

INTERPRETING MACH

This volume presents new essays on the work and thought of physicist, psychologist, and philosopher Ernst Mach. Moving away from previous estimations of Mach as a pre-logical positivist, the essays reflect his rehabilitation as a thinker of direct relevance to debates in the contemporary philosophies of natural science, psychology, metaphysics, and mind. Topics covered include Mach's work on acoustical psychophysics and physics; his ideas on analogy and the principle of conservation of energy; the correct interpretation of his scheme of 'elements' and its relationship to his 'historical-critical' method; the relationship of his thought to movements such as American pragmatism, realism, and neutral monism, as well as to contemporary figures such as Friedrich Nietzsche; and the reception and influence of his works in Germany and Austria, particularly by the Vienna Circle.

JOHN PRESTON is Professor of Philosophy at the University of Reading. He is the author of *Feyerabend: Philosophy, Science and Society* (1997) and *Kuhn's The Structure of Scientific Revolutions: A Reader's Guide* (2008). He edited the third volume of Feyerabend's *Philosophical Papers* (1999) and co-edited *The Worst Enemy of Science?: Essays in Memory of Paul Feyerabend* (with Gonzalo Munévar and David Lamb, 2000).

INTERPRETING MACH

Critical Essays

Edited by

JOHN PRESTON

University of Reading



CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
79 Anson Road, #06-04/06, Singapore 079906
Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108474016
DOI: 10.1017/9781108564311

© Cambridge University Press 2021

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2021

A catalogue record for this publication is available from the British Library.

Library of Congress Cataloging-in-Publication Data

Names: Preston, John, 1957– editor.

Title: Interpreting Mach : critical essays / edited by John Preston, University of Reading.

Description: New York : Cambridge University Press, 2021. | Includes bibliographical references and index.

Identifiers: LCCN 2020041974 (print) | LCCN 2020041975 (ebook) | ISBN 9781108474016 (hardback) | ISBN 9781108463287 (paperback) | ISBN 9781108564311 (epub)

Subjects: LCSH: Mach, Ernst, 1838-1916.

Classification: LCC B3303 .I58 2021 (print) | LCC B3303 (ebook) | DDC 193–dc23

LC record available at <https://lcn.loc.gov/2020041974>

LC ebook record available at <https://lcn.loc.gov/2020041975>

ISBN 978-1-108-47401-6 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

For Erik C. Banks
(1970–2017)

CONTENTS

List of Figures ix

List of Tables x

List of Contributors xi

Introduction: A New Mach for a New Millennium 1

JOHN PRESTON

- 1 Ernst Mach's Piano and the Making of a
Psychophysical Imaginarium 10

ALEXANDRA HUI

- 2 Mother's Milk and More: On the Role of Ernst Mach's
Relational Physics in the Development of Einstein's Theory
of Relativity 28

RICHARD STALEY

- 3 Meaningful Work: Ernst Mach on Energy Conservation 48

DAAN WEGENER

- 4 Mach on Analogy in Science 67

S. G. STERRETT

- 5 Ernst Mach's Enlightenment Pragmatism: History and Economy in
Scientific Cognition 84

THOMAS UEBEL

- 6 On the Philosophical and Scientific Relationship between Ernst Mach
and William James 103

ALEXANDER KLEIN

- 7 Ernst Mach and Friedrich Nietzsche: On the Prejudices
of Scientists 123

PIETRO GORI

- 8 Abstraction, Pragmatism, and History in Mach's Economy of Science 142
LYDIA PATTON
- 9 Holding the Hand of History: Mach on the History of Science, the Analysis of Sensations, and the Economy of Thought 164
LUCA GUZZARDI
- 10 Ernst Mach and the Vienna Circle: A Re-evaluation of the Reception and Influence of His Work 184
FRIEDRICH STADLER
- 11 Narratives Divided: The Austrian and the German Mach 208
MICHAEL STÖLTZNER
- 12 Phenomenalism, or Neutral Monism, in Mach's *Analysis of Sensations?* 235
JOHN PRESTON
- 13 The Case for Mach's Neutral Monism 258
†ERIK C. BANKS
- Index* 280

FIGURES

- 1.1 Mach reclined on his sofa with his right eye closed, observing himself observing (Mach 1886, p. 14) 15
- 1.2 Ernst Mach, undated letter to Eduard Kulke 22
- 4.1 Foci of an ellipse 73
- 4.2 Conic sections 74
- 8.1 Left: Stevin's inclined plane with endless chain (Mach 1919, pp. 24–25). Right: Stevin's plane with the symmetrical portion of the chain removed (Mach 1919, pp. 24–25) 148

TABLES

8.1 Typology of the economy of science	152
--	-----

CONTRIBUTORS

†Erik C. Banks was a professor of philosophy at Wright State University, Ohio, the United States.

Pietro Gori is a researcher and invited professor in the Institute of Philosophy / Faculty of Social and Human Sciences at the New University of Lisbon, Portugal.

Luca Guzzardi is an assistant professor of philosophy of science in the Department of Philosophy at the University of Milan, Italy.

Alexandra Hui is an associate professor in the Department of History at Mississippi State University, the United States.

Alexander Klein is Canada Research Chair and associate professor of philosophy at McMaster University, Canada.

Lydia Patton is a professor in the Department of Philosophy at Virginia Tech, the United States.

John Preston is a professor in the Department of Philosophy at the University of Reading, the United Kingdom.

Friedrich Stadler is a professor emeritus of history and philosophy of science at the University of Vienna, Austria.

Richard Staley is a reader in the Department of History and Philosophy of Science at the University of Cambridge, the United Kingdom.

S. G. Sterrett is the Curtis D. Gridley Distinguished Professor of History and Philosophy of Science in the Department of Philosophy at Wichita State University, Kansas, the United States.

Michael Stöltzner is a professor in the Department of Philosophy at the University of South Carolina, the United States.

Thomas Uebel is Professor Emeritus in the Department of Philosophy at the University of Manchester, United Kingdom.

Daan Wegener is a lecturer in history of science at Utrecht University, the Netherlands.

On the Philosophical and Scientific Relationship between Ernst Mach and William James

ALEXANDER KLEIN

Recent Interest in Mach and James

Perhaps nobody more clearly embodies the productive and complicated relationship between American Pragmatism and Logical Positivism¹ than two respective forefathers of those movements, William James and Ernst Mach. Positivists themselves had long understood that these men were personal friends and that they engaged one another's work (Feigl 1963/1981, p. 41, 1969/1981, p. 69) for more than a quarter of a century.

There has been a quiet uptick in scholarly attention to the relationship between Mach and James recently, largely fuelled by interest in the historical connections between the big philosophical movements they inspired.² Attention has focused on the pragmatist (small 'p') tendencies of three figures who constituted the so-called First Vienna Circle (henceforth FVC; Haller 1991), and who began meeting regularly in 1907: Philipp Frank, Hans Hahn, and Otto Neurath. This group was particularly strongly influenced by Mach, and they also developed explicit sympathies for American Pragmatism.

The FVC was well aware of James's 1907 book *Pragmatism* upon its publication (it appeared in both English and German in the same year that the group began meeting in a Vienna coffee house),³ and they *later* came to see common ground with the American movement which that book helped inspire.⁴ But one striking revelation in recent scholarship is that, nevertheless,

¹ Mach's scientific epistemology was of course a major inspiration for Logical Positivism (Stadler 1992, 2015, prologue and ch. 1).

² The most important developments in this literature, for my purposes, are to be found in Uebel's recent work (cited throughout the text); also see Ferrari (2017, esp. pp. 22–27), Visser (2001), Hiebert (1976, pp. xiii, xxvi), Stadler (2017) and Blackmore (1972, pp. 126–128). Holton has also treated the Mach/James relationship in material largely repeated in Holton (1992, pp. 33–36, 1993a, pp. 50–51, 1993b, pp. 7–11).

³ Wilhelm Jerusalem's German translation carried a 1908 imprint, but in fact it was first released in 1907 (Uebel 2017, p. 84).

⁴ Uebel dates the acknowledgement of deep commonalities to about 1929 (Uebel 2015, pp. 6–7).

the pragmatist tendencies one finds among members of the FVC are likely to have been ‘home-grown’ (Uebel 2014, p. 632), largely inspired by Mach and to a lesser extent by his Viennese ally, Wilhelm Jerusalem, and *not* (at least primarily and at least not directly) by James or any other American figure (also see Uebel 2015, p. 2, 2017, pp. 93–94; Stadler 2017, p. 14).

Mach began publicly developing what we might well regard as a pragmatist outlook on science at least as early as his 1872 *Die Geschichte und die Wurzel des Satzes von der Erhaltung der Arbeit* (*History and Root of the Principle of the Conservation of Energy*) (Mach 1872/1911; see Uebel 2014, p. 634), decades before James first employed the word ‘pragmatism’ in print (in 1898), and five years before Peirce published what are commonly regarded as the founding documents, *avant la lettre*, of the American Pragmatist movement (Peirce 1877, 1878).⁵ There can be no question that Mach’s scientific methodology had a major impact on the FVC (and on many of their later allies; Stadler 1992, 2015, prologue and ch. 1). In contrast, whatever influence James might have had seems to have been less direct,⁶ and the FVC’s early engagement with his work typically resulted in an ambivalent response (as in Neurath’s 1909 review of *Pragmatism*; Uebel 2015, p. 9), so that it would be a stretch to call James a serious inspiration, at least for the *First* Vienna Circle. And Peirce remained largely unknown in Europe until the early 1930s, so is unlikely to have exerted much early influence either (Uebel 2014, p. 628, Ferrari 2017, p. 19).

This important research (led by Thomas Uebel in particular) has not yet received the attention it deserves. It raises crucial questions for, among others, historians of American Pragmatism. Some Pragmatist historians have recently claimed that Analytic Philosophy can include Peirce and (to a lesser extent) James among its founding fathers (Misak 2013, 2015, 2016; Aikin and Talisse 2017; cf. Klein 2018). The thinking is that, after the 1930s, one can find distinct pragmatist threads in the Analytic tradition – threads that run right through to today. If Quine, Wittgenstein, or Ramsey (to give three oft-cited examples) were influenced in important ways by Peirce or James (or perhaps Dewey), then one can think of those pragmatist

⁵ Mach’s 1872 book appeared in the same year that Peirce and James’s fabled ‘Metaphysical Club’ convened in Cambridge (Menand 2001, pp. 201–232), but this was a private group that Mach would have been unlikely to hear about. James had not yet been hired to a permanent position at Harvard and had yet to publish anything but short reviews, and it would be ten years before James would meet Mach in person.

⁶ One must not overstate this point. Ferrari offers evidence that James’s *Pragmatism* was probably ‘much discussed’ in the FVC (Ferrari 2017, pp. 27 and ff.), although one can learn about various reservations they had by consulting Uebel (2014, p. 628, 2015, pp. 4–5, 9, 15–16). One major worry concerned what they perceived as James’s psychologism (Uebel 2015, p. 12; cf. Klein 2016).

threads that have long been part of mainstream Analytic philosophy as having a Pragmatist (big 'P') provenance. I am sympathetic with this line. But note that if Uebel is right, then these pragmatist threads may also owe something important to a Machian influence on Logical Positivism (first via the FVC, later perhaps via Carnap).

This chapter pursues a necessary next step for scholars interested in the historical origins of pragmatist thinking in Analytic philosophy: to investigate in more detail the relationship between Mach and James, for if Mach and James came around to similarly pragmatist views about science, it might be that one friend influenced the other. Perhaps Mach co-opted pragmatist moves from his American friend and interlocutor, such that we can preserve the revisionist story that Peirce and James *are* the original fabricators of pragmatist threads in Analytic philosophy.

In the next section, I shall explain why this response is not quite right. For one thing, James and Mach seem rarely to have discussed philosophical issues at much length with one another, and in published work, they cite one another's philosophical views only in passing. Instead, instrumentalism about science seems to have been in the transatlantic air during much of their careers, so that American Pragmatism and Machian Empiricism are better regarded as partaking in, and contributing to, this larger trend in scientific philosophy. To the extent that there is evidence of philosophical influence, the evidence suggests that the influence flowed from Europe to the USA – particularly from Mach to James, who was fluent in German (and extraordinarily cosmopolitan). There is less evidence of a reciprocal philosophical influence from James to Mach.

The next question becomes: if philosophical pragmatism was not the basis for James and Mach's intellectual relationship, then what *was* that basis? It turns out that the majority of references each makes to the other's work concern empirical matters, most particularly the role of the semicircular canals in the perception of bodily orientation and the question of whether there is a distinctive 'feeling of effort' (*Innervationsgefühl*). And given that Mach, Helmholtz, and others had appealed to a supposed *Innervationsgefühl* as a cue in their accounts of spatial perception, this latter issue inevitably crops up as a topic as well. In the third section of this chapter, I shall touch on the debate over the *Innervationsgefühl* in order to emphasise the actual, empirical matters that the two men actually spent the most energy engaging one another on. That debate is interesting in part because it ended in James helping to change Mach's mind.

We remember Mach as a master experimentalist and James as a philosophical renegade, so it is a surprise to learn that the main *philosophical* influence apparently flowed from Mach to James, while the main influence when it comes to matters of *empirical* interest actually flowed quite the other way.

Philosophical Arrows of Influence

James and Mach died in 1910 and 1916, respectively, but institutional and intellectual connections between Pragmatism and Logical Positivism continued, particularly after leading advocates of the latter movement migrated to the USA around the time of World War II. Many Pragmatists and Positivists saw one another as fellow travellers thanks in part to a shared commitment to empiricism, and alliances between figures such as Herbert Feigl, Charles Morris, Ernest Nagel, Otto Neurath, John Dewey, and Philipp Frank were instrumental in helping the refugees settle into new professional positions (Richardson 2003; Reisch 2005; Klein 2007, pp. 389–399). It is therefore not surprising that in the recent literature on James and Mach the focus has tended to be on the shared affinities between the two men for *pragmatism* (which Mach himself acknowledged in a 1907 letter; see Thiele 1966, p. 305) and for *neutral monism*, another shared commitment that at one time influenced the development of both Pragmatism and Analytic Philosophy at large.⁷

However, when one examines surviving letters of James and Mach, along with their published writings, pragmatism and neutral monism are not topics that seem to have animated much discussion between the two. Certainly, James both was happy to regard Mach as a fellow pragmatist traveller⁸ and also was deferential (in correspondence) towards Mach's pioneering work on neutral monism.⁹ But the book *Pragmatism* does not engage Mach very much

⁷ Some important treatments on James and Mach on the issue of pragmatism include Stadler (2017), Ferrari (2017), Weinberg (1937), and Perry (1935, vol. II, pp. 579–580), and some important treatments that deal with their shared neutral monism include Banks (2014) and Hatfield (2002). 'Neutral monism' is Russell's term for the view he came to share with Mach and James: viz., that minds and bodies are not two different kinds of things, but both rather are composites built from a single kind of underlying stuff (hence 'monism') that is itself 'neutral' between counting as psychical or physical (Banks 2004, p. 41).

⁸ In a letter to F. C. S. Schiller on 16 January 1906, James specifically calls Mach's *Erkenntnis und Irrtum* 'excellent wise stuff, and very pragmatic' (James 1992–2004, 11.147). Interestingly, in a 1 June 1907 letter to Charles A. Strong, James expresses some reservation about whether Mach is really a pragmatist, since the latter's 'pure phenomenism is expressly denied by him to be a *philosophy*[:] it is only a point of view which he calls sufficient for scientific purposes' (James 1992–2004, 11.372). For Mach's own denial that he himself is a philosopher, see Mach (1886/1914, p. 30, note): 'I make no pretensions to the title of philosopher. I only seek to adopt in physics a point of view that need not be changed the moment our glance is carried over into the domain of another science; for, ultimately, all must form one whole.' Also see Mach (1926/1976, pp. XXXI–XXXII).

⁹ For James's acknowledgement of Mach's influence on his radical empiricism, see his letter to Mach of 19 November 1902: 'I am now trying to build up before my students a sort of elementary description of the constitution of the world as built up of "pure experiences" (in the plural) related to each other in various ways, which are also definite experiences in

beyond namechecking him; and perhaps more surprisingly, Mach's name does not even appear once in *Essays in Radical Empiricism*, the posthumous collection of essays in which James lays out his own neutral monism.

Nevertheless, by the time James began talking about either pragmatism or neutral monism in public (in James 1898, 1904, respectively), the two men had already been in regular contact for almost two decades, and James had been citing Mach in print for almost three. The first published reference to Mach in James's writing is from an 1875 book review on Wundt's *Grundzüge der physiologischen Psychologie* (James 1987, p. 297).¹⁰ Mach is mentioned only in passing there, but his 1875 *Grundlinien der Lehre von den Bewegungsempfindungen* (*Fundamentals of the Theory of Movement Perception*) is preserved in James's personal library (James was indeed working on movement perception at the time).¹¹ The two men did not meet until November of 1882 when James was in Prague, and Mach seems not to have noticed James's work before then. A few years later – in the 1886 *Beiträge zur Analyse der Empfindungen* (*Contributions to the Analysis of the Sensations*) – we find Mach's first reference to James (Mach 1886, p. 70, note). Subsequently, the two men engaged each other's works through the years, and also maintained a personal correspondence until they died.

Still, it is really empirical work that forms the basis for the connection between the two men, with philosophical issues typically falling into the background. Tellingly, in the book that James thought 'very pragmatic'¹² – Mach's 1905 *Erkenntnis und Irrtum* (*Knowledge and Error*) – the numerous references to James are all to the latter's psychological work, particularly from *The Principles of Psychology*. Mach also dedicated the first, 1895 edition of his *Popular Scientific Lectures* to James – but again, the basis for the dedication was James's *scientific* popularisation.¹³

James was keen to recruit Mach as an ally of Pragmatism, though Mach's return endorsement was somewhat 'perfunctory', as Perry put it (Perry 1935,

their turn. . . . I wish you could hear how frequently your name gets mentioned, and your books referred to' (James 1992–2004, 10.150). In addition, James's annotations in his copy of the fourth (German) edition of Mach's *Analysis of Sensations*, published in the following year, are clearly aimed at probing the overlaps and divergences between the two men on neutral monism (at Houghton, WJ 753.13; see esp. ch. 1).

¹⁰ The first evidence we have of James mentioning Mach in the classroom is from lecture notes for Philosophy 3, which James taught between 1879 and 1885 (James 1988 170).

¹¹ This volume has moderate marginalia and can be found at the Houghton Library at call number WJ 753.13.4. 'Wm. James / 20 Quincy St. / Cambridge' is inscribed in James's hand in the front flyleaf. James lived at that address from 1866 through late 1889. Perry reports only one Mach volume from James's library having been sold – the 1895 McCormack translation of *Popular Scientific Lectures*; see Houghton (BMS Am 1092.9 (4578)) for Perry's list of books that were sold off.

¹² See Note 8.

¹³ A full history of this dedication can be found in Stadler (2017).

vol. II, p. 463). Thus, in a 1911 letter quoted by the late Erik C. Banks, Mach wrote the following to the Danish philosopher Anton Thomsen:

The center of his [James's] work certainly lies in his excellent Psychology. I cannot quite come to terms with his Pragmatism. 'We cannot give up the concept of God because it promises too much.' That is a rather dangerous argument.¹⁴

Banks writes that although the two men shared a remarkable intellectual respect for one another, Mach was nevertheless uncomfortable with the way James sought to 'squeeze in "*Spiritualismus und Schwärmerei*" [spiritualism and fanaticism; Banks attributes these words to Mach]¹⁵ alongside science'.

At least a general sympathy for James's pragmatism nevertheless did develop among Mach and Mach's followers, and this is not entirely surprising. James had portrayed pragmatism as a scientific 'tendency' in philosophy, a tendency he claimed was already being exemplified by various European scientists and scientifically minded philosophers, including Mach, Sigwart, Ostwald, Pearson, Milhaud,¹⁶ Poincaré, Duhem, and Ruysen¹⁷ (James 1907/1975, pp. 34, 93). Early Logical Positivists would have looked favourably upon many of these figures, particularly Mach.

Here is James sketching a similar story in his 1904 review of F. C. S. Schiller's *Humanism*:

Thus has arisen the pragmatism of Pearson in England, of Mach in Austria, and of the somewhat more reluctant Poincaré in France, all of whom say that our sciences are but *Denkmittel* [instruments of thought – more on this term, below] – 'true' in no other sense than that of yielding a conceptual shorthand, economical for our descriptions. Thus does

¹⁴ This translation is from Banks (2003, p. 143). The original German letter can be found in Blackmore and Hentschel (1985, p. 86).

¹⁵ This is actually a minor misquote. In an earlier letter to Thomsen (4 September 1909), Mach had written that he thinks James's *Principles of Psychology* is 'the best of the current books' on the topic. Mach wrote that James did seem to be 'somewhat prone to fanaticism and *spiritism* [*Schwärmerei und Spiritismus*]', but that nevertheless, 'one does well to retain his other services' (my translation; Blackmore and Hentschel 1985, pp. 62–63). For more on the correspondence between Mach and Thomsen, see Koch (1991).

¹⁶ Gaston Milhaud was trained as a mathematician, and he established and occupied the first chair in the History of Philosophy in Its Relation to the Sciences at the Sorbonne (Chimisso 2008, p. 24). Abel Rey, who later established the Sorbonne's Institut d'Histoire des Sciences, would later occupy Milhaud's chair (Brenner 2005, p. 435). Along with Mach, Poincaré, and Duhem, the young Rey was another key influence on the FVC (Haller 1991, p. 97).

¹⁷ James apparently read and notated Theodore Ruysen's 1904 *L'Evolution Psychologique du Jugement*. Ruysen's name only appears in this list starting in the fourth impression of *Pragmatism*; the first three impressions instead listed Gerardus Heymans, a Dutch philosopher and psychologist (see note 34.3 in James 1907/1975, p. 162).

Simmel in Berlin suggest that no human conception whatever is more than an instrument of biological utility; and that if it be successfully that, we may call it true, whatever it resembles or fails to resemble. Bergson, and more particularly his disciples Wilbois, Le Roy, and others in France, have defended a very similar doctrine. Ostwald in Leipzig, with his 'Energetics', belongs to the same school, which has received the most thoroughgoing philosophical of its expressions here in America, in the publications of Professor Dewey and his pupils in Chicago University, publications of which the volume *Studies in Logical Theory* (1903) forms only the most systematised installment.

(James 1987, p. 551)

From this passage, one can see how so-called scientific philosophers¹⁸ attracted to Mach's economy of thought might appreciate James's pragmatism, here characterised as the view that scientific theory amounts to 'conceptual shorthand, economical for our descriptions', rather than quasi-images meant to 'resemble' their objects. He also portrays this kind of philosophical view as in line with the scientific methodology and philosophy of respected European figures. For young scientific philosophers, James might have seemed a fellow traveller, even if his propensity for offering more of a *Weltanschauung* than a targeted philosophy of science seems to have limited his actual influence (Uebel 2015, pp. 5, 9).

And if we come at their relationship from Mach's perspective, we can also see some deep affinities. Following C. B. Weinberg (1937), we can usefully think of Mach as having two epistemologically basic commitments, both of which James shared, broadly speaking. The first is Mach's commitment to empiricism or positivism, summed up in his slogan: 'where neither confirmation nor refutation is possible, science is not concerned' (Mach 1883/1893, p. 490). In a similar vein, he often portrays science as being motivated by humans' basic, biological need to have their thoughts 'conform to what they have observed' (Mach 1895, p. 224), or as he elsewhere puts it: '[s]cience always takes its origin in the adaptation of thought to some definite field of experience' (Mach 1886/1897, p. 24). Mach's empiricism culminates in his treatment of sensations as the 'fundamental' 'elements of the world' out of which the facts of both physics and psychology alike are to be built (Mach 1886/1897, pp. 10, 25).

For his part, James also advocated a reliance on experience as that to which our theorising must ultimately be responsible, calling his position 'radical empiricism': 'To be radical, an empiricism must neither admit into its constructions any element that is not directly experienced, nor exclude from them

¹⁸ For two relevant discussions of the history of so-called scientific philosophy during this era, see Richardson (1997, 2003).

any element that is directly experienced' (James 1912/1976, p. 22). And like Mach, James would also cultivate a form of 'neutral monism' (as Russell would later term the position) in his own empiricist soil (James 1912/1976, p. 81; Banks 2014).

Mach's other core epistemological commitment is to construe science as ultimately aiming at saving mental labour. 'It is the object of science to replace, or save, experiences, by the reproduction and anticipation of facts in thought. . . . This economical office of science, which fills its whole life, is apparent at first glance' (Mach 1883/1893, p. 481). This is his doctrine of the 'economy of thought', a doctrine that has often been thought to resonate with pragmatism (e.g. Weinberg 1937), for instance because of Mach's related rejection of a copy-theory of truth and his emphasis on the role of interest in enquiry:

In the reproduction of facts in thought, we never reproduce the facts in full, but only that side of them which is important to us, moved to this directly or indirectly by a practical interest. Our reproductions are invariably abstractions. Here again is an economical tendency.

(Mach 1883/1893, p. 482)

Like Mach, James was interested in the psychology of science, including the evolutionary psychology of science. In fact, even before the (just-quoted) 1883 *Die Mechanik in ihrer Entwicklung historisch-kritisch dargestellt* (*The Science of Mechanics: A Critical and Historical Account of Its Development*), we find James's early *Mind* essay 'The Sentiment of Rationality' also suggesting that we theorise for the purpose of saving energy:

[A] philosophic conception of nature is thus in no metaphorical sense a labour-saving contrivance. The passion for parsimony, for economy of means in thought, is thus the philosophic passion *par excellence*, and any character or aspect of the world's phenomena which gathers up their diversity into simplicity will gratify that passion, and in the philosopher's mind stand for that essence of things compared with which all their other determinations may by him be overlooked.

(James 1879, p. 320)¹⁹

There is evidence, though it is extremely limited, that this passage *might* have been directly inspired by Mach. As I have mentioned, Mach had developed similar themes already in his 1872 book on the history of the conservation of energy, and James references this book (in this connection) in the 1907

¹⁹ We find James expressing similar views almost three decades later in *Pragmatism*, where confirmed hypotheses are called the 'sovereign triumphs of economy in thought' (James 1907/1975, p. 93; also see pp. 18, 109).

Pragmatism (p. 105);²⁰ but it is hard to ascertain whether James might have read that work early enough for it to have influenced the formulation of his own instrumentalism in ‘The Sentiment of Rationality’.²¹ In addition, Mach’s 1875 *Grundlinien* articulates a similar view, but it does so only briefly and in passing. The passage in question is unmarked in James’s personal copy.²² We do know that James read this work in the 1870s, but the work is concerned with a technical treatment of bodily-movement perception (as are James’s explicit references to that work); the brief reflection on scientific methodology comes up quite in passing.

In any case, Mach first became aware of his friend’s statements about the economising aims of science, and the role of interest in enquiry, from this 1879 paper. We know from an 1884 letter that James sent this essay to Mach shortly after their original meeting two years earlier in Prague (Perry 1935, vol. I, p. 588; Thiele 1966, p. 300). And in the 1886 *Beiträge zur Analyse der Empfindungen*, in presenting his own views on the economy of thought, Mach says that James had pointed out in conversation that ‘The Sentiment of Rationality’ had articulated a kindred view of ‘*der Begriffe als ökonomische Mittel*’ (‘concepts as economical instruments’; Mach 1886, p. 141, note 83).

Let us now take a closer look at this construal of concepts as instruments – ‘*Mittel*’ in the Mach passage just quoted, or ‘*Denkmittel*’ in the James passage quoted above. James began using the latter, German phrase regularly in 1903 to describe concepts or theories that we retain because they are helpful for organising experience.

One obvious source for James’s use of the word is Mach himself, the only figure of the three who James initially mentions as holding that ‘our sciences are but *Denkmittel*’ who wrote in German. Mach only seldom used this

²⁰ James reproduces an epigram of Lessing that he says ‘Mach quotes somewhere’, without identifying the source. The quotation appears in Mach (1872, p. 1).

²¹ James’s personal library at Houghton does not include Mach (1872), and Perry does not list it as having been sold (bMS Am 1092.9 (4578)). By his own account, Mach had come in his teaching to portray science in instrumental terms as early as 1861, and he connected this instrumentalism to an *economy* of thought in 1864 under the influence of his friend, the political economist E. Hermann (Weinberg 1937, p. 3). James does cite a short, technical piece from this time period (Mach 1863) in the *Principles* (at James 1890/1981, p. 413, note), and James’s chapter on time repeatedly cites Mach’s experiments on aural temporal perception from another short, technical piece of the era (Mach 1865). But the 1872 *Conservation* book seems to be the earliest of Mach’s publications in which James might plausibly have encountered Mach’s instrumentalist reflections on methodology, and it is difficult to know *when* James read that work.

²² Mach writes that ‘the essence of natural science’ is to learn the ‘rules governing how [“natural phenomena”] . . . reoccur’. Knowledge of these rules is desirable because it ‘allows us to avoid fully observing the phenomena each time’ (Mach 1875/2001, p. 54).

unusual term. But James might well have had in mind the following usage from his friend's 1883 *Mechanik*:

The division of labour [*Die Theilung der Arbeit*], the confinement of a researcher to a small domain, the investigation of these domains as a life's work, is the necessary condition [*die nothwendige Bedingung*] for the fruitful development of science. Only with this one-sidedness and limitation can the special economical *instruments of coping* [*Mittel zur Bewältigung*] with the domain achieve the necessary refinement [*Ausbildung*]. At the same time, however, there lies here the danger of overestimating these instruments [*diese Mittel*] – with which we are always occupied, and which are nothing but tools of the trade – of holding them as the actual object of science [*eigentliche Ziel der Wissenschaft*].

2. In our opinion, such a state of affairs has really been created in physics due to its disproportionately large, formal development as compared with the rest of the natural sciences. Most natural inquirers attribute to *the instruments of thought* [*Den Denkmitteln*] of physics – the concepts mass, force, atom, and so on, whose sole function is economically and orderly to revive experiences – a reality beyond and independent of thought.

(Mach 1883, p. 476, emphasis added, my translation, in consultation with McCormack's translation from Mach 1883/1893, p. 505)

Mach's view is that each special science must narrow its scope to attain precision, and in turn to effect a more fruitful 'division of labour' in science at large. The conceptual 'tools of the trade' that scientists use to achieve this precision he here calls '*Denkmitteln*' – instruments of thought – and cautions not to treat these concepts (such as mass, force, and atom) as corresponding to real, natural objects themselves. Physics is not in the business of investigating some things in the world called 'forces' that act on other natural objects called 'atoms', according to Mach; instead, he thinks physics employs the concepts of 'force' and 'atom' as *Denkmitteln*, tools for constructing theories that efficiently and economically give us predictive control over our future experiences.

This passage in James's copy is indeed highlighted,²³ and it reverberates with James's own writing. Reflecting on scientific methodology in the wake of the publication of *The Principles of Psychology* (1890), James would similarly argue that each special science begins with convenient presuppositions about its subject matter. These presuppositions help narrow the domain of each science so as to encourage precision, James thinks; and when the presuppositions are properly fashioned, they also help 'distribute the labour' between

²³ The passage contains sideling and 'NB', in James's hand (WJ 753.13.6). The flyleaf bears 'Wm. James / 95 Irving St. / Cambridge', which suggests that he only acquired this volume sometime after late 1889, when he and his family moved to that address.

specialised disciplines in 'the most efficient' way (James 1983, p. 273; for a discussion, see Klein 2008).

Even more to the point, Mach's use of '*Denkmittel*' here matches nicely with James's use of that term in the 1904 passage I quoted above – key scientific terms do not denote real natural entities, but rather are to be treated as instruments for coping with experience. Indeed, one respect in which Frank, Hahn, and Neurath's views have all been called 'pragmatic' is that they all shared 'the view that scientific statements and theories are tools and instruments' for gaining predictive control over nature, and must be assessed as such (Uebel 2015, p. 13) – in other words, they shared a commitment to what I will call 'instrumentalism'.

So to sum up, we have Mach articulating an early version of his 'economy of thought'-style instrumentalism in his 1872 *Conservation of Energy* book. We do not see James referencing this work until much later, in his own 1907 *Pragmatism*. But in the meantime, we have James developing an instrumentalism about scientific 'conceptions' similar to Mach's in 1879. James subsequently gave Mach a copy of this article, and Mach acknowledged the overlap in their views in 1886. Meanwhile, we have Mach describing scientific concepts as '*Denkmitteln*' in 1883, in a passage that James read, but probably sometime after 1889. James echoes some themes from Mach's '*Denkmitteln*' passage in an 1892 methodological reflection on psychology, but James does not yet use that word. Starting in 1903, James begins repeatedly using the word '*Denkmittel*' to flesh out his own pragmatic treatment of scientific concepts and to portray pragmatism as allied with a larger European movement in scientific philosophy.

Thus, Mach's instrumentalism largely predated his awareness of James. The only reference I can find in Mach to James's pragmatic (small 'p') ideas is the early reference in a footnote to James's 1879 'The Sentiment of Rationality'. There are no references in Mach's published work to James's neutral monism and no references in James's papers on neutral monism to Mach's published work. And neither pragmatism nor neutral monism constituted important threads in any correspondence between the two. Still, there is a case for a (quasi-)philosophical influence between the two, and it goes from Mach (and Central Europe more generally) to James, and not vice versa, for James likely encountered Mach's instrumentalism early on. James's use of '*Denkmittel*', along with his citing of a host of other European scientific philosophers, suggests that Mach and other Central European sources inform a core aspect of James's pragmatism – especially his instrumentalism about scientific theories.

Of course, James would have encountered instrumentalist tendencies among American friends such as C. S. Peirce and Chauncey Wright as well, so that perhaps it is most accurate to say that this sort of view was just 'in the air' at the time. Still, neither James, Peirce, nor Wright seems to have

influenced the development of *European* instrumentalism of the era; the general influence is more likely to have been moving from east to west.

The Empirical Conversation between Mach and James

Earlier, I suggested that empirical and not philosophical topics constituted the more common focus of intellectual exchange between the two friends, and here we see a surprising influence going from James to Mach.

James's first two important, in-print confrontations with Mach appear in 1880. 'The Feeling of Effort' (James 1880) contains a rebuttal of some German views on volition that Mach had accepted (we will return to this), and James's review of a book by Karl Spamer on the physiology of the semicircular canals contains a passing reference to Mach's work on this topic (James 1987, p. 376). The physiological function of the semicircular canals turns out to be another important source of early contact between the two, and I will briefly canvas their work on this latter topic before turning to a disagreement they had over volition.

In 1842, Jean-Pierre Flourens had published studies showing that pigeons with portions of their semicircular canals removed often lose their equilibrium. Friedrich Goltz had later suggested that the semicircular canals are organs of balance (Henn and Young 1975, p. 139).

In his 1875 *Grundlinien*, Mach then offered a mechanistic account of *how* the semicircular canals produce sensations of bodily motion and how these sensations help agents keep their balance (Mach 1875/2001). He ran some experiments that sought to rule out rival hypotheses concerning the possible source of bodily-motion perception, including pressure on the soles of the feet, blood flow in the body at large, and pressure on the head. Mach concluded that the semicircular canals indeed contribute to the sensation of motion, and that they do so by detecting bodily acceleration (other important, contemporaneous sources for this view were Josef Breuer and Alexander Crum Brown).

Now James had conducted some experiments in hopes of supporting the Machian position in this debate. At first, he failed to produce conclusive results, but he reported the work nonetheless in the 1880 review of Spamer (James 1987, p. 375, note). James had prepared twenty-one frogs by destroying pairings of semicircular canals in the same plane (i.e. left anterior and right posterior, or vice versa; or left and right horizontal), and then he had whirled the frogs around on spinning bowls to test their resulting vertigo.

More importantly, he also conducted an extensive study of deaf students in support of the general Mach–Breuer–Brown theory, which he published in 1881. It is these experiments that Mach eventually took notice of. James wrote that if the semicircular canals were organs 'of translation through space, which

in its more extreme degrees becomes the feeling of dizziness or vertigo', then one should expect that 'some, at least, of the inmates of deaf and dumb institutions ought to prove insusceptible of experiencing this latter sensation' (James 1983, p. 125).

He travelled to a series of such institutions, using a swing apparatus to try to instil dizziness (James 1983, pp. 125–126). He also distributed questionnaires to gather self-reports of susceptibility to dizziness from other deaf subjects he could not examine directly. Of the 519 deaf subjects about whom he eventually gathered data, James reported that 320 of them were either not susceptible to dizziness at all or were only slightly so susceptible. In contrast, of 200 non-deaf Harvard professors, only one was found to be unsusceptible to dizziness at all (James 1983, p. 128).

James and Mach's personal relationship dates to a month after James published the completed results of his work on dizziness in deaf subjects (James 1882), so this is an apt place to say a bit more about that relationship. To begin with, in a colourful letter to his wife, James describes meeting Mach in Prague on 1 November 1882. Stumpf and Mach had insisted on 'trotting me about, day & night, over the whole length & breadth of Prague'. James describes his conversation with Mach in particular as 'unforgettable':

I don't think any one ever gave me so strong an impression of pure intellectual genius. He apparently has read everything & thought about everything, and has an absolute simplicity of manner and winningness of smile when his face lights up that are charming.

(James 1992–2004, 5.285–286)

The first surviving correspondence between the two men is a letter from Mach to James dated 'Prague, Jan. 29, 1884' (alluded to above). Mach acknowledges receipt of, but has not yet had time to read, James's 'The Sentiment of Rationality', and he says, 'Your fine experiments on rotary dizziness you will find already taken account of in my new book.'

The book in question (Mach's *Beiträge*) would be published two years later. In a long footnote discussing the Mach–Breuer–Brown hypothesis, Mach calls James's observations 'the most remarkable' (*merkwürdigsten*) of all the empirical evidence available in its favour (Mach 1886, p. 70).

The issue that would eventually command the most sustained discussion between the two, however, was volition. Throughout the nineteenth century, psychologists and philosophers had come to associate volition with the feeling of muscular effort (Scheerer 1989, pp. 41–42). James extensively criticises an account of the physiological basis for this feeling that he claims was pioneered by Johannes Müller. Müller is supposed to have identified volition with the feeling of the *effluent* (outflowing) nerve current – for (James's) Müller, the

feeling of effort *just is* the feeling of the efferent nerve 'telling' my muscles to contract.²⁴

Wundt and Helmholtz both supported the efferent hypothesis by appealing to observations of patients with various forms of paresis (Wundt 1863, Helmholtz 1867). These patients reportedly experience a feeling of effort when they attempt to move a wholly or partially paralysed limb. Such a feeling cannot arise from the afferent (inflowing) nerve current, the efferent-theorists reason, because the feeling reportedly arises even when the limb is actually moved little or not at all (see esp. Wundt 1863, vol. I, p. 222). Wundt termed this feeling of effort the '*Innervationsgefühl*' (literally, innervation-feeling).

James was a staunch critic of the *Innervationsgefühl*. Here he is registering his dissent in his 1880 essay 'The Feeling of Effort':

In opposition to this popular view, I maintain that the feeling of muscular energy put forth is a complex afferent sensation coming from the tense muscles, the strained ligaments, squeezed joints, fixed chest, closed glottis, contracted brow, clenched jaws, etc., etc. That there is over and above this another feeling of effort involved, I do not deny; but this latter is purely moral and has nothing to do with the motor discharge.

(James 1983, p. 85)

James claimed that the feeling of effort arises only from *afferent* nerve currents. When I lift a heavy object, for James, the feeling of effort is the feeling of my muscles having flexed, not the antecedent feeling of *attempting* to flex.

But how can James explain effort feelings in partially paralysed patients, then? James points to Alfred Vulpian's observations of hemiplegic patients who are asked to try to squeeze a ball with their paralysed hand. Vulpian confirms Wundt's report that such a patient *does* experience a feeling of effort. But such a patient also 'unconsciously performs this action with the sound' hand at the same time. James says he 'repeatedly verified' Vulpian's observations himself (James 1983, p. 92).

James takes Vulpian's observation to support a general conjecture: that *whenever* 'effort' is felt in connection with a totally or partially paralysed body part, that effort is coming from the 'tense muscles, the strained ligaments, squeezed joints, fixed chest, closed glottis, contracted brow, clenched jaws, etc., etc.' that are being moved *elsewhere in the body*, perhaps without the subject's direct awareness.

²⁴ At any rate, this is according to James (1983, p. 84), who cites Müller (1837, vol. II, p. 500). In the cited location, I do not see Müller saying that the *only* feeling of effort comes from efferent nerves. In fact, he elsewhere seems happy to accept the existence of afferent muscular feelings as well (as Scheerer 1989, p. 44 points out; see Müller 1837, vol. II, p. 363).

Mach enters the discussion with more sophisticated, abductive versions of the argument from paresis, with Helmholtz offering similar considerations. He and Helmholtz both appeal to the *Innervationsgefühl* as a cue in spatial perception. They reason as follows. Objects normally appear to move in two cases:²⁵

- (1) When the retinal image changes relative position but the eyeballs remain stationary or
- (2) When the retinal image retains the same relative position but the eyeballs move.

Now, *eyeball* paresis can introduce translocation illusions. For example, when a patient who can only move an eyeball with difficulty is asked visually to track a moving object, the object may appear to move more in the direction of eyeball rotation (Helmholtz 1856–1867/2005, vol. III, pp. 245–246). The efferent theorist says that what *would* explain such illusions is if subjects typically judge themselves to be in the type (2) situation not based on having felt their eyeballs actually moving, but based on feeling themselves *trying* to move their eyeballs – that is, when they have a feeling of the efferent nerve current (the supposed *Innervationsgefühl*).²⁶ If that is correct, then the translocation illusion associated with eyeball paresis constitutes a confirmatory prediction of the efferent hypothesis.

James has a simple response: when the paralysis (or paresis) is in the *right* eye, one finds that the *left* eyeball continues to move even after the right one is impeded. The feeling of this *left* eyeball motion could provide the misleading (i.e. illusion-inducing) cue (James 1983, pp. 96–97).

Mach's 1886 *Beiträge* does not reference James on the feeling of effort, but it adds a curious new experiment that gives an implicit rejoinder to James's right eye/left eye account. Using himself as a subject, Mach rotated his eyeballs as far to the left as possible, then jammed 'two large lumps of fairly firm putty' (*zwei grosse Klumpen von ziemlich festem Glaserkitt*) on his eyeballs, in the rightmost corner of each eye. He reports getting the same sort of translocation illusion reported by patients with paresis in one eyeball. But the experiment is important because the putty effectively induces eyeball paresis *in both eyes at once*, so James cannot account for the illusion by appealing to the feeling of unimpeded movement in a non-paralysed eye. Mach concludes, perhaps overly dramatically: 'The will to perform movements of the eyes or the innervation of the act, is itself the space-sensation' (Mach 1886, p. 57, 1886/1897, p. 60).

²⁵ This is James's way of framing the issue (James 1983, p. 94), but it goes back at least to Müller (1837, vol. II, p. 363).

²⁶ An important early version of this argument in Mach is in his 1886 *Beiträge* (Mach 1886, pp. 55–57, 1886/1897, pp. 57–59).

James reported that he did not get the expected illusion when he jammed putty into his own eyes. But he responded that even if the effect could be reliably elicited, 'the conditions are much too complicated for Professor Mach's theoretic conclusions to be safely drawn' (James 1890/1981, p. 1118) because having large foreign objects stuck to your eyeballs produces too many 'peripheral sensations'. These are strong (and unusual) enough that they may cause any number of illusions, and do so 'quite apart from the innervation feelings which Professor Mach supposes to coexist'.

Surprisingly, when Mach expanded the *Analysis of Sensations* for the second, 1900 edition (he now dropped the 'Contributions to ...' (*Beiträge*) prefix), he came around to James's view. Mach added a completely new chapter on 'Will', in which he now *denied* that there is any feeling associated with the efferent nerve current at all.²⁷

Citing both his own experience with a recent stroke along with James's work on the subject, Mach says it now 'seems to me plausible to suppose that this [his own feeling of effort when trying to move his own stroke-paralysed legs] was caused by the energetic innervation of other muscle-groups in addition to the muscles of the paralysed extremities' (Mach 1886/1914, p. 175). The most important consideration seems to be this:

The hypothesis of specific sensations of innervation is not required for the explanation of the phenomena, and, on the principle of economy, is consequently to be avoided. Finally, sensations of innervation are not directly observed.

(Mach 1886/1914, p. 174)

Considerations of parsimony,²⁸ ultimately, have pushed Mach over to James's side. He sees that James is able to account for the variety of paresis cases that have been discussed, and to do so *without* postulating any special feeling of innervation. And such a feeling would indeed have to be postulated, Mach now concedes, because it cannot be directly observed.

The final feeling one is left with from following three decades of discussion and debate between Mach and James, through their private correspondence and their professional publications, is that these are two men who admired one another enormously. They shared a broad philosophical outlook that involved turning empiricism in a strongly instrumentalist direction. I have provided

²⁷ He actually retained the earlier essay on spatial perception (complete with the *Innervationsgefühl* employed as a cue) largely unchanged, because 'I do not wish to conceal the method by which I was led to my theory', though he now acknowledges the correctness of James's view (he also cites Münsterberg and Hering as important sources, along with James; Mach 1886/1914, p. 168, note).

²⁸ James had long argued that parsimony demands that we abandon the *Innervationsgefühl* (James 1983, p. 86).

limited evidence that Mach might have exerted a modest influence on James in this capacity, but philosophical issues only motivated a small minority of their intellectual exchanges; the two friends largely settled into their philosophical views independently, it seems. They are much more likely to cite one another, to engage one another, to argue with one another, and to praise one another on matters of experiment. And here the surprise is that on the most contentious experimental issue that divided them, it was James who ultimately helped changed Mach's mind, not the reverse.

References

- Aikin, Scott F., and Talisse, Robert B. 2017. *Pragmatism, Pluralism, and the Nature of Philosophy* Routledge.
- Banks, Erik C. 2003. *Ernst Mach's World Elements: A Study in Natural Philosophy*. Kluwer.
2004. 'The Philosophical Roots of Ernst Mach's Economy of Thought', *Synthese* 139: 23–53.
2014. *The Realistic Empiricism of Mach, James, and Russell: Neutral Monism Reconsidered*. Cambridge University Press.
- Blackmore, John T. 1972. *Ernst Mach: His Work, Life, and Influence*. University of California Press.
- Blackmore, John T. and Hentschel, Klaus (eds.) 1985. *Ernst Mach als Aussenseiter*. W. Braumüller.
- Brenner, Anastasios 2005. 'Réconcilier les Sciences et les Lettres: Le Rôle de L'Histoire des Sciences selon Paul Tannery, Gaston Milhaud et Abel Rey', *Revue D'Histoire des Sciences* 58: 433–454.
- Chimisso, Cristina 2008. *Writing the History of the Mind: Philosophy and Science in France, 1900 to 1960s*. Ashgate.
- Feigl, Herbert 1963/1981. 'The Power of Positivistic Thinking: An Essay on the Quandaries of Transcendence', in R. S. Cohen (ed.), *Inquiries and Provocations: Selected Writings, 1929–1974*. D. Reidel, pp. 38–56.
- 1969/1981. 'The Wiener Kreis in America', in R. S. Cohen (ed.), *Inquiries and Provocations: Selected Writings, 1929–1974*. D. Reidel, pp. 57–94.
- Ferrari, Massimo 2017. 'William James and the Vienna Circle', in Sami Pihlström, Friedrich Stadler, and Niels Weidtmann (eds.), *Logical Empiricism and Pragmatism*. Springer, pp. 15–42.
- Haller, Rudolf 1991. 'The First Vienna Circle', in T. Uebel (ed.), *Rediscovering the Forgotten Vienna Circle: Austrian Studies on Otto Neurath and the Vienna Circle*. Springer Netherlands, pp. 95–108.
- Hatfield, Gary C. 2002. 'Sense-Data and the Philosophy of Mind: Russell, James, and Mach', *Principia: Revista Internacional de Epistemologia* 6: 203–230.
- Helmholtz, Hermann von 1856–1867/2005. *Treatise on Physiological Optics*, 3 vols. Trans. James Powell Cooke Southall. Dover.

- 1867 *Handbuch der Physiologischen Optik, Allgemeine Encyclopädie der Physik*. Leopold Voss.
- Henn, V. and Young, L. R. 1975. 'Ernst Mach on the Vestibular Organ 100 Years Ago', *Journal of Otorhinolaryngology and its Related Specialties* 37: 138–148.
- Hiebert, Erwin N. 1976. 'Introduction', in Ernst Mach, *Knowledge and Error: Sketches on the Psychology of Enquiry*. Trans. Thomas J. McCormack from the 5th German edn. D. Reidel, 1926/1976, pp. xi–xxx.
- Holton, Gerald 1992. 'Ernst Mach and the Fortunes of Positivism in America', *Isis* 83: 27–60.
- 1993a. 'From the Vienna Circle to Harvard Square: The Americanization of a European World Conception', in F. Stadler (ed.), *Scientific Philosophy – Origins and Developments*. Kluwer, pp. 47–73.
- 1993b. *Science and Anti-Science*. Harvard University Press.
- James, William 1879. 'The Sentiment of Rationality', *Mind* 4: 317–346.
1880. 'The Feeling of Effort', *Anniversary Memoirs of the Boston Society of Natural History* (Boston, MA).
1882. 'The Sense of Dizziness in Deaf–Mutes', *American Journal of Otology* 4: 239–254.
- 1890/1981. 'The Principles of Psychology', in F. H. Burkhardt, F. Bowers, and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
1898. 'Philosophical Conceptions and Practical Results', *The University Chronicle (University of California)* 1: 287–310.
1904. 'Does "Consciousness" Exist?', *Journal of Philosophy, Psychology, and Scientific Methods* 1: 477–491.
- 1907/1975. *Pragmatism*, in F. Bowers and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
- 1912/1976. *Essays in Radical Empiricism*, in F. Bowers and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
1983. *Essays in Psychology*, in F. H. Burkhardt, F. Bowers, and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
1987. *Essays, Comments and Reviews*. in F. H. Burkhardt, F. Bowers, and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
1988. Manuscript Lectures, in F. H. Burkhardt, F. Bowers, and I. K. Skrupskelis (eds.), *The Works of William James*. Harvard University Press.
- 1992–2004. *The Correspondence of William James*, 12 vols. Edited by I. K. Skrupskelis and E. M. Berkeley. University Press of Virginia.
- Klein, Alexander 2007. *The Rise of Empiricism: William James, Thomas Hill Green, and the Struggle over Psychology*. Doctoral dissertation, Indiana University.
2008. 'Divide Et Impera! William James's Pragmatist Tradition in the Philosophy of Science', *Philosophical Topics* 36: 129–166.
2016. 'Was James Psychologistic?', *Journal for the History of Analytical Philosophy* 4: 1–21.
2018. 'In Defense of Wishful Thinking: James, Quine, Emotions, and the Web of Belief', in M. Baghramian and S. Marchetti (eds.), *Pragmatism and the*

- European Traditions: Encounters with Analytic Philosophy and Phenomenology before the Great Divide*. Routledge, pp. 228–250.
- Koch, Carl Henrik 1991. 'The Correspondence of Ernst Mach with a Young Danish Philosopher', *Danish Yearbook of Philosophy* 26: 97–112.
- Mach, Ernst 1863. 'Zur Theorie des Gehörorgans', *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Classe* 48: 283–300.
1865. 'Untersuchungen über den Zeitsinn des Ohres', *Sitzungsberichte* 51: 133–150.
1872. *Die Geschichte und die Wurzel des Satzes von der Erhaltung der Arbeit*. J.G. Calve'sche.
- 1872/1911. *History and Root of the Principle of the Conservation of Energy*. Transl. by Philip E. B. Jourdain. Open Court.
- 1875/2001. *Fundamentals of the Theory of Movement Perception*. Transl. by Laurence R. Young, Volker Henn, and Hansjörg Scherberger. Kluwer Academic/Plenum Publishers.
1883. *Die Mechanik in ihrer Entwicklung: Historisch-kritisch dargestellt*. F. A. Brockhaus.
- 1883/1893. *The Science of Mechanics: A Critical and Historical Account of its Development*. Transl. by Thomas J. McCormack from the 2nd (1888) edn. Open Court.
1886. *Beiträge zur Analyse der Empfindungen*. Gustav Fischer.
- 1886/1897. *Contributions to the Analysis of the Sensations*. Transl. by C. M. Williams from the 1st edn. Open Court.
- 1886/1914. *The Analysis of Sensations and the Relation of the Physical to the Psychical*. Transl. by C. M. Williams and S. Waterlow. From the 5th German edn. Open Court.
1895. *Popular Scientific Lectures*. Transl. by Thomas J. McCormack from the 1st (1896 [sic]) edn. Open Court.
- 1926/1976. *Knowledge and Error: Sketches on the Psychology of Enquiry*. Transl. by Thomas J. McCormack from the 5th German edn. D. Reidel.
- Menand, Louis 2001. *The Metaphysical Club: A Story of Ideas in America*. Farrar, Straus, and Giroux.
- Misak, Cheryl J. 2013. *The American Pragmatists*. Oxford University Press.
2015. 'James on Religious Experience', presented at Conference on Issues in Modern Philosophy: God, New York University, 7 November 2015.
2016. *Cambridge Pragmatism: From Peirce and James to Ramsey and Wittgenstein*. Oxford University Press.
- Müller, Johannes 1837. *Handbuch der Physiologie des Menschen*, 2 vols. Verlag von J. Hölscher.
- Peirce, Charles Sanders 1877. 'The Fixation of Belief', *Popular Science Monthly* 12: 1–15.
1878. 'How to Make Our Ideas Clear', *Popular Science Monthly* 12: 286–302.

- Perry, Ralph Barton 1935. *The Thought and Character of William James*, 2 vols. Harvard University Press.
- Pihlström, Sami, Stadler, Friedrich, and Weidtmann, Niels (eds.) 2017. *Logical Empiricism and Pragmatism*. Springer.
- Reisch, George A. 2005. *How the Cold War Transformed Philosophy of Science: To the Icy Slopes of Logic*. Cambridge University Press.
- Richardson, Alan W. 1997. 'Toward a History of Scientific Philosophy', *Perspectives on Science* 5: 418–451.
2003. 'Logical Empiricism, American Pragmatism, and the Fate of Scientific Philosophy in North America', in G. L. Hardcastle and A. W. Richardson (eds.), *Logical Empiricism in North America*. University of Minnesota Press, pp. 1–24.
- Scheerer, Eckart 1989. 'On the Will: An Historical Perspective', in W. A. Hershberger (ed.), *Volitional Action: Conation and Control*. North-Holland, pp. 39–62.
- Stadler, Friedrich 1992. 'The "Verein Ernst Mach": What Was It Really?', in J. T. Blackmore (ed.), *Ernst Mach – A Deeper Look: Documents and New Perspectives*. Kluwer, pp. 363–378.
2015. *The Vienna Circle: Studies in the Origins, Development, and Influence of Logical Empiricism*. Springer.
2017. 'Ernst Mach and Pragmatism – the Case of Mach's Popular Scientific Lectures (1895)', in Sami Pihlström, Friedrich Stadler, and Niels Weidtmann (eds.), *Logical Empiricism and Pragmatism*. Springer, pp. 3–14.
- Thiele, Joachim 1966. 'William James und Ernst Mach', *Philosophia Naturalis* 9: 298–310.
- Uebel, Thomas 2014. 'European Pragmatism? Further Thoughts on the German and Austrian Reception of American Pragmatism', in M. C. Galavotti et al. (eds.), *New Directions in the Philosophy of Science*. Springer, pp. 627–643.
2015. 'American Pragmatism and the Vienna Circle: The Early Years', *Journal for the History of Analytical Philosophy* 3: 1–35.
2017. 'American Pragmatism, Central-European Pragmatism and the First Vienna Circle', in Sami Pihlström, Friedrich Stadler, and Niels Weidtmann (eds.), *Logical Empiricism and Pragmatism*. Springer, pp. 83–102.
- Visser, Henk 2001. 'Wittgenstein's Machist Sources', in J. T. Blackmore, R. Itagaki and S. Tanaka (eds.), *Ernst Mach's Vienna, 1895–1930, or, Phenomenalism as Philosophy of Science*. Kluwer, pp. 139–158.
- Weinberg, Carlton Berenda 1937. *Mach's Empirio-Pragmatism in Physical Science*. Albee Press.
- Wundt, Wilhelm Max 1863. *Vorlesungen über die Menschen- und Tier-Seele*, 2 vols. Leopold Voss.