ERNST MACH CENTENARY CONFERENCE 2016
Ernst Mach (1838–1916) – Life, Work, and Influence

Abstracts

Invited speakers

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Mach's influence on Einstein's "biggest blunder" and the Consequences for Modern Cosmology

It is well known that Einstein was strongly influenced by Mach's Ideas in his struggle for a new theory of gravitation. In 1915 he published what he thought to be the final equations, but only one year later he modified them by adding a "cosmological constant" One of the reasons for this modification was to implement what Einstein called "Mach's principle". I discuss the history of the cosmological constant and the puzzle of modern cosmology.

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The Specter of "Austrian Philosophy": Ernst Mach and a Modern Tradition of Post-Philosophy

The idea of an "Austrian philosophy" ghosts its way through intellectual history, usually in reference to a very limited set of philosophical projects and significant players (Brentano, Mach, Wittgenstein, "Austrian Economics," the Vienna Circle, Quine, sometimes Bolzano). That term, however, reflects the Anglo-American-German canon of Idealist "continental" philosophies that prefers to see Kant as an idealist and Hegel as the source of historical thought.

The proposed paper will take up the case of Ernst Mach's textbooks and popular-scientific writings, especially his *Knowledge and Error* (*Erkenntnis und Irrtum: Skizzen zur Psychologie der Forschung*, 1905), as a guide to a different history of philosophy based on a specific reception of Kant, one which might be "Austrian" but which is neglected as peripheral to the history of philosophy. This Kantian tradition takes the shape of a critical epistemology that tied the production, validation, and valuation of knowledge into an embodied philosophical critique. As such, it reflects the transformation of philosophy into something closer to what Kant had described in his *Conflict of the Faculties* (1798) – a heuristic for epistemological critique, explaining how understanding is embedded in the power exerted by groups, social organization, and historical inheritance.

Ernst Mach is central to my account of this "Austrian" tradition, as "not a philosopher, nor wishing to be one," as he models not psychophysics or philosophy (not disciplines), but rather a "philosophical" systematic critique of physics, drawn from the traditions more encompassing heuristic for understanding knowledge production within imminent systems of thought. Mach's goal is thus neither classical ontology nor epistemology, but an almost Foucauldian approach to knowledge and power, exploring how knowledge is produced and used within regional ontologies as truth practices upheld by socio-culturally identifiable groups. Thus his project does not pretend to understand mind as functioning in terms of abstract logical principles, but rather accounts for the problems and effects of embodied rationalities inculcated in groups by rule-governed practice, inheritance, and the autopoesis of semiosis in grasping experience.[1]

The "Austrians" who are part of this tradition of philosophical innovation are tied together by their commitment to knowledge production as culture *in process* (Kristeva's *en procès*, meaning both *in production* and *on trial* for its validity and worth). Critically, they are not exclusively Austrian, even though Austrian theorists of many different disciplines are overrepresented in this tradition. Many of them point to a source for their interest in the critique of disciplinary knowledge: Robert von Zimmerman (1824–1898), a student of Bernard Bolzano, who provided the textbook that inculcated the how to of this critical approach to three generations of the Austrian intelligentsia, his *Philosophische Propädeutik* (1852).[2]

As a representative of their shared program, Mach's goal is to produce something closer to a Wissenschaftslehre, one that simultaneously interrogates the structure and value of knowledge, the conditions for its production, and its necessary limits within frames of reference. Mach's work thus suggests that the rubric of "Austrian philosophy" obscures a fundamental transformation of the discipline of philosophy into the tradition reaching from Bolzano to Wittgenstein and the Vienna Circle, and beyond. Mach shows us how knowledge production can be critiqued from the point of view of a Wissenschaftslehre, where the profound social engagement built into a heuristic for scientific critique emerges not only as a heuristic, but also as a Lehre, a teachable engagement with the conditions for knowledge production. Thus Mach's textbooks and popular scientific writings are key to understanding this alternate Kantian tradition – not as a disciplinary formation, but as a social and critical epistemological practice within a historically situated frame of reference.

The model for an Austrian post-Kantian critical tradition (rather than a "philosophy") rests on a reception of Kant's work that adheres more closely to Kant's account of the Begriff as a psycho-physical act (an act shaping both mind and knowledge production). In the first Critique, the concept is a created entity, grasped

1 And thus a quite other semiosis than is described by Charles Sanders Peirce and more like what Julia Kristeva describes in *Séméiôtiké: recherches pour une sémanalyse,* Paris: Edition du Seuil, 1969. (English translation: *Desire in Language: A Semiotic Approach to Literature and Art*, Oxford: Blackwell, 1980.)

2 And also very like Gaston Bachelard's *La formation de l'esprit scientifique: contribution à une psychanalyse de la connaissance objective* (1938); *The Formation of the Scientific Mind*. Clinamen, Bolton, 2002. Translation by M. McAllester Jones. (*La formation de l'esprit scientifique*)

through the mediation of the material, including both visual and verbal signs construed as the elements of logical patterns, but also the habits and cultural inheritance, defined as systems of meaning-making and -transmission that are shared within (social, historical, professional) groups and passed down between generations, sometimes in the form of praxis rather than logos. In attending to semiosis and praxis alongside logical truth production and verificationism, this tradition of critical epistemology systematically eschews ontology as a purely hypothetical discipline and concentrates instead on the implications of how group mind produces knowledge through memory and mediation.

This "Austrian tradition" requires experts to reach beyond the truth of propositions and to engage also the frame of reference in which they are generated. It is also utterly empirical but not an empiricism of objects. Thus this critical epistemology becomes a new kind of empirical discipline. The Kant preserved in this tradition is the Kant of all three Critiques together, offering a vision of epistemology as an analysis of the conditions for the possibility of knowledge production within three fundamental and indivisible frames of reference within which the act of judging takes place. It assumes that all knowledge production will proceed in light of not only logics, but also of morals (utilitarian and otherwise) and the physical record (aesthetics as defined by Baumgarten, the act of judging through the body).

Most critically, this alternate Kantian tradition to which this paper turns emerges as a true "Copernican revolution" in philosophy because it moves beyond the emphasis on mind in and of itself that the Enlightenment highlighted. In his popular work, for example, Mach sketches out how knowledge production in physics depends on historical frames of reference, based on the potential of individual mind but ultimately functioning within a broader set of human rationales and potentials. In all cases, mind's production of knowledge is also absolutely constrained and pre-ordered by historical situation, inheritance, and the norms for semiosis and praxis existing within the community defining and defined by particular regimes of truth – a function of knowledge production that reaches far beyond the logocentrism of the earlier Enlightenment.

This heuristic at the heart of this tradition also points up the limits on classical hermeneutics, and allows an explanation of the "linguistic turn" of twentieth-century "Austrian philosophy" as a move toward specifying a more general hermeneutic-critical impulse as the condition for knowledge production. Classical hermeneutics models the transfer of information between a text (with the term referring to both written texts and artifacts) and its consumer (reader, viewer, user), as a guarantor of human ability to recover meaning from texts, hence oriented toward the past. The analysis strategy represented in Mach's work redefines the hermeneutic circle as a circuit of inductive and deductive judgments about evidence gathered perceptually-physiologically, but then processed into knowledge within a specific frame of reference, defined culturally, and with the goals of cultural communication and of pointing towards the present and the future. This heuristic thus operates through a critique of the production, circulation, and production of knowledge as meaningful only in situated frames of reference, not as a model of understanding an sich.

My presentation thus samples Mach's project as part of philosophy's turn toward a new identity in the 20th century. No longer a master discipline, the "Austrian" project of scientific critique reclaims the space for knowledge production within frames of reference (e.g. disciplinary communities); it seeks within those frames not only logic, but also human experience and values, as well as the influence of more specialized or localized communication communities, imbued with the kind of power that would become the focus, in the twentieth century, of the great post-philosophy philosophical-critical project of poststructuralism.

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"The Land of my Deepest Longing". The American Reception of Ernst Mach's Ideas

Ernst Mach's philosophical ideas were warmly received in America, which already had a pragmatist tradition close to Machian empiricism and budding schools of philosophy, psychology, and physics more or free of the neo-Kantian influences which were a strong academic competitor to the spread of empiricism in Europe. The founding pragmatists Charles Sanders Peirce and William James engaged directly with Mach and Paul Carus, the editor of the Monist and publisher of the Open Court press actively translated and published Mach's works for the American public. A generation later when members of the Vienna Circle sought Academic posts in elite American universities, the ground was well prepared for their arrival as Holton and Stadler have described. Beneath the surface however, the American reaction to Mach was not one of naïve admiration but fairly staunch criticism, which Mach himself appreciated and welcomed. Peirce was highly critical of Mach's mechanics in a review and Peirce famously described Mach's empiricism as akin to riding a horse to death. In some ways, Peirce himself had anticipated aspects of Mach's views on mind and body, a surprising discovery I made recently. Even Carus, who declared himself an admirer, was highly critical of Mach's theory of economy of thought. James, too, who admired Mach greatly, had major disagreements with Mach on so-called sensations of innervation in psychology, and although's James' own radical empiricist essays owed much to Mach's neutral monist ideas in the Analysis, James broke away from what he saw as Mach's excessive physical reductionism, rejecting the monism about nature that was Mach's trademark. In short Mach's ideas acted as a stimulus to American thinkers, but they had their own tradition and they were able to resist his authority and contribute in reverse to Mach's own refinement of his positions.

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"Mach, Duhem and the Historical Method in Philosophy of Science"

In 1903 Mach and Duhem, discovering one another's writings, acknowledged the proximity of the philosophical views that they had been elaborating independently. A correspondence followed, which lasted several years. And in their ensuing publications both of these philosopher-scientists were careful to discuss their interlocutor's claims. We have here ample matter for consideration. Mach and Duhem were to have an impact on the development of the Vienna Circle. Yet their conceptions are indeed different from those that followed. Characteristically, they drew on history and psychology. They were interested in the genesis of concepts, the evolution of theories and the patterns of discovery. If rational reconstruction and logical analysis were admitted, these techniques were counter-balanced by historical study. In view of recent evolutions in philosophy of science — the growing importance of cognitive science, history of science, interdisciplinarity — it is worthwhile to return again to the beginning of the 20th century. The aim of this paper is then to reexamine the relation between Duhem and Mach, in particular with regard to the methods whereby they sought to provide a philosophical reflection on science.

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The Principle of Inertial Rotatory Motion in Newton´s Lex I and Ernst Mach

1. Newton´s First law of motion is interpreted by all translators starting with Mott (1729) until todays as the principle of inertial translatory motion (constant vector of velocity).
2. Newton, however, succeeded after all in his effort to formulate the principle of inertial rotatory motion besides that of translatory motion (constant vector of velocity and constant vector of angular velocity) in one-sentence Lex I. At first, in a manuscript preceding the *Principia*, he formulated Lex I in two sentences:

> "Law 1. By reason of its innate force every body preserves in its state of rest or of moving uniformly in a straight line (in *linea recta*) unless in so far as it is obliged to change its state by forces impressed on it. This uniform motion, however, is of two kinds, progressivus along a straight line which the body describes uniformly with its centre, and circular about a certain axis which either rests or with a motion of constant size always remains parallel to its previous position."

3. In the *Principia* Newton combines the one-sentence enunciation of the Lex I with a commentary. The second explicative sentence ("This uniform motion …") is perfectly projected, point-by-point, into the translatory/rotatory commentary examples (translation, rotation, superposition of both):

> "Law I. Every body continues in its state of rest or of uniform motion in the given direction straight on ahead (*in directum*), unless it is compelled to change its state by forces impressed upon it.
> Projectiles continue in their motions, so far as they are not retarded by the resistance of the air, or impelled towards by the force of gravity. A top, whose parts by their cohesion are continually drawn aside fom rectilinear motions, does not cease its rotation, otherwise than as it is retarded by the air. The greater bodies of the planets and comets, meeting with less resistance in freer spaces, preserve their motions both progressive and circular for a much longer time."

4. The translators consider Newton´s "in directum" improperly to be a synonym to "in linea recta". Thus the Lex I is a special case of the Lex II with all consequences involved.
5. Ernst Mach's translation of the Lex I is unwittingly very well usable not only for the translatory motion, for which it is meant, but also for the rotatory motion. Ernst Mach´s involvement is to be considered first of all, of course, in the light of the influence on Mach´s criticism concerning Newton´s work.
6. From *Principia*, Liber III, Prop. XVII, Theor. IV.

> "Diurnal motions of the planets are uniform; and the libration of the Moon arises from its diurnal motion. This is obvious from Law I of motion and Coroll. 22. Prop. LXVI, Book I. . . .
> If Law I were meant only for the translatory motion, there would be no reason for this reference.

7. The most interesting and decisive fact is to be found in the material of Project Newton. There is a Newton´s manuscript enabling to follow Newton´s ways of thoughts when seeking for a proper term. Newton´s decision was "in directum".
8. As far as Ernst Mach is concerned, his translation reads

> "Jeder Körper behält seine Richtung und Geschwindigkeit bei, solange dieselbe nicht durch äussere Kräfte abgeändert wird."

And such a formulation may be applied as well for the translatory motion as for the rotatory one.

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Dynamics and Determinism in General Relativity

I shall describe the problem of dynamics (the "initial value problem") for the vacuum equations of general relativity, and how this seems to stand in contrast to the earlier "Machian" ideas which had inspired Einstein. I will then describe how Laplacian determinism can spontaneously fail for the initial value problem, without the spacetime becoming singular, and the various open problems in the theory which this has given rise to.

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What Mach Owes to Fechner and what he Made of it

In what follows I would like to discuss Mach's considerable debt to Gustav Theodor Fechner, the Leipzig physicist and founder of psychophysics. This is not the appropriate place to review the historical evidence of Mach's strong dependence on Fechner – this has already been done elsewhere. Instead, I want to draw a systematic comparison between Mach's and Fechner's conceptions. It turns out that the major disagreement between Mach and Fechner is over the nature and reach of metaphysics and the relation of the different scientific disciplines to each other. I hasten to add that this is not a story of the brave and heroic anti-metaphysician Mach against the speculative panpsychist Fechner. As is usually the case, things are more complicated than that.

It seems appropriate to start from Fechner's scientific realism in general and his atomism in particular as discussed first in his Über die physikalische und philosophische Atomenlehre of 1855 (2nd ed. 1864). His argument for atomism is a straightforward "inference to the best explanation", as we would call it today. He tried to show in detail that of all known conceptions atomism fares best in explaining pertinent phenomena. He concluded that "until now all our experiences could be grasped and united only on the assumption of atoms; therefore atoms must exist, or at least there is nothing more probable than atoms." Mach wholeheartedly embraced this viewpoint before he started favoring anti-atomism with his Geschichte und die Wurzel des Satzes von der Erhaltung der Arbeit of 1872.

So far, so good. There is, however, a further strain in Fechner's scientific realism that distinguishes it significantly from current conceptions and brought Mach's thought to an antirealist fermentation. Fechner tried to explain the relation of unobservable atoms to observable phenomena in a new way by making use of a bundle theory of substance. Appearances are accordingly seen as parts or constituents of atoms. Any object is made up of given and possible appearances that are 'held together' by natural law. So if we talk of atoms we do not refer to never-appearing objects like things-in-themselves, but to objects whose properties either are actually given in experience or could in principle be given under certain circumstances. What many see as an "obscure something" behind the veil of perception, Fechner contends, is in truth "the possibility linked up in itself of the appearances that can be attached to given ones." Fechner's alternative is very similar to John Stuart Mill's later definition of matter as the "permanent possibility of sensation" (1865) or to Bertrand Russell's doctrine of bodies as collections of given sense-data and unsensed "sensibilia" (1914).

In my talk I will try to reconstruct the essential features of Mach's thought as 'corrections' or transformations of Fechner's outlook. Such modifications were needed in order to account for changes in the relationship of scientific disciplines toward each other that had taken place in the meantime – especially with Darwinism and the new psychology. In particular, I will deal with Mach's antirealism, his conception of causality, his Elementenlehre and his solution of the mind-body problem, all in relation to Fechner. In the final part, I will consider different conceptions of anti-metaphysics and show that, compared with Fechner's views, Mach's anti-metaphysics is in certain regards too restrictive for science. Speculative metaphysics is to be rejected, but we need a healthy dose of Fechnerian inductive metaphysics.

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The Plan to Prepare a Complete Edition of Ernst Mach's Correspondence

A comprehensive edition of the correspondence of the world-famous physicist, physiologist, philosopher, and pioneer historian of science, Ernst Mach (1838–1916), has yet to be compiled. The largest part of this correspondence totaling some 4,000 letters (most of the letters addressed to Mach in his estate after his death in Vaterstetten near Munich in 1916), formerly kept in the Ernst Mach Institut für Kurzzeitdynamik der Fraunhofergesellschaft in Freiburg/Breisgau, is now preserved at the Deutsche Museum in Munich: cf. the detailed published finding aid of these 2,729 letters and other materials: Wilhelm Füßl & Margrit Prussat: Der wissenschaftliche Nachlass von Ernst Mach (1838-1916) (Veröffentlichungen aus dem Archiv des Deutschen Museums, vol. 4). Munich 2001, online summaries http://www.deutsches-museum.de/archiv/bestaende/nachlaesse/verzeichnis/m/mach-ernst/ and http://www.deutsches-museum.de/archiv/archiv-online/ernst-mach/ A smaller partial estate, based on collections by Ernst Mach's son Ludwig has been transferred to the Staats- und Universitäts¬bibliothek Göttingen, and others are kept in Konstanz, Vienna, Prague etc. Mach's own letters are spread throughout Europe and North America in hundreds of archives hosting estates of his contacts.

The projected edition will strive at complete coverage of all of his existing correspondence in an online edition, similar in style to the already completed Sommerfeld correspondence project, prepared in Munich under the guidance of Dr. Michael Eckert (Deutsches Museum, Munich), possibly combined with a select edition of several volumes in book format. Both the complete online edition and the select paper edition will be organized strictly chronologically, which already demarcates the first difference from the various selective correspondence editions that have already been published in book form or as articles, most importantly the following:

- Joachim Thiele: Wissenschaftliche Kommunikation, Die Korrespondenz Ernst Machs, Kastellaun: Henn, 1978 (based on various older articles in journals by Thiele on single correspondents, sorted by groups of correspondents covered in different chapters).
- J.T. Blackmore & K. Hentschel: Ernst Mach als Außenseiter, Machs Briefwechsel über Philosophie und Relativitätstheorie mit Persönlichkeiten seiner Zeit, Auszug aus dem letzten Notizbuch (Faksimile) von Ernst Mach, Vienna, Braumüller 1985 (sorted chronologically).
- Klaus Hentschel: Die Korrespondenz Duhem-Mach: Zur ‚Modellbeladenheit' von Wissenschaftsgeschichte. In: Annals of Science 45 (1988): 73–91 (with their complete letters).
- John T. Blackmore, Ryoichi Itagaki, Setsuko Tanaka (Hrsg.): Ernst Mach's Vienna 1895–1930. Dordrecht: Kluwer Academic Publishers, 2001 (specific letters to and from, e.g., Friedrich Adler, Philipp Frank, Edmund Husserl, Wilhelm Jerusalem,Wilhelm Ostwald et al.).

These publications focus on a few select correspondents. Some, such as the correspondence appendices to Blackmore, Itagaki & Tanaka (eds. 2001), or Blackmore & Hentschel (eds. 1985), are sparcely annotated without text criticism; others, such as Thiele (1978) or Hentschel (1988), are very thoroughly annotated with commentary but are restricted to individual correspondents. The planned online edition will offer full annotation in a format that can be phased in and out on-screen, so that the reader can either concentrate on the professionally presented primary source or select the option including annotation and commentary. Provided permission by the copyright holders is granted, we will also present the original documents in facsimile right next to the scrupulously checked transcription. The advantage of an interactive and collaborative online edition is that the scientific and historical annotation can be intensified and mutually corroborated as the project advances – online presentation also allows the incorporation of cross-links to other documents, and to external sources; furthermore it will be easy to search for particular terms, names, or places in the hugh bulk of many thousands of documents. All mentions to persons and places will be identified and linked to viaf, GND and other standard identifiers. Access to all on-line documents will be free of charge, but active contribution to the edition will be limited to a group of experts who will meet on a regular basis (perhaps once a year) to coordinate their activities in the prospective centers involved, i.e., Stuttgart, the main coordination point; Halle, as the seat of the Leopoldina Academy of Science, with its Studienzentrum; Munich, the location of the bulk of Mach papers; Göttingen; and Konstanz, with its smaller holdings; perhaps also Vienna, Graz and Prague, as the cities of Mach's academic activities, and perhaps others as well (depending on the feedback in the Vienna conference).

The funding of this long-term research and publication project, which will continue for at least a decade, will be sought in the coordinated Academy long-term-grant format, under the umbrella of the German National Academy of Sciences Leopoldina, of which Ernst Mach was a member since 1873 cf. http://www.leopoldina.org/de/mitglieder/mitgliederverzeichnis/member/4264/

The coordination of this project will be assumed by Prof. Dr. Klaus Hentschel (full professor and head of section for the history of science & technology at the University of Stuttgart), who has a long-standing record on working and publishing on Ernst Mach reaching back to 1985. Contributions by other experts on Ernst Mach and/or his some 500 correspondents, who were located throughout Europe, America and Asia, is highly welcome – please contact Prof. Hentschel by email Klaus.hentschel (at) hi.uni-stuttgart.de.

For further literature, see the references in Klaus Hentschel's entry on Ernst Mach in the NDB (1987) http://www.deutsche-biographie.de/sfz70598.html and the various links in https://portal.dnb.de/opac.htm?method=simpleSearch&query=118575767 and https://www.deutsche-digitale-bibliothek.de/entity/118575767 and further links collected in https://de.wikipedia.org/wiki/Ernst_Mach.

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Paris vs. Prague: On Photographs and Epistemological Prerequisites

In spring 1888, an anonymous critic raised severe doubts about Ernst Mach and Peter Salcher's studies, published one year before, on the processes in the air caused by very rapid projectiles. Paraphrasing the experiments for the French popular science magazine "La Nature," the critic insinuated that the photographs upon which Mach and Salcher's argument were ostensibly based must have been of such low quality that they did not allow any well-founded conclusion. The critic did not deny the phenomena Mach and Salcher had presented in their article; he denied that the photographs taken in the course of the experiments could permit any observation of the phenomena. I take the resulting quarrel as a window into the actors' ideas on the requirements of 'good observations' and the role of technical devices in this case. In particular I enquire how the various arguments relate to Lorraine Daston and Peter Galison's framing of photography as an emblem of "mechanical objectivity". We will see that in the case under debate actors neither necessarily favoured photography over naked-eye observation, nor that photographs on their own were valid evidence for a scientific argument.

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Ernst Mach als Experimentalphysiker - ein Überblick

Ernst Mach ist heute gemeinhin als theoretischer Physiker, Wissenschaftsphilosoph und -historiker bekannt, doch hat er den größten Teil seines wissenschaftlichen Lebens als Experimentalphysiker gewirkt und als solcher bedeutende Leistungen als Experimentator und Gerätekonstrukteur vollbracht. Das ungemein breite Spektrum seines diesbezüglichen Schaffens reicht von den ersten Momentaufnahmen schnell fliegender Projektile und den damit verknüpften Pionierarbeiten zur Gasdynamik aus den 1880er Jahren über die experimentelle Prüfung des Dopplereffektes (1861/62) bis hin zu den sinnesphysiologischen Studien, die seine wissenschaftliche Jugendliebe und den Schwerpunkt seiner Forschungen bis weit in die siebziger Jahre bildeten. Der Vortrag wird einen einführenden Überblick zu den experimentalphysikalischen Forschungen Machs geben, sie mit anderen Teilen seines Schaffens verknüpfen sowie ihre physikhistorischen und biographischen Kontexte beleuchten.

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Back to the Future: Ernst Mach and Integrated History and Philosophy of Science for the Twenty-first Century

Mach has long been wrongly interpreted as a reductionist phenomenalist, this thanks partly to the manner in which the Vienna Circle appropriated the legacy of Mach to legitimate its own, somewhat different, philosophical project. An interpretation closer to Mach's clearly-stated self-understanding emphasizes Mach's epistemological naturalism, what Mach termed the „biologico-economical" point of view, and his creative appropriation of the tradition of critical hermeneutics, what he termed the „historical-critical" approach. Attention must also be paid to the fact that, contrary to later misunderstandings, Mach's project was understood by himself and other important thinkers, like Philipp Frank, as deeply compatible with the holist underderdeterminationism of Pierre Duhem, the centenary of whose death we also celebrate this year. Thus properly understood, Mach's program has much to offer today as a model for how integrated history and philosophy of science should be done. This talk will first review the history of misreadings of Mach. It will then sketch the argument for a critical naturalist interpretation of Mach and will present the case for a reconciliation of Mach and Duhem. We will conclude with a discussion of the future of integrated history and philosophy of science as it might be inspired by the example of Mach.

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Mach's Evolutionary Conception of Knowledge

This talk will explore how Ernst Mach's conception of knowledge incorporated evolutionary and developmental ideas. We will argue that this conception is more inclusive than most subsequent accounts of a naturalized conception of knowledge, which emphasized only specific aspects of knowledge and knowledge production. The divergent developments in the sequel of Mach of the philosophy and history of science as well as of other disciplines dealing with the evolution of knowledge amounts to a split of rationality that a more comprehensive account promisses to overcome (Note: A similar trend exists within biology, where a mid-19th conception of Entwicklung was separated in individual pieces of development, inheritance, and evolution — we are still trying to piece these all together). It is OUR thesis that Mach's ideas represent an antecedent case of "extended evolution" as it is discussed today.

The Extended Evolution of Knowledge

This talk will develop an evolutionary account of knowledge evolution based on the principles of extended evolution theory (Laubichler and Renn 2015). We will show how this approach can be seen as a further development of Mach's ideas.

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Ernst Mach and Education

Ernst Mach (1838–1916) was one of the great philosopher-scientists in the late nineteenth and early twentieth centuries. He was among the first to deal systematically with the contribution that the history and philosophy of science can make to science education. His teaching was the occasion to unite pedagogical, psychological, philosophical and scientific concerns. His ideas on education are scattered throughout his books, textbooks and journal articles. However, there are three lectures where he explicitly addressed pedagogical issues. – 'On Instruction in the Classics and the Mathematico-Physical Sciences' (Mach 1886/1986), 'On Instruction in Heat Theory' (1887), and 'On the Psychological and Logical Moment in Scientific Instruction' (1890). As well as intellectual and practical interests in education, Mach had a notable Enlightenment-inspired political involvement in educational reform. Mach's relative neglect by English-speaking science educators is unfortunate.

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"Variation" and "elements" in Ernst Mach and Otto Neurath

For Ernst Mach, variation is the most important experimental method (die „Grundmethode des Experiments") and therefore at the center of science. It consists in studying for each element of a particular complex of elements the variation that is related to the variation of each other element. Mach's concept of „elements" is notoriously difficult to grasp. In this paper I suggest that by looking more closely at the different contexts in which Mach talks about the method of variation, we can achieve a richer understanding of the theoretical and practical status of those „elements". Against this backdrop I will discuss some Machian features of Neurath's economic theory. In a letter to Mach in 1916, Neurath explicitly addressed the manner in which Mach's "Mechanics" had influenced his economic thought: „It was your tendency to derive the meaning of particulars from the whole rather than the meaning of the whole from a summation of the particulars, which has been so important. It is in value theory in particular that these impulses have benefited me through indirect paths." In 1917, Neurath suggested a conceptual framework for developing a new type of economic reasoning in which both the method of variation and the concept of „elements" play a crucial role.

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Spatiotemporal Continuity in Mach's Economy of Science"

Ernst Mach's analysis of the economy of science, and his views on space and time, are central to his influence on philosophy and on the history and philosophy of science. These two elements of his thought usually are discussed separately. However, recent work by Erik Banks and Margaret Schabas, among others, encourages a novel assessment of Mach's analysis of the economy of thought. In my view, such an assessment allows for a broader perspective, which reveals deep connections to Mach's views on space and time. In Die Mechanik in ihrer Entwickelung, Mach describes the contribution the the requirement of continuity of experience makes to the economy of thought and to the experimental method. In a paper for The Monist of 1903, "Space and Geometry from the Point of View of Physical Inquiry," Mach argues for the "locative qualities" of objects as a "fixed and permanent system or register" of sensations. I argue for a unified reading of these texts, according to which the fixed system of location contributes to the continuity and the resulting transparency of experience, and thus to the economy of thought and to the discovery of the laws of mechanics. Central to the account is my reading of Der Mechanik as providing a method for, not just an explanation of, the economy of thought and of science. The unified reading allows for a middle ground between Howard Stein's reading of Mach as "abusive empiricism" and what Robert DiSalle has called an "overly sympathetic" reading in response, which obscures what is distinctive about Mach's view. Finally, it explains puzzling aspects of Mach's criticisms of Riemann on manifold theory, and of Mach's account of experiments and thought experiments in science.

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Mach, Boltzmann und die Wiener Akademie der Wissenschaften

Die kaiserliche Akademie der Wissenschaften in Wien entwickelte sich mit ihrer Gründung 1847 und zunehmend ab dem letzten Drittel des 19. Jahrhundert neben den Universitäten der Monarchie als einer der zentralen Orte des wissenschaftlichen und akademischen Lebens. Die Mitgliedschaft in der Akademie als Gelehrtengesellschaft gewann damit einen hohen Stellenwert im akademischen Gratifikationssystem der Zeit. In diesem weitgehend biographisch und institutionengeschichtlich orientierten Referat werden Ernst Mach und Ludwig Boltzmann im Kontext ihrer Mitgliedschaften in der Wiener Akademie der Wissenschaften einer nähern Betrachtung unterzogen, da dieser Aspekt ihres Wirkens bisher in der einschlägigen Literatur nur sporadisch und kaum systematisch gewürdigt wurde. Ausgehend von der Darstellung des formalen Vorgangs bei den Wahlen zu korrespondierenden bzw. wirklichen Mitgliedern der Akademie werden die Aufnahmen von Mach und Boltzmann in die Akademie im Detail in ihren zeitlichen Verläufen präsentiert und deren Mitwirkung und Funktionen in Kommissionen, Redaktionen, Archiven und anderen Einrichtungen der Akademie im zeitlichen Verlauf dargestellt. Hervorzuheben ist auch die Rolle der Akademie und deren Publikationsorgane für die Verbreitung der wissenschaftlichen Arbeiten der beiden Gelehrten und deren Rezeption im beginnenden Wandel einer sich herausbildenden Internationalisierung der wissenschaftlichen Kommunikation.

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The Psychology of Education from Beneke to Mach

According to Friedrich Eduard Beneke, "pedagogy is mainly an applied psychology". Ernst Mach was not explicitly aware of Beneke's influence on him, but he seemingly took nearly all his major scientific ideas from Beneke. They and the major arguments can already be found in Beneke's Metaphysik: the concept of gestalt, the criticism on Newton's concepts of absolute space and time, the criticism on Newton's concept of metaphysics and the role of hypotheses, the criticism of the a priori, of Kant's thing-in-itself, etc. Additionally, the Metaphysik is probably the most accessible of Beneke's works. Unfortunately, it also contains little from Beneke's psychology, which is the foundation for all of his ideas.

Mach intuitively applies Beneke's pedagogy in many ways. It was extremely successful and influential as Einstein (1916) noted, but „It is difficult […] to answer the question: „What has Mach taught, which was principally new relative to Bacon and Hume?"". It is genetically im-portant to show, which theoretical ideas led to Mach's influence. Only in such a way, the ideas can be reproduced not only by strict copying, but "living", i.e. adaptive and transformative.

Mach never wrote a theoretical pedagogy, but Beneke did. Can Beneke's psychological peda-gogy be applied as the basis for a Machian pedagogical theory? Without a theory, pedagogy is not replicable. If a Machian pedagogical theory is "successful" can only be found out empirically.

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Mach and Menger on Positivistic Geometry

The relation between geometry in the mathematician's sense and the geometry of physical space has a long history, with contributions by Gauss and Einstein as high points. In this talk some of the views by Ernst Mach and Karl Menger will be described and discussed.

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Revisiting Einstein's Happiest Thought: From the Physiology of Perception to Experimental Propositions and Principles in the History of Relativity

Mach has long been an important figure in the history of relativity, but the nature of his role has remained controversial. This paper contributes to this discussion by connecting Mach's critical philosophical perspective more fully to his diverse experimental research and pedagogical contributions to mechanics, and charting his changing presentations of these over some time. Building on the studies of Wolters and Renn in particular, and linking Mach's early research in sense perception and psychophysics to his conceptual critiques of mechanics, I aim to offer new perspectives on relativist physics in general and Einstein's debts to Mach in particular. Mach's early work on the Doppler effect, together with studies of visual and motor perception explored subtle interrelations between physiology, physics and psychology, and offered new approaches to physiological space and time (which Mach contrasted to geometrical space). I will examine the extent to which these may have informed the critical conceptual attacks on Newtonian absolutes that Mach famously outlined in The Science of Mechanics in 1883, paying attention also to his positive account of the fundamental laws of physics in terms of experimental propositions and definitions. In 1908 Mach identified a growing group of "Relativisten," and his critiques had helped form a foundation for later work in electrodynamics (in which he did not participate). Yet revisiting Mach's early work will suggest he was still more important to the development of new approaches to inertia and gravitation than has been commonly appreciated. In addition to what Einstein later called "Mach's principle," I will argue that a thought experiment on falling bodies in Mach's Science of Mechanics also provided a point of inspiration for the happy thought that led Einstein to the equivalence principle.

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A History of Divided Reception: The Austrian and the German Mach

In his 1908 Leiden speech "The Unity of the Physical World Picture", Max Planck criticized Ernst Mach's misunderstanding of the second law of thermodynamics and charged positivism of being harmful within modern physics. The speech launched a fierce polemic with Mach that shaped the understanding of Mach's epistemology within the German-speaking scientific community for more than a generation. This polemic often served as a reference point for the many philosophical papers and academic addresses that German-speaking physicists and philosophers delivered during the 1920s and 1930s in response to the dramatic changes in fundamental physics. In many of these papers, so I shall argue, one can discern the emergence of two different understandings of Mach's philosophical heritage, to wit, a German one that was largely informed by Planck's reading and an Austrian one that focused on Mach's broader empiricist approach and his understanding of natural laws.

One of the first examples of this divergence were the two obituaries published in the influential scientific weekly Die Naturwissenschaften. While the Jena physicist Felix Auerbach, in 1916, set out to defend Mach's philosophical system and its phenomenalist basis against Planck, the Prague physicist and later Vienna Circle member Philipp Frank, in 1917, emphasized the broader significance of Mach for a new scientific world view and tried to separate Mach's philosophical heritage from specific claims made by various Machians that were at odds with the recent progress in physics. At about the same time the Viennese experimental physicist Franz Serafin Exner had his own, yet less overt, polemic with Planck. In 1908, Exner had touted the idea that the rigorous dynamical laws we observe in the macroscopic world were only the limit of random events at the atomic level. Exner's goal was not to advocate metaphysical indeterminism, but to take fluctuation phenomena seriously and search for statistical laws about them. Using Mach's notion of natural law as a basis to recognize statistical laws as genuine laws, Exner continued a defense of statistical physics that Boltzmann had developed against energeticism. By investigating such statistical laws in non-foundational fields, such as atmospheric electricity or Brownian motion, Exner additionally shifted the debate into fields that were much closer to Mach's bottom-up experimental approach. Planck, as a consequence of his Kantian understanding of natural law, could not accept statistical regularities without a dynamic foundation and was primarily focused on the theoretical principles of physics.

The differences between these two readings of Mach also figured center-stage in the opening session of the 1929 Prague Congress of the German Physical Society where, on the one hand, Frank and Richard von Mises claimed concepts, such as relativity and probability, for the empiricist tradition fathered by Mach at Prague. Arnold Sommerfeld, on the other hand, continued Planck's battle against positivism and phenomenalism, railing against Mach's "sloppy laws of nature". The polemics also had put Moritz Schlick, Planck's former student and president of the Verein Ernst Mach, in a bind. Yet in 1932 he declared that the verificationist criterion of meaning allowed a reconciliation between positivism and realism. While Planck, to Schlick's surprise, largely accepted the rejection of metaphysics as meaningless, he rejected what later became known as distinction between context of justification and context of discovery and held that the structure of scientific theories cannot be separated from the corresponding historical actors.

When the Vienna Circle, in the 1930s, went international, they soon favored the distinction Logical Empiricism as compared to Logical Positivism. While many of the Austrians in the Circle, among them Frank, did not consider this a significant change, the choice of wording eventually paid tribute to that fact that the association of Mach with positivism, and of positivism with phenomenalism, had ultimately carried the day. Doing so, I argue, they also paid tribute to the fact that the German Mach had become the consensus view about Mach's legacy. The Austrian Mach had instead become merely a part in Otto Neurath's much more ambitious construction of an Austrian tradition in philosophy.

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Ein Ohr für Leibniz und Newton – Ernst Machs Beiträge zur Otologie

See p. 35

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Mach, Jerusalem and Pragmatism

This paper will consider Mach's influence on the development of pragmatism in both its native American form and its European manifestation in the work of Jerusalem. Particular attention will be paid to the significance of this development for social science.

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To What Extent are Mach's Ideas Realized in General Relativity?

It is well known that "Mach's Principle" was an important motivation for Einstein in the formulation of general relativity. My aim in this talk is to analyze – from the viewpoint of a practitioner of general relativity – the extent to which Mach's ideas on inertia and (lack of) absolute space and time as expressed in chapter 2 of his "The Science of Mechanics" (6th English edition) are realized in general relativity. There is a major mis-match of frameworks in comparing Mach's ideas to general relativity, in that Mach is considering the classical particle mechanics, whereas only local interactions involving fields are possible in general relativity. Nevertheless, the "dragging of inertial frames" effect in general relativity is a remarkable realization of Mach's comments on "Newton's bucket" – although possibly not to the extent Mach would have liked. However, I will argue that Mach's ideas on mass are not reflected at all in general relativity (even though Einstein seems to have thought that they were).

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Mach and Relativity – A Never-Ending Story?

As is well known, Einstein counted Mach among the important forerunners of relativity, particularly of general relativity. He was the more surprised, when in the preface to Mach's posthumous Optik (1921) he could read an argument-free rejection of relativity and of all attempts to be counted as one of its forerunners. Years ago it was shown with a probability bordering on certainty, and based on up to that point unknown documents, that the preface to the Optik was a free invention of Mach's eldest son Ludwig, caused by his personal pretentions as a scientist and the prospect of getting money from anti-Semitic anti-relativists. Interestingly, much later Mach's seeming rejection of relativity was used by opponents of his philosophy (Gerald Holton and others) as proof of the harmfulness of his philosophical approach. My talk will show that a careful reading of Mach's works fully confirms Einstein's assessment of Mach as forerunner of relativity. There will be a subtext to my talk as to the reception of the forgery thesis in a philosophical world, dominated by Anglophone predominance.

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Mach and Viennese Medicine

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Stefan Hegemann
Ernst Mach und das Gleichgewicht

Ernst Mach war ein Aussenseiter der Wissenschaft, der nicht den allgemeinen Dogmen seiner Zeit folgte, sondern die Welt mit eigenen, sehr feinen Augen – als pars pro totum für Sinne – wahrnahm und erklärte. Seine Beschäftigung mit dem Gleichgewichtssystem stellte die Beschleunigung als den eigentlichen Reiz für die Bogengänge dar und nicht die Geschwindigkeit. Das hat heute angeblich jeder begriffen, aber hat er es wirklich? Anhand der kalorischen vestibulären Prüfung, für die Robert Barany den Nobelpreis erhalten hat, der Ernst Mach leider vorenthalten blieb, wird das immer noch bestehende Missverständnis von Geschwindigkeit und Beschleunigung verdeutlicht werden. In Zürich wurde von Volker Henn nicht nur ein für das Gleichgewicht wichtiges Lehrbuch von Mach ins Englische übersetzt, sondern es wurde auch der weltbeste dreiachsige Drehstuhl errichtet, vermutlich auch, um die Ideen von Mach zu überprüfen. Wir sollten den Hut ziehen vor einem Mann, der selbstständig dachte, auch wenn er dadurch als Aussenseiter seiner Zeit galt.

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Rüdiger Hoffmann and Lutz-Peter Löbe
Ernst Mach and Johannes Kessel in Prague 1871–1874

The importance of Ernst Mach for the development of the psychophysics is well known. His work in optics, acoustics, and the sensation of equilibrium is mainly concentrated to his early years in Vienna, Graz, and Prague. Among his numerous activities, there is a period of cooperation with the German otologist Johannes Kessel (1839-1907) in Prague from 1871 to 1874, which was not investigated in detail before. This cooperation was important because a number of essential findings in the psychophysics of hearing were published by both authors. We released a monography about the life and work of Johannes Kessel in 2015, where we collected new material about his cooperation with Mach from hitherto unpublished letters, archive material, and from Mach's diaries from the corresponding years. This paper gives an overview of our findings and underlines the impact of the cooperation of Mach and Kessel on the development of otology.

Mach started his psychophysical work with lectures influenced by the most recent works of G.Th.Fechner and H. Helmholtz in Vienna 1863/64. This resulted in contacts with the famous physiologists E.Brücke and C. Ludwig who worked in Vienna at that time. Mach recognized that the theory of hearing offered numerous unsolved problems and published his first paper in this field in 1863.

It is also important that Mach contributed significantly to the development of the kymographion. In 1860, the important French researcher E.J.Marey developed his version of a sphygmograph (a kymographion for recording the blood pressure). It is highly probable that he visited the laboratory of C.Ludwig in Vienna before, who was the inventor of the kymographion. Mach investigated the sphygmograph in 1862/63 and published three papers on it. He remembers in his autobiography, that he was directed from the theory of the kymographion to the theory of the hearing organ. In 1863, he planned the investigation of anatomic dissections of the ear as well as the construction of artificial ear models. For the first task, he wanted to study the movement of the parts of the ear in cooperation with A. Politzer, who was an outside lecturer for otology in Vienna since 1861. Politzer (18351920) was one of the most important persons in the development of the

otology.

In even that year 1863, Mach received a grant from the Imperial Academy of Sciences in Vienna due to an initiative of the members of the Academy, Brücke and Ludwig. Mach was encouraged, to "investigate the sound conduction in the human hearing organ through the middle ear and especially through the ossicles" and to publish the results in the proceedings of the academy.

Mach gratefully accepted the grant, but he moved to the Graz University in the following year and remained there until 1867. Although he published a number of papers on some problems of hearing there, the conditions were not sufficient for complicated experiments. The investigation of the sound conduction in the ear had to wait until Mach was appointed Professor of Experimental Physics at the Prague University. Obviously, Politzer was no longer available for the cooperation, and Mach had to look for another expert in otology, who could play the medical part of the project. We do not know how Mach came in contact to Kessel, but he arrived at Prague as a postdoc in 1871.

The physician Johannes Kessel was only one year younger than Mach, but he was still in his postdoctoral phase. His father was a wealthy winegrower in Germany, which allowed Kessel to spend a long time for his studies in Gießen at the important surgeon A.Werner and in Würzburg at the "father of otology", A.v.Tröltsch. He finished his studies in 1866 and turned to Vienna no later than 1869 like many young scientists, who wanted to improve their knowledge at the famous Medical Faculty, where the "second Vienna medical school" flourished. Kessel worked as a guest scientist at the Institute for Experimental Pathology, which was directed by Salomon Stricker. There he carried out his histological studies of the ear, which were published as a part of Stricker's "Manual of Human and Comparative Histology" in 1871 and also served as the habilitation thesis of Kessel.

At that time, Mach had improved the stroboscopic methods for the observation of vibrations. He proposed the "stroboscopic self-control" to prevent synchronization problems. Mach and Kessel published a short notice, that they started the investigation of the ear using this technology in February 1871.

The following cooperation of Mach and Kessel may be subdivided into three steps: In a common working period 1871/72, they performed investigations of anatomic dissections by means of Lissajous figures of the vibrations, first investigations of the behavior of the living ear, and stroboscopic measurement of pitch. In 1873, they worked separately (because Mach served as Dean). Kessel continued to investigate dissections of the eardrum and applied stroboscopic methods. Mach was mainly interested in experiments on the sensation of equilibrium and movements. In a final period (1874), both authors published a summarizing paper. There they proposed a coordinate system for the geometric description of the middle ear, published examples from real measurements, and described new stroboscopic analyses of the mechanics of the middle ear.

The importance of this work is that Mach and Kessel did the most influential investigations of geometry and mechanics of the middle ear after Helmholtz. They utilized the available technology in a perfect way. Refined results were not obtained before the 20th century, when improved laboratory equipment was available.

Kessel also applied the results to diagnostic problems and wrote his first conference paper on this topic (Wiesbaden 1873). Supported from Mach, he moved to the University of Graz as an outside lecturer for otology in 1875. There he performed the first stapes mobilization, followed by further new procedures in the surgery of the middle ear which may be characterized as steps towards tympanoplasty. From 1886, he worked as a professor for otology at the Jena University. His work was important for hearing acoustics, otology, and rehabilitation engineering.

With the end of the cooperation of Mach and Kessel, Mach finished his active work in the psychophysics of hearing. However, he remained to be a member of the board of the "Archiv für Ohrenheilkunde" until 1903. In his biographical notes, he mentions the time with Kessel mainly as an application of the stroboscopic methods.

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Ein Ohr für Leibniz und Newton – Ernst Machs Beiträge zur Otologie

Ernst Machs wissenschaftliches Werk und die experimentelle Otologie entfalteten sich gleichzeitig. Sein Interesse für Sinnesphysiologie, Musik, Psychologie und Didaktik prädestinierten ihn als Begleiter der Otologie. Seine Physik für Mediziner und Musiker, sein Nachweis des Doppler-Effekts und seine Experimente am Ohr waren im Kern des Fachs. Die Mach'schen Streifen dienten Békésy zur Stützung seiner Wanderwellentheorie (Nobelpreis 1961). Machs Funktionsmodell der Bogengänge gab über Báránys Nobelpreis 1914 hinaus den Anstoß zur Weiterentwicklung der Labyrinthologie nach 1930. Die Geschoßfotografie mit Salcher begründete die Strömungsmechanik, die die mikromechanische Schallübertragung ins Nervensystem erklärt. Sie schuf Grundlagen zum Verständnis der Verletzungen durch Hochgeschwindigkeitsprojektile. Machs Interesse an Röntgens Entdeckung weist in die Richtung der von Schüller begründeten Neuroradiologie.

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Special symposium: "Mach, Duhem and French philosophy of science"

Marco Buzzoni (Università di Macerata)
Laurent Clauzade (Université de Caen Normandie)
Cristina Chimisso (The Open University)
Anastasios Brenner (Université Paul-Valéry Montpellier 3)

General summary:

Duhem's meeting with Mach is significant in several respects. The former, who had written a book on the history of mechanics, gave a lengthy and commendatory review of the latter's The Science of Mechanics. Duhem singled out the central concept of economy of thought or Denkökonomie in these terms: "This summary, this abstraction, in the etymological sense of the term, is the main object of scientific work. In every field, the progress of Science has for aim to bring together as much reality as possible in the minimum form possible; the essence of this progress is a greater economy of thought" ("Analyse de l'ouvrage d'Ernst Mach La Mécanique", 1903, p. 444). Duhem perceived a connection with his own definition of physical theory as an abstract representation of laws and recognized Mach as a forerunner. He later, in The Aim and Structure of Physical Theory, went on to qualify him as "One of the thinkers who have insisted most energetically on the point that physical theories should be regarded as condensed representations and not as explanations" (p. 39). In turn, Mach expressed their assent most forcefully "Duhem's La Theorie physique… has given me great pleasure. I had not hoped to find so soon such far-reaching agreement in any physicist. Duhem rejects any metaphysical interpretation of questions in physics. He sees it as the aim of that science to determine the facts in a conceptually economic way. The historical and genetic method of presenting physical theories seems to him the only correct one and pedagogically the most effective. These are views that I have championed over a good three decades. I value the agreement between us all the more because Duhem arrived at the same results quite independently" (Preface to the second edition of Knowledge and Error, p. 5-6). The claim that the aim of science is thought economy or abstract representation opened up a new perspective with regard to traditional views. Duhem and Mach came to share several other theses regarding experimental testing, measurement and mathematization.

Yet there are obvious differences between the two thinkers. First, Mach allots a good amount of space in his historical studies to methods of observation, instruments, and experimental setups, whereas Duhem focuses on concepts and theories. The Science of Mechanics provides an abundant documentation on the history of experimental techniques, and Mach does not fail to mention some apparatuses he had devised for his teaching. On the other hand, Duhem is attentive in his works to the philosophical background, the conceptual changes, presenting the contrast between descriptive and explanatory theories in a broad discursive context. In summary, they approached the goal and nature of science from different angles, and one could point to other differences in scientific research, philosophical views and political opinions.

Despite such differences both thinkers suggest a reading in which their endeavors complement one another. Duhem seized the opportunity of his agreement with Mach to dispel some objections raised by his views: although his presentation of physics is heavily mathematical and highly theoretical, his intention was not to overlook the empirical basis. Concrete procedures of measurement make it possible to give meaning to abstract mathematical methods. The analysis of phenomena into simple properties was to be grounded on experimental techniques. Economy of thought as deployed by Mach allows us to understand the passage from concrete facts to scientific laws and, subsequently, from laws to theories. This leads to bring out the steps involved in building theories as well as the components on which the conceptual framework rests.

Conversely, Mach could show how his analysis of experimental techniques threw light on the development of physics as a mathematized science. His aim was to understand the association of mathematics and the empirical world. One can claim that Mach and Duhem were pioneering what came to be a central theme in the philosophy of science, that is concept formation and the logic of measurement. As Duhem puts it, measurement is the key that enables us to translate physical properties into mathematical terms and vice versa. Furthermore, it is interesting to note that Mach readily accepted Duhem's remarks concerning the imbrication of theory and experiment, or again his strictures on a naïve conception of induction. This allows him to clarify his conception with regard to thought experiments or Gedankenexperimente: "Duhem is justified in warning against presenting thought experiments as if they were physical experiments, in other words passing off postulates for facts" (Knowledge and Error, p. 189). Duhem and Mach were thus engaged in a constructive dialogue.

Indeed, the interaction of Duhem and Mach attracted the attention of their contemporaries. One can point to two major directions in this respect. On the one hand, a philosophical discussion group, involving Philipp Frank, Hans Hahn and Otto Neurath, among others, which commentators would call the First Vienna Circle, associated Mach and Duhem in their effort to formulate a new positivism. On the other hand, Abel Rey discussed at length both thinkers in his endeavor to develop what he calls "historical epistemology". This decidedly historical orientation of philosophy of science was followed up in France by Hélène Metzger and Gaston Bachelard. Here lies the point of departure of a major methodological divide, which continues to this day to plague philosophers.

References to Duhem and Mach were to reappear later in new settings. Their analyses were often called on in arguing against logical empiricism, revealing the possibility of different readings of their works. The dialogue between Duhem and Mach thus touches on issues that have come again to the fore: scientific representation as one of the options in the debate over realism, the psychology of science as renewed by cognitive science, the revival of historical epistemology.

The aim of this symposium is to offer a study of Duhem and Mach, the context of their work as well as their legacy, by drawing on new material and current debates.

Marco Buzzoni

Mach and Duhem about thought experiments

This paper defends the following two theses: 1) The stereotype according to which Duhem proscribes any type of thought experiment should be rejected. There are some interesting remarks made by Mach himself that suggest a very different reading of Duhem's position. According to this reading, Duhem, like Mach, only denies that thought experiments can break free from the ultimate authority of experience. Duhem's view on this point was often misunderstood due to inaccurate translations (motivated by interpretive bias) of his works into the main philosophical languages. 2) The similarities between Mach and Duhem are not only of historical significance, but of a systematic one as well. The primacy of thought experiments over real ones depends in Mach both on his view that the latter are the ultimate testing criterion of the former, and on a requirement that agrees with Duhem's conventionalism, but clashes with Mach's own radical empiricism. There results a strong oscillation, or tension, in Mach's conception of thought experiment.

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Laurent Clauzade

Comte, Mach and Duhem on scientific explanation

The opposition between description (Ernst Mach) or représentation (Pierre Duhem) and explanation is undoubtedly a positivist one, which we can already find in Auguste Comte's writings. For Comte a phenomenon is said to be explained if it is "subjected to an invariable natural law" (Cours de philosophie positive, 1st lesson). This anti-metaphysical posture is common to the three thinkers. But how far does such a common anti-metaphysical stance go?

It is easy to show that Duhem's thesis that a scientific theory is (or tends to be) a natural classification would have been rejected as metaphysical both by Comte and Mach. On the contrary, a comparative study shows that Mach is very close to Comte's positivism. The conception of fetishism; the practical origin of scientific knowledge; the continuity between common knowledge and science; the idea that an explanation is only the replacement of an unfamiliar fact by another fact which is simply more familiar, all these claims are also Comtian claims. However, the psychological and empirical vein which leads Mach to state that "nature is composed of sensations as its elements" is certainly the limit of the agreement between Comte and Mach.

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Cristina Chimisso

Scientific concepts and the (dis)continuity of history of science: Hélène Metzger as reader of Pierre Duhem

Abstract: The historian and philosopher of science Hélène Metzger (1889-1944) argued that past study of nature should be interpreted as the result of mental a priori (her concept, similar to that of mentality) that is different from that of modern science. For her, the historian's task is to understand the concepts that dominated the organisation of knowledge in a historical period. However, past a prioris are not lost to modern people, and may re-emerge in later theories, as exemplified by the ancient concept of action at a distance that re-emerged in Newtonianism. Metzger relied on Duhem's work when providing examples of past concepts, and admired Duhem's highly persuasive style. But can Duhem's continuist view of history of science be reconciled with Metzger's historiography? I shall compare their respective approaches, and highlight points of contacts as well as what I regard as fundamental differences.

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Anastasios Brenner

Mach, Duhem and the historical method in philosophy of science

In 1903 Mach and Duhem, discovering one another's writings, acknowledged the proximity of the philosophical views that they had been elaborating independently. A correspondence followed, which lasted several years. And in their ensuing publications both of these philosopher-scientists were careful to discuss their interlocutor's claims. We have here ample matter for consideration. Mach and Duhem were to have an impact on the development of the Vienna Circle. Yet their conceptions are indeed different from those that followed. Characteristically, they drew on history and psychology. They were interested in the genesis of concepts, the evolution of theories and the patterns of discovery. If rational reconstruction and logical analysis were admitted, these techniques were counter-balanced by historical study. In view of recent evolutions in philosophy of science — the growing importance of cognitive science, history of science, interdisciplinarity — it is worthwhile to return again to the beginning of the 20th century. The aim of this paper is then to reexamine the relation between Duhem and Mach, in particular with regard to the methods whereby they sought to provide a philosophical reflection on science.

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Mach and the School of Brentano

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Guillaume Fréchette (University of Salzburg)
Kevin Mulligan (University of Geneva)
Denis Seron (University of Liège)

Denis Fisette
Brentano's Lecture on Positivism and Monism (1893-1894) and his Criticism of Ernst Mach

In a letter to Mach from May 20 1895, Brentano related his position on positivism to Mach in his 1893-1894 lecture in Vienna ("Contemporary philosophical questions") that takes as theme the relations between positivism and monism in Comte, Kirchhoff, Mach, and Mill. Brentano writes about this lecture:

"You probably do not know that, by happenstance, in the first part of the lecture I taught last winter on the theme of positivism and monism, I addressed your positions on that theme in detail. I considered Comte and Kirchhoff as the representatives of a thoughtless positivism, whereas I considered J. Stuart Mill and Mach as the representatives of an evolved positivism. However, I attempted to show why one form or another of positivism proves to be untenable." (Über Ernst Machs 'Erkenntnis und Irrtum', p. 204-205)

My contribution to this workshop pertains to Brentano's criticism of Mach's theory of elements in this lecture. Brentano's main criticism rests on Mach's identification of the class of mental phenomena with the class of physical phenomena. However, Brentano argues that the core of Mach's theory can be preserved if one replaces the identity relation between two classes of phenomena with that of correlation (intentional relation).

Guillaume Fréchette
From Brentano to Mach. Carving Austrian Philosophy at Its Joints

In many respects, Mach's arrival in Vienna in 1895 marks the beginning of a new era in Austrian philosophy, paving the way for young philosophers and scientists like Hahn and Neurath and preparing the soil for the Vienna Circle. While this understanding of Mach's contribution to the development of Viennese philosophy seems correct to an important extent, it leaves aside the role of Brentano and his school in this development. I argue that the Brentanian and Machian moments of Austrian philosophy are jointed. I propose a description of the nature of these joints based on institutional, methodological, and philosophical aspects of these phases, and suggest a diagnosis which supports what I take to be the right carving between these two moments.

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Kevin Mulligan
Claims and their Cash Value

If there is one idea in Mach to which Brentano and his heirs were very sympathetic, it is that it is always important to ask how to cash out a claim. I consider the ways this idea is developed by Mach and Brentano's heirs in their accounts of perception, intuition, observation, confirmation, verification and meaningfulness.

Denis Seron

Intentionality vs. Psychophysical Identity

Brentano's empiricism displays striking similarities with Mach's phenomenalism. Both authors hold physical reality to be a "fiction" and reject the traditional view of truth and existence. In this paper, I seek to clarify some aspects of the debate opposing Mach to Brentano and the Brentanians, with a special focus on the theory of intentionality. First, I link this debate to an earlier one and argue that it was already old in 1874 when the Psychology from an Empirical Standpoint was published. Secondly, I construe Brentano's intentionalism as an alternative to the psychophysical identity thesis as defended by (among others) Ernst Mach. Finally, I point out some of its advantages over the psychophysical identity thesis.

Ernst Mach and Brno-Prague

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Emilie Těšínská (Academy of Sciences of the Czech Republic)
Marie Fojtíková
Jana Musilová:

Martin Černohorský
Ernst Mach´s early childhood in Brno and in Zlín. Adolescence in Kremsier

Grandparents from North-Bohemia (Ernst Mach´s fathers family) and from South-Moravia (mothers family). A quaint "engagement" of parents 1826. Their wedding 1836. How nurseling Ernst being in bad health was brought through. The years 1852-1855 in Gymnasium in Kroměříž/Kremsier. Influence of teachers.

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Emilie Těšínská
Ernst Mach as an Applicant and the Candidate *secundo loco* for two Professorships of Physics in Prague in 1866/67

Within winter term 1866/67, two professorships of physics were announced to be vacant in Prague with the beginning of summer term 1867, namely the only one professorship of physics at the Carl Ferdinands-Universität in Prague and one of two professorships of general and technical physics at the Landes Polytechnisches Institut in Prague. Ernst Mach, 29-year-old Professor of Physics at the Carl Franzens-Universität in Graz, applied for both the Prague professorships mentioned above in 1866.

The paper aims to concentrate on the consideration of Ernst Mach´s candidacy for the two Prague Professorships of Physics by the bodies of professors of Prague University and Prague Polytechnic Institute respectively in context of other applicants for the posts and of the qualification criteria set for the new holders of the posts.

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Ernst-Mach Days, Brno 1938, 1988, 2008, 2016. Excursion Brno, Sunday 19.6.2016.

1938: Ernst Mach centenary celebration in Chrlice was organized shared by the Elektrotechnický svaz československý and the Deutsche Gesellschaft für Wissenschaft und Kunst in Brünn (Czechoslovakian Electrotechnic Association and German Society for Science and Arts in Brno). A valuable bronze tablet with Ernst Mach´s relief was unveiled on the front face of his birth house. 1950: the tablet was removed for political reasons and afterwards destroyed.
1988: A new tablet, a simple stone one, was installed on the same place as in 1938. Its unveiling, yet before the Velvet revolution, was the flashpoint of the first post-war Ernst-Mach Days. It was the Brno branch of the Union of Czechoslovak mathematicians and physicists who managed to realize this enterprise.
2008: The second Ernst-Mach Days were connected with adjunction of Ernst Mach´s relief to the tablet.
2016: The small exposition prepared for the third Ernst-Mach Days will be installed in Brno-Chrlice for the participants on the excursion to Brno on Sunday June 19.
Excursion Brno. Explanations concerning the items of the programme will be offered.

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Peter Salcher – The Mach's Corresponding Collaborator

Among the nowadays well known and top physicists who collaborated with Ernst Mach , like Boltzmann and Einstein, there is one less known, almost forgotten – Dr. Peter Salcher, professor of physics and mechanics at i.&r. Naval Academy in Fiume (now Rijeka, Croatia).

Interestingly, it was Mach's iniciative for collaboration, who sent him a letter with the proposal to make the experiment with flying bullet. That was the first of more than 150 letters written between Fiume and Prag, with description and discussion of the experimental results. Accordsing to the letters, Mach visited Fiume only once, in spring 1887. Though these experiments were decisive for Mach's acouistic theory, the role os Salcher was forgotten. Even Einstain, in the obituary to Mach mentioned students as collaborators in physical experiments, including those in acoustics (Költsch, 2014). Subsequent to fiding the missing Mach's leters, the role of Petar Salcher in early investigation of the gas dynamic and supersonic aerodynamic phenomena is mostly clarified. According to some scientists, who were involved in the subject the Salcher's role in the work was underrated and this injustice should be corrected, at least, giving his name to some unnamed phenomena in this area, if existed (Settle, 2001). In my opinion, it would be better to return the name to the phenomena he observed (Salcher Lyra, today known as Mach Disk) and technical set-up he proposed (wind tunnel).

Besides this world known experiment, during his 35 years of teaching at the I&R. Naval Academy in Fiume, he was active in other fields of research, as well as in social life in the town. He was one of the founders of the Club for natural sciences in Rijeka (Naturwissentsaftliche Club in Fiume) that was founded on 23rd October 1883, where he held iportant positions as secretary, vice- president and president. His merit was also publishing the Bulletin of the Club for natural sciences, a bilingual (italian-german) annual publication reporting not only the activities and lectures held in the Club, but also quality papers on various subjects of interest for the municipality. He himself gave 33 lectures in 20 years, mostly dealing with physics and technique, but also medicine and education. With his collaborator S. Riegler, he gave lecture on „Taking photographs on fast movements" already on May 7th 1886., presenting the results of the experiment done in team with Ernst Mach. Only three weeks after the famous Roentgen lecture in Wurtzburg, Salcher gave the same in the Club, taking first two photograph with X-rays. The lecture was a great success, so that on his iniciative a Röntgen Committee was formed with the task to purchase the Röntgen apparatus. This was realized in mid 1897, and accompanied with the second lectures on X-rays, where he gave a plausible explanation (almost correct) of the X-rays nature, a matter that was proved only in 1914 by von Laue. The apparatus was used for medical diagnosis and two years later was ceased to the municipal hospital. This is considered as the beginning of the Radiology in Rijeka. Two more lectures held in Club were of particular concern: «The connection between light and electricity»,(12.04.1894.) giving the very modern view (though not entirely correct) about equality of light and electricity that was theoretically proven only in 1924 by Louis de Broglie, and «Promotion of health and natural way of healing» (October&November1895), where he described the irritative action of airborne particulates on human respiratory system. This approach was established in environmental health only in1980'. It is hard to say if these up to date oppinions on natural sciences were his own, or general scientific opinion, but in the latter case poses a question: how it was forgotten. Maybe another consequence of the World War I?

Peter Salcher also took charge of the modern meteorological station founded by the Viennase Academy and Adriatic Commision in November 1868, only 5 years after first such a station in London. He wrote the first book on *The Climate in Fiume and Abbazia* , where he evaluated the meteorological data in the same way as it is done today.For this reason these data might be used in climate change studies (Alebic-Juretic, 2012). At the end of his professional career, in 1909, with Dr. Trippold from Abbazzia (Opatija) he undertook measurements of radioactivity of sea water in the Rijeka Bay using an electroscope. From the fact that radioactivity was found higher in the vicinity of the settlements, he concluded that it should be of antropogenic origin and calling for reexamining the use of radioactivity (emanates) for welness reasons. He was also very

active in photographic section of the Club for natural sciences, where he exhibited his artistic shots. Some of this photgraph are still in use in various occasions.

Last, but not least, his book on history of i&r Naval Academy (Geschichte der k u k Marine Akademie, 1902) is practically the only evidendce from the period the Academy spent in Fiume (1866-1914), as all documentation is lost during turnoils of the 20th century.

The Croatian Academy of Science and Faculty of Engineering, University of Rijeka organized in 2004 a symposium «Peter Salcher & Ernst Mach – A Succecfull Teamwork» where this collaboration was analysed from various points of view and published in a beautifull (by content and by sight) trilingual proceedings, the result of Croatian-Austrian collaboration.

Key words: Peter Salcher, Rijeka/Fiume, Club for natural sciences, acoustic experiments, Röntgen apparatus, meteorology, sea radioactivity

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Ernst Mach: Science and Buddhism. A Misunderstanding under Globalization's Signature

Ernst Mach was one of the most influential intellectuals in Vienna`s cultural life during the fin de siècle. His assumption of the non-existence of the "I" influenced poets like Hoffmannsthal, Schnitzler and Musil. During these years Buddhism, which shares the same assumption, was discovered by Western intellectuals among them also intellectuals critical of religion. Buddhism was hardly known at that time and frequently misinterpreted. Nevertheless, the apparent parallels between Mach's thought – especially in his "Analysis of Sensations" – and Buddhism inspired contemporaries to bestow Mach with the title of a "Buddha of Science"(Gomperz).

That Buddhism and science are closely related is today a commonplace – mainly in neuroscience; sometimes science is used to substantiate Buddhist claims, and vice versa. A closer look at Ernst Mach's "Analysis of Sensation" could prove that the supposed relationship is a category mistake. The "Scientific Buddha" (Lopez) is the result of a complex process of reception of Buddhism in Europe, the US and Asia. Western representations and interpretations of Buddhism were turned into anticolonial propaganda during the fights in Sri Lanka and Japan against Western colonial powers and their ally, Christianity. This modernized Buddhism is then re-exported as the authentic version to Europe and the US and welcomed there as traditional wisdom.

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Ernst Machs Bedeutung für die Herausbildung einer naturwissenschaftlichen Psychologie – Ein Missverständnis mit Folgen?

Die Bedeutung von Ernst Machs Beiträgen zur Analyse der Empfindungen für die Frühgeschichte der naturwissenschaftlichen Psychologie ist kaum zu überschätzen: Schließlich ist es die Rezeption des Empiriokritizismus gewesen, die dem Wundtschen Methodendualismus, demzufolge die Psychologie der einfachen psychischen Funktionen als Teil der Naturwissenschaften, die Psychologie der höheren psychischen Leistungen aber als Teil der Geisteswissenschaften zu behandeln sei, ein Ende bereiten sollte. Allerdings lässt sich zeigen, dass diese Mach-Rezeption in der Psychologie von allem Anfang mit einem kuriosen Missverständnis belastet war – einem Missverständnis, das Konsequenzen zeitigte, die in dem gegenwärtig so eng an den Neurowissenschaften orientierten Fach heute noch fortwirken. Was die Psychologen zu Beginn des 20. Jahrhunderts an Mach übersehen hatten, war gerade einer der Hauptgrundsätze seiner Wissenschaftstheorie: dass nämlich Substanzbegriffe als metaphysische Setzungen aus der Wissenschaft zu eliminieren sind.

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Appraisal and influence of Mach's works in South America

Perhaps the first approach in South America to the work of Mach which we got knowledge of is the study (1911) on the Analyse der Empfindungen made by Colombian philosopher Julio Enrique Blanco (1890-1986) in Barranquilla, which was derived from his interest in the explanation of living phenomena in general and the psychophysical problem in particular. Despite the difficulty in tracing the path of the work of Mach on South American soil, another point of contact was identified through the influence exerted by Hans A. Lindemann in Buenos Aires, who attended the Schlick Circle on a regular basis. His works, which were reviewed in some journals, offer us the chance to start giving an account of the conceptual lineage of Machian root in South American territories. This work aims to constitute a contribution in that sense. Machian ideas were spread more recently due to the Mach-Einstein connection. Gonzalo Munévar represents a remarkable exception to this pattern due to his account of machian ideas related to the theory of knowledge and evolution and his relationship with Feyerabend and Hempel.
KEY WORDS: Ernst Mach, South America, Julio E. Blanco, Hans A. Lindemann, Revista Voces, Revista Minerva.

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L'influence de Mach, via Michele Besso, sur les jeunes années d'Einstein

On accorde traditionnellement une influence de Mach sur la pensée d'Einstein, en particulier concernant la relativité générale. Il nous semble cependant nécessaire de placer aussi cette influence dans le cadre

de l'environnement scientifique du jeune Einstein avant 1905 auquel son ami Michele Besso a largement contribué. À la lecture de leur correspondance, il apparaît que Mach a fortement marqué Besso mais qu'il a pu conduire aussi Einstein sur de « mauvaises pistes » dans ses « jeunes années » (ce qu'il a implicitement reconnu en 1949 dans ses Notes autobiographiques). On reviendra notamment sur les questions relatives à la « séparation essentielle de l'éther et de la matière » (objet d'une idée d'expérience), aux « forces moléculaires » (objet d'une thèse abandonnée) et à la « dissociation » dont ils discutent en avril 1901 avant qu'Einstein ne se tourne vers la physique statistique.

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Some remarks on Mach's philosophical doctrines

In his general philosophical remarks, scattered across dierent oeuvres, Mach subscribed to a number of doctrines. Among them the following can be identified:

- Economy of science: The primary, perhaps the only legitimate goal of scientific theories is to achieve the economy of thought. Instead of recording many facts, science codifies them under the heading of laws. Instead of attending to individual diverse sensations, science postulates the existence of bodies.
- Evolutionism: Human activities must ultimately be understood in terms of Darwin's theory. A man is a biological product of evolutionary development. But only human activities: history of knowledge, ideas, thoughts is only intelligible by the lights of evolutionary theory.
- Phenomenalism: Sensations are denizens of the world, whereas bodies (material substances) are symbols constructed in thought, chiefly to serve the purposes of economy.

Are these views jointly consistent? I argue that the role of naturalism, prominent in the endorsement of the evolutionary theory, creates an unresolved tension among those views. Phenomenalism in particular is deeply revisionary. It appears to be a remnant of empiricist metaphysics casting doubt on pretty much every area of scientific discourse. The adoption of full-fledged philosophical naturalism should be able to resolve the tension without ruling out the possibility of a methodological critique of scientific theories.

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Mach in Italy: Giovanni Vailati (1863–1909) as Reader and Interpreter of Ernst Mach

The way E. Mach incorporated a wide range of critical remarks and historical researches from historians, physicists and philosophers in the several editions of Die Mechanik in ihrer Entwickelung: historisch-kritisch dargestellt is of special interest to Mach scholars. Mach's successive additions were recorded in the prefaces to the nine editions of the Mechanik, published between 1883 and 1933. Among those who helped to shape the book, P. Duhem and G. Vailati were probably the closest to Mach's way of thinking, for they were at the same time scientists, historians of mechanics and philosophers of science. Giovanni Vailati (1863-1909) studied mathematics and graduated from the University of Turin in 1888. After graduation, the University employed him to assist first G. Peano, and then V. Volterra. In 1896 Volterra entrusted him with a course on the history of mechanics. From about 1896 Vailati regularly corresponded with Mach. It is through Vailati's efforts that the Mechanik was translated into Italian in 1909.

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Joachim Thiele: Machs Pädagogik in Briefen und Dokumenten

Vor hundert Jahren in seinem Nachruf an Ernst Mach von 1916 hat Einstein nicht nur den geistigen Einfluss von Mach auf ihn selbst und eine „ganze Generation von Physikern" belegt. Er hat auch die Frage gestellt, woran dieser pädagogische Effekt gelegen hat und ob er reproduziert werden kann. In einer Vorlesung in Hamburg 1963/64 hat Carl Friedrich von Weizsäcker diese Frage aufgegriffen. Joachim Thiele saß in der Vorlesung und hat in der Folgezeit die Frage systematisch untersucht. Was war das Besondere an Machs Pädagogik? Was hat die Physik des 20. Jahrhunderts und deren Nobelpreisträger, was hat Machs Einfluss in vielen Bereichen hervorgebracht?

Mach hat außer einzelnen Aufsätzen nie systematisch in der Pädagogik publiziert. Thiele hat dann angefangen, den Nachlass von Mach aufzuarbeiten. Dabei hat er nicht nur entdeckt, wie groß Machs Einfluss auf zentrale wissenschaftliche Größen seiner Zeit, z.B. William James war. Er hat auch wichtige Begriffe von Mach und deren Entwicklung, z.B. den Ökonomiebegriff und die „Adaptation" aufgearbeitet. Über lange Zeit war Thiele *die* zentrale Person in der Forschung zu Machs Pädagogik, insbesondere soweit sie über die Physik hinausgegangen ist. Thiele hatte zum Ende seines Lebens noch Pläne, dies in weitere Richtungen auszuarbeiten. Sie konnten leider nicht zu Ende geführt werden. Thieles Arbeiten wurden dann für weitere Forscher wegweisend, in dieser Richtung Einsteins Fragestellung nachzugehen.

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L'empirisme post-kantien de Mach : la conquête d'un nouveau concept de « donné »

Le positivisme de Mach partage avec la phénoménologie de Husserl l'exigence anti-métaphysique de dépouiller l'expérience des catégories que nous y avons projetées. Or, dès lors qu'il s'agit d'en déterminer le contenu, apparaissent des problèmes qu'aujourd'hui encore l'on a peine à résoudre. Que ce soit pour blâmer Mach d'avoir renoué avec le mythe empiriste de l'atome impressionnel ou que ce soit pour le louer d'avoir préfiguré la Gestaltpsychologie, il nous semble que l'on manque l'essentiel. Là-contre, nous voudrions insister sur la radicale subversion du concept kantien de donné (Gegebenheit) que Mach met en œuvre. En premier lieu il se défait de la conception représentationaliste du donné et l'affranchit d'un double mythe, celui du sujet et celui de l'objet. En second lieu, il dissocie le donné de la philosophie transcendantale qui en a été à l'origine et l'affranchit de la problématique de l'objectivité et de la constitution. Cette déconstruction des présupposés hylémorphiques permet ainsi à Mach de délivrer un nouveau sens du donné, comme épreuve irréductible de ce qui arrive, ce par quoi son empirisme post-kantien se révèle indépassable et singulier dans l'histoire de la philosophie. Ni donné logique (école de Marbourg) ni concept opératoire qui tire son sens du système dans lequel il s'inscrit (une partie du positivisme logique), le donné chez Mach n'est restituable qu'à la mesure de la neutralisation catégoriale à laquelle il a été soumis.

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Mach's Criticism, or, a Discourse on the Method

Mach's work hasn't been properly acknowledged by historiography; it has no clear place in the history of philosophy, nor in the history of science. Nevertheless, prominent intellectuals and scientists attributed a

great worth to it: not merely a worth relative to its given point in history, but a groundbreaking one.

In this paper I take Mach's work as the result of a radical critique of the foundations and the forms of knowledge, as well as a toolkit for the present-time basic research. My focus will not be the direct contribution of Mach's work to particular disciplinary research, but rather the indirect benefit and significance for science of two unfaltering attitudes that he was able to jointly apply along his life. These are, according to Einstein, an "incorruptible skepticism" and the passionate confidence that any prospects were attainable for experimental scientific research. I will elucidate the features of Mach's criticism with an emphasis on its relationship with Kant's philosophy and on the idea that the only possible foundational discourse is the one on the method.

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The Transdisciplinary Legacy of Ernst Mach From the Analysis of Sensations to the GPS Inside of the Brain

The present contribution seeks to relate Mach's work and ideas regarding space sensation and other issues of the physiology of the senses to current research on cognitive neuroscience on innate spatial maps. The view presented here shows us the contribution of the philosopher and physicist to the reflection upon intuition of space as a cognitive feature, among other significant points.

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Ernst Mach and Wilhelm Ostwald: Two kinds of Neopositivism and their Influence on the Vienna Circle

Ernst Mach and Wilhelm Ostwald were the two most important representatives of neo-positivism around the turn to the 20ties century in the German-speaking world: the former in Austria-Hungary, the latter in Germany. Both were already famous natural scientists (Mach as a physicist, Ostwald as physical chemist), when they turned to philosophy: Mach accepted a call to a chair for philosophy of the inductive sciences in Vienna in 1995, Ostwald left his chemistry chair in Leipzig altogether in order to dedicate himself to foundational and philosophical problems from 1905 onwards. Both had a positivist/empiricist philosophical outlook and were critical of metaphysics.

I start by comparing their philosophies on the basis of their major works and their correspondence. Then I will present the influence they had on the Vienna Circle of Logical Empiricism. Up to now only Machs impact has been widely discussed. And this is only small wonder, since people like Philipp Frank, Hans Hahn and Otto Neurath saw themselves as followers of Mach and christened the public organization of the Circle "Verein Ernst Mach". But recently also the influence of Wilhelm Ostwald finds some interest, since Rudolf Carnap in his younger years was clearly impressed by him (e.g. his system of the sciences and the construction of artificial languages).

The question then is, to which degree the differences between the two lines of neopositivist traditions can be traced as well within the later developments in the Vienna Circle.

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Das bedrängte *Ich*. *Ich*-Konzepte bei Freud und Mach

In den metapsychologischen Überlegungen Sigmund Freuds wie in jenen Ernst Machs ist das Ich im Fluss begriffen. Es ist weder unveränderlich noch substanzhaft, sondern wird im Verlauf psychischer Prozesse hervorgebracht, wohl auch modifiziert und neu formiert. Bei allen Unterschieden in ihren theoretischen Grundannahmen zur menschlichen Psyche und deren Funktionsweisen, teilen Mach und Freud eine differenzierte Inblicknahme des Ich, die beide Autoren zumindest in Opposition zu vorherrschenden philosophischen und psychologischen Überzeugungen des späten 19. und frühen 20. Jahrhunderts bringt. In diesem Zusammenhang bietet sich naturgemäß die Frage an, welche sonstigen Bezüge sich zwischen den Überlegungen Freuds und Machs zum menschlichen Seelenleben herstellen lassen, jenseits gefälliger lexikalischer Unterscheidungen zwischen Psychoanalyse und Gestalttheorie, aber in stetem Blick auf historische Kontexte und wirkungsmächtige Rezeptionsmodi.

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Ernst Mach in Prague and the Dawn of Gasdynamics

Ernst Mach came to Prague in 1867 to become Professor of Experimental Physics and Director of the Institute of Physics of the Carlo-Ferdinand University.He spent in Prague 28 years before leaving for Vienna in 1895 to become Professor of Natural Philosophy at the University of Vienna.

Besides teaching duties during the first years in Prague, he resumed his former research in physiology of sensations and experimentally proved the Doppler effect. With his students he carried out a systematic investigation into propagation and interaction of acoustic waves. As an empirio-critical philosopher Mach subjected to critique Newton´s mechanics in a book on mechanics which strongly influenced Einstein. However, most important was his contribution to the science of gas dynamics: he was the first to visualize successfully the high-speed flow phenomena and to unveil the secrets of shock waves – the most typical and important phenomenon of high speed aerodynamics.

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Otto Blüh and Ernst Mach's Legacy: Inheritance and Task

Followed by the performance of a short skit by Otto Blüh / Gefolgt von der Aufführung einer kurzen Parodie von Otto Blüh: „Ernst Machs ‚Bekehrung' zum Atomismus. Ein Gespräch zwischen Ernst Mach und Josef Popper-Lynkeus" (Vorgetragen von Raimund Brandner). The English translation will be provided.

Otto Blüh (1902–1981) was a professor of physics who maintained a lifelong interest in Mach and contributed actively to previous commemorations. Dozent and first assistant to Rausch v. Traubenberg and R. Fürth at the German Charles University of Prague, after he was expelled and forced into exile as a result of the German occupation, he held research and academic positions first in Birmingham (UK), during the war and later at the Univ. of British Columbia and Vanderbilt Univ. (Nashville, USA). Blüh not only was a pioneer in recognizing the relevance of physics teaching in Mach's ideas, but he himself cultivated many of them. Blüh's work and publications highlight critical thinking and the importance of the history and philosophy

of science in the understanding of physics, bridging specialization and bringing humanism back to science. My paper will provide an overview of Otto Blüh's life and ideas, with a Bildung and Machian influence, and their relevance for today.

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On the Influence of Ernst Mach on Contemporary Physics Curriculum at Schools: The Concept of Weight

The famous example of the essential impact on the philosophy of physics by Ernst Mach was the critique and substitution of Newtonian definition of mass within the new operational (positivistic) approach to physical concepts. This definition appeared in the rewritten course of Mechanics (Mach, 1883/1989[i]) and since then, it is commonly used in many popular physics textbooks of General Physics. Following the new ideology promoted by the new physics of the 20th century, the Machian approach was applied to another physical concept also originally defined by Newton – the concept of weight a sthe gravitational force. The critique of this concept started by Reichenbach in 1927 in the philosophy of science[ii], arrived to physics education in the 60s (King, 1962[iii]) and was implemented then for the first in physics textbooks (Chakin, 1962[iv]). The vivid discussion and confrontation between the old and new, gravitational and operational, definitions of weight concept is still continuing in physics education (Galili, 2001[v]) and divides between two types of practice in public physics education, at schools. I will review this development in physics education research and practice and show the relevance of Mach's ideas for the present educational discourse and curriculum, the slow progress towards the new operational definition of weight in textbooks and curricula of different countries (Stein et al. 2015[vi]).

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What does it Mean to Orient Oneself in Science? On Ernst Mach's Pragmatism

The aim of this paper is to investigate some aspects of Ernst Mach's epistemology in the light of the problem of human orientation in relation to the world (Weltorientierung), which is a main topic of Western philosophy since Kant. As I shall argue, Mach has been concerned with that problem, insofar as he developed an original pragmatist epistemology. In order to support my argument, I shall first investigate whether Mach supported a nominalist or a realist account of knowledge, and compare his view to those of other pragmatist thinkers, such as W. James, H. Vaihinger and H. Poincaré. Secondly, I shall address the question of what does it mean, for Mach, to orient ourselves in science, and argue that, although Mach insisted in keeping his epistemology restricted to a mere operational and economical account of science, that question involves

the wider plane of practical philosophy.

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The Graz Physical Institute after Ernst Mach

In the second half of the 19th century an extremely fruitful development of the Institute of Physics at the Karl-Franzens-University Graz leads to a world leading place of physical research. Ernst Mach stands at the beginning of a long succession of world famous scientists at the Graz Physical Institute with names like August Toepler, Ludwig Boltzmann, the Nobel prize winners Victor Franz Hess and Erwin Schrödinger as well as Alfred Wegener, the originator of the theory of continental drift. From 1875 on the Institute was situated in the new building constructed by August Toepler and leaded by Ludwig Boltzmann till 1890. Nevertheless, the starting point of this remarkable scientific area in Graz coincides with the upcoming career of Ernst Mach as physicist. How much on the one hand Mach's stay at Graz University influenced his scientific life, but also on the other hand how he influenced the development of the Institute of physics in Graz are interesting questions. One way to elucidate these questions is the analysis of the performed research, scientific papers and used instruments.

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Light and Shadow: The Experimental Collaboration between Ernst and Ludwig Mach, Father and Son

The history of physics in the 19th and 20th knows of several prominent examples of transmission of research interests or passion for science between two generations of family members. Active scientific collaboration on the same research subject between members of one family is, however, less frequently encountered. Ernst Mach's oldest son Ludwig started to conduct experiments together with his father already during his medical studies in Prague, leading to a particularly fruitful and productive collaboration during the early years. In this talk, we will look more closely on the respective experimental contributions of both researchers which often tend to be commingled in secondary literature. It is argued that the cooperation between father and son was also a source of conflict as Ludwig, in spite of his own achievements, could not step out of the shadow of his eminent father.

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Ernst Mach und die Wiener Hirnanatomie

Mein Vortrag möchte die Bedeutung des Wiener Psychiaters und Hirnanatomen Theodor Meynert (1833–1892) für die Physikalisierung des Ich hervorheben. Es soll gezeigt werden, warum Theodor Meynert als bedeutender Vorläufer von Ernst Mach bezeichnet werden kann, auf dessen Untersuchungen dieser zurückgriff, um zu beweisen, dass das Ich unrettbar sei.

Meynert war ein wichtiger Vertreter der Zweiten Wiener Medizinischen Schule. Auf der Grundlage seiner hirnanatomischen Untersuchungen, versuchte er psychische Phänomene wie Vorstellen, Wollen oder Denken, auf Gehirnprozesse zurückzuführen. Insbesondere wollte er das Bewusstsein sowie den Begriff des Ich als aus der Alltagspsychologie stammende Konstrukte herausstellen. Die Wirkung seiner Thesen findet ihren Widerhall in den auf ihn bezogenen Modellen einer physiologischen Beschreibung geistiger Vorgänge von Friedrich Albert Lange, Wilhelm Wundt oder Richard Wahle. Ernst Mach bezog sich in „Erkenntnis und Irrtum" auf Untersuchungen Meynerts zum Ich.

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Mach as a Panqualityist

According to the traditional interpretation, Mach was a precursor of the Vienna Circle. In fact, he had very little in common with the logical-linguistic approach which was dominant among logical empiricists. Mach's interests were really first-order and metaphysical, rather than second-order and linguistic. He wished to offer an alternative to both monistic physicalism, which disregarded the rich phenomenology of experience, as well as to monistic idealism, which reduced physical events objects and events to experience. Recently, a position similar to Mach's has enjoyed a renaissance in the debates on Russellian Monism. Although it is widely agreed that Russell's views were at one time virtually indistinguishable from Mach's, I wish to explore the relationship between the two theories more closely. In particular, I want to develop a suggestion by David Chalmers (2015) that Mach was a "panqualityist."

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Mach, Duhem and the Limits of Scientific Knowledge

The aim of this paper is to establish how Ernst Mach's account of the aim of science and his distinction between metaphysics and physics influenced Pierre Duhem's philosophy of science. I start with Mach's important distinction between science and metaphysics and his understanding of scientific theories as 'economy of thought'. I show how these ideas influenced Duhem in developing two central theses in his philosophy – the distinction between representation and explanation, on which he grounds the difference between science and metaphysics, and the concept of natural classification. I show that as Duhem developed the

concept of natural classification, he departed from Mach's instrumentatism and advocated a more moderate position between instrumentalism and realism.

According to Mach, the aim of science is to be an 'economy of thought', that is, to offer us a simple and concise classification of the observable appearances and enable the prediction of phenomena (1883/1960, p. 577). Mach argues that what science can give us is a simple formula including variables covering a range of possible values: "in the investigation of nature, we always and alone have to do with the finding of the best and the simplest rules for the derivation of the phenomena from one another" (1872, p. 57). As he explains, in nature there is no law of refraction, but by constructing the law of refraction we are able to appeal to a simple mental reconstruction of this fact which aids the prediction of events. Mach's instrumentalism holds that all physical knowledge that science aims to provide us concerns observables. His opposition to atomism was grounded in the idea that atoms are not observable.

Mach's idea that science deals with the observable realm and not with unobservables deeply influenced Duhem. Duhem took the principle of economy of thought seriously when discussing the aim of physical theory and the limits of scientific knowledge. Influenced by Mach's idea that science aims at classification of observable phenonema and not at revealing the unobservable, Duhem distinguished between explanation and representation (1906, p. 39). Explanations are delivered by metaphysical theories; these claim to go beyond the 'veil of appearances' and reveal reality as it is. Science, on the other hand, is restricted to observation and thus cannot reveal the causes of the phenomena. Its scope is more limited; it offers a classification of the observable phenomena. Taking theories to be abstract systems that summarise and classify in a logical manner a set of experimental laws, Duhem opposed any attempt to explain the phenomena by searching for a reality hidden under the veil of appearances. Theories should aim simply at saving the phenomena and not at revealing whether there is a distinct reality behind the phenomena we observe. His central idea was that science could be practiced in a satisfactory manner without scientists being concerned with whether there are unobservable entities causing the observable phenomena and whether they should aim to describe their nature. This fact renders physics autonomous of metaphysics.

While Mach's positivism and instrumentalism remained the core of his philosophy of science, for Duhem instrumentalism presented a worry. If theories are nothing but classifications of observable phenomena, how can we accout for their novel predictive success and furthermore explain scientific progress? Maintaining the idea that metaphysical truths are deeper, even if unreachable by the scientific method, Duhem needed a way to present some positive argument in support of the idea that our knowledge, even in light is it's limitations, is progressing and we are getting better insights into nature. Duhem argued that history teaches us that new theories usually build on old ones, evolve from old ones, become part of a unified system and manage to predict novel facts. These facts about science needed to be accounted for and Duhem tried to do so by developing the concept of 'natural classification'. According to Duhem, physical theory is not just a representation of the laws discovered by the experimentalist but also a classification of these laws. The fact that this classification manages to unify wide variety of phenomena shows us that it cannot simply be an artificial classification created by the physicist, but instead that it becomes more and more natural. According to Duhem, even though physical theory cannot reveal the unobservable reality, it can still teach us something of the world, because "the more complete it becomes, the more we apprehend that the logical order in which theory orders experimental laws is the reflection of an ontological order, the more we suspect that the relations it establishes among the data of observation correspond to real relations among things" (ibid., p. 26).

I argue that while Duhem never became a realist, as shown by his refusal to believe in the existence of atoms even after the strong empirical evidence presented by Perrin in 1913, he was nevertheless committed to a middle way between instrumentalism and realism. Since physical theory is a representation and not an explanation, even at the 'ideal end of science' it will not reveal the real causes of phenomena. That is, because we are epistemically restricted, we can never "strip reality of the appearances covering it like a veil, in order to see the bare reality itself" (ibid., p. 7). However, Duhem claimed that the more successful in their predictions our theories are, the more they manage to uncover relations in nature and "arrange experimental laws in an order more and more analogous to the transcendent order according to which the realities are classified" (ibid., p. 297). I argue that Duhem's concept of 'natural classification' can thus be seen as a direct response to Mach's idea of economical classifications and his desire to draw a middle position that explained the predictive success of science.

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Ernst Mach und die Kinematographie

Im Mai 1914 kommt es im Rahmen der in Leipzig stattfindenen Internationalen Ausstellung für Buchhandel und Graphik zu einer der letzten internationalen Präsentationen von Forschungsergebnissen Ernst Machs zu seinen Lebzeiten.

Im „Österreichischen Haus" zeigt der Kurator der Ausstellung, Josef Eder in der Sektion „III. Wissenschaftliche Photographie. F, Kinematographie" Exponate unter folgendem Titel:

- "Deutsches naturwissenschaftliches Institut der k.k. deutschen Universität in Prag (Hofrat Dr. A. Lampa): L. Machs Momentaufnahmen von abgeschossenen Werndl- und Mannlichergewehrprojektilen, Schallwellen, Luftstrahlen und Luftstromlinien, hergestellt nach der Schlierenmethode, zum Teile mit Hilfe des Interferenzrefraktometers.
- E. Machs Studien über Funkenwellen".[1]

Wenigstens ein Teil der Exponate der Ausstellung waren von Theresa Zuckerkandl (geb. Kern) hergestellte Kopien von Originaltabelaux[2], die sich zu diesem Zeitpunkt noch in der Universität Prag befunden hatten. Anton Lampa, der mit Ernst Mach zumindest seit der Jahrhundertwende auch in gelegentlichem persönlichem Kontakt stand[3] und zu diesem Zeitpunkt die Professur auf dem mehr als zwanzig Jahre von Ernst Mach gehaltenen Lehrstuhl in Prag inne hatte, war in die Beschaffung involviert gewesen. Er bittet Ernst Mach in einem Brief vom April 1914 "um nachträgliche Zustimmung (…) dass ich, der Aufforderung des Prof. Eder entsprechend, Kopien von dem im hiesigen Institut befindlichen Tableux, die Schießversuche betreffend, herstellen ließ und für die Ausstellung in Leipzig zur Verfügung gestellt habe. Ich bitte auch Hrn. Dr. Ludwig Mach in gleicher Weise um seine nachträgliche Zustimung."[4] Dieses Detail aus der wissenschaftlichen Biographie Ernst Machs stellt in meinem Beitrag den Ausgangspunkt dar, um seine Positionen zur wissenschaftlichen Photographie/Kinematographie vor dem Hintergrund der internationalen Entwicklung zu rekapitulieren und gleichzeitig unterschiedliche Ebenen bzw. Strategien der Präsentation von Forschungsleistung offen zu legen.

Da die Recherearbeiten erst im Laufe des Frühjahrs abgeschlossen werden, können hier noch keine Ergebnisse bekannt gegeben werden.

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1 Internationale Ausstellung für Buchgewerbe und Graphik. Leipzig 1914. Österreichisches Haus. Ausstellungskatalog, S.167.
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3 vgl. Briefe Anton Lampa an Ernst Mach. Ernst Mach Nachlass. Deutsches Museum, München.
4 Anton Lampa an Ernst Mach, Prag, 14. April 1914. Ernst Mach Nachlass. Deutsches Museum, München.

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Experiencing and Experimenting. Mach's Theory of Scientific Experiment in Context

Whereas in the first decades of the 20th century philosophers of science almost exclusively focused on scientific theory, the New Experimentalism movement in the 1980s has led to a shift of attention towards experimental practices (see, e.g., Franklin 1986 and Hacking 1983). Since then many researchers in the philosophy, the history and the sociology of science have started to investigate these practices and their specific role for the development of scientific knowledge (see, e.g., Radder 2003). The aim of my paper is to show that Ernst Mach cannot be accused of having neglected the important role experiments play in science. Furthermore, I shall argue that his theory of scientific experimentation offers some resources that might be helpful for recent discussions about the nature and role of experiments. This especially concerns the questions about how we should define or classify scientific experiments and about how experimentation relates to (sensual) experience.

In the first part of my paper, I will reconstruct Mach's theory of scientific experiments, which is for the most part contained in his *Erkenntnis und Irrtum* [1905]. Mach presents a systematic approach to scientific experimentation by defining it in terms of its basic method of variation (cf. Mach 2011, p. 193). According to him, experimentation differs from mere observation insofar as experimentators intentionally influence the phenomena they investigate. Thus, experimentation is not merely a passive reception of sensations, but rather an active process that is controllable and adaptable to our needs and, as such, of economic, practical, and intellectual importance (cf. Ibid.). Whereas raw experience only provides us with vague images of the world, experiments are considered sources of much richer and finegrained experience. Furthermore, Mach traces the tendency to experimentation back to an instinctive behaviour that is not only found in human beings, but also—though in a more limited sense—in non-human animals (cf. Mach 2011, p. 195).

An important feature of Mach's approach to scientific experiments is that it embraces an „experimentalism" about thought experiments (cf. Brown and Fehige 2014). According to that view, thought experiments are not a mere play of imagination or argument, but rather represent some border cases of ordinary experiments. Being one of the first philosophers who coined the term „thought experiment", Mach indeed argued that these experiments and realworld experiments are continuous. Although he admits that thought experiments are experiments performed „at lower costs" that do not express the same explanatory power as real-world experiments, he claims that the method of variation can also be employed in thoughts and, accordingly, that there is no clear border between the two kinds of experiments. Moreover, he considers thought experiments as necessary conditions for real-world experiments (cf. Mach 2011, p. 197). Against this background, physical experiments are described as natural sequel to thought experiments that come into play whenever the results of thought experiments are only vague and indeterminate (cf. Mach 2011, 198). Within Mach's picture, an experiment—whether performed in thoughts or in the real world—can be described as „the autonomous search for new reactions or their interconnections" (Ibid.).

Beyond these basic characterizations of thought experiments and real-world experiments, Mach describes a number of different principles guiding experimental practice, e.g. the principle of parallelism, of substitution or of composition. As Mach admits, all these principles are derived from abstraction of actually conducted experiments (mostly in physics). The list of principles should be neither be regarded as complete (because genius researchers might invent others) nor should it be used as a classifation of experiments (because the principles do not mutually exclude each other) (cf. Mach 2011, 224).

The second part of the paper is dedicated to an interpretation of Mach's theory in the light of the New Experimentalism movement. As I shall argue, we can gain some insights from Mach's analysis of scientific experimentation that might be helpful for the recent discussion in two different respects. First, his comments about the status of the principles of experiments seem to mirror a problem we have to deal with when trying to define or classify scientific experiments. It seems impossible to find some necessary or sufficient conditions or experiments that go beyond the main principle of active intervention and the method of variation. As an answer to that problem, I sketch a prototype theory of experiment that shows some parallels to Mach's theory. Second, Mach emphasizes the intimate relationship between scientific experiments and (sensual) experience. However, this relationship is not unproblematic. To give an example, Hugo Dinger (cf. Dingler 2014[1928]) refutes Mach's theory of experiment by claiming that his anti-metaphysic background (see Mach 2008[1886]) is untenable. I shall examine in how far Mach's theory can be defended against these objections.

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Mach's Views on Physical Space and Time and their Grounding in Perceptual Space and Time"

Mach's views on space and time originate in his critical reflections on then-accepted views in light of empirical studies of perception. He concluded that perceptual space and time to a significant extent serve as the basis for physical space and time. That is, there is a multiplicity of sensory spaces, each with its own features, that are integrated in imagination, from which space and time concepts are formed. Thus, perception is the starting point for physical space and time, but not the sole determinant.

The primary additional determinant is the operation of measurement. This is the source of the major features of the systemic space in Euclidean geometry. Eventually, physics included time in that systemic idea. But Euclid's system is only one of several that are applicable, since those of Riemann and Lobachevsky work as well within limits.

Mach further concluded that space and time variables are not essential, although they are useful. The primary notion is that of 'state.' The primary feature of physical space is its being a 'relation of mediacy' among states, and physical time is a 'relation of immediacy.' This is central to the relativity of physical time and space.(996 char.)

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Mach and Czech Positivism

Ernst Mach´s life and work are closely connected to Czech territory and its intellectual milieu. The purpose of the following analysis is to shed light on the reasons why Mach´s philosophy did not find fertile ground in Czech positivism, which was the dominant philosophy in its time. For an explanation of this fact we must look back to the main specific features of Czech positivism. Along with certain tolerance towards metaphysics, it was mainly the key role of psychology, which did not enable Czech positivists to accept Mach´s philosophy.

The key figure of Czech positivism, philosopher and psychologist František Krejčí, considered psychophysical parallelism to be the core of positivistic conception of the world while Mach denied the difference between these kinds of phenomena and thus cast doubt on the possibility of psychology as an autonomous

discipline. He challenged the core of positivism and that was why Czech positivists did not follow him.

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Le monisme peut-il être «neutre» ? Les raisons épistémologiques du refus chez Schlick du monisme de Mach

Contre Mach, Schlick affirme que ce qu'on a plus tard appelé le «monisme neutre» n'est pas une position satisfaisante et encore moins la meilleure solution du problème psychophysique. Le désaccord ne porte pourtant pas sur la nature de l'esprit, mais sur la notion de causalité. La solution du problème psychophysique est avant tout une solution du problème des deux images (manifeste et scientifique) du monde. Mach tente de le résoudre grâce au concept d'élément neutre, Schlick grâce à une théorie causale de la perception. La communication montre que Schlick et Mach partagent un certain nombre d'exigences, qui caractérisent une pensée d'orientation empiriste et antimétaphysique (I). C'est à l'aune de ces exigences que Schlick rejette la solution de Mach et les solutions apparentées (II). Sa position repose en définitive sur une inférence à la meilleure explication et donc sur l'assomption de la régularité de la nature. Nous concluons en soulignant l'originalité et la stabilité de la position de Schlick sur ce point. (III)
Mots-clé : problème psycho-physique, monisme, causalité

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The Connection between Mach's Principle and the Relativity Principle in Einstein's Work

In an important 1918 paper Einstein admits that he had up to then not clearly distinguished between the relativity principle, the equivalence principle and Mach's principle, and goes on to define them as conceptually independent but related foundations of the general theory of relativity (GR). The admission is striking, since it was made two years after he found the field equations that form the mathematical foundation of GR. Furthermore, the three principles from 1918 differ, each and every one of them, from the principles which Einstein had used in the construction of GR. In this talk I will investigate how it came that Einstein had not distinguished the three principles earlier, how it came that he had seen the equivalence principle as a special case of the relativity principle, and an earlier version of Mach's principle (namely, the principle of the relativity of inertia) as intimately related to the relativity principle in turn. Finally, I will describe how Einstein came to divorce the three principles, and why this development took place in 1918: it was a natural result of Einstein's debates with the early commentators of GR, in particular de Sitter, Kretschmann, Mie, and Kottler.

Throughout the development of General Relativity, Einstein saw himself in line with Mach's criticism of Newton's concept of absolute space. In GR, he wanted to eliminate from the category of fundamental constituents of the world what he saw as the successor of Newton's absolute space: the metric field. For a long time, Einstein thought that what makes a body move inertially according to GR should be entirely

determined by the distribution of the other material bodies. Likewise, the inertial mass of each and every body should be determined by its relations to the other material bodies. Consequentially, there should not be non-trivial solutions to the Einstein field equations if the mass-energy-momentum tensor of all the matter in the universe is equal to zero. Indeed, in 1917 Einstein suggested a modified form of the field equations (introducing the cosmological constant) in part to ensure that Minkowski spacetime (and other non-trivial vacuum spacetimes) would not be among the solutions of the field equations. Alas, Willem de Sitter showed within months that even the modified field equations did have non-trivial vacuum solutions: GR allowed for non-trivial inertial structure, non-trivial spacetime structure, even in the absence of matter. The debate with de Sitter, Mie and Kottler led Einstein to a change of position more fundamental maybe than any other in his life: by the beginning of the 1920s Einstein accepted that the metric field had to be accepted as a non-reducible element of reality. At the same time, Einstein began his project of an entirely field-theoretic conception of modern physics, an idea he had already considered in 1909 but that would now be at the core of his research programme for the rest of his life.

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The ''Mach argument" and its Use by Vladimir Fock to Criticize Einstein in Soviet Union

In *Materialism and Empirio-criticism* published in 1909, Lenin deeply criticized Mach's philosophy and defined the position to adopt concerning the theory of knowledge in dialectical materialism, a current of Marxism which became later the official one in Soviet Union. Then, in a context of strong ideological pressure, Mach's name was frequently used by Soviet philosophers or scientists to discredit a philosophical position, a theory, or a person. This is what we call the "Mach argument". We will study here its specific use to discredit Einstein's interpretation of the General Relativity by the physicist Vladimir Fock. It will help us to reconsider the question of the scientific discourse under ideological pressure, the value of what can be considered as a simple rhetorical argument, and show that its use do not necessarily mean for scientists to deny their convictions.

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Ernst Mach's Didactics in Context

On the didactical work of Mach focused already Adolf Hohenester and Michael Matthews. Recently there are tendencies that go beyond this established accounts. Siemsen puts Mach in a broader line of tradition, bringing together rather different names and times. Compared to Mach`s entire work, the extent of his didactical contributions are small and the attribution to a didactical tradition seems doubtful. The paper addresses this assumed contradiction between oeuvre and impact as well as the influence on Mach as it is described by Siemsen. Avoiding presentism, it focuses on the texts and the respective historical context, i.e. how Mach wrote and for what purpose he wrote.

This historical account leads to the result, that Mach didn`t create an own didactical system or that you can attribute to him a specific tradition, but that his didactical works reflect and comment the educational changes of the time.

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Ernst Mach and the Remarks on Science in Wittgenstein's Tractatus'

Henk Visser has claimed that Ludwig Wittgenstein got some of his most important philosophical ideas directly from having read certain works by Ernst Mach. Visser portrays Wittgenstein as a Machian philosopher, as opposed to a Kantian one. He supposes Wittgenstein to have taken his Tractatus views on space and time, the principles of physics, causality, and necessity directly from Mach's writings.

After a reviewing what Wittgenstein scholars have said about the relationship between Mach and Wittgenstein, I outline certain general considerations thought to tell against Visser's claims, but argue that these are inconclusive.

I then critically evaluate each of Visser's claims, and show that their plausibility varies greatly, but that the claims with most plausibility relate to the issues from philosophy of physics discussed in the Tractatus. Somewhat surprisingly, in light of received views of the Mach-Wittgenstein relationship, Visser's suggestion that Mach might have influenced Wittgenstein (either directly or indirectly) is fairly plausible in the case of some of these topics, and can even be extended in some areas.

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Links between Mach's Functional Relations, the Systems Approach and the Complexity Perspective

Based on Ernst Mach's concept of functional relations two related approaches are proposed to improve systems science: the first is to focus on the question where to 'cut' system definitions and systemic relations and the second on the perspective of the involved stakeholders. Both are historically related to the genetic historical /-critical, monist approach of psychophysicist Ernst Mach, who influenced Ludwig von Bertalanffy and Herbert Simon via the ideas of the Vienna circle. As a step towards this goal, the paper traces the links between Bertalanffy's and Mach's approaches and Simon's formal approach to derive requirements for 'tools' to converse about system definition, decomposition, and aggregation (modularization) interrelated with and dependent on scientists' worldviews.

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Ernst Mach's Geometry of Solids

Two basic theses underlie Mach's philosophy of space and geometry: (1) it is the solid body which first excites our interest in spatial matters and (2) measurement of volume is prior to that of areas and lengths. According to Mach, the area of a surface can be measured by counting the solids necessary for a gapless paving of it thereby "abstracting away" from their heights. Brentano rejects Mach's paving method since "abstracting away from height" means that we really consider the two-dimensional faces of the solids rather than their volumes. Furthermore, he argues that Mach's attempt to "reduce geometry basically to the counting of volumes" is faulty because any method for proving that the solids counted are equal in volume will rely on congruence relationships between their surfaces, edges, and angles.

In my paper, I shall investigate the possibility of a mereological account to geometry along the lines suggested by Mach which avoids Brentano's objections.

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Mach's 'Sensation', Gomperz's 'Feeling', and the Positivist Debate about the Nature of the Elementary Constituents of Experience. A Comparative Study in Psychological and Epistemological Context

My talk will deal with sensation (Empfindung) and feeling (Gefühl) in, respectively, Mach's and Gomperz's theory of experience. First, I will revisit the notion of experience (Erfahrung) as formalized by the theorists of Immanenzpositivismus. Second, I will say a word about the three psychological concepts of sensation, representation (Vorstellung), and feeling, by insisting on their importance in contemporary epistemology. In the third part, I will discuss the centrality of sensation in Mach's "sensualistic positivism", while, in the fourth part, analyzing the role ascribed to affective states in Gomperz's pathempiricism. Fifth, I will compare Mach's sensation-based with Gomperz's feeling-based epistemological model, by arguing that the latter is, perhaps, a more satisfactory solution to the problems addressed by Immanenzpositivismus. Sixth and last, I will show that the question of the mind's ontological and functional division can serve as a basis for a typological analysis of the positivist studies carried out between the late 19th and the early 20th centuries.

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The First Professorship of Ernst Mach at the Graz Karl-Franzens-University

From 1864 to 1867 Ernst Mach held a Professorship at the Karl-Franzens-University and he was the first one of numerous world-famous physicists acting at the Graz Institute of Physics in the course of time. His activities as a professor of mathematics and later on of mathematical physics correspond with times of changes for the Physical Institute in Graz. Mach was especially and intensively engaged with physiological phenomena and he performed experiments although the experimental possibilities were extremely constricted at Graz University during these times.

After Mach left to Prague he did not lose connection with the Institute and many years later he still kept in touch with colleagues from Graz. When he already held a chair for experimental physics in Prague he was strongly intended to return to the Graz Institute as successor of August Töpler in 1876 but finally Mach gave precedence for this position to Ludwig Boltzmann although the excellent experimental possibilities at the newly erected building of Graz Institute of Physics were a great attraction for an experimentalist. There are still some apparatus and instruments existing at the Institute of Physics in Graz associated with Ernst Mach.

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Ernst Mach's Historical Epistemology of Pre-Classical Mechanics

My paper will focus on the first chapter of Mach's *Mechanik*, entirely devoted to the principles of statics and their historical development, including hydrostatics, equilibrium in fluids, and the theory of elementary machines. I will discuss in particular Mach's account for the discovery and formulation of two fundamental principles, at the common roots of modern statics and dynamics: that of virtual displacements/velocities and that of composition of forces. According to Mach, these mutually dependent principles were the necessary basis upon which the whole construction of classical mechanics was logically and historically possible,

starting from the notions of inertia, force, and mechanical work. At the same time, their conceptual evolution provides an ideal case-study of Mach's epistemological approach to history of physics from his empiriocritical, inductivist, and post-positivist perspective, which will be the main topic of my presentation.

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Spätaufklärung und exakte Wissenschaft. Der Verein Ernst Mach und die Berliner Gesellschaft für empirische/wissenschaftliche Philosophie

In den späten 1920er Jahren formierten sich in Wien und in Berlin Vereine, die sich mit unterschiedlicher Intensität auf das intellektuelle Erbe von Ernst Mach beriefen: der Verein Ernst Mach in Wien und die Gesellschaft für empirische Philosophie in Berlin. Die Gründungen dieser beiden Organisationen erfolgten weitgehend unabhängig voneinander. Umso erstaunlicher sind daher Übereinstimmungen, die sich sowohl im philosophischen und weltanschaulichen Entstehungsmilieu als auch in den Organisationsstrukturen und Aufgabenstellungen der beiden Vereine zeigen.

Der Beitrag untersucht in einem ersten Schritt vergleichend das intellektuelle Gründungsmilieu und die Frühphase der beiden Verbände und versucht dabei die jeweilige Bedeutung von Ernst Mach als Reverenz- und Orientierungsgröße herauszuarbeiten. In einem zweiten Schritt werden vergleichend programmatische Texte und wissenschaftliche und pädagogische Aktivitäten (inkl. der Kooperationen) des Vereins Ernst Mach und der Berliner Gesellschaft für empirische/wissenschaftliche Philosophie in den Blick genommen.

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Ernst Mach on the Self: The Deconstruction of the Ego as an Attempt to Avoid Solipsism

If we believe that the manifold of sensations ("the given") is ontologically fundamental – as the phenomenalist Mach clearly does: "For us, colors, sounds, spaces, times,… are the ultimate elements" (Mach 1885: 23) – then we are in danger to end up with solipsism: the thesis that only we (better: "I alone") exist. That is, unless we can show that there is no Self, no Ego, no "I", in the first place, for then the question whether there are others might not arise: it is ok that the others do not exist because, really, I do not exist either. This is the solution Mach favours to counter solipsism: "the primary fact is not the I, the Ego, but the elements (sensations)" (1885: 19). I address two questions: (i) Do we need independent additional support for the denial of the Self or is the avoidance of solipsism reason enough to assume the Ego's nonexistence? (No!) (ii) Is the deconstruction of the I, even if sufficient support can be found, really adequate to stop us from worrying about solipsism? (Maybe!)

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Ernst Mach and the Rise of Theoretical Physics

Mach has occupied a peculiar position in the rise of theoretical physics of the late nineteenth century. On the one hand, his criticism of such absolutist notions as space and mass has left indelible impression on Einstein, who in turn helped initiate modern theoretical physics with the theories of relativity. His critique of atomism and his controversy with Planck, on the other, have been regarded as showing he went against the stream in the rise of theoretical physics. This paper aims at a better appreciation of Mach's relationship with the rise of theoretical physics by juxtaposing his theoretical ideal of 'economy of thought' with other axiological talks of his allies about theoretical virtues: Poincaré's aesthetic intuition for theoretical harmony, and Duhem's good sense for logical unity. I will argue that it was these scientist-philosophers of an anti-scientific realist bent who offered what Kuhn called "standard criteria for evaluating the adequacy of a theory" as anti-realist alternatives to discipline the free theoretical space, norms to guard the theoretical physics not to fall into a speculation, which was related to Mach's debate with Planck. Within this common agenda, however, their emphases were different in terms of theoretical values and their corresponding scientific practices. I will show how these differences could help us in our better understanding of their contrasting philosophical and historiographical stances.

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Vom Empiriokritizismus zum Empiriomonismus: Aleksander Bogdanovs Rezeption der Epistemologie von Ernst Mach

Machs Philosophie genoss außerordentliche Popularität in Russland anfangs des 20. Jahrhunderts. Ein Indiz dafür ist, dass eine Reihe positivistisch ausgerichteter Positionen als „Machismus" bezeichnet wurden. Dies kann damit erklärt werden, dass die russischen Autoren einen erkenntnistheoretischen Orientierungsrahmen für den Marxismus erarbeiten wollen und daher eine „sozial-genetische" Auslegung des Empiriokritizismus Machs vorschlugen. Eine wichtige Rolle spielte dabei Aleksander Bogdanov.

Man kann den Empiriokritizismus als eine Quelle des Bogdanovschen Empiriomonismus betrachten. Die Kontroverse zwischen Bogdanov und Mach entfaltete sich um die Methode der Überwindung des epistemologischen Dualismus. Der Position Machs, die Bogdanov im Gegensatz zu dem ontologischen als methodologischen Dualismus charakterisierte, stellte er seinen methodologischen Monismus entgegen. Die Polemik Bogdanovs gegen Mach und seine Transformation des Empiriokritizismus bildet den Schwerpunk des Vortrages.

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Mach's Reception in Pre-Revolutionary Russia

Mach had an extraordinary reception in Russia: his works were translated in Russian so promptly and completely as in no other language, and his thought was discussed on the press, in salons, in political debates. Such a success has been considered mainly through Lenin's Materialism and Empiriocriticism. But a harsh polemic work is not a reliable source to grasp the positions of its rivals. J.T. Blackmore, in 1972, successfully inquired into Ernst Mach Institute Archive in Freiburg in order to sketch out Mach's Russian reception. How-

ever he could not investigate Russian sources. Relying on Mach's correspondence, and on a general reconstruction of the "second positivism" in Russia, my paper outlines three main aspects of Mach's influence in Russia: Mach's direct contact with Russian scholars and teachers; the work of P. K. Engel'mejer, Mach's main popularizer in Russia, and the "Machomakia" that enlivened Russian Marxism in 1905-1910.

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‚He hits the target but misses the bull's eye': Ernst Mach, Charles Sanders Peirce und die pragmatische Maxime

Das Verhältnis von Ernst Mach zum amerikanischen Pragmatismus wird seit einigen Jahren wieder intensiv diskutiert. Im Fokus der Aufmerksamkeit stehen dabei insbesondere die Kontakte zu William James, die mittlerweile recht gut dokumentiert sind. Dagegen haben mögliche Wechselwirkungen zu anderen Pragmatisten wie etwa Charles Sanders Peirce bislang weniger Behandlung gefunden, was insofern überraschend ist, als sich gerade zwischen den Werken von Mach und Peirce deutliche Parallelen aufzeigen lassen. In dem bahnbrechenden Aufsatz How to make our ideas clear aus dem Jahre 1878 hat Peirce erstmalig seine experimentelle Bedeutungstheorie vorgeführt, die später als sogenannte „pragmatische Maxime" bekannt geworden ist: Nach Ansicht von Peirce ist die Bedeutung (der Begriff) eines Gegenstandes identisch, mit der Summe der ihm hypothetisch zugrunde gelegten und durch experimentelles Handeln vorzubringenden praktischen Konsequenzen: „Consider what effects, which might conceivably have practical bearings, we conceive the objetc of our conception to have. Then, our conception of these effects is the whole of our conception of the object". Vergleicht man die pragmatische Maxime bei Peirce mit Machs Überlegungen zur Begriffskonstruktion, wie er sie insbesondere in seinen späteren Arbeiten entwickelt hat, so stößt man auf eine nahezu identische Konzeption: Der Begriff eines Gegenstandes, so Mach in den Prinzipien der Wärmelehre (1896), sei keine „fertige Vorstellung", sondern eine Anweisung „eine Vorstellung von bestimmten Eigenschaften herzustellen". Ähnlich wie Peirce betrachtet er dabei den Begriff als Verhaltensdisposition: „Worauf in gleicher Weise reagiert wird, das fällt unter einen Begriff". Während Mach nach heutiger Quellenlage von seinem amerikanischen Kollegen kaum Notiz genommen hat, war sich Peirce der vorliegenden Parallelen durchweg bewusst. Zugleich hat er dabei, gerade was die hypothetische Rolle von Begriffen anbelangt, immer wieder auf klare Unterschiede hingewiesen. So schreibt er 1903 in einem bislang kaum beachteten Manuskript: „Although Mach missed the bull's eye he hits the target; for it is quite true that the whole meaning […] that can be attributed to any proposition in physics lies in the expectation that it will lead to anticipations of experience that may become of practical consequence"(Ms 332). In meinem Vortrag möchte ich die Ähnlichkeiten und Unterschiede der beiden Begriffstheorien näher vorführen. Dabei geht es mir um zwei Dinge: Zum einen lässt sich entgegen der üblichen positivistischen Zuschreibungen ein eigenständiger Pragmatismus Machs herausarbeiten, der andere österreichische Philosophen wie Heinrich Gomperz oder Wilhelm Jerusalem stark beeinflusst hat. Zum anderen verweist gerade die Kritik von Peirce an Mach auf grundlegende Differenzen, die etwa in den späteren Debatten zum Verifikationismus – zwischen Mitgliedern des Wiener Kreises und der zweiten Generation des amerikanischen Pragmatismus – erneut eine zentrale Rolle spielen sollten.

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Determinism and Indeterminism in the Philosophies of Mach, Boltzmann and Poincaré

This paper argues that Mach, Boltzmann and Poincaré worked with a conception of determinism that was not tied to the laws of mechanics, and not a provable feature of physics; rather, it played the role of a methodological principle or an aim of physics. The development of this conception of determinism is explained by a change in the status of mechanics: the idea that mechanics has absolute certainty was given up, and the idea that all of physics should be reducible to mechanics was criticized. In light of this development, it no longer made sense to argue for universal determinism on the basis of mechanics.

It is a well-described fact that already before the introduction of quantum mechanics, physicists including Reichenbach and Schrödinger argued for the possibility of indeterminism in physics. The question arises in how far their ideas go beyond those of Boltzmann, Mach and Poincaré. Working out these connections will give a better understanding of the gradual development towards the acceptance of indeterminism in physics.

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Economical Unification in Philosophy of Science

The history and the present status of the principle of economy in philosophy of science is reviewed and the inseparability of unification and economy is emphasized. Of all available empirically sufficient theories, the principle of economy favours the theory which incorporates the least sum of metaphysics. Unification and economy are inseparable: if an empirically sufficient theory is genuinely unified it is also economical as a unified theory does not need extra metaphysics (or extra parameters); a disunified theory especially incorporates extra metaphysics and is proportionally uneconomical. Ernst Mach coined in the term 'the principle of economy of thought' and emphasised the importance of economy and unification in science. Although the preference for simplest empirically sufficient theories has been present in philosophical and scientific thinking throughout the history, the present status of the principle of economy is largely a result of a certain interpretation of Mach.

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On the Principle of Permanence as a Principle of Rationality

This paper focuses on the significance of the principle of permanence, in the context of Mach's conception of science as an optimization strategy. The paper draws on the history of the principle, in the work of Hankel, discusses Musil's interpretation of the principle, and then argues that Mach's use of the principle refutes Husserl's criticism according to which the view of science as an optimization strategy should be justified on a rational, rather than biological, basis.

In his *Mechanik in ihrer Entwickelung: historisch-kritisch dargestellt* (1883), Mach famously maintained that science, as developed by biological organisms like us, can be conceived of as an adaptation, that is, as an optimization strategy for obtaining scientific knowledge of natural phenomena – a strategy that maximizes epistemic benefits and minimizes epistemic costs: "Within the short span of a human life and with man's limited powers of memory, any knowledge worthy of the name is unattainable except by the great-

est economy of thought. Science itself, therefore, may be regarded as a minimum problem, consisting of the completest possible presentation of facts with the least possible expenditure of thought." According to Mach, scientific idealization (for instance, the concept of a space of more than three dimensions) is essential in this respect: idealization is thought-economical because it focuses attention on signs and operations with signs, rather than on the objects signified and the operations with such objects. That purely syntactic operations are most thought-economical is obvious, Mach believed, in mathematics: "Even a total disburdening of the mind can be effected in mathematical operations, for operations of counting hitherto performed are symbolised by mechanical operation with signs, and our brain energy, instead of being wasted on the repetition of old operations, is spared for more important tasks."

As is well known, Mach's view was met with criticism. To be sure, Mach himself acknowledged that idealization, and more generally any strategy aiming at increasing thought economy, is typically believed to cause unintelligibility, at least in didactic contexts if not also in scientific practice. But his view was also considered problematic in that it does not make clear one's justification for believing that science is an optimization strategy in the first place. Mach's own conviction that science is just such a strategy is defended on the basis of biological principles of adaptation, but as Husserl emphasized, this basis is epistemologically inadequate. To be adequately defended, the belief that science strives to bring about scientific knowledge in the most optimal way should be justified on a rational, rather than biological, basis. This criticism is rather covertly addressed in his *Erkenntnis und Irrtum* (1905), where Mach emphasizes the role of the principle of permanence as an ordering and simplifying principle.

The principle of permanence had been formulated by Hermann Hankel as a rule demanding invariance across interpretations of algebraic operations over any domains of quantities: "If two forms expressed in the general signs of universal arithmetic are equal to one another, they shall remain equal even if the signs cease to denote simple quantities and the operations thereby take on a different content as well." (Theorie der complexen Zahlensysteme, 1867) For example, the law of associative multiplication, a x (b x c) = (a x b) x c, is to remain valid across all interpretations, over any domains of quantities. The principle would also be defended by Hilbert in his arguments against intuitionist restrictions of the validity of the classical logical forms of judgment and inference.

On Mach's view, as presented in *Erkenntnis und Irrtum*, science requires not only adaptation of thoughts to facts, but also adaptation of thoughts to one another, which in turn requires logical consistency. However, even if logically consistent, a multitude of new and different ideas often still burdens the mind to a great extent. As he puts it, "The mutual adaptation of thoughts is not exhausted in the removal of contradictions: whatever divides attention or burdens the memory by excessive variety, is felt as uncomfortable, even when there are no contradictions left. The mind feels relieved whenever the new and unknown is recognized as a combination of the known, or the seemingly different is revealed as the same, or the number of sufficient leading ideas is reduced and they are arranged according to the principles of permanence and sufficient differentiation. Economizing, harmonizing and organizing of thoughts are felt as a biological need far beyond the demand for logical consistency." As Musil interpreted Mach's use of the principle of permanence, this stipulated that "once in possession of a certain number of ideas [our mind] does not construct new ideas when faced with new facts but rather adapts to the new tasks those ideas already at its disposal. And this is done with the least possible expenditure of effort by retaining the original thoughts and modifying them only to the extent required in order to deal with the new demands. … It is in them – in constant laws and equations as well as in the fixed marks of concepts – that thought seeks to grasp those ideas which can be held on to permanently whatever individual changes may occur, ideas without which change would be incomprehensible and incoherent." Insofar as the principle of permanence orders and simplifies our thoughts independently of their adaptation to facts, it can be regarded as a principle of rationality, just like logical consistency. Husserl's criticism of Mach's view on science as an optimization strategy is thus rejected.

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Machs und Salchers Schlierenphotographien inspirieren ein Multimedia-Projekt an der Graphischen

1887 konnten Ernst Mach und Peter Salcher die Ergebnisse ihrer Versuchsreihen zur Sichtabarmachung der Überschall-Druckwellen von Projektile abschließen, die in mehrerlei Hinsicht bahnbrechend waren: Mit Hilfe von Funkenttladung wurde die extrem schnelle Bewegung der Geschoße photographisch „fixirt", und durch die Verwendung der sogenannten Schlieren-Optik konnten die Druckwellen als Dichteschwankungen der Luft auch im Bild sichtbar gemacht werden. Anlässlich des 100-Jahr Gedenkens an den Todestag von Ernst Mach wird die Schlierenmethode von Studierenden der Höheren Bundes-Lehr- und Versuchsanstalt in Wien neu aufgegriffen um mit modernen Technologien ein faszinierendes Multimedia Projekt zu realisieren. Damit soll Mach auch in seiner Eigenschaft als leidenschaftlicher Pädagoge in Erinnerung gerufen werden, der – ebenfalls 1887 – sein Unterrichtswerk „Grundriss der Naturlehre für die unteren Classen der Mittelschulen" verfasste, und als Mitherausgeber der „Zeitschrift für den physikalischen und chemischen Unterricht" fungierte.

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"The most artistic lesson I ever heard" – a Contribution to the Reflection on the Comment Made by William James Regarding a Lesson by Ernst Mach

On November the 2nd 1882, William James visits Ernst Mach in Prague, and attends one of his classes. The conversation with Mach and the class were marking events for James. Based on Mach's lectures for teachers, and on his texts for the general public, we propose a reflection on the defining traits that made this class "the most artistic lesson [James] ever heard". We shall remark on the imaginative joy contained in these texts, which appear to embody some of James' key ideas on Education. The experience of knowledge about the world, in these texts, reveals that "to experiment" means " not coldly to observe a thing happening outside us, but to undergo, to feel within oneself, to live oneself this or that manner of being".

Keywords: artistic lesson; to experiment; imagination; sensibility; imaginative joy

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POSTER SESSION

The names of those who will present the papers are in *Italics*.

Karl Hayo Siemsen

Der Lernende, der aus der Oortschen Wolke kam (Anmerkungen zur Freiheit des Studiums)

Die Situation erweist sich als realistisch für einige Länder: Dort werden Lernende nach dem Modell Platos erzogen. Treffen nun Lernende, die nach einem machianisch-gestaltorientierten, d.h. genetischen (sensualistischen) Konzept gebildet werden, auf die platonisch ausgebildeten Lernenden, wird sich ein Spannungsfeld ergeben. Die Ersteren möchten ihr Ziel erreichen, mit logischem Vorgehen zur platonischen Elite zu gehören. Lernen läuft in linearen „Happen" ab. Die Anderen möchten gründlich, verstehend auf empirischer Grundlage von ihren Sinnen ausgehend einen Inhalt erlernen, mit dem sie später ihren Beruf dann sicher ausüben können. Die Ersteren möchten den Eindruck der Überflieger erwecken, die Anderen möchten ihr Ziel von Grund auf, auf einfachste Weise und auf sensualistischem Weg erreichen. Dies sind die beiden Pole innerhalb eines Bildungsauftrages: unterschiedliche Erwartungen an Rollen, unterschiedliche Vorgehensweisen beim Lernen.

Nach platonistischer Theorie bleiben Lernende unter 15 Jahren unbeachtet. Die Sinnes-wahrnehmungen ab 15 Jahren bleiben weitgehend ausgeschaltet. Das Ziel ist eine auf Logik gestützte Oligarchie mit einem Herrscher (Philosoph und Mathematiker) an der Spitze, die Oligarchen (Mathematikoi) ihm treu ergeben (beschrieben in Platos Republik). Weitere Lernende sind als Zuhörer (Akusmatikoi) akzeptiert, allerdings ohne eine Chance des Aufstiegs. Dann gibt es noch die nicht in diesem Sinne Gebildeten, eine Mehrheit, für die ein Bildungsauftrag nicht erkennbar ist.

Nach der Beneke-Machschen Theorie in der Kaila-Nevanlinnaschen Ausprägung ist für Lernen ein Prozess, eine Genese wesentlich. Diese kann im Kindergarten beginnen. Dabei ist vor Allem der Bezug zu den Sinnen bedeutsam. Die Sinne in Kombination mit den eigenen inneren Prozessen liefern dem Lernenden Gestalten an, die er langsam aufbaut zu komplexeren Strukturen. Der Lehrende hilft, indem er (z.B. historisch) nach Gestalten sucht und sie dem Lernenden mitteilt. Lernen läuft in exponentieller Form ab.

Viele der Lernenden zeigen beim Lernen anfangs Schwierigkeiten in der Erfassung und Verarbeitung von Sinnesdaten. Es sind Reflexe, die über die den Menschen kennzeichnende Neotenie in bewusstes Handeln abgewandelt werden. Die „inneren Prozesse" müssen erst „angelernt" werden, die Sinnesdaten spezifisch zu verarbeiten. Die „inneren", d.h. psycho-physiologischen Prozesse (Vermögen und Urvermögen bei Beneke) sind spezifisch. Viele der zum Lernen notwendigen „inneren Prozesse" sind bei Lernenden nach einigen Jahren Lebenserfahrung bereits ausreichend trainiert, manche jedoch durch irgendein Problem oder ein pädagogisches „Übersehen" nicht. Typisch beziehen sich die Schwierigkeiten daher nur auf einen Bereich, der allerdings das Lernen stark erschweren kann. Diese Schwierigkeiten kann man mit frühen sensualistischen Übungen und Spielen (ab Kita) sicher entfernen. Man kann dies allerdings auch an der Hochschule noch nachholen.

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***Joachim Schwarz, Rahel Münkel*, Annika Wagner, Svea Wiedemuth & Hayo Siemsen**

Plasticity of Spatial Perception by the Inner Ear and the Correlation with Eye Movements

Ernst Mach (1875) has (co-)found the function of the inner ear as the main organ of the perception of space. Building on Mach, Magnus (1924) and Fukuda (1981/1984) have researched in detail, the inner ear is related to specific statokinetic reflexes, which show a high plasticity in humans, like other "childhood reflexes" (see Goddard-Blythe 2004). This plasticity needs to be developed as otherwise the reflexes can hinder learning. In a positive way, adapted reflexes can form a very "vivid" basis of "sensual elements" for highly effective gestalts in learning (see Beneke 1835, 1836/1876). Statokinetic reflexes can, for instance, cause dyslexia or nausea. They are used by gymnasts, other acrobatic activities or flight pilots to orient themselves in space while performing complex movements.

How can this plasticity be achieved regarding the statokinetic reflexes? This is tested in an experiment in kindergarten. Two groups use for training an adapted cardgame (Ligretto), which requires a high focus of eye movements. The time factor in the adapted version of the game is scalable, i.e. it can be played slow or faster and faster. Additional to the cardgame, one group is trained in "movement games", similar to the method developed by Goddard-Blythe (2004). The experiment will show, how high plasticity can be achieved by short (3 weeks) training at a young age, if this is done in a Machian, empirical genetic way with gestalts. If successful, the method could be standardized for general training, for instance against specific forms of dyslexia (see Siemsen 2016).

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Using games to teach gestalts in management trainings

Trainings in a business environment have to respect some constraints: very short duration for complex subjects, high expectation to applicability, employees should be immediately persuaded of new knowledge. The market for business trainings is highly competitive. If a trainer is not immediately successful, the next job will be given to a different training organization. How can you – as a trainer or change agent – make sure, that important concepts are understood in a very short time?

The less time, the more intense any learning experience has to be. Good games allow intense experiences. But one cannot choose just any game for a training. They must be selected carefully in order to deepen the understanding of important concepts.

We show how to find, modify and use board and card games and gestalt-oriented teaching in management trainings.

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Ein Spieleregal für das Leben – (Brett-)Spiele als intuitive empirisch-genetische Lernmethode

Ernst Mach und Friedrich Eduard Beneke haben eine empirisch-genetische Pädagogik begründet. Nach dieser Pädagogik werden psycho-physiologische Gegebenheiten durch Anpassung der Gedanken an die Tatsachen und der Gedanken aneinander "langsam" auf Erfahrung aufgebaut, mit einer Bedingung: nicht zu viel „Neues" auf einmal. Dieser Prozess ist im Wesentlichen unabhängig vom Alter. Dabei ist es für die „Erfahrungen" einfacher, wenn sie analog zunächst in einfachen Modellen („Toy Models") gemacht und dann in der „Breite" angewendet werden. Die so „gebauten" Intuitionen sind stabil und führen zu breiter Anwendung.

In diesem Sinne wurde in einem Kindergarten experimentell ein „Spieleregal" entwickelt, welches den Kindern die für die Schule notwendigen Denk- und Verhaltensweisen beibringt. Ziel ist, dass in der Schule, insbesondere in Mathematik und Lesen/ Schreiben, aber auch soziales Verhalten, etc. möglichst keine „Probleme", im Sinne von Legasthenie, Dyskalkulie, ADHS, etc. mehr auftreten. Da die Kinder es gewohnt sind, sich gegenseitig die Spiele beizubringen, tun sie dies auch bei Verständnisproblemen. Außerdem wird den Kindern Erkenntnistheorie beigebracht, da sie eigenständig sich die Spiele aussuchen, welche für sie zum gegebenen Zeitpunkt genetisch den größten Lernerfolg versprechen.

Das „genetische Spieleregal" besteht im Wesentlichen aus „Standardspielen", welche einfach und günstig gekauft werden können. Es soll damit einfach reproduzierbar sein. Die empirischen Resultate, die im Kindergarten und in der Schule beobachtbar und messbar sind, zeigen klare genetische Effekte. Hier soll jedoch schwerpunktmäßig zunächst das „genetische Spieleregal" dokumentiert werden.

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IWSSP – A Curious Science Education Experiment

We summarize the science education experiment carried out by Department of Theoretical Physics and Astrophysics at Faculty of Science, Masaryk University in Brno, in year 2008. The experiment was conducted in by a T.A. of the "Introduction to Physics of Stellar Systems" course. The enrolled undergraduate students were enforced to make a contribution to the workshop named "International Workshop on Stellar System Physics" (IWSSP). Workshop topics thoroughly covered part of the mandatory curriculum, thus it was still valid part of the classes; nevertheless, the form of IWSSP mimicked real international scientific workshop. This sudden change of the whole frame of reality had remarkable impact on students' engagement and also their understanding of the subject. Due to outstanding success, the experiment was repeated in 2010, with the same positive outcome. Unfortunately, IWSSP has never become genuine part of thecurriculum.

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Mach's Principle and the Creation of Matter by Hoyle and Narlikar

In 1962, during a discussion on The Present State of Relativity, F. Hoyle and J.V. Narlikar present their research on the link between the Mach's principle and the matter creation. This talk and the following discussion with, among others, Dirac, Bondi and Davidson, are published later in a proceeding [1]. By this time, a wholer version of their article, improved by the latter debate, was published [2]. With the Mach's principle applied to cosmology, the question is "Given $T^{\mu\nu,}$ do the Einstein's field equations lead uniquely to the line element of the most general form ?" In this contribution, we will review the basics of Hoyle and Narlikar argumentation about how creation of matter has the effect of smoothing out any irregularities. This could explain the observed remarkable degree of homogeneity and isotropy in the univers. We will put their approach in perspectives with the key modern questions of the Cauchy problem in gravitation, Brans and Dicke approach to Mach's principle and the homogeneity problem in cosmology.

[1] F. Hoyle and J.V. Narlikar [1962], 'Mach's principle and the creation of matter', Proceeding of the Royal Society of London, A 270.
[2] F. Hoyle and J.V. Narlikar [1963], 'Mach's principle and the creation of matter', Proceeding of the Royal Society of London, A 230.

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