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TOWARDS THE NOTION OF RESEARCH PROGRAM LATTICE FOR INTERDISCIPLINARY RESEARCH

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Abstract. In this paper I put forward the notion of *research program lattice*, an extension of Imre Lakatos's methodology of research programs, in order to account for scientific progress in interdisciplinary research contexts. My starting point is twofold: the conception of science as a problem-solving activity as well as full recognition of (methodological) pluralism. From this perspective, scientific progress is viewed as a dynamic evolution of several research programs running in parallel, instead of a mere replacement of isolated theories. A *research program lattice* is characterized by the existence of a leading idea—analogous to the Lakatosian hard core—, a shared problem domain, a set of relevant questions, compatible methodological assumptions, and a common language enabling communication between diverse approaches. This model is particularly suitable for questions such as: What is consciousness? What is artificial intelligence? where several research programs coming from disciplines as diverse as neurology, philosophy, computer science, and literature, contribute with a partial, irreducible, yet a complementary perspective for understanding a complex problem. I conclude that the philosophy of science can play a reconstructive and a normative role for the advancement of interdisciplinary research.

Keywords: research programs • research program lattice • methodological pluralism • scientific progress • interdisciplinary research

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1. Introduction

It is well known that in the philosophy of science it is possible to distinguish between approaches focused on a particular discipline and those oriented toward the analysis of methodological aspects in all of them. The position I adopt is placed in the second realm. My approach is methodological, and my motivation is placed in two central topics in general philosophy of science, namely scientific discovery, and empirical progress. The question guiding my analysis is the following: How to model a research problem approached from several disciplines, each one with its methodology, as found in interdisciplinary research?

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My proposal draws on the work of Imre Lakatos, whose methodology will be adopted in this paper. Although his approach was not designed to reflect upon interdisciplinary research, extending his model seems appropriate to provide a conceptual framework for scientific progress in this peculiar style of research. Lakatosian methodology not only allows for a rational reconstruction of scientific development but also offers normative tools to guide future research. I put forward the notion of *research program lattice* (RPL), a framework to represent complex problems addressed from an interdisciplinary perspective.

In the second section I present Imre Lakatos's methodology for scientific research programs (SRPs) as a theoretical framework. Its central elements—hard core, protective belt, and positive and negative heuristics—and his proposal, also known as sophisticated falsificationism, for it is an alternative to both Popper's naive falsificationism and certain discontinuous interpretations of scientific change. The aim of this section is to show how the Lakatosian model allows us to understand scientific progress as a historical evolution of consecutive research traditions.

In the third section, I present the problem-solving conception of science. In this perspective attention shifts from disciplines to problems, giving a natural place to interdisciplinarity. I also examine several formulations of methodological pluralism in contemporary philosophy of science, highlighting those contributions made by Suppes (1979), Feyerabend (1975), Longino (2006), and von Eckardt (1995). The purpose here is to substantiate the idea that the coexistence of multiple methods is not an anomaly, but it is rather a structural feature of scientific practice.

In the fourth section I present the proposal of this paper, namely the notion of a *research program lattice* (RPL), as an extension of Lakatos's proposal of research programs. I argue that, in complex research problems each of the several research programs involved offers a partial, methodologically and an irreducible perspective. The RPL is then proposed as a model that allows these contributions to be articulated through a leading idea, a common problem domain, a set of relevant questions, compatible methodological assumptions, and a language that facilitates communication between approaches. It advocates for a structured coordination of plurality, instead of aiming for theoretical unification.

Finally, I conclude that in an interdisciplinary context, scientific progress should be understood in terms of dynamic configurations of research programs articulated within a lattice. From this perspective, the philosophy of science can play a reconstructive role, as well as a normative one, by offering a conceptual framework for rational evaluation of the interaction between diverse methodologies, instead of imposing a single one. Thus, the RPL is proposed as a conceptual tool for reflecting on scientific progress in interdisciplinary contexts.

2. Research Programs

Imre Lakatos, a Hungarian philosopher of science (1922–1974), is known for his contribution to the topic of scientific progress, particularly by the notion of *scientific research programs* (SRPs). His approach (1978), called *the methodology of SRPs*, focuses on understanding how scientific theories evolve and change over time. It is a view that attempts to reconcile the perspectives of Karl Popper (1959) and Thomas Kuhn (1962) on science, something that, at first glance, seems impossible. On the one hand, he takes up Popper's idea of progress and rationality—in fact, he is considered a critical rationalist—; on the other, he draws on Kuhn's notion of *paradigm* and the different types of scientific advances, framing them within what he calls *research programs*.

The Lakatosian proposal has been characterized as *sophisticated falsificationism*, within the accepted view that Popperian falsificationism is somewhat naive. According to Karl Popper, scientific theories are distinguished by their empirical refutability; that is, upon the first discrepancy between theory and experience, our theories ought to be discarded. However, in actual scientific practice, this is not often the case: no theory is perfect, and unsolved problems are typically set aside with the expectation that they will be addressed in the future.

Lakatos argues that scientific research programs (SRPs) are structured around a *hard core*—composed of fundamental principles—surrounded by a *protective belt* of auxiliary hypotheses. These hypotheses may be modified in order to shield the core from potential empirical refutations; thus, when persistent anomalies arise, it is the protective belt that adapts, thereby preserving the integrity of the hard core.

Moreover, each SRP includes a set of positive and negative heuristics. Positive heuristics consist of strategies for developing and defending a research program, whereas negative heuristics refer to the prohibition against modifying the hard core and, more broadly, to the program's capacity to anticipate and explain phenomena that rival programs fail to address.

Each research program is therefore characterized by a hard core of fundamental assumptions that is not readily altered, and a protective belt composed of auxiliary hypotheses that can be adjusted in response to empirical anomalies. Positive and negative heuristics play a central role in this model, guiding the development of the program and delineating what kinds of modifications are considered acceptable.

> [...] positive heuristic consists of a partially articulated set of suggestions or hints on how to change, develop the 'refutable variants' of the research-programme, how to modify, sophisticate, the 'refutable' protective belt. (Lakatos 1978, p.50)

From this perspective, theories are not evaluated in isolation, but as part of a

historical sequence. The relevant question is not whether a particular theory faces anomalies, but whether the program as a whole is progressive or degenerative—that is, whether it generates new, empirically corroborated predictions or merely makes defensive adjustments. Within this framework, a theory's capacity should not be assessed solely by its ability to explain existing data, but also by its heuristic potential: its ability to open new lines of inquiry and generate novel questions.

Degenerative SRPs are those that fail to predict or explain new phenomena, limiting themselves to reinterpreting already known facts without contributing with substantial advances.

The essential elements of SRPs are the following:

- $\langle RP \rangle$: A progressive or degenerative research program;
- $\langle T_1, \ldots, T_n \rangle$: Succession of *RP Theories*;
- $[h_1, \ldots, h_m]$: Auxiliary Hypotheses (AH) for each T_i;
- When a refutation looms, $\langle T_i, h_j \rangle$ the scientific community builds a new theory T_k, the next one in the series.

Thus, when a refutation threatens a theory with its auxiliary hypotheses $\langle T_i, h_j \rangle$, the scientific community finds itself in need of constructing a new theory T_k, belonging to the same series: same hard core, a modified AH set.

3. For a problem-based and pluralistic science

From a more general perspective, science is conceived here as a problem-solving activity. In this sense, it is pertinent to revisit Popper's conception that science progresses from problem to problem, thereby increasing its explanatory depth.

> Yet what I really wish to suggest is that science should be visualized as progressing from problems to problems —to problems of ever increasing depth. For a scientific theory —an explanatory theory— is, if anything, an attempt to solve a scientific problem, that is to say, a problem concerned or connected with the discovery of an explanation. (Popper 1963, p.222)

A scientific theory, in virtue of its being explanatory, is an attempt to solve a scientific problem related to the discovery of an explanation. This conception allows us to shift our focus from disciplines to problems suggesting a suitable framework for the reflection on interdisciplinary research, without having to navigate into a classificatory map of various approaches and committing to any particular one (Aliseda & Gillies, 2007).

Regarding methodological pluralism within contemporary philosophy of science, various approaches can be identified from the 20th century to the present. The analysis in this text will allow us to establish a bridge between a set of *research programs* with its corresponding *research program lattice*. But let me first say a few words about the several views on what pluralism is.

In the 20th century and beyond, there are several characterizations of pluralism and of a related notion, perspectivism, such as found in *Scientific Pluralism*, co-edited by Kellert; Longino; Waters (2006); as suggested in *Understanding Perspectivism: Scientific and Methodological Prospects* edited by Massimi & McCoy (2020); and of *interdisciplinarity*, as found in Barbara von Eckardt (1995) book *What Is Cognitive Science?* which offers a methodological point of view.

On the other hand, Patrick Suppes argued against the unity of science and of reductionism, emphasizing the impossibility of achieving absolute certainty and the fallible nature of scientific knowledge.

> The rallying cry of unity followed by three cheers for reductionism should now be replaced by a patient examination of the many ways in which different sciences differ in language, subject matter, and method, as well as by synoptic views of the ways in which they are alike. The nostalgic lament for unity followed by three toasts to reductionism should now be replaced by a patient examination of the different ways in which different sciences differ in language, object of study and method, as well as synoptic approaches to the ways in which they are similar. (Suppes 1978, p.9)

From this perspective, theories cannot be completed and must be subjected to constant revision.

> Some of the claims about scientific revolutions, for example, would seem to require quantitative and statistical analyses of data if they are to be taken as serious claims having the same status as other scientific claims about natural or social phenomena. (Suppes 1979, p.18)

Science is thus conceived as a self-correcting activity, characterized by the coexistence of multiple methods and problems: "[in] the foreseeable future we will have to face a wide variety of methods and problems" (Suppes 1978, p.94).

For his part, Paul Feyerabend took this idea further by explicitly defending methodological pluralism and questioning the existence of a single scientific method.

> A scientist who wishes to maximize the empirical content of the views he holds and who wants to understand them as clearly as he possibly can, must therefore introduce other views; that is, he must adopt a *pluralistic methodology*. (Feyerabend 1993, p.21)

According to this view, maximizing the empirical content and conceptual clarity of theories requires considering alternative, even incompatible, perspectives. This approach can be interpreted as a radicalization of critical rationalism, insofar as it emphasizes the need to continually test theories against diverse perspectives.

Lakatos's research program methodology offers an alternative for a rational reconstruction of scientific progress. This proposal attempts to model how theories change over time while also providing a methodology for scientific progress. Lakatos certainly tries to refine Popperian falsificationism, at least with respect to the idea that theories are not abandoned at the first empirical refutation, and proposes, instead, analyzing historical sequences of theories organized into a series of research programs.

4. Research Program Lattice

My proposal in this text consists of extending Lakatos's research program architecture to what I call *a research program lattice* (RPL). This extension, firstly, stems from the recognition of methodological pluralism as a structural feature of contemporary science, in which there is a diversity of research methods $\langle M_1, \ldots, M_n \rangle$ at hand within the following disciplinary categories: formal, empirical, philosophical, computational, introspective methods and perhaps many more.

In complex problems several research programs offer partial perspectives that cannot be reduced to a single theoretical framework. Examples from the philosophy of medicine clearly illustrate this point. In the case of cancer, various research programs offer partial explanations of a complex and heterogeneous phenomenon. The search for a unified theory or a single necessary condition is methodologically inadequate. Each program provides a specific perspective that contributes to a broader understanding of the problem, without any single program exhausting the field of research.

> Searching for a unified theory or one necessary condition on carcinogenesis is exactly the wrong strategy. Contrary to what defenders on these "revolutionary" new theories suppose, cancer is neither a disease of mutations nor a disease of the tissue stem cells. Rather, each of these research programs provides a novel but partial perspective on a complex heterogeneous disease. (Plutynski 2020, p.167)

For her part, Barbara von Eckardt (2006) proposes, in an analogous way, that research in cognitive science has the following elements:

- D: Domain / Phenomena

- Q/P: Questions about D
- SA: Significant Assumptions
- MA: Methodological Assumptions

In this enterprise, the methodological challenge is not on developing a comprehensive theory, but rather on designing a network of research programs capable of accounting for interactions amongst the various research programs sharing a leading idea. An RPL consists of the following elements: a leading idea that would function analogously to a core concept, a shared problem domain, a set of relevant questions, common methodological assumptions, and, crucially, a common language enabling communication between approaches.

An RPL may also include other guiding ideas serving as a steering wheel, in order to delimit the search space of the research problem, allowing to distinguish internal from external approaches to the lattice, without eliminating the internal plurality.

One case I analyzed, for pedagogical purposes, is the study of consciousness, of phenomenal experience. In Aliseda (2011), I proposed a research architecture (as I called it at the time) to articulate several approaches to the study of consciousness, each one stemming from a discipline (neurology, philosophy, literature). Each one of these approaches could be framed as a research program, studying consciousness under its own methodological perspective (and hard core and auxiliary hypotheses for each research program in the sequence). In this case, the guiding idea may be phrased as follows:

> Consciousness manifests itself in the articulation and connection of the biological, the psychological, and the social: the three aspects involved in every experience and every lived experience. (Díaz 2007 cited in Aliseda 2011, p.15)

Even when formulated in such general terms, this idea is committed to a form of emergentism in which consciousness is neither a localized phenomenon nor it is reducible to a single dimension. It is rather a function that emerges precisely from the dynamic interaction between several aspects. This perspective may guide future research across diverse areas where consciousness is studied by providing a common framework which integrates various methodologies, from empirical brain studies to first-person narratives and approaches from the humanities. A research program lattice aims for a model capable of integrating philosophical, neurological, psychological, computational, and literary approaches—all of them at the heart of the cognitive sciences.

Another case worth of mention, even if brief, is the question What is artificial intelligence? from its origins in the work of Alan Turing (Aliseda 2011), to its official founding in the fifties of previous century (Nilsson 2012) known as the symbolic (logical) approach, and to the present moment in which the approach is based on a very different methodology, that of deep neural networks. In the year 1956 some of the pioneers of this relatively new field, dictated its problem domain as follows: "For the present purpose the artificial intelligence problem is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving." (Nilsson 2012, p.4). And one of its main assumptions was set as follows: "every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it." (Nilsson 2012, p.4). Of course, it would require an in-depth analysis to put forward a research program lattice, integrating several approaches, each one with its own methodology. Unfortunately, this would take us beyond the purpose of this paper.

5. Conclusions

The thesis I suggested in this text is that interdisciplinary problems and questions such as What is consciousness? What is artificial intelligence? may be articulated within *a research lattice*, a framework designed to address problems that exceed the capabilities of a single discipline. Scientific progress should then be understood in terms of these dynamic configurations, rather than replacements of previous theories. I frame this proposal within the conception of science as a problem-solving activity, and in full recognition of a pluralistic methodology, that is, when several methodologies are involved in a research program lattice.

From my perspective, it is clear that the philosophy of science can contribute to the analysis of interdisciplinary research by offering a conceptual framework allowing us to rationally reconstruct and evaluate how different approaches and methodologies are combined to address specific problems. This task is not only possible, but desirable, given the complexity of many problems faced in contemporary science, many of which require to be tackled from an interdisciplinary perspective.

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