductive inferences that Champollion discovered and understood the system of hieroglyphs of old documents of Egyptians and that Ferdinand de Saussure discovered some phonemes of the (non observed and hypothetical) Indo-European Language. In astronomy, the discovery of movements of planets around the sun has been imagined

by an abductive process, against the Ticho-Brahe's system. According to Georges Polya, abduction is also very important in mathematics.

Dieks, Dennis

Continuity and Discontinuity in Theory Change

According to Laudan's "pessimistic meta-induction" the scientific realist's epistemic optimism is misplaced: the history of science is a history of theories that have proved to be false, so there is little reason to think that our present theories are (approximately) true. Realists have responded that there is nevertheless continuity in theory change, namely in structural features of theories and in some of the entities successive theories deal with. Thus, according to this argument realism with respect to such structures and entities receives support from the history of science after all.

In the talk we will take a closer look at this presumed continuity of structures and entities, for the case of fundamental physics. Our conclusion will be skeptical: we will argue that there is more discontinuity in theory replacement than often recognized. However, with the help of the notion of *emergence* it seems possible to define a middle road between continuity and discontinuity in scientific progress. Relevant structures and entities from earlier theories usually emerge, in limiting situations, from descriptions provided by successor theories; and in this sense they survive. It is debatable, though, whether this provides sufficient support for scientific realism.

Hidden structures in physics and their discoverability

Fano, Vincenzo

Thought experiments in empirical science. Necessary but unreliable

I will defend an empiricist interpretation of the cognitive role of thought experiments in natural sciences, similar to that proposed by John Norton and opposed to that formulated by James Brown. One of the consequences of this approach is that thought experiments belong more to the context of discovery than to the context of justification. Indeed, thought experiments are highly unreliable, in the sense that, in general, it is not possible to evaluate their probative value. Nonetheless the relevance of thought experiments in science is not so simple. Indeed, the passage from data to hypotheses is quite mysterious. Neither can we delegate the task of this passage to machines, as someone today is maintaining. In this issue thought experiments are one of the possible guides; probably not the only one, but in a certain sense a sufficient but unnecessary part of a necessary but insufficient (SUNI) condition to fill the gap between data and hypotheses.

Ghins, Michel

Justifying scientific beliefs: an anti-pragmatist and anti-naturalist perspective

Today, most empiricists adopt a pragmatist and naturalist perspective when it comes to evaluate the truth credentials of scientific discoveries. While a pragmatist epistemological stance inevitably leads to some form of damaging relativism, a naturalist attitude restricts philosophy to the description of some states of affairs, deprives it from normative role and, at the end of the day, also conducts to a kind of relativism.

In this paper, while remaining faithful to a version of moderate empiricism, I attempt to make a case in favour of an alternative epistemological approach, which focuses on the products of scientific activity, namely theories, and aims at assessing the legitimacy of some scientific claims. Such approach is normative and thus genuinely philosophical; I call it "contemplative".

Within this framework, I argue that inductive reasoning is more effective than abduction for justifying some scientific beliefs about entities that cannot be immediately observed. At the same time I will vindicate the merits of explanationist strategies for discovering hitherto unknown entities, provided those are detectable.

Grosshans, Hans-Peter

The concept of Creativity in respect to the sciences – Reflections on some problems

The concept of creativity plays an important role in philosophy of religion and in theology. In Christianity God is believed to have the creativity to create a full world (universe) out of nothing. It is understood as pure free creativity to begin a new state without relating to something already existing. Following Immanuel Kant, such creativity is equivalent to freedom par excellence (KrV B 561: Freiheit ist "das Vermögen, einen Zustand von selbst anzufangen, deren Kausalität also nicht nach dem Naturgesetze wiederum unter einer anderen Ursache steht, welche sie der Zeit nach bestimmte"). Consequently, Kant called this a pure transcendental idea – conceiving something outside experience, a kind of limiting concept of all experiences. The paper will present some reflections in theology and philosophy of religion, in which the concept of creativity is defined in respect to God (in a kind of ideal way). Then the paper will apply this concept of creativity to phenomena within human experience in order to clarify the possibilities and the kinds of creativity within our world and in human life, including in the sciences.

Heinzmann, Gerhard

Justification, Creativity and Discoverability in Mathematics: the Example of Predicativity

Predicativity is a central concept in mathematics, which illustrates the unresolved tension between justification, creativity and discoverability in mathematics.
The foundational problem that was occupying Bertrand Russell and Henri Poincaré in the wake of the discovery of the famous Russell paradox was trying to answer the question as to which propositional functions define in a non-circular way, i. e. predicatively, sets. However, the discussion about an explicit characterization of a predicative definition and of what constitutes a vicious circle lasted about more than 50 years and is not definitively ended.
The creativity of the search centered on an effort to show as much classical mathematics as possible to be predicative.
In a first section, we discuss the predicative definability of Russell and Poincaré to Weyl, Wang and Lorenzen. In a second section, we move on to relative predicativity, predicative provability, and a denotation system of the limit number Γ0 of predicativity. From this we conclude that predicativity does not provide a standard account of the condition to be fulfilled to have evidence for the general concept of mathematical definitions or proofs proceeding by inferences. The demarcation line between evident and suspect reasoning remains vague.

Kahle, Reinhard

Justifying Axioms

Knowledge is justified true belief. Here, justification has to beunderstood as something which conforms proof in mathematics. But mathematical proofs start with axioms. As the old understanding of axioms as evident truths is outdated with the discovery of non-euclidean geometry, other ways to justify axioms have to be considered. In this talk we will discuss the possibility to justify axioms, not only in mathematics, but also in science in general.

Magnani, Lorenzo

Discoverability - The Critical Need for and Ecology of Human Creativity

Discoverability is a new concept I think we have to seriously consider and study. Discoverability is closely related to the sustainability of human creativity from an "eco-cognitive" perspective. in my presentation I will advocate the need of an integral ecology taking advantage of some results that derive from my research on abductive cognition. I will contend that an ecology of human creativity should have priority over other needs, i.e that the first ecological duty is to protect and sustain discoverability. Enhancing discoverability will protect human creativity, and it is exactly human creativity, a form of innovative abductive cognition, that can promote the implementation of the other kinds of ecology. I will discuss in detail the intertwining between discoverability, eco-cognitive situatedness, and eco-cognitive openness and closure. By describing some key real-world examples, I will highlight some of the main challenges that are currently posed to human creativity and epistemic integrity. I sum, I will try to fill an important gap in the available literature on the nexus abduction – creativity - discovery, offering an entirely new integrated perspective, also touching on the current pressing problem of epistemic integrity of research.

Minazzi, Fabio

On Scientific Creativity and Its Contrains

Science was born, with Galileo, in the 17th century, the century whose culture was dominated by the Baroque mentality that continually intertwined imagination and a sense of reality. Is this birth of science an accident? This thesis is hardly credible, since science was only born when the historical time was ripe for its formulation. Otherwise, one would not understand why science did not arise earlier, for instance in the ancient world of the Greeks or the Romans.

In contrast to this precise historical genesis and in contrast to almost all of Galileo Galilei's work, a different image of science soon became widespread in modernity. An image in which science was not grasped in its intrinsic dual nature that always relates the imaginative and conceptual dimension to a precise sense of reality with which one must always be confronted. On the contrary, a tendentially empiricist conception of science soon imposed itself and spread, both at the epistemological level and at the level of common sense. Thanks to this empiricist conception, it was generally assumed that science derives from experience. Not only that: the idea has also spread that scientific discourse must be able to be reduced, without residue, to the plane of experimental experience. This has introduced a questionable and problematic reductivism that has caused the realist component of science to be lost sight of. Anti-realism has thus become a common and widespread feature of many epistemological images of scientific knowledge. This has also made us lose sight of the *normativist* and *deductivist* nature of science. A vision that is instead always very clear in Galileo's conception and also in Einstein's. According to this *normativist* vision, the link between scientific creativity and the 'obstacles' and 'limits' that this vision has to contend with are as follows:

a) critical difference between being and phenomenon: 'physical objectivity rests on an interaction between the object and the measuring instrument': the phenomenon constitutes a relational reality by definition;
b) the shift from a descriptive to a prescriptive conception of knowledge: 'objectivity consists in imposing an order of legality on empirical phenomena'; a fact exists only when it is legally/physically qualified;
c) presence of the eidetic-constitutive component: "the prescriptive, normative and legal dimension makes the object a system of eidetic-constitutive rules";
d) new concept of objectivity: "objectivity no longer has anything to do with traditional metaphysical ontology. Epistemic conditions are, at the same time, conditions of observability and intrinsic constitutive elements of every phenomenon'.

Rheinberger, Hans-Jörg

On the Moment of Creativity in Science – Two Vistas

Creative moments, that is, moments of novelty, in the sciences are usually coupled to a heterodoxy in one form or another. The supposition that I would like to articulate in this paper is that there is a connection between the phenomenon of discipline formation and, very generally speaking, the reception of heterodoxies in the sciences. One can, grosso modo, distinguish three phases as far as the status and the dynamics of scientific disciplines is concerned. A first phase extending up to the middle of the eighteenth century could be addressed as pre-disciplinary. Around the middle of the eighteenth century, a disciplinary differentiation begins to take hold, with its climax toward the end of the nineteenth century. Since the beginning of the twentieth century, a movement is to be observed that one could address as post-disciplinary. Here, I will concentrate on the disciplinary and post-disciplinary "images of knowledge." The important thing for our discussion here is that both phases go along with a characteristic and tendentially opposed attitude toward the heterodox, with the disciplinary vision trying to exclude heterodoxy, and the post-disciplinary vision rather in favor of it. Their philosophical reflection by Thomas Kuhn and Gaston Bachelard, respectively, form the core of the paper.

Schurz, Gerhard

The Optimality of Meta-Induction: A New Account to Hume's Problem

Hume's problem is the problem of establishing a justification of the rationality of induction: the transfer of observed regularities from the past to the future. This talk introduces to a new account to Hume's problem. This account concedes the force of Hume's skeptical arguments against the possibility of a non-circular justification of the reliability of induction. What it demonstrates is that one can nevertheless give a non-circular justification of the optimality of induction, more precisely of meta-induction, that is, induction applied at the level of competing methods of prediction. Based on discoveries in machine learning theory it is demonstrated that a strategy called attractivity-weighted meta-induction is predictively optimal in all possible worlds among all prediction methods that are accessible to the epistemic agent. Moreover, the a priori justification of meta-induction generates a non-circular a posteriori justification of object-induction based on its superior track record. Beyond its importance for foundation-oriented epistemology, meta-induction (MI) has a variety of applications in neighboring disciplines, including: forecasting sciences (MI as a superior prediction tool), cognitive science (MI as a new account to adaptive rationality) and social epistemology (MI as a means for the spread of knowledge).

Zovko, Jure

The Role of Judgment in Scientific Discovery

Kant saw in the reflective power of judgement a "heuristic principle", i.e. the ability to "investigate the particular laws of nature" (AA V, 411.). One of the most important characteristics of science since the 17th century has obviously been the expansion of knowledge and the discovery of new dimensions. In Kant's view, the heuristic segment of judgement consists in the reflective search for adequate explanatory models through experimental research. Discoveries of new knowledge are among the most important achievements of reflective judgement. Cognitive achievements that lead to the discovery of the new in the sciences are in most cases an accomplishment of reflective judgement, which is not bound to theories and rules, but rather a case of ingenious achievement, which is essentially different from the usual methodology of the sciences. Without the activity of reflective judgement, our scientific procedure remains a mere mechanical subsuming (Cf. Kant, AA V, 417.). This paper explores the heuristic dimension of judgement for scientific research.

NOTES