Transversal
International Journal for the Historiography of Science

Transversal: International Journal for the Historiography of Science, 2025 (19): 1-18
ISSN 2526-2270
Belo Horizonte – MG / Brazil

Special Issue
Paul Feyerabend and the History and Philosophy of Science

Feyerabend on Mach and Einstein: Theory Proliferation and the Idea of "Free Creations"

Miguel Agustín Aguilar Sandoval[1] [https://orcid.org/0000-0002-1014-5516]

Abstract:
Feyerabend is known for emphasizing the need to proliferate incompatible theories as a means of scientific progress. However, he also strongly criticized the idea of "free theory creation" in the course of the debate over the interpretation of Ernst Mach's philosophical work and its influence on Albert Einstein's discovery of relativity. This criticism implies that Feyerabend conceived restrictions on theory creation. The purpose of this text is to identify what these restrictions were and whether they imply an internal tension in Feyerabend's philosophy.

Keywords: Creativity in science; History of relativity; Scientific discovery

Received: August 30, 2025. Reviewed: November 14, 2025. Accepted: November 22, 2025.
DOI: http://dx.doi.org/10.24117/2526-2270.2025.i19.04

Introduction

Paul Feyerabend is known, among other things, for defending what is known as the principle of proliferation of alternative theories. A standard formulation of this idea is found in *Against Method.*[2] In very general terms, he considered it important for scientific progress to cultivate a wide variety of theories that differed from, or even contradicted, those accepted at a given time. Contrasting different theories would make it possible to reveal the limitations and biases of each; moreover, it would allow us to identify facts that would otherwise remain completely ignored. According to Feyerabend, there are facts that we can only plausibly identify when we are guided in our research by a particular theory, and other facts that we can only hope to identify with a different theory, incompatible with the first. Therefore, if we cling to a single theory we risk severely limiting our ability to identify new facts. "Empiricism, at least in some of its more sophisticated versions, demands that the empirical content of whatever knowledge we possess be increased as much as possible. *Hence the invention of*

[1] Miguel Agustín Aguilar Sandoval is a philosopher of science whose research focuses on the history of Philosophy of Science. He received his Ph.D. in Philosophy of Science from the National Autonomous University of Mexico (UNAM). Address: Av. Universidad 3000, Ciudad Universitaria, Coyoacán, C.P. 04510, Ciudad de México – Mexico. Email: miguelllzim@hotmail.com

[2] For example, chapters 3, 4, and 11 of the 3rd edition.

alternatives to the view at the centre of discussion constitutes an essential part of the empirical method" (Feyerabend 1993/1970, 29, emphasis added).

The proliferation principle, of course, evolved in Feyerabend's thought over the years, and various versions of it can be discerned, not all of them identical to what is described in the previous paragraph. Its interpretation can also be disputed. However, it does seem that a central aspect of Feyerabend's thought over the years was the idea that it is preferable to have as many alternative theories as possible. Authors such as Eric Oberheim and John Preston (2025) have emphasized this position of Feyerabend's. Also, Jamie Shaw, for example, states that for Feyerabend, "there isn't a single context in which it is rational to refrain from proliferating alternatives" (Shaw 2017, 7). Also, Hasok Chang considers that Feyerabend implies "that any theory that anyone really cares to pursue is worth pursuing" (Chang 2021, 42).

Despite the current consensus that the proliferation of alternative theories is a key aspect of Feyerabend's philosophy, there is at least one context in which he argued *against* free theory creation. During the 1970s and 1980s (the same period in which he developed the ideas about theory proliferation outlined in the opening paragraph), Feyerabend became involved in a debate over the relationship between Ernst Mach (1838–1916) and Albert Einstein (1879–1955). Several authors, such as Gerald Holton (1968) and Elie Zahar (1977), had argued that there were inconsistencies between Mach's philosophy of science and Einstein's relativity. They thus concluded that there were important deficiencies in Mach's ideas about science. Feyerabend, on the other hand, vigorously defended Mach from the criticisms of these authors. But in his defense of Mach, Feyerabend also criticized Einstein's position that the principles of theories are "free creations of the mind".

It is, at the very least, paradoxical that Feyerabend criticized Einstein for speaking of the free creation of theories, when he himself emphasized the need to proliferate alternative theories. This criticism of Einstein raises the question: Is there an inconsistency between Feyerabend's two positions? In other words, is the idea that we should proliferate theories consistent with the idea that these are not free creations? To begin with, there shouldn't necessarily be a contradiction if we consider that the proliferation of theories is achieved in a way that isn't exactly free. But then, did Feyerabend conceived of restrictions on theory creation? If so, what were those restrictions and how did he motivate them? *The purpose of this paper is to show that the position taken by Feyerabend in the debate over Mach's interpretations does imply that he conceived of restrictions on theory creation.* These limitations consisted of taking contextual considerations as criteria of relevance, so that theories that do not comply with the limitations imposed by these considerations should be avoided.

To explain why I think the debate about Mach and Einstein shows that Feyerabend conceived of restrictions on theory-making, I will begin, in the next section, by stating what that debate consisted of. I will not elaborate on all the details of the debate in question since that is not the central focus of this paper. I will limit myself to giving a general sense of what the debate consisted of and how some of the arguments that were important to Feyerabend arose. After that, I will explain Feyerabend's position in that debate. Here, we will look at some central aspects of how Feyerabend interpreted Ernst Mach's ideas. It will be important to keep in mind that some aspects of Feyerabend's reading of Mach are controversial. John Preston (2024), for example, rejects some aspects of Feyerabend's interpretation. However, my aim is not to assess the accuracy of Feyerabend's reading of Mach, but only to highlight the implications of that reading for our understanding of Feyerabend's own philosophy. In the subsequent section, in particular, I will analyze Feyerabend's contrast between Mach ideas and Einstein's idea that theories are "free creations". In "Feyerabend on Discovery and 'Free Creations'", I will elaborate the implications of Feyerabend's support for Mach's position. Finally, in the last section before the conclusions, I will show how Feyerabend's siding with Mach, and his rejection of Einstein's idea of "free creations", can be explained. In

the conclusions, I will mention how this case illustrates the importance of studying neglected aspects of scientific discovery.

The Debate About Mach and Einstein Towards the Second Half of the 20th Century

Ernst Mach was undoubtedly a fundamental figure in the physics and philosophy of science of the late 19th and early 20th centuries. A testament to his importance is, for example, the well-known fact that the philosophers of the Vienna Circle called their organization the "Ernst Mach Society". Moreover, Albert Einstein himself acknowledged having been inspired by Mach's books and even went so far as to say that: "It is not improbable that Mach would have hit on relativity theory when in his time – when he was in fresh and youthful spirit – physicists would have been stirred by the question of the meaning of the constancy of the speed of light" (1996/1916, 144).

Despite Einstein's own observations, by the second half of the 20th century, some philosophers and historians began to question Mach's supposed importance in the discovery of the theory of relativity. Authors such as Gerald Holton (1968), John Blackmore (1972), Elie Zahar (1977), and Arthur Miller (1981), for example, attempted to identify conflicts, or some form of incompatibility, between Mach's ideas and relativity. The motivation for finding such conflicts was largely due to a preface that appeared in one of Mach's posthumous books. In 1921, Ernst Mach's son, Ludwig, published the book his father had left unfinished, *The Principles of Physical Optics*, and the preface to that book contains a firm rejection of relativity:

> The reason why, and the extent to which, I discredit the present-day relativity theory, which I find to be growing more and more *dogmatical*, together with the particular reasons which have led me to such a view – the considerations based on, the physiology of the senses, the theoretical ideas, and above all the conceptions resulting from my experiments – must remain to be treated in the sequel. (Mach 1926, viii, emphasis added)

That second part of the book, in which Mach would explain his reasons for rejecting relativity, could not be written due to his death.[3] Thus, Mach's reasons for rejecting relativi-

[3] Actually, the authorship of the preface has been questioned primarily by Gereon Wolters (1987, 2012, and 2019). Wolters gives strong evidence to think that the preface was actually written by Mach's son, Ludwig, who passed it off as his father's. In other words, Wolters claims that *the preface is a forgery*. Feyerabend, at first, agreed with Wolters: "When I first had told Paul about my findings in the mid-eighties and had shown him some documentation, he was enthusiastic…" (Wolters 2019, 382). Feyerabend acknowledged this in the first edition of *Farewell to Reason*. There he says that "It now appears that the foreword to the *Physikalische Optik* and the foreword to the 9th edition of the *Mechanik*, which contain passages critical of the special theory of relativity, were written by Ludwig Mach, Ernst Mach's son, and inserted without Ernst Mach's knowledge. In a word, both texts are fake. The evidence, which is strong though circumstantial and which to me seems entirely convincing, has been assembled by Dr. Gereon Wolters of the University of Konstanz. I accept his conclusions and the interpretation he bases on them" (quoted in Wolters 2019, 382-383). Nonetheless, later, in the German translation to *Farewell to Reason*, Feyerabend showed that he had changed his mind: "Mach, however, does not need a rescue of this sort. If we assume that the critical remarks are of himself – would that be really so bad?... The attempt to 'save' Mach with the aid of a forgery theory takes a certain stage of physical research still too seriously to live up to Mach's own attitude" (quoted in Wolters 2019, 383). The reasons behind Feyerabend's change of mind are not so clear though. "The only explanation for

ty have been a subject of debate since the publication of the preface.[4]

Einstein was unaware of the preface in question when he wrote the text (cited above), in which he argues that Mach could have discovered relativity on his own. In fact, Einstein expressed himself more negatively toward Mach in the years that followed. Gerald Holton (1968) argues that this change in Einstein's attitude is evidence that he began his career with a "positivist" conception (close to Mach's), which gradually shifted toward a "rational realism".[5] Moreover, Holton considers that, even in his early period, some aspects of this "rational realism" were already implicit in Einstein's texts from the outset. It would be these aspects that, according to Holton, would have motivated Mach to reject relativity. "To put it very simply, Mach had recognized more and more clearly, years before Einstein did so himself, that Einstein had indeed fallen away from the faith, had left behind him the confines of Machist empirio-criticism" (Holton 1968, 649).

Holton emphasizes Einstein's lecture entitled "On the Method of Theoretical Physics" as evidence of his "rational realism". In that lecture, Einstein points out that the fundamental concepts and principles of physics "would simply be *free inventions of the human mind* which admit of no a priori justification either through the nature of the human mind or in any other way at all" (Einstein 1934, 165, emphasis added).[6] Moreover, Einstein highlights the "purely fictitious character of the fundamentals of scientific theory". For Holton, "It is this penetrating insight which Mach must have smelled out much earlier and dismissed as 'dogmatism'" (1968, 650). For Einstein, theories do not begin with formal statements, but with a "creative digestion of the totality of experience." Theories emerge from inventions, not from discoveries. Additionally, Holton points out other reasons for rejecting Mach, some of them are also emphasized by John Blackmore (1972), who also points out other, different, aspects of relativity that would have displeased Mach.

Taking up some of the arguments of authors such as Holton and Blackmore, Elie Zahar (1977) concludes that if Einstein had adhered to Mach's methodology, he would never have arrived at relativity. According to Zahar, this is because, to introduce special relativity, Einstein had to violate central principles of Mach's philosophy, and had he not done so, special relativity would never have seen the light of day. Furthermore, Zahar argues that Mach's philosophy was largely irrelevant to modern physics. As to what these principles of Mach's philosophy were, Zahar points out that he sought to define the concepts of physics

Feyerabend's new view on the forgery thesis that comes to my mind is that he wanted his hero Mach a bit more anarchical, a bit more Feyerabendian, as it were" (Wolters 2019, 383).

[4] John Blackmore says that "Albert Einstein and Hans Reichenbach reacted to the hostile preface to Mach's *Optics* by blaming it on his age and presumed intellectual senility, as if he had become too old to change his mind" (Blackmore 1972, 261). However, Blackmore also points out that Mach, at the same time he supposedly rejected relativity, wrote the book *Culture and Mechanics*, and many papers. In them "There is not the slightest sign of any diminution in his [Mach's] mental powers".

[5] Don Howard (1993) shows that it is, in fact, possible to recognize an epistemological position in Einstein's thought much more consistent throughout his life than Holton maintains. Furthermore, Howard warns of the risks of applying anachronistic categories to Einstein's ideas, such as, he considers, the category of "realism". The realism that Holton recognizes in Einstein is not exactly what we understand today as realism in philosophy of science, but refers only to the idea: "that there exists an external, objective, physical reality which we may hope to grasp – not directly, empirically, or logically, or with fullest certainty, but at least by an intuitive leap..." (Holton 1968, 662).

[6] As a reviewer pointed out, it might seem puzzling that Holton characterises Einstein's position as a kind of "realism" given this description of scientific concepts as "freely invented". Nonetheless, it is important to keep in mind that the semantic dimension of modern scientific realism developed mainly after the 1970s. Einstein's realism envisioned scientific theories as aiming to provide a mental image (*Weltbild*) of a mind-independent reality, but it did not require that every theoretical term have a definite factual reference from the very beginning.

in an operational (measurable) manner, non-circular, and that they avoided all unobservables. The relativity definition of time is based on that of velocity, which, in turn, depends on the concept of time. Zahar argues that this is not problematic for Einstein, but it does put him in conflict with Mach's 'cardinal methodological principles.' Furthermore, the notion of simultaneity in relativity is conventional. Additionally, Zahar (1977, 206) also points out that Einstein's frames of reference are defined without necessary reference to anything observable, and so are absolute, like Newton's absolute space. Mach had sought to eliminate Newton's absolute space and, for the same reasons, would have rejected the frames of reference used by Einstein. For Einstein, the form of laws adapts depending on the frame of reference, and there is no form that is generally simplest, which, for Mach, in Zahar's reading, would not be economical. This would go against Mach's famous "principle of economy", which, succinctly put, expressed the importance of simplicity as an epistemic value.

Feyerabend's Contribution to the Debate: Defending Mach

Much of the argument mentioned in the previous section to explain Mach's rejection of relativity depends on a simplistic understanding of Mach. Perhaps this simplistic reading of Mach was prompted by the reaction of the time (1960s and 1970s) against positivism. Given the strong criticism of the philosophers of the time against the previous generation (who had appropriated Mach as their founding hero), it is natural to expect an uncharitable reading.

In fact, Feyerabend himself seems to have shared the simplistic reading of Mach early in his career. However, in his later years, Feyerabend vigorously defended Mach against his critics. John Preston (2024) points out that Feyerabend seems to have abandoned the simplistic reading of Mach from the mid-1960s. From that time on, Feyerabend saw himself as a follower of Mach and other physicists of the late 19th and early 20th centuries.

A key text that highlights Feyerabend's new attitude toward Mach is his 1970 "Philosophy of science: A subject with a great past". In it, Feyerabend complained that much of the philosophy of science had become irrelevant to science itself (or simply irrelevant). According to him, this irrelevance was a consequence of the fact that philosophers were no longer willing to carry out a critical analysis of scientific theories, but rather accepted them dogmatically. All philosophers did, in Feyerabend's view, was discuss problems independent of science. In this way, they could continue to accept scientific theories without question, but at the cost of becoming irrelevant. However, Feyerabend pointed out that, in contrast to the current situation: "The nineteenth century produced one philosopher who was not prepared to accept the status quo, who was not content to criticize science from the safe distance of a special subject either, but who proceeded to suggest concrete means for its change. The nineteenth century produced Ernst Mach" (Feyerabend 1999/1970, 129).

Feyerabend's admiration for Mach soon became a distinctive aspect of his thought. As Preston points out: "[…] from the early 1970s onwards his [Feyerabend's] attitude to Mach remained relatively constant. Some new themes emerge, others pass into desuetude, and emphases change, but Mach appears as a constant role-model for Feyerabend" (Preston 2024, 68). For the publication of the German translation of *Against Method*, Feyerabend even points out that "the views in this book are not new – for physicists like Mach, Boltzmann, Einstein and Bohr they were a triviality" (cited in Oberheim 2006, 39). That is, Feyerabend considered that many of his own ideas were similar to those of Mach and, moreover, that they would have been obvious to the latter.

Given his admiration for Mach, it was only natural that Feyerabend would feel the need to respond to the authors of the previous section. In an article entitled "Zahar on Mach, Einstein, and modern science", published in 1980, Feyerabend criticizes Zahar's (1977) reading of Mach. Overall, Feyerabend considers that "There is a great distance indeed

between Mach's 'philosophy' and Zahar's rather unbelievable distortion of it" (Feyerabend 1980, 278). Regarding Zahar's statement that Einstein's definition of simultaneity would be inadmissible for Mach, due to its conventional nature, Feyerabend points out that Mach distinguished several types of definitions, including stipulative ones. "Einstein's definition of simultaneity falls into this category and is therefore anything but a 'violation…of Mach's cardinal methodological principle'" (Feyerabend 1980, 276).

Regarding the concept of time, Feyerabend points out that Mach "is well aware of the fact that concepts, being dependent on each other in many ways, cannot always be explained in isolation…[moreover] 'Which concepts we form' writes Mach, 'how we delimit them with respect to each other – all that can be decided only by the needs of practice, or of science': Mach is much more liberal than modern philosophers of science and his 'cardinal methodological principle' is nothing but a chimaera in Zahar's head" (Feyerabend 1980, 276).

Regarding Zahar's argument that the frames of reference in Einsteinian physics create a new absolute that Mach would reject, Feyerabend points out that "Mach, far from treating inertial systems as metaphysical monsters, examined their properties and watched with interest and approval the attempt to make them a basis for astronomical measurement... Mach's aversion to relativity has no connection with the occurrence of inertial systems in it" (Feyerabend 1980, 273-274). Additionally, Feyerabend (1980, 275-276) claims that Zahar has a simplistic conception of Mach's economics of science.

In another article from 1984 entitled "Mach's theory of research and its relation to Einstein", Feyerabend continues his defense of Mach against the other authors mentioned in the previous section. As we saw, Holton argues that Einstein's principles were not facts of experience for Mach and that he would therefore have objected to them. To this, Feyerabend points out that "Mach is very critical towards naive inductive procedures and prefers the direct and 'instinctive' use of principles of great generality. Moreover, there exist many passages in his work which, when viewed with this background in mind, seem to use the term 'facts of experience' in a rather general way" (1984, 6). In a footnote, Feyerabend gives several examples of Mach referring to abstract ideas as "facts" such as the principle of parallelogram of forces or the law of inertia.

As Feyerabend himself points out, Holton's criticism relates to the common idea that Mach considered science to consist solely of a systematization of relationships between data from experience. This is why Holton highlights Einstein's assertions that scientific theories and concepts are "free creations of the human mind" and "have a purely fictitious character." If, for Mach, science is merely the systematization of data from experience, without adding anything, then the idea that theories contribute anything new or have a fictitious character would be unacceptable. However, here Feyerabend presents two different attitudes: first, he rejects Holton's reading, but then he indicates that there is indeed a difference between Mach's and Einstein's conceptions. This difference between Mach and Einstein will be the subject of the next section, but before moving on to it, it is important to note what Feyerabend rejects about Holton's reading.

Feyerabend clarifies that Mach does not hold the conception attributed to him (by Holton, among others) that all science consists of systematic relations of data from experience. Feyerabend provides documentary evidence that, for Mach, the principles of science express abstract ideas that are key to understanding a multitude of facts; they are not mere sensory data. The process of arriving at these abstract principles, according to Feyerabend's reading of Mach, requires imagination and the ability to identify which aspects of observable phenomena are important in constructing a general view of them. "Finding principles involves observations side by side with ingredients which the scientist 'adds *on his own*, using his own reservoir of ideas'" (Feyerabend 1984, 8). Therefore, Feyerabend

establishes that it cannot be the idea that the scientist creates new ideas and, in doing so, adds something to experience, what Mach rejects.[7]

Mach's Rejection of Relativity According to Feyerabend

A peculiar aspect of Feyerabend's defense of Mach is his criticism of Einstein's idea that theories are "free creations". This idea is the point Feyerabend emphasizes to distinguish Einstein from Mach. Although at the end of the previous section we saw that Feyerabend rejects that Mach conceived of science as a mere systematization of sensory experience, he does consider that there are relevant differences between Mach's and Einstein's conceptions. Feyerabend highlights these differences because, having refuted the simplistic explanations for Mach's rejection of relativity, he still needs to propose his own explanation for that rejection.

To elaborate his explanation, Feyerabend returns to the following quote from Einstein in which he describes his conception of the process for conceptualizing experience:

> [...] the first step in the setting up of a "real external world" is the formation of the concept of bodily objects and of bodily objects of various kinds. Out of the multitude of our sense experiences we take, mentally and arbitrarily, certain repeatedly occurring complexes of sense impressions... and we correlate to them a concept – the concept of the bodily object. Considered logically this concept is not identical with the totality of sense impressions referred to; but it is a *free creation* of the human (or animal) mind [...]. The second step is to be found in the fact that, in our thinking (which determines our expectations) we attribute to this concept of the bodily object a significance, which is to a high degree independent of the sense impressions which originally give rise to it [...]. The justification of such a setting rests exclusively on the fact that, by means of such concepts and mental relations between them, we are able to orient ourselves in the labyrinth of sense impressions. These notions and relations, although *free mental creations*, appear to us as stronger and more unalterable than the individual sense experience itself [...]. (cited in Feyerabend 1984, 12; also in Einstein 1954/1936, 291, emphasis added)

Feyerabend then argues that this description from Einstein "is *utterly unreal*. There exists no stage in history, or in the growth of the individual that corresponds to the 'first stage'; there is no stage when [...] we 'mentally and arbitrarily' select special bundles of experience, 'freely create' concepts, and correlate the concepts with the bundles'" (Feyerabend 1984, 12). According to Feyerabend, Einstein's description of the formation of concepts and theories (ironically) is closer to positivism than Mach's description of these processes.

In contrast to Einstein, Feyerabend points out that Mach presents a more sophisticated account of the formation of scientific concepts and theories. For Mach, there is no stage at which we have mere perceptions without ideas or concepts. That first stage cannot exist, for Mach, because there is no experience alone without thought. Neither concepts nor sensations can exist independently of one another. Furthermore, Feyerabend points out that, according to Mach, there is not even a clear distinction between perceptions and ideas, any more than between memory and imagination, or even between scientific ideas and common sense.

Feyerabend (1984) highlights Mach's conception that the earliest sensations one can experience are already determined by "the innate state of the organism and tradition". Mach

[7] Zahar (1981) and Hentschel (1985) respond to several of Feyerabend's criticisms. A more detailed analysis of these arguments and their limitations can be found in Wolters (1987).

was deeply influenced by ideas about evolution, as can be seen, for example, in his book *Knowledge and Error*. There, Mach describes how organisms are already prepared by evolution to react instinctively to stimuli in their environment. These reactions are designed to allow the organism to achieve its survival goals. Furthermore, Mach argues that the development of human mental capacity was a means that allowed humans to develop increasingly complex (and indirect) processes to achieve their survival goals. The result of these new processes are the diverse human practices, of which language and culture in general are a part. According to Mach (1976, 4), from birth, human beings already possess dispositions that are the consequence of an evolutionary process, and by the time they become fully conscious, they also already possess conceptions and ideas inherited from their culture. There is no stage in which human beings are confronted with mere sensations, and, in Feyerabend's reading, one cannot even speak of a clear distinction between sensations and ideas.[8]

For Mach (1976), the different human practices that constitute culture emerge in continuity with the processes by which human beings have adapted to our environment. These practices gradually develop their own objectives so that they are only indirectly related to survival goals. Mach considers that the ideas that constitute what we might call common sense are a consequence of these developments. In turn, science emerges from common sense.

Feyerabend (1984, 13-14) acknowledges that Einstein also accepts that science arises in continuity with common sense, but considers that he is mistaken in his description of how this occurs. Feyerabend points out that if, as Einstein says, concepts are "free inventions" for ordering sensory experience, we only have to create several of them and choose the one that does the best job; "The procedure may be long and tedious, but it has no intrinsic difficulty. All it involves is a 'free play with concepts'" (Feyerabend 1984, 14). On the other hand, if there is no separation between sensations and thought, then the invention of concepts (and theoretical principles) cannot be so free or reduced to simply rearranging pieces. There is no moment in which we have, so to speak, a "pure sensory experience" and then form a concept to represent it. There is the same complex and dynamic process in which we identify sensory experience and conceptualize it.[9] Rearranging pieces would mean that the pieces are already identified and determined in advance, independently of each other, which is not possible. Realizing this "he [Mach] became one of the forerunners of gestalt psychology, constructivism in mathematics, Piaget, Lorenz, Polanyi and Wittgenstein II" (Feyerabend 1984, 14).

According to Feyerabend, Mach also believed that there are a variety of historical factors that lead to the creation of concepts and principles, one of which is *instinct*. Elaborating on this point, Feyerabend mentions Max Planck as someone who presented a similar position to Einstein. Feyerabend acknowledges that both Einstein and Planck believed that there are factors that guide the formation of scientific concepts and principles in the course of research: "Planck and Einstein, of course, also recognized the need for an agency that moves research from one stage to another and they called this agency intuition or faith. However there is a great difference between intuition, or faith as conceived by Planck and Einstein, and Mach's instinct" (Feyerabend 1984, 16). This difference is crucial for

[8] John Preston (2024) disputes this aspect of Feyerabend's reading, however, and as I mentioned in the introduction, what is important here is not how accurate this reading is, but rather the implications that the very fact that he advances and defends it has for our understanding of Feyerabend's own philosophy.

[9] There is an echo of this idea in *Against Method*: "Creation of a thing, and creation plus full understanding of a correct idea of the thing, are very often parts of one and the same indivisible process and cannot be separated without bringing the process to a stop" (Feyerabend 1993/1970, 17).

Feyerabend. According to him, Mach realized that the relationship between different principles is historical; explaining an idea consists of showing both the reasons and the paths that led to it and its confirmation.

In contrast to Mach, Feyerabend believes that Planck and Einstein explain the origin of the principles of theories through "rational reconstructions". According to him, these reconstructions consist of relating theoretical principles to old opinions, without indicating why these should be accepted. What he means is that Planck and Einstein take entities they consider indisputable, sense data, and a set of opinions they also consider indisputable, logic, and attempt to relate both to scientific theories. In other words, Planck and Einstein take entities and opinions that they do not analyze, sense data and logic, to try to explain the origin and justification of theoretical principles. But "there are no immediate sensations anywhere in science or in commonsense" (Feyerabend 1984, 16). The problem for Feyerabend is that, since they do not discuss the origin and authority of sense data or logic, their explanations inevitably remain incomplete: "existing principles of science, compared in an incomplete fashion with fictitious entities supposed to be their one and only subject matter naturally will appear arbitrary and fictitious themselves. And an agency that connects the fictions with reality – Einstein's 'intuition', Planck's 'faith' (Dirac's 'beauty') – is bound to have some very strange properties" (Feyerabend 1984, 16-17). According to Feyerabend, this is why Einstein speaks of a "religious basis for scientific endeavor". Such comments (and others like them) are a consequence of how artificial and incomplete his conception of scientific discovery is. That's not the case with Mach.

Finally, Feyerabend uses the idea that Mach sought to eliminate the sharp distinction between facts and ideas to explain the latter's rejection of relativity. According to Feyerabend, Mach considered those theories which did not eliminate these distinctions to be provisional. The attitude of some followers of relativity, such as Planck, who saw the theory as capturing reality, would be what Mach would have perceived as dogmatism.[10]

Feyerabend on Discovery and "Free Creations"

For Feyerabend, the critique of theoretical principles as "free creations" is not merely a critique of an unrealistic account of the process of discovery. Feyerabend considers that there are negative consequences to believing that theoretical principles are "free creations".

> Talking of "free creations" (or "bold hypotheses") disregards this complex net of determinants, replaces it by a naive and fictitious account and deceives the researcher about his task. For – and this is Mach's warning – any train of thought that leads away from instinct loses touch with reality and causes "dreamlike excesses and unfortunate monstrous special theories". (Feyerabend 1984, 19)

Feyerabend emphasizes not only Mach's warning to avoid thinking of theoretical principles as "free creations", but also the idea that ignoring this warning has negative consequences, namely the creation of "monstrous theories". Feyerabend's point strongly suggests that we should refrain from creating such "monstrous theories". This conclusion is surprising, considering that it comes from a proponent of the principle of theory proliferation.

Feyerabend is known for arguing that, when it comes to deciding which theories we should investigate, there are no valid general methodological considerations that would rule them out, i.e., "anything goes". Some authors, such as Oberheim (2006), argue that Feyerabend proposed the idea that "anything goes" only as part of a *reductio ad absurdum* to refute that there are universal methodological principles. On the other hand, Jamie Shaw

[10] Significant criticisms of Feyerabend explanation have been presented by Wolters (1987, 252-254).

(2017) argues that, in fact, "anything goes" is a positive thesis defending methodological opportunism or is a consequence of the tenacity principle and pluralism. In any case, and despite the fact that it is a more sophisticated thesis than is often thought, the secondary literature seems to agree that Feyerabend's "anything goes" does imply that "there isn't a single context in which it is rational to refrain from proliferating alternatives or tenaciously developing established theories" (Shaw 2017, 7). Also, "as Feyerabend hints in *Against Method*: 'Galileo is to be applauded here because he preferred protecting an interesting hypothesis to protecting a dull one'. And perhaps that comes to saying that any theory that anyone really cares to pursue is worth pursuing" (Chang 2021, 42). But then the question arises: how do we understand Feyerabend's warning from Mach about not assuming that theory creation is "free" and thus avoiding "monstrous theories"? It is at least strange, if not paradoxical, that Feyerabend sided with Mach against the idea of theoretical principles as "free creations". How do we understand that the defender of the proliferation of alternative theories opposes the idea of "free theory creation"?

To clear this issue it is useful first to clear what we are talking about a bit more. Theory creation is part of what is traditionally called the "context of discovery". However, as Larry Laudan (1981, 181-182) points out, what we call "discovery" here is ambiguous. According to Laudan, the traditional distinction between the "context of discovery" and the "context of justification" assumes that the latter concerns only the study of evidence relevant to the final product of research. Then "discovery" concerns everything that comes before. Discovery "would include an account of how a theory was first invented, how it was preliminarily evaluated and tested, how it was modified, and the like" (Laudan 1981, 181). Laudan proposes reducing ambiguity by introducing a third category, between the "context of discovery" and the "context of justification", which he calls the "context of pursuit". The "context of pursuit" would include the processes by which we evaluate whether a proposed theory is worth further discussion, articulation, and research.[11] Thus, we can refer to discovery more precisely as the "eureka moment", the moment when a new idea first emerges. In discussing whether theories are "free creations", Feyerabend seems to be referring to discovery in the latter sense.[12]

Today, we hardly think of moments of invention, or discovery (in the sense established), as subjected to rules or restrictions. However, according to Laudan, during the 17th and 18th centuries, it was thought possible to articulate inductive rules for the discovery of theories. Induction was understood as an inferential process that could be controlled by rules which, if properly identified and followed, could lead to the formulation of new and fruitful theories. However, "By the last half of the 19th century, this enterprise was dead, unambiguously repudiated by such philosophers of science as Peirce, Jevons, Mach, and Duhem" (Laudan 1981, 183). In fact, Einstein seems to use the phrase "free creations" precisely in contrast to the idea of previous generations who sought a logic of discovery: "[...] the scientists of those times were for the most part convinced that the basic concepts and laws of physics were not in a logical sense *free inventions* of the human mind, but rather that they were derivable by abstraction, i.e. by a logical process, from experiments. It was the general Theory of Relativity which showed in a convincing manner the incorrectness of this view" (Einstein 1934, 166, emphasis added). However, there is a difference between saying that there are no rigid inductive rules for discovery and saying that there are no rules at all.

[11] In recent years, there has been a resurgence of interest in the context of pursuit. A more recent exposition of this concept can be found, for example, in Jamie Shaw (2022).

[12] Feyerabend rejected the distinction between "context of discovery" and "context of justification" in *Against Method*. However, I think it useful to point out that the issue Feyerabend was addressing in the debate about Mach and Einstein is related to what we usually call discovery, in the sense explained.

In "Creativity – A dangerous myth", Feyerabend takes up the contrast between Mach and Einstein to argue that we should avoid viewing the process of creating new ideas as something mystical or occult. Rather, we should view this process as a natural phenomenon, something that happens under the right circumstances. Feyerabend emphasizes here that Mach also rejected the inductivist conception of discovery. For Mach, induction does not create new knowledge: "The name 'inductive sciences' for the natural sciences is therefore not justified" (Mach 1976, 231). Despite this, Mach resists the idea of viewing concepts as "free creations".

> Numbers are often called "*free creations* of the human spirit". [...] However, an understanding of this creation is helped much more if we pursue its instinctive beginnings and consider the circumstances that produced the need for it. Perhaps this will lead us to the insight that the first formations in this field were *unconsciously forced by biological and material conditions*, and their value could not be appreciated until they were in existence and had often proved useful. (Mach 1976, 243, emphasis added)

Rather than speaking of free creation, Mach believes we should try to understand how biological and material conditions give rise to new ideas. The contrast Feyerabend sees between Einstein and Mach is that the former does not offer an analysis of how ideas arise, but rather speaks of intuition or connects the matter with a "religious attitude". Mach at least makes an attempt to analyze the process of idea creation. Mach's instinct is different from Einstein's intuition, in that the former is analyzable while the latter is not. In the case of Einstein's intuition, we only have a mysterious faculty that can produce a new idea for some reason. Mach "replies that the instinct that makes a researcher formulate general principles without a detailed examination of relevant empirical evidence is the result of a long process of adaptation to which all of us, scientists as well as non-scientists, are subjected" (Feyerabend 1987, 706-707).

Specifically, Feyerabend highlights two key differences between Mach's concept of instinct and the intuition or faith of Einstein and Planck. "First, instinct does not operate on sensations, it operates in a concrete historical situation [...]. Secondly, 'instead of engaging in mysticism', Mach asks 'how do these instinctive pieces of knowledge arise [...] what is contained in them?' and 'what is the source of their greater authority' greater, that is, than experimental results?" (Feyerabend 1984, 17). Mach indicates, in response to the first question about the content of instinctive knowledge, that it contains restrictions on our expectations. It points out what kinds of events cannot occur when conducting an experiment. An example is found at the beginning of the *History of Mechanics*, in which Mach exemplifies instinctive knowledge with the idea that perpetual motion cannot occur. Regarding the second question, Mach maintains that instinctive knowledge is based on countless experiences, not those of a single researcher but rather those of countless people. Because of this, instinctive knowledge, despite being fallible, is much more reliable than the experience that a single researcher can produce.

Feyerabend highlights Einstein's emphasis on the arbitrary and fictitious nature of theoretical principles, arguing that there is no logical path from experience to those principles. Mach would agree with this last point. "But Mach did not admit that the principles were therefore 'freely created by the human mind', and *rightly so*, for there are many constraints beyond those allegedly imposed by logic, and 'rational' action not merely attends to these additional constraints but is also carried along by them" (Feyerabend 1984, 19-20, emphasis added). Feyerabend explicitly sides here with Mach against Einstein's idea that theoretical principles are "free creations". Principles are not determined by sensations or inductions, but this does not make them completely free, since they are still determined by factors such as instinct and circumstances. Although it is true that neither Mach nor Feyerabend has a complete explanation of how new ideas are generated, both consider the

process susceptible to study and propose that biological and material conditions are determining factors.

It may seem doubtful that it's possible to explain the formation of new ideas based solely on the circumstances in which they occur. Creativity seems to imply the need for something beyond those circumstances. That is, although circumstances may contain the elements we need to create something new, an agency is still required to identify how to bring those elements together. "But as we can read in many descriptions of scientific discovery, this 'bringing together' occurs almost by itself and is disturbed rather than helped by conscious intervention. Thus Mach has provided the elements of an explanatory sketch where Einstein (and Planck, and others) simply speak of 'free creations of the human mind'" (Feyerabend 1987, 707). Mach's sketch is to point out how instinctive tendencies can operate to generate new ideas, even without us having to resort to the idea of something like consciousness.

Feyerabend concludes his article on creativity by pointing out that the idea of hidden faculties (such as creativity itself, or even the idea of consciousness) separates us from the natural world. Human beings are distinct from the world around them because, while the latter can be explained, human consciousness and creativity are seen as inexplicable. Feyerabend urges us to reintegrate our conception of human beings with the natural world.

Proliferation of Theories Without Free Creations?

Feyerabend's criticism of Einstein and of the very idea of creativity is part of a rejection of what he considered a misguided view of the origin (or discovery) of ideas. Now, if Feyerabend was just trying to point out the correct way to understand how new ideas are produced, then there isn't really a tension with the proliferation principle. In other words, if the idea of "free creation" is for Feyerabend merely an inadequate description of the process for producing new theories, then rejecting that description wouldn't necessarily imply the need for any kind of restriction on that process. However, Feyerabend seems to be saying something else. He claims that "Talking of 'free creations' (or 'bold hypotheses') disregards this complex net of determinants, replaces it by a naive and fictitious account and deceives the researcher about his task. For – and this is Mach's warning – any train of thought that leads away from instinct loses touch with reality and causes 'dreamlike excesses and unfortunate monstrous special theories'" (Feyerabend 1984, 19). Here, Feyerabend states that there are indeed negative consequences of assuming that theories are free creations. This assertion can be understood as motivating some form of restriction, since it strongly implies that we should avoid "monstrous theories". Unfortunately, Feyerabend doesn't elaborate sufficiently on this point.

There appear to be at least two negative consequences for scientific practice that Feyerabend attributes to the idea of theories as "free creations". The idea that theories are "free creations" has the consequences, according to Feyerabend, of disregarding the "complex net of determinants" and "deceiving the researcher about his task". What Feyerabend seems to be saying is that the notion of "free creations" leads researchers to misunderstand how new theories are formed. As a consequence, the researcher may underestimate the contextual characteristics of the situation being investigated (the nature of the problem, the material resources available to him, his own cultural and social biases, or even the peculiarities of his cognitive and instinctual resources). Instead of paying attention to these "determinants", the researcher may come to believe that she possesses hidden faculties that she recognizes, for example, through aesthetic sensations. Thus, the researcher gives herself permission to speculate much more than the specific situation allows. She trusts that her intuition or aesthetic sensations will tell her whether she is on the right path. "And an agency that connects the fictions with reality – Einstein's 'intuition',

Planck's 'faith' (*Dirac's 'beauty'*) – is bound to have some very strange properties" (Feyerabend 1984, 16-17, emphasis added).

It's not that intuitions or aesthetic sensations aren't important in the discovery process; on the contrary, they certainly are. The problem is that, by not understanding the process by which we produce new ideas, we can end up attributing to these sensations functions that possibly aren't theirs, such as justification. "For – and this is Mach's warning – any train of thought that leads away from instinct loses touch with reality and causes 'dreamlike excesses and unfortunate monstrous special theories'" (Feyerabend 1984, 19). In contrast, the elements that Feyerabend calls "determinants" consist primarily of contextual aspects and are therefore the ones that can guide thinking toward *relevant* ideas, that is, those in tune with the research situation at hand.

I think we can understand the warning Feyerabend takes from Mach against the idea of "free creations", and its relationship to the proliferation principle, as follows: for Feyerabend, any theory may be worth pursuing, in principle, but in practice, we must still ensure that theories are *relevant* in the first place.

The concept of *relevance*, as I understand it here, assumes that all research is primarily defined by an objective. We investigate because there is something we want to know. In turn, this epistemic goal is motivated by a wide diversity of concerns and interests. In the process of discovery, we ideally seek theories that contribute to producing the knowledge necessary to satisfy these concerns and interests. A theory will be more relevant to us to the extent that it satisfactorily addresses a greater proportion of our concerns and interests. No theory can be completely satisfactory with respect to all our concerns; it is a matter of degree. Furthermore, what these concerns and interests are, as well as what makes our response to them satisfactory, depends strongly on the context. A theory may be of little relevance in one era if the appropriate technological means to test it are lacking, but it may be relevant in a more advanced era. Contextual aspects, such as technological and material resources, contribute to determining the relevance of a theory. Unlike notions such as "empirical adequacy" or "problem-solving capacity", relevance is not assessed in general terms, but rather in relation to the specific research objective. A theory can be empirically adequate or solve multiple problems without necessarily contributing to the specific objective of the research in which we are participating. Furthermore, the notion of problem-solving capacity, as such, does not consider the degree to which a solution to a difficulty is satisfactory. We can solve the problem of having a broken-down car by getting rid of it, but presumably it will be more satisfying to identify what it needs to function properly.

In principle, all theories may be worth pursuing, since they can all lead us to new predictions, but not all are equally relevant in all cases. In some circumstances, theories may not offer compelling solutions for us, even if they are sophisticated. Theories are not created in a vacuum, they are responses to specific situations, and in them, some theories may be more relevant than others. Believing that theories are "free creations" misleads the researcher about their task because it causes them to lose sight of relevance. We evaluate relevance precisely by the way theories answer or resolve specific concerns. Viewing theories as "free creations" disconnects them from the contextual factors that motivate their creation. Investigating any theory that relevantly addresses our needs is not the same as investigating any theory just for the sake of having theories. Feyerabend may at times seem to argue that the principle of proliferation implies that any means of proliferation is acceptable. However, the critique of the idea of "free creations" suggests that even the proliferation of theories is limited or guided by the relevance of the theories to specific needs.

The idea here is that a "monstrous theory" is one that lacks relevance. It is not that Feyerabend considers such theories to be "free creations", given his own argument that there are no such things in the first place. Rather, Feyerabend considers that it is the very idea that theories are "free creations" that leads to the creation of "monstrous" theories.

There are a variety of contextual aspects that must be considered when proposing theories, which Feyerabend refers to as a "complex net of determinants". But the mere fact of thinking of theories as "free creations" leads us to "disregard this complex net of determinants [as a consequence our thought] loses touch with reality and causes 'dreamlike excesses and unfortunate monstrous special theories'" (Feyerabend 1984, 19). In other words, monstrous theories are not truly "free creations" but rather theories elaborated by researchers who, believing them to be "free creations", fails to consider the context of their research (the net of determinants) with sufficient care. Ignoring relevant aspects of the research context is precisely what causes theories to ultimately prove irrelevant.

In Feyerabend's critique of Einstein, we can distinguish: 1) the epistemological assertion that theories are never created entirely freely; 2) the normative assertion regarding how scientists should approach the creation of theories (carefully considering contextual aspects such as the nature of the problem, the material resources available to them, their own cultural and social biases, or even the peculiarities of their cognitive and instinctual resources), and; 3) the practical consequence of creating monstrous (irrelevant) theories due to a misunderstanding of the discovery process.[13] There is no conflict between 1) and 3), that is, between the assertion that there are no theories that are "free creations" and the consequence of creating monstrous theories. It is the inadequate understanding of the discovery process (and not the impossible free creation) that generates such monstrous theories. From there follows 2), we should search theories that contribute to an objective in a manner that considers our concerns and interests.

Feyerabend even points out that the very idea that we should proliferate alternative theories is motivated, or justified, in the context of a goal. In *Against Method*, Feyerabend (1993/1970, 23) argues that he does not seek to propose a new methodology, substituting some general rules for others. According to Feyerabend (1993/1970, 29), the demand to increase the empirical content of our knowledge is what makes the proliferation of alternative theories advisable. More than a general rule, proliferation of alternatives is a means advisable if we want to increase the empirical content of our knowledge. Then, if there are ways of proliferating theories that might negatively affect our ability to achieve that goal of increasing empirical content, it would make sense to avoid them.

Also, we can understand Feyerabend's defense of Mach by considering that what Feyerabend is really defending is Mach's right to reject a theory that was not relevant to his purposes. It is not that relativity did not have the value that Feyerabend himself knows it has, it is that (in his reading) Mach is looking for a kind of approach for which that theory was not relevant. Feyerabend considers that behind Mach's reservations against relativity is the conjecture that "mental' events have 'material' ingredients (and vice versa), and his attempt to develop a point of view that took these matters into account" (Feyerabend 1984, 21). According to Feyerabend, it is the reluctance of other physicists to consider these questions that justifies the charge of dogmatism. Such dogmatism is, therefore, linked to an underestimation of the plurality of concerns that must be considered when proposing theories. Accepting a theory as a given can lead us to ignore concerns that the theory does not answer. In such cases, a particular researcher's rejection of an accepted theory may be justified, not because everyone must also reject it, but because such rejection reminds us of concerns that remain unanswered.

One still might question why anyone would ignore their context and propose, or to defend, an irrelevant theory. In other words, isn't Feyerabend's warning empty, since no one in their right mind would create theories just for the sake of creating them and not to address some relevant need? As already indicated, one answer is that, by mistaking their role, researchers may try to create theories without worrying about attuning to the concerns

[13] I thank one of the reviewers for pointing out to me the importance of making this distinction explicit.

arising from their context. If we believe we should freely create theories, then we may assume that theory creation is an end in itself. Furthermore, we may come to believe that other, more mundane ends, such as keeping our jobs or publishing articles, may be sufficient motivation to create theories, even if these theories lack relevance to the problems facing our society.

Whatever the process that generates new ideas in the mind is, it is plausible that an agent's brain produces those ideas as responses to the concerns that plague him. If those concerns include only personal considerations, and the particular research problem supposedly being addressed is only a tangential concern, it is possible that the brain will only produce ideas that are meant to save face and not actually advance the research. Recall that Feyerabend considers that most of what we consider a "creative process" is unconscious; it is our mind responding to the situation we have presented to it, which may not contain concerns relevant to the research.

A possible example of the type of situation Feyerabend seems to be warning against is what is said to be happening in some areas of physics. In recent years, authors such as Sabine Hossenfelder (2018) and Johannes Branahl (2024) have expressed concern about an apparent lack of progress in particle physics. According to them, there is currently an overemphasis among physicists on the aesthetic aspects of theories, which has led to the *proliferation* of unsuccessful theories. The same authors point to the *tenacity* of many physicists who cling to their theories even when their predictions fail. Aesthetic concerns or a sense of "naturalness" are assumed to be sufficient reasons to propose such theories. The construction of more and more expensive particle accelerators only refutes the predictions of these theories again and again, but physicists, far from abandoning them, seek explanations that can only be tested using even more expensive accelerators. Now, I am not trying to say that I agree with this diagnosis of the current state of physics. I am not in a position to evaluate that, and in any case, it would require a very different discussion from the one presented here. What I am trying to point out is simply that the kind of situation described by some authors in current physics can be understood as a possible example of how the emergence of the "monstrous theories" Feyerabend pointed out can occur. The connection between the current situation of particle physics and Feyerabend concerns is, admittedly, only tentative. But I believe it illustrates well enough the warning he was recovering from Mach. It is the misconception of the process of discovery, namely the idea that aesthetic concerns of a sense of naturalness are more important than other contextual factors, that leads to the creation of theories that ultimately result irrelevant.

Too much concern with aesthetic issues is misguided, not because those issues are unimportant, but because their function is not evaluated. The aesthetic reactions that theories generate in us are indicative of something, but it is not clear what. The aesthetic sensation can be understood, for example, as the feeling of relief from tensions that previously seemed unresolved. Sometimes, these tensions may have been partially identified by experts, even if they have not been explicitly articulated. That science is more than knowledge articulated in propositions has been pointed out for several years. The resolution of these unarticulated tensions can generate aesthetic sensations and are therefore not unimportant. On the other hand, this does not mean that those aesthetic sensations can ever provide justification in and of themselves. Furthermore, it is possible that aesthetic sensations can also occur for other reasons, some of them spurious. Feyerabend appreciated Mach's effort to evaluate the function of imagination and sensations in the creation of theories. Again, failure to investigate these issues misleads the researcher. When one assumes that the aesthetic sensations of physicists (or Einstein's intuition or Planck's faith) come from occult, mysterious, or even mystical faculties, one concludes that these sensations in themselves justify interest in theories. But without a clear understanding of how and why these sensations occur, it will also be unclear what we can actually infer from them.

Finally, we can add that Feyerabend explicitly recognized a situation like the one that supposedly plagues current physics, but which plagued (or continues to plague) the philosophy of science. As we saw, Feyerabend began to express his interest in Mach in the same article in which he criticized the philosophy of science of his time: "Philosophy of science: A subject with a great past". In this text, Feyerabend points out that much of the philosophy of science had become irrelevant for the purpose of analyzing science. We create formal and abstract theories that may even be aesthetic, but that have little or nothing to do with scientific practice.

> What we must do is to replace the beautiful but useless formal castles in the air by a detailed study of primary sources in the history of science. *This* is the material to be analysed, and *this* is the material from which philosophical problems should arise. And such problems should not at once be blown up into formalistic tumours which grow incessantly by feeding on their own juices but they should be kept in close contact with the process of science even if this means lots of uncertainty and a low level of precision. (Feyerabend 1999/1970, 137)

Clearly, Feyerabend did not consider it fruitful here to proliferate irrelevant theories about science and tenaciously cling to them.

Conclusion

As stated in the introduction, *the purpose of this paper is to show that the position taken by Feyerabend in the debate over interpretations of Mach does imply that he conceived of restrictions on theory creation*. These limitations consisted of taking contextual considerations as criteria of relevance, so that theories that do not comply with the limitations imposed by these considerations should be avoided. As we saw, Feyerabend not only rejects the description of the process of theory creation as free, but insists that there is an attitude that derives from this idea and that should be avoided. Assuming that theory creation is a free process results in theories being produced in ways that do not effectively respond to the circumstances in which they are proposed.

It remains true that, for Feyerabend, it is important to proliferate theories. There is no reason to think that limiting ourselves to considering only relevant theories generates unique theories; that is, it is always possible for us to multiply the number of relevant theories. But there is a danger in assuming that the multiplication of theories is an end in itself. We risk forgetting the particular circumstances to which we seek to respond with theories. This danger is a genuine one, and examples of its consequences can possibly be found, as we saw in section 6.

Finally, this analysis shows that the study of "discovery" processes, and not just the "contexts of pursuit" and "justification", is more relevant than is currently assumed. Feyerabend's discussion shows that there are important implications, not only for our understanding of science but for scientific practice itself, of failing to analyze the conditions under which new scientific ideas are produced. Although it is widely recognized that it is not fruitful to separate what has traditionally been called the "context of justification" from that of "discovery", there are still aspects of the latter that seem to be forgotten. In recent years, there have been more detailed studies of the "context of pursuit", but it is important to remember that this context is not the entirety of what we commonly call discovery. Feyerabend and Mach's warning is that we ignore important aspects of "discovery" to the detriment of our own discipline and of science itself.

Acknowledgements

I would like to thank Godfrey Guillaumin for encouraging me to read Mach and Feyerabend's texts on Mach.

References

Blackmore, John. 1972. *Ernst Mach. His work, life, and influence*. Berkeley: University of California Press.

Branahl, Johannes. 2024. The reasonable ineffectiveness of aesthetics in particle physics. *arXiv* (june). https://doi.org/10.48550/arXiv.2406.15837.

Chang, Hasok. 2021. The coherence of Feyerabend's pluralist realism. In *Interpreting Feyerabend,* edited by Karim Bschir and Jamie Shaw, 40-56. Cambridge: Cambridge University Press.

Einstein, Albert. 1934. On the method of theoretical physics. *Philosophy of Science* 1 (2): 163-169.

Einstein, Albert. 1954/1936. Physics and reality. In *Ideas and opinions*, edited by Carl Seelig, 290-323. New York: Bonanza Books.

Einstein, Albert. 1996/1916. Ernst Mach. In *The collected papers of Albert Einstein, Vol. 6*, edited by A. J. Kox, M. J. Klein and R. Schulmann, 141-145 (doc. 29). Princeton: Princeton University Press.

Feyerabend, Paul. 1980. Zahar on Mach Einstein and modern science. *The British Journal for the Philosophy of Science* 31: 273-288.

Feyerabend, Paul. 1984. Mach's theory of research and its relation to Einstein. *Studies in History and Philosophy of Science* 15 (1): 1-22.

Feyerabend, Paul. 1987. Creativity. A dangerous myth. *Critical Inquiry* 13: 700-711.

Feyerabend, Paul. 1993/1970. *Against method.* 3rd edition. London: New Left Books.

Feyerabend, Paul. 1999/1970. Philosophy of science. A subject with a great past. In *Knowledge, science and relativism (Philosophical papers Vol. 3)*, edited by John Preston, 127-137. Cambridge: Cambridge University Press.

Hentschel, Klaus. 1985. On Feyerabend's version of "'Mach's theory of research and its relation to Einstein". *Studies in History and Philosophy of Science* 16 (4): 387-394.

Holton, Gerald. 1968. Mach, Einstein, and the search for reality. *Historical Population Studies*: 636-673.

Hossenfelder, Sabine. 2018. *Lost in math. How beauty leads physics astray*. New York: Hachette Book Group.

Howard, Don. 1993. Was Einstein really a realist? *Perspectives on Science: Historical, Philosophical, Social* 1 (2): 204-251.

Laudan, Larry, 1981 *Science and hypothesis. Historical essays on scientific methodology*. Dordrecht: D. Reidel Publishing Company.

Mach, Ernst. 1926. *The principles of physical optics*, translated by John S. Anderson and A. F. A. Young. Dover Publications, INC.

Mach. Ernst. 1976. *Knowledge and error*, translated by Thomas J. McCormack and Paul Foulkes. Dordrecht: D. Reidel Publishing Company.

Mach Ernst. 2013. *The science of mechanics*, translated by Thomas J. McCormack. Cambridge: Cambridge University Press.

Miller, Arthur. 1981. *Albert Einstein's special theory of relativity*. Massachusetts: Reading.

Oberheim, Eric. 2006. *Feyerabend's philosophy*. New York: De Gruyter.

Oberheim, Eric and John Preston. 2025. Paul Feyerabend. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta and Uri Nodelman.

https://plato.stanford.edu/archives/spr2025/entries/feyerabend/ Accessed August 29, 2025.

Preston, John. 2024. Feyerabend and Mach. In *Feyerabend in dialogue*, edited by Stefano Gattei and Robert Corvi, 59-91. Cham: Springer.

Shaw, Jamie. 2017. Was Feyerabend an anarchist? The structure(s) of "anything goes". *Studies in History and Philosophy of Science* 64: 11-21.

Shaw, Jamie. 2022. On the very idea of pursuitworthiness. *Studies in History and Philosophy of Science* 91: 103-112.

Wolters, Gereon. 1987. *Mach I, Mach II, Einstein, und Die Relativitätstheorie. Eine Fälschung und ihre Folgen*. Berlin: Walter de Gruyter & Co.

Wolters, Gereon. 2012. Mach and Einstein, or, clearing troubled waters in the history of science. In *Einstein and the changing worldviews of physics*, edited by Christoph Lehner, Jürgen Renn and Matthias Schemmel, 39-57. Boston: Birkhäuser.

Wolters, Gereon. 2019. Mach and relativity theory. A neverending story in HOPOSia? In *Ernst Mach. Life, work, influence*, edited by Friedrich Stadler, 367-385. Cham: Springer.

Zahar, Elie. 1977. Mach, Einstein, and the rise of modern science. *British Journal for the Philosophy of Science* 28: 195-213.

Zahar, Elie. 1981. Second thoughts about Machian positivism. A reply to Feyerabend. *The British Journal for the Philosophy of Science* 32 (3): 267-276.