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Tendiendo Puentes: Los Themata de Holton y su Nexo con Marcos Filosóficos Establecidos en la Investigación Científica

(Bridging the Gap: Holton's Themata and their Nexus with Established Philosophical Frameworks in Scientific Research)

Resumen: Este artículo examina la rica textura de los themata de Holton. Holton argumenta que dentro de las normas racionales establecidas hay espacio para elementos subjetivos, incluida la imaginación científica. Sostiene que estas influencias entre pares, conocidas como themata, no solo no obstaculizan el progreso científico, sino que también sirven como un conducto para nuevos descubrimientos científicos. El objetivo del artículo es obtener una comprensión integral de su impacto en la academia y la investigación científica, investigando su posible convergencia o divergencia con otros marcos cognitivos en la filosofía de la ciencia, como las Categorías de Kant, los paradigmas de Kuhn y los programas de investigación de Lakatos. Al comparar los themata con estos marcos bien establecidos comúnmente utilizados para desentrañar el conocimiento y la investigación científica, este estudio tiene como objetivo aclarar posibles confusiones y profundizar nuestra comprensión de la influencia a menudo pasada por alto o subestimada ejercida por los themata en la ciencia. En un sentido específico, esta investigación destaca el papel vital desempeñado por la imaginación y las estructuras de pensamiento preexistentes en la formulación y avance de teorías científicas. A través de este análisis, se proporciona una comprensión integral de la esencia de los themata, destacando la importancia de reconocer y comprender los themata como componentes esenciales de la investigación científica en ciertos momentos. Como resultado, esta investigación refuerza la validez de la afirmación, objeto de debate continuo, de que los datos empíricos, la experiencia matemática o el razonamiento lógico por sí solos no pueden suplantar a estos componentes integrales.
Palabras clave: imaginación, investigación científica, Categorías de Kant, paradigmas de Kuhn, programas de investigación de Lakatos.

Abstract: This article examines the rich texture of Holton's themata. Holton argues that within established rational norms, there is room for subjective elements, including scientific imagination. He posits that these peer influences, known as themata, not only fail to impede scientific progress but also serve as a conduit for new scientific discoveries. The paper aims to gain a comprehensive understanding of their impact on academics and scientific research, by investigating their potential convergence or divergence with other cognitive frameworks in the philosophy of science, such as Kant's Categories, Kuhn's paradigms, and Lakatos' research programmes. By comparing themata to these well-established frameworks commonly used to unravel scientific knowledge and research, this study aims to clarify potential confusion and deepen our understanding of the often overlooked or underestimated influence exerted by themata in science. In a specific sense, this investigation highlights the vital role played by imagination and pre-existing thought structures in the formulation and advancement of scientific theories. Through this analysis, a comprehensive understanding of the essence of themata is provided, highlighting the importance of recognising and understanding themata as essential components of scientific research at certain points. As a result, this investigation reinforces the validity of the assertion, an ongoing subject of debate, that empirical data, mathematical expertise, or logical reasoning alone cannot supplant these integral constituents.
Keywords: Imagination, scientific research, Kant's Categories, Kuhn's paradigms, Lakatos' research programmes.

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1 Bridging the Gap: Holton's Themata and their Nexus with Established Philosophical Frameworks in Scientific Research[1]

The quest for scientific knowledge has long been characterised by a dynamic interaction between established frameworks and emerging conceptualisations, wherein new approaches often seek to address perceived inadequacies or rectify errors within preceding approaches. This dynamism has been exemplified by figures such as Kant, Kuhn, and Lakatos, each offering distinctive lenses through which to interpret and advance scientific understanding through their respective categories, paradigms, and research programmes. Amidst this landscape of established frameworks, Gerald James Holton introduced a novel proposition: the concept of themata and thematic analysis within the philosophy of science as an epistemological approach to account for scientific endeavour rationally.

Considering that new approaches typically emerge to address problems left by or within existing frameworks, the following questions deserve to be posed: to what extent do themata contribute to the understanding of scientific research and how do they complement or challenge established frameworks? How do the answers provided by Kant, Kuhn, and Lakatos fall short in addressing the unique problematics posed by themata?

These questions align with a need, often acknowledged by Holton himself, which, for some like Toulmin 1974, takes the form of a genuine regret regarding his philosophical works. This need is to see Holton thoroughly address certain questions that have unfortunately been left fallow in his endeavour. These issues include those of objectivity (Toulmin, 1974), the clarification of the total number of themata that Holton (1998a, p.18) puts forth as underpinning all of science to date, and the risk of confusion between themata and several other cognitive structures that, while potentially bearing similarities to themata, possess very different natures and modes of operation (Barbosa, 2020; Holton, 1973, 1996, 1998b). While Holton's contributions to the philosophy of science are widely recognised, these questions persist.

This article focuses on the latter question and aims to provide both a clarification of the influence of themata in scientific research and a parallel study between Holton's themata and other thought structures that also contribute to knowledge building, namely Kant's Categories, Kuhn's paradigms, and Lakatos's research programmes. The choice of these three cognitive entities is not arbitrary, as they are among the entities mentioned by Holton himself as presenting risks of confusion with his themata.

The research fills a void in the current body of research. Based on the available scholarly literature, apart from Sabine Rabourdin's 2017 attempt to offer a concise response to the question "what differences do themata have compared to other similar concepts or tools?" in her doctoral thesis, there have been two notable contributions pertaining to the subject matter. Firstly, Lee Harvey conducted a survey in 2022 that focused on themata and emphasised Holton's warning about the risk of confusion mentioned earlier (Harvey, 2022). Secondly, in 2020, João Barbosa authored a Portuguese article aiming to conduct a comprehensive examination of the Themata/Paradigm relationship (Barbosa, 2020). While Barbosa's work is undeniably appealing and provides some useful results of the search, its focus solely on the relationship between themata and paradigm raises certain concerns. Barbosa 2020 contends, based on the findings of his study, that Holton's treatment of Lakatos' proposed research programmes was cursory, with a singular reference made in Holton's publication of 1975 (1988, p.44). Barbosa further observes that Holton did not engage in subsequent discourse on this subject matter. Conversely, Barbosa underscores Holton's consistent attention and recurring engagement with the notion of paradigm, as expounded upon by Thomas Kuhn in his seminal work, *The Structure of Scientific Revolutions*.

Although this may diminish the significance of comparing themata with research programmes, Barbosa's argument for this exclusive comparison becomes debatable in light of Holton's statement (1996, p.7): "Among the concepts that may be confused with themata, the most obvious is what Immanuel Kant, following Aristotle, called 'Categories.'" This raises valid questions about the relationship between Kant's Categories and themata, and why neither Holton nor Barbosa seem to address this issue despite such a strong argument. It is precisely due to these concerns that the objective is to encompass Kant's Categories, Lakatos's research programmes, and Kuhn's paradigms in this study. These significant cases, mentioned by Holton, will undergo a thorough examination in our consideration. By doing so, in line with Holton's concerns and as an essential endeavour to fully comprehend his thought and the role of themata in the advancement of scientific theory, this work will contribute to a deeper and broader understanding compared to previous works in this comparative task. To achieve this, we start by presenting a preliminary overview of Holton's purpose, highlighting the innovative aim of his themata within the established frameworks. Subsequently, we contrast themata with these aforementioned key concepts commonly employed to elucidate knowledge and scientific inquiry.

2 Themata and Thematic Analysis: A Contribution to an Alternative Study of Science

In one of his scholarly articles (Holton, 2005), Holton expressed a paradox that aptly illustrates the title of this initial section: despite his tutelage under honoured proponents of logical empiricism, with a promising trajectory delineated by their teachings, he came to the realisation that the conception of science elucidated by his mentors fell short of encapsulating the dynamic interplay between human agency as the architects of scientific endeavour and society as the crucible of scientific advancement. This awareness compelled him to reevaluate the essence of science, prompting a departure from conventional paradigms. While significant strides had already

[1]This article is an edited chapter from my PhD Thesis. Quotations from works originally written in French are my translations.

been made in this direction, notably by Kuhn, Holton perceived the thematic underpinnings – discerned through his meticulous historiographical inquiry into the works of luminaries such as Einstein – as offering an additional layer of insight crucial to the ongoing discourse. The elucidation of the unsuspected role played by these themata in the construction and progress of science, a task that subsequent sections seek to bring to light, empowered Holton to present his thematic analysis as an additional perspective within the field of philosophy of science.

2.1 Situation of Holton's work in the field of philosophy of science

Holton, a well-known professor of physics at Harvard and a historian of science, emphasises the role of themata in tying breakthroughs together in scientific thought. In essence, the issue of themata and the thematic analysis that accompanies it as a tool is to offer a view of science that is not truncated but complete. For this reason, Holton was interested in how the individual scientific mind ("discovery context") arrives at the products upon which the scientific community makes judgements ("justification context"). In doing so, he aligns himself with thinkers who resist logical positivism, whose merit lies in revealing two fundamental objections to a view that seemed to impose itself as the major, if not sole, perspective on science. Francis Jacques echoed these objections:

> (a) The model (separation of "discovery context" / "justification context") is too alien to real science to be relevant. Analysing the internal form of theory leads to a correlative loss of historicity; (b) The logical and empirical criteria required to justify construction are not as independent of historical or psychological factors as is often claimed (Jaques, 1989, p.66).

In these theoretical elaborations that criticise logical positivism and Popper, there have also been warnings about the risks of *relativism* (see Sokal Alan and Bricmont Jean, 2011), even *unrestrained relativism*[2]. Hence the terms "sociologism" and "historicism" used to describe some of these works. These qualifiers call for vigilance, the consideration of which explains the emergence of a new rationalism that sifts through what is viable in the legacy of the resistance movement against logical positivism, and considers "discovery context" and "justification context" as complementary, seeing an interaction between them. This advancement, where scientific and extra-scientific factors retain their validity in conducting an analysis of scientific production to allow a comprehensive view of science, also necessitates a new angle on questions of scientificity and the correlated concepts of rationality or objectivity. Logical positivists believed historians and sociologists of science should be the ones to resolve these issues within their works, but ironically, within their own communities, these scholars often held biases against each other's work. In this setting, Holton dedicated his efforts to revealing the concealed dynamics within scientific endeavours.

2.2 The contribution of Holton and its relevance

The concern to rationally account for how a scientist arrives at a discovery has made Holton sensitive to the hidden action of what he called themata in scientific research and offers his thematic analysis in the field of philosophy of science as an approach capable of elucidating the question of scientific discovery. In this pursuit, Holton's thematic analysis aligns him with scholars such as Imre Lakatos, Thomas S. Kuhn, among others, who have expanded the field of study in epistemology by focusing their approach on the history and sociology of science.

Despite their differences and complementarities, they unanimously defend the thesis that "science is not simply a method of knowledge or even a body of knowledge, but a sociocultural phenomenon" which undoubtedly includes a "third component." Holton put forward themata as evidence of this "third component", and his thematic analysis first presents itself as an irreconcilable response to the "non-validity" verdict formulated by neo-positivism and Popper (Popper, 2005a; Reichenbach, 1961) regarding the study of discovery by epistemology.

Without claiming to reduce the question of scientific discovery to his research object (the themata), Holton shows that scientific invention is amenable to analytical and rational interpretation. What underlies the analyses that led Holton to perceive similarities but also differences between his themata and the prevailing frameworks (categories, paradigms, research programmes) is a set of historiographical findings on the exact relationship between *experience* and *imagination* in the scientific process.

The rigour of his thematic analysis probably made him one of the most convinced and convincing philosophers of science of the fact that the "empirical" and "analytical" contents – considered by the thinkers of the Vienna Circle to be the determining factors of science as a whole – were in reality factors among many others, often affected by a third factor inducing discovery and progress in science.

3 Themata in the process of scientific thought: essential components shaping scientific understanding and findings

Holton is recognised as the pioneer in introducing thematic analysis within the realm of philosophy of science, offering a valuable approach to explore scientific findings. Through this methodology, he enhances our comprehension of the intricate processes involved in constructing scientific theories, as well as the mechanisms underlying the acceptance or rejection of such theories (Barbosa, 2020, p.33). Holton (2000, p.89) advances the idea according to which, within the framework of research, the scientist is often provided only with "hard data plus solid skills of mathematics and praxis, plus theoretical preconceptions, all working together in the theater of the mind. And in this mix, the visual imagination has often been crucial." This information puts one on the trail of themata that Holton presents as real raw materials of the scientific imagination, as very general, unverifiable and irrefutable

[2]This term refers in this case to the writings of Paul Feyerabend and above all to *Against Method*.

structures of thought, which organise, at a given moment, scientific work. But before expanding on the nature and place of themata in the mechanism of research, it is important to first look at their discovery, that is to say how one came to evoke them in the philosophy of science and for what need(s). Without the clarifications we intend to provide here on themata, it would be legitimate and reasonable to deny them, because of their connection with the imagination, any distinguished place in science and philosophy. To fully analyse the themata, it is important to note the remarks given by Holton (1988, p.281):

> Historical statements, like those in physics, have meaning only relative to a specifiable framework. The discovery of the contextual setting will sometimes be as interesting as the use to which a "relativistic" piece of evidence can be put, and thus the light thrown on a specialised problem may help to illuminate a chapter in the history of ideas.

3.1 Uncovering and presenting some properties of themata

Themata have a history that cannot be disregarded if one seeks to have a clearer understanding of what themata are. Consequently, it is vital to delve into this historical background and subsequently outline key attributes of themata. This endeavour aims to effectively position them within the domain of knowledge and various fields associated with its study.

3.1.1 Brief history of themata

Holton's concept of "themata" is derived from case studies, with a particular focus on the work of Einstein and has become a significant tool for understanding the success or failure of scientific research, chiefly in their early stages, as well as the progress of science (Holton, 1998b). His work on themata can be found in the book titled *Thematic Origins of Scientific Thought* (1988). Additionally, an article titled "The Role of Themata in Scientific Thought" (1996) provides further insights into Holton's study. We still have much to learn about the origin of themata, warns Holton (1998b, pp. 22–23), who asserts, however, that Copernicus can be cited as the one who represents the first clear case of the introduction into science "of essentially *thematic presuppositions* – that is, of deep convictions about nature on which the initial proposal and eventual acceptance of some of the most powerful scientific theories are still based" (Holton, 2000, p. 59). But if a date were to be considered historical for themata, "it is February 10, 1605; the date on which", writes Holton (1988, p. 2), "he [Kepler] revealed for the first time his devotion to the thema of the universe as a physical machine in which universal terrestrial force laws would hold for the operation of the whole cosmos".

3.1.2 The themata: from the point of view of their detection and their necessity in the study of scientific inventions

Holton's themata encompass thematic concepts, methodological thema, and thematic propositions or hypotheses. Holton (1998b, p.9) explicitly distinguishes these three applications of the concept as distinct from one another. To detect themata, Holton had to probe *private science*, which includes private documents, physicists' correspondence, and exchanges where innovative ideas crystallise before passing into the common body of scientific knowledge. "The attitude I have taken in the task of identifying and ordering thematic elements in scientific discussions is to some degree analogous to that of a folklorist or anthropologist who listens to the epic stories for their underlying thematic structure and recurrence" (Holton, 1998b, p.9).

Using this empirical and inductive mode, Holton identified innovative ideas, sometimes in opposition, such as continuity/discontinuity, simplicity/complexity, analysis/synthesis, in the works of Kepler, Newton, Poincaré, Ernst Mach, Millikan, Einstein, Bohr, Heisenberg, Fermi, as well as contemporary scientists. These ideas have always shaped thought.

Although Holton's (2005, p.2-3) early intellectual formation was shaped by the positivist logic movement and certain of its pillars, the themata do not provide an answer to the major question that animated the epistemology developed by the Vienna Circle, which is: "how to distinguish what is scientific from what is not?" The interest of themata lies more in situations that lead to discussions about the absence of logic in certain choices made by scientists within the realm of their cutting-edge work, namely research.

Why does a researcher support a working hypothesis, or rather a set of daring postulates, rather than another set of evidently fundamental postulates, even when they are unable, at the moment, to provide reasons for their choice, their option? What drives them forward, without apparent reason, along one path rather than another? How can their attachment to one vision, one representation of reality be explained, even when the facts seem initially unfavourable? It is these kinds of questions revolving around the act of innovation in science that allow one to satisfactorily establish the conceptual framework of themata and grasp their nature or their place in the field of philosophy of science.

By postulating the themata, Holton distances himself from many epistemologists of his generation (especially those associated with the Vienna Circle and Popper) who sought to interpret everything through the "lenses" of logic. In alignment with the historico-socio-epistemologist Kuhn (1962/2012), Holton supports the idea that science cannot be solely driven by logic. Instead, he advocates for the significance of scientific imagination. Holton argues that in instances where reason and logic are called into question during scientific activity, the influence of themata becomes evident (Holton, 1998b). From a critical standpoint, this situation can be understood in the following manner: while for the Vienna Circle and Popper, discoveries defy analysis because they do not follow any logic, for Holton, it is simply because they result from scientists' attachment to themata. These themata encompass ontological beliefs (such as continuity/discontinuity), which manifest as foundational and overarching guiding ideas. These ideas are neither unverifiable nor unfalsifiable, yet they are not arbitrary conceptions or hypotheses (Holton, 1998b, p.99). They may be non-logical (not pertaining to logic), but not illogical (contrary to logic; lacking sense or sound reasoning).

Holton proposes an explanation for these indemonstra-

ble and unverifiable ideas (generally implicit assumptions, expressed directly only after scientific activity most of the time) by highlighting a sort of framework (presuppositions or regulatory metaphysical principles) in scientists' intellectual functioning. The critical importance of these metaphysical presuppositions, which Holton calls themata, for scientific research can be measured by the progress they allow epistemology to make in understanding the process of discoveries.

3.2 The notion of themata and its connotation in philosophy of science

The concept of themata emerges in the lexicon of philosophy of science in the 1960s-70s. This was marked by two successive publications in English by Holton: *Thematic Origins of Scientific Thought: Kepler to Einstein* (1973) and *The Scientific Imagination: Case Studies* (1978). Holton did not invent the word "themata" (singular "thema"), which derives from the Greek θεμα, and means that which is posited, proposition, prime word, first conceptions, with the underlying idea of what gives rise to reflection and discussion. It also refers to a proposition or opinion that one seeks to support. Themata, the plural form of thema, exhibits notable disparities when compared to Barbara Anne Kipfe's thamata (2021, p. 1378), which denotes "large units of the Byzantine armed forces in the period between the seventh and tenth centuries AD. Each themata was governed by a strategos (general)", with its plural form being thematas.

As a knowledgeable person about the semantic richness of the word, Holton introduces it into the language of history and philosophy of science (Holton & Yehuda, 2014, p. 2012) to designate, in connection with its etymological sense, presuppositions upon which science is based. For the sake of clarity, Holton provides us with the reasons behind the introduction of the new term ("themata") into the vocabulary of philosophy of science:

> Since these fundamental presuppositions are not directly derivable either from observation or from analytic ratiocination, they require a term of their own. I have called *themata* (singular *thema*, from the Greek θεματα: meaning "that which is laid down, proposition, primary word"). (Holton, 2000, p. 158)

This indicates that science, which enjoys recognition for its objectivity, certainty, and communicability of knowledge it produces, is not solely the result of logic and experiential grounding but incorporates presuppositions into its constitution. To emphasise this point as Holton suggests, it is important to note, following Jean Ladrière (1981, p. 30), that by "presupposition", one should understand:

> not the hypotheses that appear explicitly in the scientific discourse, even if they are of a very general nature, nor the methodological decisions that are also formulated explicitly, but the immanent regulatory ideas, which are, for the most part, unconscious and yet confer value, justification, and consistency to the scientific enterprise.

Based on this definition, which sheds light on the meaning of the term "presupposition", one can conceive of themata as theoretical working hypotheses. In other words, they are pure intellectual creations that are far removed from sensible perceptions and cannot be reduced to observation or calculation. More explicitly, according to Holton's indications, themata are fundamental guiding ideas that are stable, widely shared, and common to a large number of scientists. As primary ideas or founding preconceptions, they help inform and motivate scientific research. For Holton, these ideas (or expressions of themata) carry emotional weight and manifest themselves either in concepts, often organised in antithetical pairs (e.g., *simplicity/complexity*), or in methods or hypothetical propositions that the scientist embraces as points of support for their imagination in research work, especially in its nascent phase. The affective relationship to the themata is due to the fact that a researcher's subscription to the themata also has an aesthetic dimension. And those who are driven by themata experience a kind of pleasure when they believe that the universe aligns with their worldview. It is in this respect that themata reveal, in a singular way, that there is a human element beneath the abstraction of the concepts used to construct science.

Consistent with the preceding viewpoint concerning the potential impact of imagination on affectively-driven creativity, Boirel (1972) offers persuasive empirical evidence through the presentation of compelling case studies. More recently, Rebecca J. M. Gotlieb, Elizabeth Hyde, and Immordino-Yang (2019 p. 709-731) contributed valuable insights by examining the interplay of cognitive and affective processes shared by both imagination and creativity. Their findings advance the idea that imagination serves as a facilitator of creativity, alongside individual factors such as expertise, personality traits, motivation, and supportive environmental conditions (2019, p. 709).

In summary, other studies demonstrate congruence with Holton's perspective, which positions imagination as a crucial element near the bedrock of knowledge formation, mediated through themata. Holton proposes that by taking into account themata, one can gain valuable insights into the processes employed by scientists to achieve breakthrough inventions. Consequently, the strong correlation established between imagination, themata, and discovery emphasises the need to consider any pertinent factors that can shed light on the nature of imagination within the framework of themata. Based on this brief discussion, it is not premature, from a theoretical perspective, to view themata as indispensable components that significantly contribute to the overall intelligibility of the scientific research process. In fact, this is Holton's perspective on themata (Holton, 1988, p. 44).

3.2.1 Nature and properties of themata

In order to interpret Holton correctly, the most banal idea that one can have when speaking of themata is to conceive of them as prenotions (the basic beliefs of thinkers) recurring in the history of science, which scientists take up throughout the ages to think and build theories. As Popper puts it, "*science begins with problems, and ends with problems*" (Popper, 2005b, p. 153). One is aware that the difficulty experienced in Antiquity by the various Greek philosophical schools in attaining an acceptable vision of the world contributed to the development

of reflective thinking. From this, a certain idea of science emerged, defining it as the apprehension of reality, nature, society, and humanity through reason.

Within this journey of thought, amidst the rise of speculative sciences (those that employ hypothetical reasoning), there arises the question of atoms: those of Leucippus (flourished around 430 BCE) and Democritus (flourished around 460-370 BCE), which etymologically evoke the existence of indivisible elementary corpuscles evolving in empty space and too small to be seen. Holton points out that this concept of atoms is an idea that has driven Democritus' thinking, speculation, and research throughout the ages, even up to the present-day study of elementary particles in high-energy physics. In essence, the idea of seeking a more adequate description of the world, which underpins the discovery of atomistic models, constitutes the background of themata. "Helping to make sense of the world in a way not possible through the demands of logicality alone is indeed one of the chief functions of a thema" (Holton, 1998b, p. 16).

With this understanding, themata inherently incorporate the fact that throughout history, the world appears more or less inaccessible to knowledge, at least when it comes to explaining its details. In this context, the idea put forth by Holton (1998b, p. 11) that themata are long-lived and consist primarily of persistent trails or entities that science investigates at different periods of time is well-grounded. Apart from the case of atomism mentioned above, several other examples illustrate these points: until the beginning of the 20th century, before quantum mechanics and general relativity changed the game, physics was a set of fairly coherent laws based on a small number of fundamental concepts (themata) such as time, space, causality, and matter. Despite significant advancements, as noted by Holton (1998b, p. 10), these key concepts have remained relatively stable, particularly in the realm of physical sciences: The overall count of singlets (such as space and time), doublets (like simplicity/complexity), and occasional triplets (like constancy/evolution/catastrophic) is found to be less than 100 (the author does not provide a list of themata). Furthermore, in the same vein, themata constitute dominant types of intelligibility that prompt new conceptual orientations. It is in this capacity that they are of interest to epistemology in its quest for a rational explanation of the mechanism of discovery.

From the atomism that constitutes one of Holton's themata, certain properties of themata emerge, such as their longevity and their ability to involve models of the universe, making the world accessible (comprehensible) to our understanding or serving as an opportunity to develop a new theory or expand an existing one (the heuristic nature of themata). But not everything about themata is clear. They fuel a paradox: despite the wide variety of scientific works, they are based on themata, which are said to exist only in limited numbers. Less than a hundred in the entire history of science. Thus, some themata are very old and persistent; and it is only occasionally that the need arises to introduce a qualitatively new thema into science, as was the case with Niels Bohr's "complementarity." This aspect of themata leads Holton (1998b, p. 11) to consider: "The persistence in time, and the spread in the community at a given time, of these relatively few themata may be what endows science, despite all its growth and change, with what constant identity it has."

The hypothesis thus put forward resonates with Holton's (1998b, p. 275; 1988, p. 409-410) support for the thesis of the "continuity of science" in epistemology, which is the view that science progresses through the linear accumulation of knowledge. The debate surrounding continuity and discontinuity in the historiography of science was once contentious (Agassi, 1973; Anouk Barberousse, Denis Bonnay, 2018,p. 225-258). However, over time, this issue has been resolved, and discontinuity is now widely accepted as the prevailing thesis (Psillos, 2022). Nevertheless, it should be noted that Holton's viewpoint does not contradict itself. The concept of themata emerges as fundamental themes shared by numerous scientists, materialising in concepts, methods, or hypothetical propositions, and guiding their research activities. It goes beyond mere suppositions, conjectures, or hypotheses; instead, it encompasses enduring conceptions and models of the universe. That is why Holton sees in the three fundamental themata of Kepler, three cosmological models as he indicates:

> the universe as a physical machine; the universe as mathematical harmony; and the universe as central theological. And this was the setting in which harmonies were interchangeable with forces, in which a theocentric conception of the universe led to specific results of crucial importance for the rise of modern physics (Holton, 1988, p. 70-71).

The role of themata is often misunderstood and sometimes even unconscious or simply denied because, on the one hand, they do not appear in the established body of science, which usually only reveals phenomena and logical and mathematical propositions. On the other hand, they are premises that mostly remain hidden, even from the person using them, in order to better control their thinking. For this reason, Holton's themata are sometimes regarded as preconceived ideas or *a priori* ideas, almost obsessive, that animate the minds of great scientists and guide, govern, or even control their thinking, blinding them to the point of refusing to admit the evident that imposes itself. "As shown by Einstein's reluctance to accept probability, and by Galileo's refusal to abandon the circle [. . .], thematic presuppositions, in themselves not verifiable or falsifiable, can lead one astray if they are held too long against mounting evidence against them" (Holton, 2000, p. 119). This pattern is evident in the examples of Albert Einstein and his commitment to determinism, Niels Bohr and his support for indeterminism (Holton, 2000, p. 120), as well as Fred Hoyle's rejection of the big bang idea, despite empirical observations (Barbosa, 2022, p. 7-8).

In reality, themata touch upon the most intimate and profound aspects of the genesis of a new scientific idea. They implicitly guide research. Not being archetypes, intuitions, ideology, irrationality, or even a theoretical framework, themata would depend on the fundamental elements of perception and even conceptual genesis in young children. Holton believes that, "perhaps most, of a scientist's thematic imagination is fashioned in the period before he becomes a professional. Some of the most fiercely held themata are evident even in childhood" (1998b, p. 23).

Themata are essential components of scientific imagination, serving as raw materials alongside empirical and analytical content in scientific endeavours. As emphasised by Holton (2000, p. 153), Einstein recognised this when he stated that the concepts forming the foundations of scientific theories are inherently figments of the human imagination, hence are initially "purely fictitious" in character.

Given this acknowledgement, which carries a certain ambivalence, the usual reduction of imagination to mere fantasy by common sense may resurface and lead to perceiving a thema (due to its association with imagination) as a form of bias that lacks a place in science aiming for accuracy and rigour. Hence, it is crucial to emphasise that by assimilating imagination to a faculty, signifying a mode of thought and understanding, as undertaken by some scholars (De Mey, 2006; Kind, 2022; Murphy, 2022), the negative connotations surrounding imagination are dispelled.

This outcome, to which Kant (1998; 2006) can also be associated, undermines the suspicion surrounding themata. Simultaneously, it reinforces the importance of studying themata by hinting at a certain similarity with the schemata used in theory construction. However, assimilating themata to schemata would deviate from Holton's perspective (Holton, 1996, p. 7). In fact, the themata, each time falling within a specific domain, give rise to original advancements and personal interpretations. As a background of knowledge, they are a source of intelligibility and otherwise a methodological presupposition. Ultimately, themata lead to a reflection on words and their usage. Even though they may appear simple, they play a crucial role in the development of thought, acting as vehicles of knowledge.

3.2.2 Themata: Unveiling the significance of word and concept selection in the realm of scientific endeavours

Holton's profound insights on themata have shed light on the paramount importance of word and concept selection, particularly within the realm of scientific pursuits. Themata are identified as cognitive structures that not only provide guiding principles for theory formulation but also serve as the bedrock of scientists' unwavering commitment. This view is evident in the majority of Holton's analyses of controversies. From a linguistic perspective, the concept of "thema" and the definition of "word" align harmoniously. Specifically, a word can be understood as a fundamental unit of language comprising one or more phonemes, which are distinct sound elements of spoken language, and possessing the ability to be represented through graphical transcription, or in other words, written form. Invernizzi (2017, p. 3) points out that "in cultures that have no written language, there is no word for 'word'", and further asserts that "word is a term specific to print". Antonio Fábregas (2014, p. 98) advises against overly emphasising transcription and, more importantly, warns against reverting to the "oldest definition" of the word "word", which defines it "as anything separated by two blanks in written form". The so-called "orthographic definition", which may seem the most intuitive to those familiar with alphabetic writing systems, ultimately falls short in encompassing the intricate interplay between words, reality, and, at the very least, shared knowledge that is of concern within the field of language studies.

"As literate adults, we take the word 'word' for granted" (Invernizzi, 2017, p. 3), yet "the use of a word and a definition of a word is always an implicit argument to attain certain goals" (Fabrizio Macagno, 2010, p. 1999). These objectives encompass serving as the building blocks of communication, allowing individuals to express thoughts, convey information, and engage in meaningful interactions. Considering this perspective and acknowledging the value, interest, and role of themata, it may be crucial to recognise the significance of designating an idea, attitude, or thing with one word over another. In any case, themata reveal that in science, what the researcher produces matters as much as the presuppositions that guide him; and these presuppositions are measured by the importance he attaches to certain "words" or "concepts" he uses. As per Jean-Charles Sacchi (2000, p. 196 (My translation)), "there comes a time when the meaning of terms matters more than anything else". This is exemplified in understanding why Einstein rejected Bohr's principle of complementarity. Karl Jaspers rightly stated,

> All knowledge is interpretation. The method we apply to the study of texts may be taken as a parallel to our study of being. And the analogy is not accidental. For we possess being only in its interpretations. To speak of it is to interpret it, and only that which is apprehended in speech falls under the head of the knowable (1960, p. 77).

Scientific theories are indeed perceived as the establishment of precise relationships between precisely defined concepts. Upon exploring the fundamental concepts of scientific discourse, it becomes evident that they play a crucial role in elucidating the phenomena under study. Furthermore, they possess the potential to direct researchers' interests towards previously unexplored facts and present new challenges. Concepts act as the fundamental building blocks of theories, showcasing their primary utility in this capacity. Simultaneously, it is worth noting that the formation of many concepts is legitimately driven by theories (Gerring, 1999, p. 381). The undeniable evidence that certain concepts hold a dominant role in authors' thinking is that, when taken to their extreme, themata become seeds of *crypto-fanaticism*[3], fuelling periodic controversies within the scientific community. Concepts can often take thinking very far, but it is partly because they bear the imprint of the researcher's personal commitment. Through the careful examination and elucidation of pivotal concepts employed by certain scholars, it will be possible to discern the relevance of Holton's argument and, most importantly, the distinctive role of thema within scientific understanding (see Barbosa,2022; Quidu, 2009; Rabourdin, 2017).

It is essential to conclude this comprehensive discussion of

[3]The term "crypto-fanaticism" refers to a hidden or concealed form of fanaticism. It suggests an extreme and uncompromising adherence to certain beliefs or ideas within a specific field or community. Crypto-fanaticism often involves a fervent and rigid adherence to particular concepts or ideologies, which can hinder open-mindedness, critical thinking, and constructive dialogue. It may lead to polarization, dogmatism, and resistance to alternative perspectives, thus potentially impeding scientific progress and the exploration of new ideas

themata by taking into account the recurring cautionary note provided by Holton, which encourages us to undertake comparative studies. Holton emphasises that among the concepts that can be mistaken for themata, one notable example is Immanuel Kant's "Categories", following Aristotle (1996, p. 7). Moreover, he asserts that themata should not be considered as theoretical frameworks that accommodate notions such as paradigms and research programmes (1975, p. 27). In addition, Holton warns against the peril of mistaking thematic analysis for other concepts, including Jungian archetypes, metaphysics, paradigms, and worldviews:

> There is always the danger of confusing analysis with something else: with Jungian archetypes, with metaphysics, with paradigms and world views. (It might well be that the latter two contain elements of themata; but the differences are overwhelming. For example, thematic oppositions persist during "normal science", and themata persist through revolutionary periods. To a much larger degree than either paradigms or world views, thematic decisions seem to come not only from the scientist's social surrounding or "community", but even more from the individual) (1998b, p. 23-24).

4 Enlightening parallels with established philosophical frameworks for a better understanding of themata

Having presented Holton's themata and aiming to grasp them thoroughly, it becomes imperative to embark on this comparative study to shed further light on this key concept. Through drawing parallels with related notions that evoke similar thoughts and are intertwined with the production of scientific knowledge, one can attain a comprehensive understanding of themata. Primarily, the examination will encompass Kant's Categories and Kuhn's paradigms. The objective is to effectively address the risks of confusion and ambiguity arising from the multiple meanings of these terms. it will be important to clarify them as much as possible, emphasising the essential aspects that differentiate "themata" from them. This commitment to clarification will also provide justification for exploring Lakatos' research programmes.

4.1 Themata *versus* Kant's Categories

The accuracy of the undertaken endeavour is unquestionable, given Holton's caution regarding the potential confusion between themata and what Immanuel Kant referred to as "Categories". In his work, Holton (1996, p. 7) shares valuable insights from Einstein, reinforcing this awareness and underscoring the significance of distinguishing the unique roles, nature, and origin of themata and Kant's "Categories" in the organisation of knowledge within the mind. Recognising these distinctions becomes imperative in the pursuit of a lucid comprehension of themata.

For a good understanding of themata, it is worth pointing out that according to Holton, the explicit manifestation of themata in scientific work dates back to Kepler, on 10 February 1605 to be precise, and it is only in retrospect that themata can be observed throughout history in various thought practices (atomism with Democritus to name one). In the same vein, it is worth noting that Kant's Categories derive their nomenclature from Aristotle's *Organon*, yet Kant's twelve Categories differ significantly from Aristotle's ten Categories (Hacking, 2001, p. 487).

If Kant takes up the term "category" from Aristotle, he changes its meaning and gives it a new meaning that allows it to express the way we think about things. Categories (twelve in number with Kant) fulfil this role as "a priori concepts for the cognition of objects that do not contain anything empirical" (Gava, 2023, p. 5). In explaining how the cognition of objects is possible, Kant (1998, p. 264) wrote: "We cannot think any object except through categories; we cannot cognise any object that is thought except through intuitions that correspond to those concepts". In another passage of the *Critique of Pure Reason*, it is stated that: "thinking is cognition through concepts. Concepts, however, as predicates of possible judgments, relate to some representation of a still undetermined object" (1998, p. 205). Thus in Kant's philosophy, the Categories no longer relate to the object to be known (as was the case with Aristotle): "they are mere forms of thought, through which no determinate object is yet cognized" (1998, p. 256). For Kant, these are *a priori* forms that the understanding can consider in themselves, independently of the existing reality "because they precede experience and yet are ingeniously designed in such a way as to organise it admirably" (Malolo-Dissaké, 2012, p. 26). In short, while Aristotelian Categories can be taken as realities, concepts or linguistic terms (Gracia, 2000, p. 337), with Kant, Categories are nothing else than "pure concepts of the understanding", functions of judgment which provide the *a priori* and necessary conditions for any rational experience of the world" (Kahn, 1978, p. 228).

To illustrate, the Categories (or *a priori* forms of understanding) would be, in a way, the lenses through which we perceive what we refer to as "reality". No longer being real determinations of being, but frames of thought, even if the Categories retain their status as fundamental concepts, they do not give us the things to know; they only give us the absolutely necessary dispositions by which we can know. This is why the fact remains that they lead to a mediate knowledge of the object, that is to say that they allow judgments to be formed. Gava (2023, p. 5 (footnote 9)) aptly points out that the Categories play a vital role in shaping our cognition of objects, while the ideas of reason, used in a regulatory manner, act as conditions for acquiring certain cognitions of objects but do not inherently form the basis of those cognitions.

When Kant uses the term "judgment", he does not refer to the act of confirming or refuting something; in other words, it is not about assessing whether our knowledge regarding a particular reality is likely to be true or false. If Kant speaks of judgment, it is rather to designate the expression of the synthesis achieved by the understanding. Following this definition, he conceives Categories as fundamental unifying concepts that relate, in this capacity, to the understanding and constitute, for it, the conditions that allow it to exercise its function, namely: to bring syn-

thesis (carried out by the imagination) back to concepts (1998, p. 211). This amounts to saying that Kant needed Categories, just as a mathematician resorts to axioms, to establish the foundation of his theory of judgment, so that, in judgment, the Categories find their rightful place. Hence the definition given by Francis Jacques (1985, p. 473) of the Kantian Categories: "by Categories we mean very general concepts which do not refer directly to any object, but which describe the organisation of other concepts". For Kant, this organisation can only aim at certain or true knowledge that science seeks to establish. It should also be emphasised here that knowledge comprises two elements: the concept through which an object is generally conceived and the intuition through which it is given (Kant, 1998, p. 224).

Reduced to their essential features, the Categories (a set of *a priori* concepts) represent the different possible modes according to which discursive thought (as opposed to intuition) can bring together the diversity offered by experience to sensibility in order to construct knowledge. Kant posits these Categories as inherent norms of thought, constituting a framework intrinsic to cognition rather than externally imposed methodological principles. Within this framework, knowledge transcends subjectivity to attain objectivity, characterised by necessity, universality, and the certainty akin to mathematical propositions.

The empiricists, by emphasising experience as the primary source of human knowledge, often overlooked this set of *a priori* concepts that act as filters or frameworks through which we organise and comprehend the chaotic flow of sensory impressions. In a certain sense, these concepts, that is Categories, shape our understanding of things and, for this reason, somewhat constitute, by analogy with the "pure forms of sensibility" (space and time), the "forms" of understanding.

Subsequently, the term "forms", now associated with the understanding and illustrating the role of Categories, warrants closer examination to reconceptualise our perspective. "Forms" within this context, can be elucidated as referring to Categories, positioning them as instrumental tools utilised by the understanding to integrate sensations into a cohesive framework, into coherent systems. Indeed, in their functional capacity, Categories may be perceived as necessary laws, universally applicable across human cognition, thereby rendering any phenomenon falling within their purview intelligible, or even, objectively comprehensible. This approach, facilitating the objectification of phenomena as Kant (1998, p. 222) concedes that objects may appear to us without being subjected to Categories, but in such instances, they remain inherently subjective), imbues Kantian Categories with an epistemological dimension, endowing them with a heuristic function akin to "themata", leading us to compare them to "themata".

Indeed, in their Kantian sense, the Categories serve as a critical faculty of the mind to eliminate nonsense in judgment, avoid ambiguity in thought, and guide reason towards asking the right questions. And what constitutes the search engine, if not the ability to ask (oneself) questions and seek answers? This is where we can say that, according to Kant, the idea that propels research, the heuristic idea, is fundamentally produced by the understanding and not generated by experience. The heuristic idea, thus linked to the understanding, ultimately reflects the Categories' ability to indicate or help find what is probably true. This is why Kant wanted the Categories to be pure and objective, qualifying them as *a priori* concepts.

Since the onset of our comparative analysis, we underscored the distinct origins of "themata" and Kant's Categories. The Kantian notion of Categories, which sets the groundwork for investigating how "themata" align with or diverge from these Categories in terms of their roles and inherent characteristics in organising knowledge within the mind.

So from the foregoing general considerations, it can be argued at the outset that the "themata" distinguish themselves from Kantian Categories precisely by the aspect that brings them closer together—namely, as "fundamental presuppositions" of scientific thought that do not directly result from observation or analytical reasoning. Apart from this common ground where Categories and "themata" converge, there are specificities that greatly set them apart. Indeed, "themata" are prior to any demonstration and will remain undemonstrable principles posited by the scholar as aids to discovery in research.

While being primary propositions, they take on more, in accordance with their etymology, the character of postulates; that is, "the hypothesis, which remains a possibility in thought and is indeed the foundation of scientific inquiry" (Philippe, 1978, p. 267). In the realm of epistemology, Kantian Categories are perceived as fundamental pillars upon which the construction of knowledge rests. Drawing a parallel with mathematical axioms, especially in the historical interpretation context where the distinction between axioms and postulates made sense, and axioms were conceived as self-evident necessary truths, offers valuable insight. Indeed, in this regard, unlike postulates, whose intrinsic clarity may not be universally recognised, Kantian Categories are posited as inherently evident and indispensable truths. This perspective, elucidated by Ullmo (1969, p. 210-213), underscores the foundational role of Kantian Categories in shaping our understanding of cognition and metaphysics. Due to this proximity to axioms, the Kantian Categories would significantly touch upon the aspect of justifying science rather than that of discovery, given that common principles, known as "axioms", are the principles from which one demonstrates (Aristotle, sd, p. I.10). This partly explains Kant's project of a categorical foundation of knowledge: the table of Categories would be indispensable "[to] completely outlining the plan for the whole of a science insofar as it rests on *a priori* concepts" (Kant, 1998, p. 214).

Contrary to what Kant prescribes, Dissaké (2012, p. 24) observes, after having set out Popper's arguments concerning the reception of Kant's doctrine of objectivity, that "it is possible that, from the perspective of modern science, the Kantian conception of the *a priori* does not possess the characteristics Kant attributed to it, and therefore, one cannot draw from it what Kant hoped for". The criticism is even sharper in Verneaux's (1972, p. 65) case:

> Are there *a priori* synthetic judgments? That is the question, that is the problem prior to the problem. But we already have the answer: there is no *a priori* judgment

> that is purely synthetic, because no judgment, whether *a priori* or not, is so if it is well-founded. However, there are synthetic *a priori* judgments in the sense of Kant, that is, non-tautological and not based on experience. Knowing where to find them is another matter.

Kremer-Marietti (1992, p. 2580) conducts an analysis that confirms these statements and emphasises in a distinctive way the irreducible nature of themata to Kant's Categories:

> Are themata synthetic *a priori*? Nowadays, the question is no longer relevant. The truth of scientific propositions and even that of themata is governed by requisites other than the necessity of being synthetic a priori. When they concern phenomena, scientific propositions are not merely empirical; they are contingent for Holton, as their truth requires reference to experience. And they are analytical, to the extent that their meaningful effect stems from their consistency within a given system of axioms.

Noteworthy is the fact that while these scholars, along with many others, regard the Kantian project of establishing a categorical foundation for knowledge as outdated, there are dissenting views from figures like Jared Warren (2022), who consider this perspective an overreaction. Warren argues that the rejection of the Kantian approach is influenced by various absurd claims from the past, suggesting the possibility of knowing the world *a priori*, where humans could make discoveries about the world without ever leaving their armchairs.

All in all, the comparison between themata and Kantian Categories that we have just made has shed further light on the notion of themata and has had the benefit of highlighting the incongruities of the Categories linked to the imperfections that affect Kant's notion of *a priori*. This comparative study has also shown that the two notions, themata and Categories, are not lacking in points of similarity likely to create confusion. Ultimately, the significance of this study extends beyond the presented findings. As noted by Holton (2000, p. 119; 157), it becomes increasingly necessary to explore how Einstein employs the notion of "themata" when referring to fundamental guiding ideas or presuppositions in the development of his theories, which he calls "Categories" but not in the traditional Kantian sense (Holton, 1998a, p. xxxii); instead, these Categories are deemed to be freely chosen. However, there is a potential risk of confusion for readers unfamiliar with these concepts, particularly in discerning between Kantian Categories and themata. To address this issue, Holton (Holton, 1998a) offers clarifications when referring to Einstein's usage of these terms. He cautions that the "Categories" should not be perceived as fixed and unalterable, as Kantian Categories are thought to be conditioned by the nature of understanding, but rather as freely adopted conventions in a logical sense. While they may appear to possess an *a priori* nature, it is important to recognise that the act of thinking without the establishment of Categories and concepts, in general, would be as impossible as attempting to breathe in a vacuum.

A comparison with Kuhn's paradigms is also necessary.

4.2 Themata *versus* Kuhn's paradigms

In order for this endeavour to infuse our comparative analysis with a palpable sense of relevance and import, it is imperative that our initial juncture revolves around an exploration of Kuhn's conceptualisation of the term "paradigm." The etymological roots of the term "paradigm" trace back to the ancient Greek word παραδειγμα (paradeigma), denoting a "model" or "example" that serves as a guide for emulation and replication. It is important to maintain focus on the initial level, which involves comprehending what must be accomplished and replicated. In this context, the "model" is often seen as an educational instrument to elucidate complex concepts or to explain difficult facts to a non-specialist audience. Consequently, the notion of intelligibility is closely tied to the concept of a paradigm. This connection is further evident in the etymology of "paradigm" itself, derived from "παραδεικνυναι" (paradeiknunai), meaning "to demonstrate" or "to teach through showing." This etymological background makes it clear that, like Holton with themata, Kuhn did not invent the term paradigm either. He acknowledges this by explicitly stating: "In its established usage, a paradigm is an accepted model or pattern, and that aspect of its meaning has enabled me, lacking a better word, to appropriate 'paradigm' here" (Kuhn, 2012, p. 23).

Kuhn introduced the term "paradigm" to the realm of scientific knowledge, particularly focusing on physics, by building on the concepts of models and examples. He identified both the cognitive and heuristic functions of the paradigm and positioned it as the ideal framework to elucidate the dynamics of scientific disciplines. Specifically, he examines the sequence of overarching frameworks within which research activities occur in a particular discipline at a specific time. The paradigm functions both as an anchor and a guide for scientific exploration. It serves as an anchor by establishing a fixed frame of reference that can be revisited and drawn upon for inspiration, either to innovate within the domain of knowledge or to refine existing theories. In essence, the paradigm embodies a collection of validated outcomes, endorsed by time and the practices of scientific communities that now consider it as exemplary or sufficient to serve as a model or blueprint for further advancement. So in contrast to Popper's perspective, Kuhn holds that scientific activity primarily revolves around enriching theories and addressing the "enigmas" (puzzles) they present, rather than simply testing them (Jorritsma, 2022, p. 1; Matalon, 1996, p. 67). Strictly speaking, therefore, "a paradigm consists of a problem (or a set of problems) accompanied by its solution, which serves as an 'exemplary example' by analogy, with which all further research should be pursued" (Barberousse, et al, 2000, p. 291).

In short, the paradigm is a guide, an organising structure that directs scientific research. Such research cannot be carried out without a paradigm, insofar as the paradigm is the basis on which we work. It belongs to a community and unites researchers, shaping their choices and providing a shared perception of phenomena, typical problems, and examples of solutions. It is in this capacity that a paradigm takes on the appearance of a research tradition and functions like a set of lenses through which researchers who are attached to it view the world. They cannot see it any other way unless they undergo a "revolutionary

change", akin to a "religious conversion."

In order to emphasise the essence that a paradigm embodies according to Kuhn, it is vital to demonstrate that a paradigm is distinct from a theory. This clarification is particularly necessary because the term "model", which is used to provide a basic idea of the paradigm, an idea that is easily accepted due to the paradigm's inherent ambiguity, sometimes replaces the term "theory" in usage due to its relative simplicity. Under the notion of "relative simplicity" lies the understanding that models play a role in describing complex reality in a straightforward and comprehensible manner, and they often rely on simpler assumptions than those of accepted theories (Barberousse, et al, 2000, p. 288).

While the *Structure* consistently emphasises the idea that a theory retains the potential to mature into a paradigm, signifying their distinction, there exists a significant and detrimental risk of confusing a paradigm with a theory. This misperception that Kuhn left unresolved (Laudan, 1977, p. 74-75) hampers the comprehensive understanding of the nature and significance of a paradigm, encompassing both scientific and philosophical standpoints. Hence, to genuinely comprehend the exact nature of a paradigm, it becomes essential to delve deeper into both the unique attributes that set theory and paradigm apart, as well as the intricate interplay between them.

Viewed broadly in a scientific context, a theory, typically defined as a collection of formulas or laws, offers the capability to tackle issues and elucidate phenomena. In essence, a theory renders a specific subject comprehensible by providing intellectual insights into the phenomenon under scrutiny, backed by empirical substantiation and well-suited contextual limitations (Sandberg, Jörgen; Alvesson, 2021). Conversely, a paradigm is primarily conceived (Laudan, 1977, p. 73) as "ways of looking at the world"; broad quasi-metaphysical insights or hunches about how the phenomena in some domain should be explained and imbued with meaning. For instance, the notion of the Sun revolving around the Earth aligns with the worldview of Tycho Brahe, situated in a reality shaped by the geocentric paradigm established by Ptolemy (which remained unchallenged from the Roman Empire until the close of the Renaissance). In contrast, Kepler, residing in a world reshaped by the Copernican revolution (in 1543), envisions the converse: the Earth orbiting the unchanging Sun, a concept that holds logical coherence in his perspective.

Kuhn's paradigms assume the aforementioned function owing to the prevailing consensus among adherents of these paradigms concerning both the theoretical underpinnings and the methodological approaches employed in addressing the enigmas of the paradigm under consideration. As elucidated by Léna (2009, p. 226), "Consensus around a single paradigm characterises what Kuhn calls 'normal science'". It is evident from all that has been mentioned above that the paradigm is not merely confined to a theory shared by all; it incorporates this theory and extends well beyond it. By way of illustration: Newtonian mechanics serves as the foundation of classical physics, yet it is not limited to it; otherwise, it could have functioned without principles like determinism or mathematical formalisation, for instance. A theory that becomes a paradigm is rejected in favour of another paradigm during a "scientific revolution".

The clarification that has just been made calls for another, without which we risk not only ignoring the true complexity of the term "paradigm", but above all, failing to appropriately utilise the present comparative study to gain further insight into the questions raised by the "themata". The main insight one can hope for here is to discern how the elucidation of scientific research can be contingent upon the "themata", and consequently, the rational or irrational character of scientific endeavours. Underlying the idea of "rational character" is the question that remains latent in our investigation, given the very nature of themata: Doesn't the emphasis on themata in the elucidation of fundamental scientific research open the door to the valorisation of the irrational in scientific endeavour? This question inevitably underpins another, which is tethered to the philosophical inquiry into science: do scientific rationality and objectivity really rest on any epistemological foundation, or are they upheld in philosophical and scientific discourse simply in the name of the demands of science?

It is important to employ an analogy to better grasp the type of connection that can be observed between paradigm and themata, which certainly brings them closer together. In this regard, paradigm and themata clearly belong to the realm of the science in the making. The former can be likened to the architectural blueprint followed to construct a building (the term "model" holds significant relevance here), while the latter would represent the scaffold used to assemble the structure level by level. However, unlike the scaffold that is removed after the completion of the building, themata possess inherent value and imply a notion of the scientific structure's dependence on them as the presuppositions upon which science is founded. In this context, themata exhibit a distinct separation from paradigms. This distinction arises from the paradigm's characterisation as a model, serving as both an illustrative example for emulation and a source of inspiration for subsequent investigations (Godfrey-Smith, 2021, p. 87-88). Yet, it is noteworthy that Kuhn's conceptualisation of paradigms transcends a mere portrayal as a disposable pedagogical instrument or an illustrative example. It influences how scientists think, formulate questions, and conduct their research in a given field; it guides scientific activities and directs the development of knowledge in a specific domain. Thus the paradigm is an essential notion for understanding the development of science. It functions as a fundamental framework that precedes and enables scientific progress. Therefore, by critically evaluating and understanding paradigms, we gain invaluable insights into the evolution of scientific thought and the trajectories of knowledge. This illustrates the heuristic function that the paradigm shares with themata, but this point of convergence does not justify considering the two concepts as synonymous.

Although paradigms and themata can be differentiated, they share the characteristic of being complex concepts and are therefore often regarded as unclear or ambiguous. In a manner reminiscent of Bolzano's advice (quoted in Hourya, 1999, p. 340) to always say precisely and clearly what one is talking about, Kuhn takes up the term "paradigm" to replace it with the expression "disciplinary matrix": "'disciplinary' because it refers to the common possession of the practitioners of a particular discipline; 'matrix' because it is composed of ordered elements of

various sorts, each requiring further specification" (2012, p. 181).

The components of a disciplinary matrix would consist of at least four types: firstly, symbolic generalisations (formal or formalisable elements as seen in the cases of Newton's "$F = mg$" or Einstein's "$E = mc^2$"); secondly, an adherence to metaphysical conceptions (received beliefs allowing for concrete analogies that substantiate phenomena and differentiate admissible explanations from those that would not be); thirdly, the sharing of certain values (such as simplicity, precision and coherence, which ultimately guide the choice of explanations and procedures while maintaining a sense of community among scholars, even during periods of crisis); and finally – the original meaning of "paradigm" would be found here – examples of problems and solutions (handed down mainly by textbooks to serve as a means of updating theoretical generalisations).

The paradigm also has a dual nature. As an epistemological concept, it is defined as a tradition of research, which corresponds to a set of canons of scientific rationality through which a community of scholars defines the methods to be followed, the scope of the problems to be solved, and the criteria for determining the value of knowledge for the human mind. In its sociological sense, it corresponds to the consensus within the scientific community regarding the fundamental results that scientific thought has achieved in a particular field of knowledge.

While not claiming to have exhaustively covered Kuhn's paradigms, we can more than we have said so far about what they share or do not share with the themata in terms of scientific knowledge.

Although they are both multi-faceted terms, themata are precise concepts (e.g. causality, atomism) and do not possess the comprehensive nature (encompassing multiple elements) of the concept of paradigm. Indeed, the paradigm, as construed by Kuhn, is a complex notion, as evidenced by the composition of the so-called "matrix". Paradigms have the potential for undergoing revolutions or transformations. The shift from normal to revolutionary science, termed as a paradigm-shift by Kuhn, is triggered by anomalies. Kuhn argues that this transition justifies the non-cumulative characteristic of science, rather than it being cumulative (Ogundele, Emmanuel Adetokunbo; Ogunyomi, 2020; Soler, Léna; Sankey, Howard; Hoyningen-Huene, 2008, p. 145-151). From this point of view, there exists, according to Kuhn, a complete transition when moving between two paradigms. This is in contrast to themata, which tend to remain stable.

Holton's themata span over long durations and primarily serve as pathways or persistent entities that animate science throughout the ages. They function as working hypotheses that regulate the growth of theories. It is rather incidental that themata, which base scientific knowledge on a small number of themata, explain the progress of science. According to Holton, the progression of science is continuous rather than discontinuous, due to the constrained number and stability of themata. A complete reorientation of science, let alone a "revolution", is not to be expected.

In a sense, no field of thought is more conservative than science. Each change necessarily encompasses previous knowledge. Science grows like a tree, ring by ring. Einstein did not prove the work of Newton wrong; he provided a larger setting within which some limitations, contradictions and symmetries in the earlier physics disappeared (Holton, 2000, p. 49).

If two rival paradigms must battle it out until the extinction of one of them, in Holton's view, antithetical themes such as continuous/discontinuous can coexist and determine even competing scientific theories without one truly prevailing. The history of science supports his argument by demonstrating, contrary to Kuhn, that during lengthy periods, several competing paradigms coexist in a conflicting manner without one of them establishing itself as the "normal science". If, according to the terminology used by Kuhn, "normal science" refers to consensus around a single paradigm, then a good illustration will suffice to support the previous assertion. It turns out, indeed, that Newton's particle theory of light (1672), challenged by the experiment on the speed of light in water (Foucault and Fizeau, 1848), comes back to life starting in 1905 with Einstein, eventually coexisting today with the wave theory in the form of a simultaneous wave-particle understanding of light.

If the paradigm has a historical component, in the sense that it is a global worldview embedded in a historical context, the thema is, for its part, detached from it and spans across eras without significant alterations.

Another fundamental difference is that a thema is specific to an individual, even though it can exert an influence on group work when adopted by the group, whereas the paradigm is shared within a community of researchers, and they cannot choose not to adhere to it.

Nonetheless, the two notions exist in close proximity. Despite not being the primary focal points of the investigation conducted by Press and Tanur (2001), their insights into "science, scientists, and scientific methods" (2001, p. 1) are likely to provide an accurate depiction of the shared characteristics of these two concepts in question. In this context, a vigilant reader of this work, well-acquainted with themata and paradigms, would be justified in identifying the core shared traits of these two concepts embedded within Press and Tanur's valuable observation, where the advancement of science often sees scientists relying on intuition, hunches, and personal convictions to extract significance from the empirical data they collect. To put it plainly, themata and paradigms inherently share the ability to propel this described process, thus potentially holding a central position in the bedrock of scientific knowledge. To be more precise, paradigms align more closely with themata through what Kuhn (2012, p. 183) refers to as "the metaphysical components of paradigms." This highlights the idea that all scientific practices are influenced by beliefs, myths, standards (models), and norms. These elements create a consensus within a community of researchers and shape the selection of problems under scrutiny, as well as the methods employed to arrive at solutions.

For Holton and Kuhn, researchers adhere, respectively, to certain themata (Holton) and specific paradigms (Kuhn), leading to consequences such as the refusal to abandon theories unsupported by evidence, or even contradicting experimental data. Speaking of the relationship between rules, paradigms, and normal science, for instance, Kuhn

demonstrates that scientists can collectively acknowledge that a paradigm has yielded lasting solutions to a set of major problems, while simultaneously holding contradictory interpretations or rationalisations of the same paradigm without realising it. To illustrate the arbitrary nature of paradigms, Kuhn recounts an anecdote he received from the researcher James K. Senior (see Kuhn, 2012, p. 50-51). The same reality is observed with themata. To underscore this, Holton examines the significance of the agreement that occasionally comes with passionate clashes between scientists, like Einstein and Bohr, Schrödinger and Heisenberg, for example (see Holton, 2000, p. 151-152).

Fundamentally, adherence to a paradigm, no more than to a thema, would not necessarily be the result of a conscious convention. In the case of themata, this adherence can be traced back to early childhood; whereas in the case of paradigms, it is more closely linked to the teaching of science through examples and model problems that inculcate in learners a belief in the value of theory and the efficiency of research methods. Meeting exemplary embodiments daily in laboratories, in their journals, and in their textbooks, scientists eventually come to see them without being explicitly pointed out to them. In the final analysis, a paradigm is nothing more than a set of ideas and practices that permeate people's minds at a given moment. Hence, the assimilation of paradigms to *metaphysical conceptions*; that is, received beliefs from which it becomes possible to draw analogies, concretise phenomena, and distinguish between acceptable and unacceptable explanations (Kuhn, 2012, p. 183-184). It is in this way that paradigms, as Kuhn (2012, p. 42) explains, *can guide research even in the absence of explicit rules.*

The notion arises that paradigms, akin to themata, function as occult principles (that is, not always rigorously determined) governing knowledge and facilitating its organisation. According to Kuhn (2012, p. 34), "Inevitably, therefore, the overwhelming majority of the problems undertaken by even the very best scientists usually fall into one of the three categories", which he calls: "determination of significant fact, matching of facts with theory, and articulation of theory". This leads Kuhn to the following conclusion: "Work under the paradigm can be conducted in no other way, and to desert the paradigm is to cease practicing the science it defines" (2012, p. 34). However, as already mentioned, the choice between paradigms is not rationally grounded (Kuhn, 2012, p. 94-95; 109). The researcher's adherence to a thema is not either. Therefore, if nothing serves to modify the notion that there exists an "unthought" within science, does the critique of scientific rationality and objectivity through the breach opened by themata not verge on futility?

In his book "The Methodology of Scientific Research Programmes" (1970/1989), Lakatos introduced the concept of "research programmes", which bears semantic resemblance to Kuhn's notion of "paradigm." Within this work, Lakatos not only engaged with Kuhn's ideas but also presented alternative perspectives (see György Kampis, Ladislav Kvasz, 2002) that warrant a parallel analysis between research programmes and Holton's Themata.

4.3 Themata versus Imre Lakatos' research programmes

The current comparative analysis will be brief, with an emphasis on elucidating the shared key aspects of themata and research programmes, while also highlighting their divergent approaches in addressing these aspects simultaneously. This approach is chosen due to the lower probability of confusion between these concepts, in contrast to the potential ambiguity that can arise when dealing with Kantian Categories and Kuhnian paradigms. Conceived with the aim of addressing "some of the problems which both Popper and Kuhn failed to solve" (Lakatos, 1989, p. 4), it is thus understandable that research programmes and paradigms share certain similarities (Godfrey-Smith, 2021, p. 109; Jorritsma, 2022, p. 1). Holton and Lakatos align with Kuhn in stressing the importance of historiographical study in elucidating issues in the philosophy of science (see Toulmin's discussion of Holton (**?**, p. 528) and Lakatos' viewpoint (1989, p. 168). Themata and research programmes can be seen as instruments employed by Holton and Lakatos, respectively, in accomplishing this objective. In this context, the correlation between themata and research programmes becomes apparent, along with Holton's warning not to conflate themata with research programmes, even though this caution is not reiterated as often as with the two other concepts discussed earlier in this paper.

Like Kuhn and Holton, who not only provided a framework for analysing sciences but also introduced innovative terminology for their analyses, Lakatos followed suit. The brevity announced for this presentation should not impede the acquisition of insight into what Lakatos regards as "research programmes." He portrays research programmes as a thorough examination of the scientific method. According to him, research programmes would be capable of accounting for scientific progress while simultaneously preserving the notion of rationality – it has even been suggested that "Lakatos wanted to rescue the rationality of science from the damage Kuhn had done" (Godfrey-Smith, 2021, p. 109). If rationality is such a concerning issue, it is primarily because, with neo-positivism, rationality is conceived as an entity tasked with determining under what conditions established human knowledge can be considered valid and ensuring the advancement of science. Also, the fact is that science, or the idea we have of it, is linked to rationality. The latter is considered one of the essential characteristics of the scientific approach. While themata may be inherently perceived as closely related to the realm of irrationality due to their nature and mode of operation, it is quite probable that Holton finds comfort in the rationality asserted by science through its peer debates on theories and inventions. When he addresses the issue of rationality, it is much more out of concern for practical purpose and the potential risks associated with irrationality, such as the outbreak of conflicts (Holton, 1993, p. 175; 1998a, p. 178; 207; 1998b, p. 100-110).

Certainly, Holton's endeavour can be construed as a manifestation of descriptive epistemology. On the contrary, identified as a disciple of Popper, Lakatos can be viewed as an advocate for normative epistemology, devoting himself to outlining the standards for substantiating specific knowledge, with the goal of "[rescuing] methodology and the idea of scientific progress" (Lakatos, 1989, p. 31). Ac-

cording to Godfrey-Smith (2021, p. 112), "Lakatos, [...] wants to have the whole enterprise guided by methodological rules—or at least, he needs for us to be able to tell ourselves a story of that kind." Unlike Lakatos' research programmes, Holton's themata do not revolve around "how a scientist should go about his business" (Holton, 1956, p. 191), but rather focus on understanding how scientists arrive at a discovery through their pursuit. Holton proposes the concept of themata as a kind of "black box", comparable to a flight recorder, which serves as a record of scientific endeavours. This aids in comprehending the inventive process employed by scientists. While it might be assumed that Lakatos' research programmes, being centred on rationality, do not delve into the emergence of new theories, the reality is quite the opposite. In Lakatos' framework, a research programme comprises a series of interconnected theories, unified by a core set of hypotheses termed the "hard core", while varying in their "protective belt" hypotheses. Each adjustment or modification to the protective belt effectively challenges the preceding theory within the research programme, thereby paving the path for subsequent developments. Thus, Lakatos' approach indeed addresses the *how* and *why* of new theories emerging, as it engages in the continual process of refining and adapting theories within the framework of a research programme.

Nonetheless, Lakatos' research programmes primarily focus on the normative aspect of the discovery problem, regarding it as a philosophical concern related to the evaluation of scientific change. This stands in contrast to the psychological problem of explaining the actual acceptance and rejection of theories (Lakatos, 1989, p. 168-169). However, it is essential to note that Lakatos identifies the "research programme" as the fundamental unit of measurement for assessing scientific progress (György Kampis, Ladislav Kvasz, 2002, p. 60).

In this picture, a research programme is, for Lakatos, a set of fundamental scientific assumptions and hypotheses that guide research in a particular field. It consists of a "hard core" of unchangeable principles and a "protective belt" of auxiliary hypotheses that can be modified to accommodate new evidence (Lakatos, 1989, p. 48). Lakatos and Holton offer contrasting perspectives on the dynamics of scientific progress and the evolution of theories within the domain of scientific inquiry. Their respective frameworks, while distinct, shed light on the broader scientific enterprise.

Lakatos argued that scientific progress occurs through the modification of the protective belt while maintaining the core assumptions.

Despite our primary goal being the distinction of research programmes from Holton's themata rather than engaging in a direct comparison to paradigms, it is worth noting that Kuhn's paradigm, functioning as a worldview, extends beyond the realm of scientific inquiry. It serves as a conduit for a reciprocal influence between science and society. In contrast, Lakatos' research programme is confined to the scientific community. It is predicated on the notion that within science, there exist clusters of theories bound together by shared principles or postulates (Morin, 1990a, p. 44-45). According to Lakatos' perspective, scientific progress is driven by the rejection of theories. However, for a theory T to be supplanted, an alternative theory T' must be proposed that satisfies the following criteria:

Firstly, T' must account for the same phenomena as T. This criterion ensures that the new theory does not discard the empirical successes of its predecessor, but rather builds upon them. Secondly, T' must generate predictions that T did not. This criterion emphasises the capacity of the new theory to expand the scope of explanatory power, providing novel insights into natural phenomena. Finally, experimental evidence must corroborate some of the new predictions made by T'. This criterion establishes a stringent empirical test, demanding that the new theory be validated through rigorous experimentation.

Competing research programmes can be assessed in a similar fashion. Thus, "Science is considered to be an ongoing competition among research programs" (György Kampis, Ladislav Kvasz, 2002, p. 60). Consequently, it can be asserted that "research programmes are sometimes abandoned." Moreover, a comprehensive theory of scientific change must encompass two distinct types of transformation: (1) shifts within individual research programmes, and (2) shifts at the level of the aggregate of research programmes within a scientific domain (Godfrey-Smith, 2021, p. 110). From this perspective, it is the transition from one theory to another that can be deemed scientific, provided that the new theory surpasses (according to the defined criteria above) the previous - or rival - theory in terms of its corroborated empirical content. Scientific progress would then be measured by the proportion of unprecedented facts - meaning each time unexpected in light of the theory being replaced - that the series of theories would lead to discover. Lakatos' criteria for progress align with the Kuhnian notion of non-accumulative change, characterised by the complete replacement of one theory by another, rather than a partial retention (György Kampis, Ladislav Kvasz, 2002, p. 63). Nevertheless, adhering solely to this perspective might be perceived as one-sided, as the criteria of progress formulated by Lakatos also apply within a research programme, allowing for the notion of cumulative progress. Lakatos acknowledges that transitioning from one Protective Immunising Belt (PIC) to another – entailing the abandonment of a programme's hard core – can be likened to a scientific revolution in Kuhn's understanding. Conversely, progress within a particular PIC can be conceptualised analogously to normal science, characterised by cumulative advancement.

While Holton does not argue for a non-accumulative approach in science (2000, p. 167-168), he concurs with the significant influence that both types of transformation (as outlined by Godfrey-Smith in connection with Lakatos' research programmes) exert on the advancement of science, particularly in relation to the role of thematic components. He expresses this viewpoint by asserting that theories undergo a rigorous refinement process within the innovator's mind before being published. Thereafter, they progress within the scientific community through vigorous discussions and occasionally even controversies (Holton, 1998a, p. 46). Ultimately, he emphasises the belief that "conflict is a fundamental necessity in the evolution of ideas" (Holton, 1988, p. 411).

In clarifying theory confrontation, often entangled with controversies, he interprets them as a clear expression of thematic conflicts, as previously discussed in this paper, which stem from a strong thematic attachment. This en-

compasses what he referred to as "intellectual commitment" or an "insuppressible desire" (1988, p. 116) along with preferences for one thematic system over another. On the other hand, Holton (2000, p. 161) observes that the diverse thematic commitments of individual scientists actually serve to save the scientific community from the potential pitfalls of focusing solely on one thema. This diversity of perspectives provides the group with the flexibility that an authoritarian research programme centred on a single thema lacks. "Thus, major scientific advances can generally be understood in terms of a process that involves battles over only a few but by no means all of the recurrent themata" (Holton, 2000, p. 168).

It is important to highlight that, as per Holton's (1988, p. 99-145) examination of the roots of *complementarity* (which was a novel thema at the time) in physics, both Bohr's articulation and Einstein's resistance to accepting this principle were influenced by individual, and at times, psychological considerations, all of which pertain to thematic commitments. This underscores the idea of an irrational attachment to a thema. Barbosa arrives at a similar conclusion regarding Hoyle's rejection of the big bang theory, stating that we should "recognize that the conditionings that themata and thematic preferences operate in the ideas and work of a scientist or a scientific community materialize in the form of selection effects and biases" (2022, p. 14).

For Holton, because of the thematic choices (which, as previously mentioned, are not inherently rational) a scientific controversy can continue for quite a long time (1998a, p. 54-55). Still, when one of the systems (scientific theories) prevails over its rival, Holton outlines two potential scenarios. In the *first scenario*, the two theory systems arrive, each on its own, at a stage of development "where there is no essential difference in the number and types of phenomena (experimental evidences) which they can handle" (1998a, p. 55). Holton concludes this first eventuality in these terms: as long as such a situation lasts for some time, "a choice is made between the two systems on the basis of the "appeal" of the fundamental presuppositions". The second scenario posited by Holton hinges on the capacity of one of the two systems to generate "more verifiable predictions of observable events than the other, and fewer (or no) uncomfortable disconfirmations" (1998a, p. 55).

Significantly, Holton's framework departs from Lakatos' approach when it comes to dealing with theories that lack empirical support. Unlike Lakatos, Holton does not advocate for outright rejection of a theory in such cases. Instead, he asserts that a theory's inability to be corroborated by facts does not *ipso facto* lead to its discredit. Holton elucidates that "during the period when attempts are made to account for apparent difficulties, the balance of opinion swings toward one of the systems in favour of the other, and the latter slowly fades from view without necessarily ever being 'disproved'" (1998a, p. 55).

In addressing this matter comprehensively, it is essential to underscore Lakatos' sophisticated falsificationism, which diverges from Popper's earlier formulation. Lakatos emphasises the potential to uphold the core hypotheses of a research programme in the face of anomalies by adjusting the protective belt to enhance empirical substantiation. Consequently, it appears that refutation within Lakatos' framework lacks definitive conclusiveness. However, this assertion may warrant scrutiny.

> For Lakatos, it is acceptable to protect a research programme for a while during a period when it is degenerating — the research programme might recover. This is even the case when another research programme has overtaken it (...). The history of science contains cases of research programmes recovering from temporary bad periods. So a reasonable person can wait around and hope for a recovery. How long is it reasonable to wait? Lakatos does not say. Feyerabend (...) swooped on this point (...). For him it was the Achilles' heel in Lakatos's whole story. (Godfrey-Smith, 2021, p. 111).

Holton's explanation parallels one of the key features of Lakatos' research programme, specifically the role of *negative heuristics*. A research programme serves as a heuristic principle grounded in a *core set* of irrefutable principles. These principles define methodological guidelines, delineating both paths to be avoided (*negative heuristic*) and those to be pursued (*positive heuristic*[4]). Positive heuristics play a crucial role in attempting to rectify anomalies encountered by a theory. This is achieved by modifying auxiliary hypotheses while preserving the core principles. In essence, the function of filtering, fulfilled by themata in Holton's framework, aligns with the role played by negative heuristics in Lakatos' model.

5 Conclusion

In the culmination of this studywhere we have delved into the theoretical exploration of "themata", we assert that they represent preconceptions, bearing elements of arbitrariness yet essential for researchers in their pursuits. They serve as foundational tools for thought and act as guiding principles in the advancement of knowledge. This paradoxical nature, as highlighted by Morin (1990b, p. 173), underscores that science thrives on elements inherently non-scientific. Thus, themata emerge as both the bedrock of discovery and constants of intelligibility within scientific inquiry.

Moreover, through a comparative lens encompassing Kant's Categories, Kuhn's paradigms, and Lakatos's research programmes, we aim to elucidate recurring confusions and misunderstandings cautioned by Holton. This comparative analysis reveals a shared conceptual architecture among Categories, paradigms, research programmes, and themata, serving as pre-existing frameworks of thought that shape scientific inquiry.

From this comparative exploration, two intertwined conclusions emerge. Firstly, there is a recognition of a commonality among Categories, paradigms, research programmes, and themata, all constituting foundational frameworks guiding scientific thought. Secondly, we endeavour to synthesise the specificity of themata, emphasising three key points:

[4]The role of positive heuristics is less about addressing anomalies and more about developing increasingly sophisticated models around the core in order to better account for reality. It is more theoretical and does not concern itself with counterexamples, at least up to a certain point.

Firstly, by linking themata to the imagination of scientists, ambiguity risks associated with various terms are mitigated, revealing themata as a fulcrum for thought with quasi-metaphysical aspects, often implicit yet influential in guiding research.

Secondly, inherent to creativity, themata underscore that scientific research is never conceptually blind, as concepts propel investigations and express researchers' interests. Wittgenstein (2009, p. 159e (n°570)) did not fail to express this idea in his reflections: "Concepts lead us to make investigations. They are the expression of our interest and direct our interest."

Thirdly, the constraining nature of themata fosters polarisation within scientific communities, facilitating the coexistence of competing theoretical or methodological approaches. From this results the advancement of science.

In conclusion, while scientific invention can be rationalised in the light of themata, they also unveil the subjective nature of science, prompting reflections on objectivity as discussed in our introduction. Thus, our study illuminates the intricate role of themata in shaping scientific inquiry, underscoring their significance in understanding the dynamics of knowledge production.

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