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Metaphysics for Positivists: Mach versus the Vienna Circle

Abstract

Ernst Mach and the Vienna Circle are linked historically, but conceptually the views of Mach do not fit well with logical positivism. My purpose in the present paper is to reconsider 1) Mach's positive natural philosophy 2) what Mach meant by "anti-metaphysics", 3) whether Mach really was "anti-metaphysical" in the sense of demanding verification in principle for every term or statement in science, and 4) how Mach's views on metaphysics differed from those of many Vienna Circle philosophers. I believe a strong case can be made for separating Mach's realistic version of empiricism from that of the Vienna Circle, but perhaps the "received view" of the Vienna Circle philosophers does not describe their views very well either.

Keywords: metaphysics, logical positivism, Ernst Mach, Vienna Circle.

1. *Introduction*

The Viennese physicist Ernst Mach (1838-1916) was a major influence on the philosophers of the Vienna Circle, such as Philipp Frank, Otto Neurath, Moritz Schlick, and Rudolf Carnap. It is commonly believed that the Vienna Circle wanted metaphysics to be eliminated from science, where "metaphysics" meant any term or proposition unverifiable in principle by experience, a program they supposedly inherited from Mach himself. So, when this verificationist "received view" of scientific theories (Suppe 1977) came under attack in the 1960s and 70s, in favor of realist and historicist philosophy of science, Mach was often lumped in with the Vienna Circle as a naïve positivist whose views could be considered refuted along with theirs. This has been a commonly held view ever since, but the story does little justice to Mach's actual views on metaphysics, or even those of the Vienna Circle philosophers. My purpose in the present paper is to reconsider 1) Mach's natural philosophy, 2) what Mach actually meant by "anti-metaphysics", 3) whether Mach really was "anti-metaphysical" in the sense of demanding verification in principle for every term or statement in science, and 4) how Mach's views on metaphysics differed from those of many Vienna Circle philosophers. I believe a strong case can be made for separating Mach's realistic brand of empiricism from that of the Vienna Circle, but perhaps "the received view" of the Vienna Circle philosophers does not de-

scribe their views very well either (as has come to light in work by Uebel 2007, Richardson 2008, Friedman 1999 and Stadler 1997 among others).

2. *Good Metaphysics: Mach's Theory of Elements*

Mach's overall view of science was really a kind of naturalistic *monism* of what he called the "elements" (Mach 1872/1910, 1883/1960, 1886/1959, 1905/1976, Banks 2003). According to Mach, the world is composed of these elements, which are events in causal-functional relations to each other, not of spatio-temporal objects (as in materialism) or minds (as in idealism). In fact, elements are what is left when we deconstruct physical objects into complexes of physical *events* causally linked together by their effects, and when we deconstruct the permanent ego into events such as sensations, images, thoughts linked together by functional connections such as memory, reasoning or association ultimately realized in the brain. For Mach, sensations of color or sound are only "mental" if we choose to concentrate on their psychological relations with memory images and other associations, otherwise they are also "physical" elements in their relation to the brain and to other physical events in the environment:

A color is a physical object as soon as we consider its dependence for instance upon its luminous source, upon other colors, upon temperature, upon spaces and so forth. When we consider, however, its dependence upon the retina [...] it is a psychological object, a sensation. Not the subject matter but the direction of our investigation is different in the two domains.

[...] it is only in their functional dependence that the elements are sensations. In another functional relation they are at the same time physical objects. We only use the additional term "sensations" to describe the elements because most people are more familiar with the elements in question as sensations (colors, sounds, pressures, spaces, times) (1886/1959, p. 16).

In themselves, elements are simply *concrete natural events*, whether these events occur in minds or in the physical universe. Even a vivid sensation of red need not be considered mental or a "secondary quality", since it is also a physical happening linked to other physical happenings. Bertrand Russell especially appreciated Mach's discovery as a breakthrough in the mind-body problem, calling it a "service to philosophy", "that what is experienced may be a part of the physical world and often is so" (Russell 1914/1984, p. 31), and that "constituents of the physical world can be immediately present to me" (p. 22). Russell called Mach's view "neutral monism" and began as a skeptic of the view until he converted in 1919 and expanded the view in books like the *Analysis of Mind* (1921) and *The Analysis of Matter* (1927).

While sensations always have a physical interpretation as elements, clearly not all elements are sensations. Nor can we avoid assuming unobserved events in nature, especially not in physics. Mach always emphasized that we “complete partially observed facts in thought” by filling in unobserved elements making up the rest of an object. For example we attribute backs and sides to chairs we don’t see, and we adjoin past and future states to presently observed phenomena such as the path of a body in a parabola, when we only actually see its present position and velocity at any one time. In his *Mechanics*, Mach gave the example of a vibrating rod in a vice (1883/1960, p. 587), to show that continuity with experience is all he demanded:

If a long elastic rod be fastened in a vice, the rod may be made to execute slow vibrations. These are directly observable, can be seen, touched and graphically recorded. If the rod be shortened, the vibrations will increase in rapidity and cannot be directly seen; the rod will present a blurred image. This is a new phenomenon. But the sensation of touch is still like that of the previous case; we can still make the rod record its movements; and if we mentally retain the conception of vibrations, we can still anticipate the results of experiments. On further shortening the rod the sensation of touch is altered; the rod begins to sound; again a new phenomenon is presented. But the phenomena do not all change at once; only this or that phenomenon changes; consequently the accompanying notion of vibration, which is not confined to any single one, is still serviceable, still economical. Even when the sound has reached so high a pitch and the vibrations have become so small that the previous means of observation are not of avail, we still advantageously imagine the sounding rod to perform vibrations, and can predict the vibrations of the dark lines in the spectrum of the polarized light of a rod of glass. If on the rod being further shortened all of the phenomena suddenly passed into new phenomena, the conception of vibration would no longer afford us a means of supplementing the new experiences by the previous ones. When we mentally add to those actions of a human being which we can perceive, sensations and ideas like our own which we cannot perceive, the idea of the object that we form is economical. The idea makes experience intelligible to us; it supplements and supplants experience. Now, this is exactly what we do when we imagine a moving body which has just disappeared behind a pillar, or a comet at the moment invisible, as continuing its motion and retaining its previously observed properties. We do this so that we may not be surprised by its reappearance. We fill out the gaps in experience by the ideas which experience suggests (1883/1960, pp. 587-588).

Mach’s view was not that science was permanently restricted to what is directly observable, but rather was limited to phenomena causally *continuous* with observation, that is open to causal interaction with the world of experienced events, experience being *one* kind of causal interaction but not the only one by any means. I believe that when Mach used the subjective sounding word “sensation” he implicitly meant to include the idea that the

sensation was also a physical element and when he used the words “experience” (*Erfahrung*) and “verification” (*kontrollieren*) he probably had in mind this broader idea of phenomena somehow *continuous* with experience in one fabric and certainly not merely what is experienced directly, which is too naïve for any practical physicist like Mach to seriously believe.

Certainly Mach was no foundationalist about his elementary events either. Mach himself often emphasized that the elements were “only provisional in nature like the elements of alchemy” which we “cannot presently divide further” (1905/1976, p. 12n). Elements are *not* epistemological “givens” or indivisible “sense data” upon which to base the rest of knowledge as a foundation, a complete misunderstanding of Mach’s naturalistic and evolutionary theory of knowledge (as Feyerabend 1984 correctly points out). We don’t begin with elements, we are supposed to *keep analyzing them further* as science progresses; the title of Mach’s famous book is the *Analysis of Sensations*. Moreover, there are no isolated elements to begin with: we are always surrounded by elements-in-complexes in one causally connected whole of material nature, and only with difficulty can we succeed in isolating elements from the rest of nature. What is “given” is the whole, if anything, not the pieces. Otto Neurath, who later emphasized holism in his discussions in the Vienna Circle, and who used the famous metaphor of “repairing the ship while at sea” to deny epistemic foundationalism, claimed in a letter to have been influenced by Mach in this view (Neurath to Mach c. 1914 in Thiele 1978, p. 100):

It was this thought in your *Mechanics* which never let loose of me from the first reading and which influenced the development of my ideas in strange ways even in the area of political economy (*Volkswirtschaft*). It is the inclination to derive the sense of the individual from the whole, not the whole from a sum of individuals.

Likewise in psychology, Mach also called attention to “holistic” overall sensations of form or symmetry, (see Mach 1871 and 1886/1959) later cited by Christian von Ehrenfels (1890) one of the founders of Gestalt psychology.

Finally, Mach’s elements were nothing like passive empiricist “sense data” or atomistic Humean “impressions”. Mach often spoke of the elements as being like *forces* or pressures, related to each other by real “variation and counter-variation” (Mach 1883/1960, pp. 604-605) in their real intensities, not mere mathematical relationships. Mach held to the view that particular element-to-element relations were as real as elements themselves and coined a principle of the functional interdependence of phenomena. He avoided mechanistic views of causation and denied that we can read off variations of elements a priori, but he should not be considered a Humean about causation. The elements, including the sensations under their physical description, are events which seem to directly manifest forces or physi-

cal “potential changes”, (Mach 1883/1960, p. 606; 1976/1905, p. 357) related by natural laws. The job of science is to bring these empirically real and objective functional relations among particulars at level one into some kind of economical order under theoretical laws and postulates at a higher order of abstraction at level two (for this idea of “two level” Machian economy see Banks 2004). I have shown at length that Mach borrowed this idea that elementary events, and even sensation qualities like red or blue, express real forces, from the psychology of German philosopher J.F. Herbart (Herbart 1964; Banks 2003, Chapter 3).

As I hope is clear by now, Mach’s view is very far from a standard empiricist or positivist philosophy à la Hume or Suppe’s “received view” of logical positivism. His view is *far* more robust and realistic about its elements and causal-functional relations than empiricists are wont to be, and much more realistic about unobserved elements than any card-carrying positivist would readily admit. I have taken to calling Mach a “realistic empiricist”, like Russell and James, to separate him from phenomenalist philosophers and positivistic scientists (see Banks forthcoming). I am really not sure how Mach came to be known as an extreme positivist or “phenomenalist” who believed only in sensations, a misreading against which he protested vigorously in his lifetime, but which seems to stick to his writings in popular thought. Certainly Lenin, in *Empiricism and Empirio-Criticism* (1909) sought to declassify Mach and his colleague Richard Avenarius, and others, as reactionary idealists, and Lenin himself was totally baffled by the new term “element”, ultimately concluding that it simply meant “sensation” as in the philosophy of Berkeley or Hume.

Mach and Avenarius *secretly* smuggle in materialism by means of the word “element”, which *supposedly* frees their theory of the one-sidedness of subjective idealism, *supposedly* permits the assumption that the mental is dependent on the retina, nerves and so forth and the assumption that the physical is independent of the human organism. In fact, of course, the trick with the word “element” is a wretched sophistry, for a materialist who reads Mach and Avenarius will immediately ask: what are the “elements”? Either the “element” is a *sensation*, as all empirio-criticists, Mach, Avenarius, Petzoldt, etc. maintain – in which case your philosophy, gentlemen, is *idealism*, vainly seeking to hide the nakedness of its solipsism under the cloak of a more “objective” terminology; or the element is not a sensation – in which case *absolutely no thought whatever* is attached to the “new” term; it is merely an empty bauble (Lenin 1908/1952, pp. 48, 49).

But Lenin’s book was a brutal *Streitschrift* against the Russian neo-Machists, which did not even try to do justice to opposing views. It is thus remarkable how many trained philosophers who should have known better (like Popper and Schlick) simply fell in line behind Lenin’s reading, and *not* for example Russell’s superior “neutral monist” reading, and this has re-

mained the case all the way up to fairly recent times (Blackmore 1973, 1992, but see Stubenberg 2010).

Much of the blame for the “phenomenalist” reading must certainly be placed at the door of Mach himself. No doubt it was easier for many authors to cite secondary works than to deal with the rigors of Mach’s own demanding works. He also had the misfortune to frame a view that is superficially similar in style to Hume, or the later Vienna Circle philosophers, and could be glossed over as such, while being completely different underneath on a closer reading. And of course Mach did sometimes write carelessly as if to suggest that the world “consisted of sensations” when he clearly meant elements, or to suggest that things that “could not enter consciousness” simply did not exist, where (presumably) he meant to say things not continuously connected or connectible with experience or the whole of natural phenomena do not exist, a far more plausible claim.

Mach was, of course, famously skeptic of atoms and the kinetic interpretation of the second law of thermodynamics, and the debates with Boltzmann and Planck around the turn of the century seemed to confirm Mach as the defender of unrealistic positivism against their more sensible belief in atoms and the idea that heat is the kinetic energy of molecules, although Mach’s replies would not confirm this reading. The actual story is much more complicated, and it is by no means clear there was a “winner” since realism also came to grief in the rise of the quantum theory; more likely both sides simply misunderstood each other. Mach himself thought the increasingly unpleasant debate with Planck was “silly” and Einstein wrote Mach that he thought Planck’s attacks on him were “unjust”.

Mach apparently thought atoms were metaphysical Kantian “things in themselves” permanently shut out from the world of observation, and even outside of space and time, imaginary objects which he says “can *never* be the object of sensory observation” whereas atoms for Planck, Boltzmann, and Einstein were *very small* objects but otherwise their properties were completely continuous with those of visible objects like space and time extension, mass, momentum and so forth (a view that also cannot be considered correct after the rise of quantum theory). Mach provisionally believed in atoms earlier in his career and he even used the atomic theory in his derivation of shock waves behind supersonic bullets. There are surprising remarks in his notebooks stored at the Deutsches Museum which describe one atom pushing on the next in the shock wave, so he was perfectly capable of using the theory when it suited him. Mach also briefly converted to atomism in 1903 when Stefan Meyer convinced him with an experiment (Blackmore 1992, Banks 2003), perhaps provoking a later remark in Mach’s notebook “atoms not occult?” But since he still published anti-atomistic statements after the so-called conversion, it seems likely that Mach still held

out for a deeper understanding of atoms through his theory of elements and deeper dynamical laws of energy transformation, believing that ultimately elements would prove more fundamental than atoms even if they did exist (see Feyereabend 1984 for that view which seems right to me).

As I hope is also clear by now, the *Elementenlehre* was indeed a genuine scientific metaphysics, or natural philosophy, although Mach would have claimed he was only doing unified science or metascience. Not being a trained philosopher, he failed to see that this is literally what “metaphysics” means in its traditional Aristotelian sense, and in fact he criticized other authors such as Gerardus Heymans for calling unified science metaphysics:

One is curious why, if on Heymans’ view the method of metaphysics is exactly the same as that of natural science, though extended to a wider field, he insists on calling it metaphysics, a term with so distasteful a flavor since Kant, and one that seems contradicted by the addition “on the basis of experience” (Mach 1905/1976, pp. 13-14n).

Mach believed that his elements already exhausted our knowledge of the material universe, in the sense that *behind* experience, figuratively speaking, we would simply find *more experience*, more of the same elements and functions continuous with those we observe *within* experience, although the process of discovery never ends and results are never set in stone. This is the real reason, I think, why Mach was dismissive of the search for unobserved entities and mechanisms in nature since, for him, the discovery would simply push the search for elements and functions another step back.

The theory of elements and functions served Mach as a kind of overarching “umbrella theory” for unifying the sciences, physics and psychology among others. It also served Mach as an engine of analysis for criticizing and streamlining science by “eliminating metaphysics”, leaving the bare elements and functions without any added residue of mechanisms or visual models. Clearly “good” metaphysics, for Mach involved the philosophical attempt to unify the sciences under one roof, metaphysics as metascience, but he refused to call this metaphysics. He was actively engaged in this project in his own work and wrote with great sensitivity about the relation between science and philosophy in his *Knowledge and Error*:

Through its many attempts to summarize the most general features of large areas, philosophy has gained ample experience in this line, even learning gradually to recognize and avoid some of its own mistakes that the philosophically untrained scientist is almost bound to commit even today. However philosophy has furnished science with some positive notions too, for example ideas of conservation (Mach 1905/1976, p. 3).

He was also aware that science often borrows “covertly” from philosophical thought, as he himself had borrowed ideas from Leibniz, Kant, Herbart, Fechner, Mayer and other philosopher-scientists. Sadly, Mach added that “few philosophers today take part in the work of science and only exceptionally do scientists address their intellectual attention to philosophical questions”. This is only more true today.

Generally, Mach favored monism over dualism, especially mind-matter monism. He emphasized the reality of immediate experience and rejected the idea that sensations are purely mental. He was nominalistic in the sense that he believed in *particular* matters of fact, individual, unique and non-repeating events, not abstractions or generalities, saying that “nature has but an individual existence”. And yet he emphasized the view of a continuously connected *whole* of particulars in causal-functional relationships, as Neurath correctly perceived. And, unlike Hume, he did believe in the reality of general laws of nature and relations between particulars. Finally, Mach thought of his general theory of elements and functions as an “umbrella theory” for the design of particular empirical theories in physics and perceptual psychology, science at a higher level of generality, which is what many would consider metaphysics by the purest Aristotelian definition. So clearly these features outline “good” metaphysics, even if Mach would have rejected the term. We now turn to what Mach considered “bad” metaphysics, and then examine his differences with the Vienna Circle on this issue.

3. *Bad Metaphysics I: Kant*

There is no doubt that Mach considered Kant to be the source of many metaphysical errors, of which the most serious were 1) the thing in itself 2) the unchanging ego or substance 3) synthetic a priori principles of natural science. Mach believed the thing in itself arose from the following faulty inference:

The vague image which we have of a given permanent complex, being an image which does not perceptibly change when one or another of the component parts is taken away, seems to be something which exists in itself. Inasmuch as it is possible to take away singly every constituent part without destroying the capacity of the image to stand for the totality and be recognized again, it is imagined that it is possible to subtract *all* the parts and to have something still remaining. Thus naturally arises the philosophical notion, at first impressive, but subsequently recognized as monstrous, of a “thing in itself”, different from is “appearance” and unknowable (Mach 1886/1959, p. 6).

Mach goes on to point out that there is no unseen substance or anchor for the elements making up a body. Remove all of the effects of the body

and nothing whatever remains. The thing in itself, or the substance, as well as any intrinsic properties it might have, would be something which exists in permanent isolation from its exercised effects and this is impossible, an *Unding*. Even if a thing exercised the same uniform effects or qualities across a variety of circumstances, this would still not prove that it would possess them alone and isolated. For example inertial mass, which is often taken to be an intrinsic property of bodies by philosophers was for Mach due to the interaction of a body with its environment, either of other gravitating bodies or of an ambient “inertial field” (Mach 1883/1960, pp. 282-283).

The unchanging (absolute) ego and unchanging substance, two pillars of Kant’s view of conservation and permanence in the *Critique of Pure Reason* are likewise seen by Mach as dangerous abstractions from experience leading to metaphysics in the bad sense. Experience presents only changing events and complexes both in the ego and in states of external objects. The idea of an absolute permanence either of substance or ego behind these events was to Mach an unjustified inference. We could account for our ideas of permanence by considering present memory traces or records, which stand for previous states no longer present. It is not necessary for anything actually to survive absolutely complete and intact from one temporal moment to the next. The idea of an “absolute time” or a fixed background or substance in which to embed these states and records was seen by Mach as metaphysical and unwarranted in the worst sense, and useless for science.

Finally of course Kant had thought that some principles of natural science itself, ideas of conservation of mass or momentum and some other principles like the principle of inertia and the Galilean relativity of uniform motion, were synthetic a priori, or based upon deeper synthetic a priori principles in the understanding and not empirical fact. In his *Conservation of Energy* and his *Mechanics*, I think it is fair to say that Mach destroyed utterly Kant’s argument for synthetic a priori principles in natural science with a withering series of attacks. Instead of an a priori truth, Mach shows that the conservation of energy is in fact an empirical assumption which cannot be proved from the understanding without making the assumption itself somewhere else. A similar criticism is applied to symmetry arguments like the one Archimedes used to prove the law of the lever. To call two cases symmetrical, like equal weights on lever arms of equal length from the fulcrum, invites the reply: symmetrical for what property? Reason or the understanding cannot simply dictate that two cases are symmetrical unless this case of symmetry can be established empirically for some property. And, as Mach showed, once the symmetry is assumed it is no great matter to “prove” it again from that assumption. The asymmetrical case of *unequal*

weights m_1 , m_2 equilibrating each other along *unequal* lever arms $m_1 \cdot l_2 = m_2 \cdot l_1$ actually lies at the foundation of the case of symmetry of equal weights at equal distances, not vice versa (Mach 1883/1960, p. 24). The superficially dazzling and seeming a priori cast of these arguments in physics is explained by the making of an empirical assumption among the premises which renders the whole deduction circular. It is not due to the magical construction of physical laws a priori by the understanding. As Stevinus (Mach 1883/1960 p. 41) remarked in proving the law of the inclined plane from his thought experiment of the endless chain: *Wonder en ist geen wonder*: “The wonderful thing about it is that it is no wonder at all”.

The parallelogram of forces, which is cited by Kant as another a priori principle is subject to the same objection as the law of the lever, once it is assumed that forces are subject to the principle of superposition, an empirical fact. In the case of the law of inertia and Galilean relativity, in which Kant saw the a priori structure of space and motion constructed by the understanding reflected in the actual motions of bodies, Mach had an equally simple (and disillusioning) answer. These cases of statics and uniform motions are only special cases of dynamical principles such as D’Alembert’s Principle. In reality, bodies are never in force free situations, they are always accelerating each other, nor do we have access to a universe free of other bodies or surrounding fields to tell us how a body would move naturally and inertially. We do know however that when *all forces on a body cancel*, then it behaves in accord with Galilean relativity and the law of inertia. These inertial motions are then interpreted by Mach as natural cases of dynamic equilibrium, not a priori truths about “natural” motion in space and time. Mach keeps Newton’s second law and derives the first law and also the fifth corollary from it. Where all of the accelerating forces on a body cancel, the body is either at rest or moves at a constant velocity (Mach 1883/1960, pp. 285-289). Mach also suggested that the law of inertia could even fail in a situation where the dynamical equilibrium was suddenly disturbed. These considerations would of course have to be modified today to recognize that Newtonian mechanics was supplanted by relativity and quantum theory, but Kant’s synthetic a priori would not gain any traction thereby.

Mach comments that much a priori knowledge is merely empirically and historically well- founded but not “apodictically” certain. Some principles come to *seem* inevitable and demanded by reason or the understanding which really are not so because we have forgotten their foundation in experience. According to Mach, historical studies are the only way to break the hold of these ideas on our minds, not studies of physics alone, where the historical prejudices are, if anything, reinforced by repetition. Mach said this a *century* before Thomas Kuhn and other critical historians of sci-

ence. He observed that principles and concepts that originally required the highest and most strenuous philosophical effort for the best minds to establish are taught to the physicist as obvious and trivial and not worth the trouble of investigating. But this also means that they do not see how to analyze and question these concepts and principles should it ever again become necessary to do so. Concepts like space, time, motion, mass, force, and energy can thus seem to be part of the a priori structure of the world established by the understanding if they are not strenuously criticized and re-examined. Of course most of Mach's best work in physics was devoted to uncovering the historical roots of these concepts (they are what all of his books on physics are about) and then subjecting them to a conceptual critique that exposed their foundation in experience. This made it easier for scientists like Einstein who were inspired by Mach to press on and take the questioning still further.

4. *Bad Metaphysics II: Metaphysical Errors of Psychology*

Psychology was the source of many metaphysical errors according to Mach. Chief among them was of course the mind-matter dualism he claimed to have overcome in his theory of neutral elements. Sensory qualities like red or blue are not secondary qualities; they are physical events and part of the physical world, as much as any natural events. That these events occur in the brain is no objection to their reality. The error was in assuming that the sensations exist in some special mental realm of the ego different and separate from the world of physics, but this is only because our view of *physics* is too limited and abstract and must be broadened to include sense experience (see Banks 2010, and forthcoming).

Other problems emerge from a confusion between physical and psychological spaces and events. For example, Mach's colleague Richard Avenarius referred to an "error of introjection" in which we observe a friend's brain while he is experiencing some color like the green of a leaf (or our own brains in a mirror). We then ask ourselves where in the friend's brain tissue we are supposed to look for his sensation of green, we introject it spatially into his brain somewhere. But nothing in the friend's brain actually looks green, not the electrochemical connections between neurons, nor events within the neurons or anything else. All we see are cells connected up in various configurations. The faulty conclusion is that colors and brain processes therefore cannot be identical.

A second, related problem is called the "error of bilocation" where we ask how it is that a sensation, say of a cup can be five feet in front of me on the table and, at the same time, be a brain process in the back of my skull, since those two events are not located in the same place. The false conclu-

sion is, once again, that sensations and brain processes cannot be identical and in fact be in the same place.

According to Mach the resolution is simpler than it seems and involves what he calls a “functional” presentation of the various elements involved (Mach 1886/1959, p. 27). In the first class are the physical-psychical sensations. They are qualities like red or blue, which are also, and at the same time, physical brain events causally connected to other physical events. In the second class are observations of brain tissue made by external observers or measuring devices. These scans or observations do not represent actual events in the brain; they are rather external events annexed to these brain events by causal chains. The scan shows where in the brain the sensation events occur and generally do show what sort of physical events and structures surround them, but they are not the *actual* blue or red experienced in the individual event itself, to the possessor of the brain. Proof: if we siphoned off the neural energy of the cells, the sensation would disappear. Those interior events are not present in the scan, but rather occur in the “mind” of the observer. But imagine a kind of super-graph or functional presentation, in which there is no problem keeping the events *distinct* in the two subspaces, while acknowledging the fact that they are causally related and participate in the same causal functional space of events. This is how the “problem of introjection” is resolved. To combat the error of bilocation, Mach offers his famous “headless body” picture (Mach 1886/1959, p. 19):

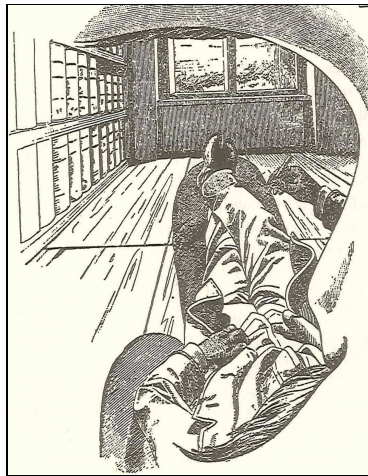


Fig. 1. Mach’s “headless body” figure (public domain)

He uses this figure to prove that in fact the sensation and the brain process do not actually exist in two different places. As the headless body picture shows, the sensation and the brain process never occupy the self-same psychological space. Rather the space of sensation loops around the brain and leaves a blank where the objector seeks to point to his sensation at the back of his skull, which he cannot do, not even with a mirror in which he observes his own brain tissue. If he does insert an electrode in the brain right at the “x” where the sensation should occur, it promptly disappears, proving they cannot share the same space and that they are identical, and not bilocated. Nor do the *externally* observed elements of the brain tissue in the mirror and the actual elements in the brain share the same space, as in bilocation, since they are different elements and simply exist side by side. These metaphysical problems can thus be resolved by expanding our view to elements and the “functional presentation” of the elements which includes *both* the space of psychology and the physical space where others observe and interact with the brain. (For more see Banks 2003, and forthcoming).

5. *Bad Metaphysics III: Mechanical Physics*

Finally physics was a major source of metaphysical errors for Mach. According to Mach, the role of the critical investigator was to separate the principles and empirically valid results of physics from the “mechanical philosophy” in which they were often embedded. The mechanical philosophy was the idea that physics necessarily represents to us a world of particulate matter and motion in space and time operating according to causal mechanisms which we can readily visualize in our spatial imaginations. It is the idea that every natural principle or postulate of experience, such as the laws of thermodynamics or the law of least action, are ultimately to be realized in a deeper mechanical explanation which makes them true. This view began in the seventeenth century with Galileo, Locke, Descartes and Newton and extended all the way through to Mach’s century, where it was represented by the acknowledged masters of classical physics: Thomson, Maxwell, Boltzmann, Helmholtz, Hertz and Planck among others.

Mach pointed out however in his *Conservation of Energy, Mechanics and Principles of the Theory of Heat* that most, if not all, of the fundamental principles of mechanics, like the conservation of energy, or the law of least action, or the second law of thermodynamics were mechanism-independent and certainly did not depend on being realized in some mechanical model of nature convenient for human visualization. Mach called these mechanism independent principles “phenomenological physics” and he called for the elimination of superfluous models, whether of hidden pulleys and wheels,

atoms, elastic bands, fluid and elastic media, absolute space and time, or what have you. Mach thought we should be satisfied to accept physical principles as postulates of experience which are not contradicted by any natural events and accept them in that stark postulate form without seeking realizing mechanisms behind them. Ultimately of course they are built into Mach's view as abstract causal-functional relations between elementary events.

Physical processes present numerous analogies with purely mechanical ones. Differences of temperature and electric differences equilibrate themselves in a similar way to the differences of the position of masses. Laws which correspond to the Newtonian principle of reaction, to the law of conservation of the center of gravity, to the conservation of the quantity of motion, the principle of least action, and so on, may be set up in all physical domains. These analogies may be made to rest upon the assumption which the physicist is fond of making, namely, that all physical processes are in reality mechanical. But I have long been of the opinion that we can discover general phenomenological laws under which the mechanical ones are to be classed as special cases. Mechanics is not to serve for the explanation of these phenomenological laws but as a model in form and as an indicator in searching for them. The chief value of mechanics seems to me to lie in this (Mach 1896/1986, pp. 328-329, Cf. Mach 1883/1960, p. 599).

According to Mach, Newton had made a great error in accepting an absolute frame of reference, or absolute space, for the accelerations and inertial motions mentioned in his second and first laws. As Mach was aware, all the second law really demanded was an equivalence class of inertial reference frames in which the accelerations remain the same, not an absolute space with unobserved (and in principle unobservable) position, direction and velocity as Newton had insisted. Proof: transform x to x^* by $x^* = x + x_0 + ct$ and differentiate twice with respect to time. First x_0 vanishes and then the c , leaving the accelerations equal, $x'' = x^{*\prime\prime}$. And of course Mach eventually came to think that even accelerated motions could be relativized in a similar manner, leaving invariant a kind of combined inertio-gravitational field, which he suggests as one possibility (Mach 1883/1960, pp. 282-283 and as I have recently suggested as my preferred reading of Mach's Principle see Banks 2012 and forthcoming) not an unobservable absolute space *prior* to this field, which he continued to see as a metaphysical "monstrosity". Unfortunately the history of Mach's Principle is very complicated, since Einstein formulated his own "Mach's Principle", and this is the one known to physicists, as well as further interpretations, which have little to do with Mach. I myself think Mach is closer to Leibniz in his views on relative motion (see Banks forthcoming).

In any case, Mach's attack on mechanical visualizations and models was as influential as his other reforms of physics. Einstein spoke movingly of this influence on his thought:

It was Ernst Mach, in his history of mechanics, who shook this dogmatic faith (i.e., in mechanics as the secure basis of physics); this book, in this relation, exercised a deep influence on me as a student. (Einstein 1949, p. 7, and for the possible influence of Mach's non-mechanical principle-driven "phenomenological physics" on Einstein, see pp. 53, 57, also Feyerabend 1984, Banks 2003, p. 188).

Unfortunately, Mach's avowed "anti-mechanism", as much as it blazed the trail for those who followed, like Einstein and Heisenberg, was also the reason why he felt he had to attack atoms so vehemently (in addition to the anti-Kantian reasons given above). As I have shown elsewhere, this was part of a much more general attack on the *spatio-temporal* form of mechanical physics. Mach was skeptical of the concepts of space, time, and motion in any fundamental sense because he believed these concepts ultimately derived from human psychology and visualization and proved convenient as a format for interpreting abstract functional laws and equations of physics without being their true natural foundation which was independent of human sensibility. A future physics could keep the abstract equations between events and dispense with the spatio-temporal format for a truly universal physics of elements and functions. As far as I know, Mach first spoke of this aim openly in an 1871 paper "Über die physikalische Bedeutung der Gesetze der Symmetrie", remarking:

If someone who could only hear wanted to try and develop a world-view in his linear space, he would come up considerably short, in that his space is not equal to the many-sidedness of the real relationships. It is no more justified when we think we can press the entire world, even the unseen parts, into the space of the eye. But all molecular theories fall under this heading. Yet we possess a sense which, in respect to the many-sidedness of the relations it is capable of contemplating, is richer than any other. It is our reason. It stands above our senses. It alone is in the position to establish a lasting and complete worldview. The mechanical worldview has achieved enormously much since Galilei. But it must make way for a freer perspective (Mach 1871, p. 147).

He then adds in a footnote:

It follows from this that the dependence of natural phenomena be expressed through relations of number, not spatially or temporally (*Ibid.*).

It had already occurred to him in 1863 that the spectral lines of chemical elements were too numerous, he claimed, to be represented as vibrations between little spatio-temporal objects like balls on springs, an argument he repeated and embellished in his *Conservation of Energy* of 1872.

Of course Mach did not try very hard to think of other spatio-temporal arrangements like atoms with internal structure, but went straight to the conclusion that atomic processes were not in space and time at all. I think this is because Mach was already convinced on philosophical grounds that the source of the spectral lines was not mechanical processes in space and time but a level beneath which only abstract functions and elements could describe. Mach was still arguing this way in 1905:

The moment we begin to operate with mere things of thought like atoms and molecules, which from their very nature can never be made the objects of sensory contemplation, we are under no obligation to think of them as standing in spatial relationships which are peculiar to the Euclidean three-dimensional space of our sensuous experience (Mach 1905/1976, pp. 324-325).

The temptation is to say that Mach was simply too early for the quantum theory, aspects of which do indeed forbid a naïve space time interpretation of events, or processes behind events, but I will resist this and say that Mach simply wanted to eliminate “psychological” space and time from physics completely for some new abstract theory that dispensed with human sensibility and appealed only to our reason.

To sum up, the “received view” that metaphysics involves entities unverifiable in principle plays a relatively small part in Mach’s thinking. He does oppose entities *completely unconnected in any way* with natural phenomena, like the permanently isolated thing in itself, but natural phenomena are much broader than immediate experience for Mach and really involve a continuously connected whole of nature and experience in one monistic fabric, of experience-reality, with parts that are observed *and* unobserved but filled in nevertheless. Of the critiques of metaphysics mentioned above, most are entirely idiosyncratic to Mach and have nothing to do with the received view or the Vienna Circle.

6. *Differences between Mach and the Vienna Circle*

Friedrich Stadler’s *Studien zum Wiener Kreis* (Stadler 1997) is still the most comprehensive attempt so far to define the influence of Ernst Mach on the philosophers of the Vienna Circle. Although the Vienna Circle has been studied intensely in recent years (in work by Uebel Richardson and Friedman) surprisingly little attention has been paid to Mach in that history despite his enormous influence on the movement. The Vienna Circle even called itself the Ernst Mach Verein at the beginning, when it issued its manifesto *Wissenschaftliche Weltauffassung: Der Wiener Kreis* in 1929.

Mach’s most direct influence on the Circle may have been via the physicist and philosopher Philipp Frank, who taught Mach the special theory of

relativity, and who had personal connections to Einstein whom he succeeded as professor in Prague, where Mach had been active. We also owe to Frank (1947, pp. 104-105) an account of the meeting between Mach and Einstein in 1910, when Mach admitted that the assumption of atoms could be indeed justified as “economical” even if the derivations were indirect and complicated (but continuous with observation). Frank himself described the origins of “logical empiricism” as an amalgam of Machian elements and Poincaré’s conventionalism (Stadler 1997, pp. 171-172, 190, quoting Frank 1949, pp. 7, 11) later replaced with considerations about formal structures, enhanced by the emergence of mathematical logic. That is, empirical science was to be considered as an interpreted *formal system* where the axioms and definitions are arbitrary and have nothing to do with reality at first. The terms get their meaning as they are “implicitly defined” by their further development in the formal structure, as Hilbert had insisted. Then one can consider the question of how to coordinate the abstract formal system to observations. Here for example Reichenbach suggested the idea of “coordinative definitions” to link formal notions in a theory (x, t) to physical objects (rods, clocks, light signals, mirrors).

What is clear already in the work of Schlick in his *Allgemeine Erkenntnislehre* (1925/1985) and Carnap in *Der Logische Aufbau der Welt* (1929/1967), was how much this formal, structural side of the project already dominated the thinking of the Vienna Circle and how little attention was actually paid to Mach’s concrete elements of reality, or to the naïve verification of the so-called “received view”. The focus was on developing a *formalism* for scientific theories, clearly not all of which was exposed to observation. This “structuralist” reading is confirmed by recent scholarship, for example by Richardson (2008) and Friedman (1999) who downplay the verificationism of Carnap and emphasize instead his focus on logical structure in the *Aufbau* and the *Logical Syntax of Language*. The only time the Vienna Circle ever considered anything like the Machian elements was during their famous *Protokollsatz* debate (see Uebel 2007) and then in shockingly dualistic terms, making sharp distinctions between a “physicalistic” and “phenomenalistic” reports which were alien to Mach’s neutral monist elements. Schlick did once hold that Machian “physical qualities” existed, but that all of our knowledge of them was structural (Schlick 1925/1985, p. 284). He then apparently converted to a “phenomenalistic” way of thinking in the *Protokollsatz* debate. Carnap also thought a physicalistic basis for the *Aufbau* was possible, perhaps in terms of Machian elements or physical qualities (Carnap 1928/1967, Sec. 62). but he then hewed to the distinction between a physicalistic and phenomenalistic vocabulary, favoring the physicalistic over the phenomenal. These distinctions simply do not exist for Mach

and are themselves indicative of a metaphysical pseudoproblem, which the Vienna Circle did not overcome.

The greatest difference between Mach and the Circle, in my view, is this: Mach was still a “first order” scientist and natural philosopher proposing a theory of real concrete elements and functions, which are not just formal devices, to serve as the template for future theories of nature, not second-order reconstructions of “the structure of scientific theories” or “the language of science” or the other circumlocutions that the Vienna Circle used. Mach was still dealing with reality, not how to *talk* about reality, a topic which Wittgenstein and Carnap (1950) clearly drove to absurd extremes. Moreover, as Feyerabend (1970) points out, Mach was critical of established science. His analysis was meant to expose logical gaps and loosen historically conditioned a priori assumptions, to “reform” science, especially with his campaign against mechanical physics and its foundational concepts of matter, motion, space, and time, which Mach actively sought to reduce to his elements. The Vienna Circle was, as Feyerabend puts it, “conformist” seeking to reconstruct what science says, but not to challenge it or try to improve on it from a philosophical perspective.

Mach clearly recognized that there is a critical role for philosophy vis a vis science, when scientific questions are approached at a higher level of generality, as for example happens when we try to unify immediate experience or sensation with the world view of physics. Many of these issues do indeed turn out to be pseudoproblems, as Mach correctly identified them, but these do not exhaust the treasure-trove of real “metascientific” philosophical questions in the foundations of empirical sciences like physics and also in the macro cross-boundary issues where different empirical sciences meet and must be reconciled. I emphasize: these are real, substantive questions about the world for Mach, not mere knots and curlicues in the structure of language as Wittgenstein (early *and* late) would have it. This metascientific domain traditionally belonged to metaphysics, but even a supposed “anti-metaphysician” like Mach was still able to see it clearly in the early twentieth century. As far as I know, and with some exceptions like Reichenbach perhaps, the Vienna Circle was utterly blind to this entire metascientific domain of inquiry, perhaps because of the pessimism of Wittgenstein, or because of their refusal to acknowledge that there could be a first order philosophico-scientific inquiry in addition to their second order studies of science.

I think these considerations taken together show that the Vienna Circle philosophers were not the heirs of Mach, despite taking his name for their original group, but represent a completely different trend which owes more to the rise of modern logic and their own peculiar linguistic interpretation of scientific theories. Mach, the anti-metaphysician, was in fact a very great

defender of metaphysics in the best Aristotelian sense. The Vienna Circle's "scientific philosophy" was not actually part of the ongoing inquiry of natural science at all but was linguistic and formal, in the sense of backing away from reality to a second-order analysis of language and structure. They ignored a central goal of philosophy, as defined by Mach, which is to come to grips with reality in its "general features" which are continuous with natural science. Many philosophers took the lesson of the failure of logical positivism to be that we should reject second-order philosophy of language and get philosophy back into connection with actual science. But this brings us back full circle to Mach again.

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