

## MACHIAN ELEMENTS AND PSYCHOPHYSICAL RELATIONS

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### Abstract

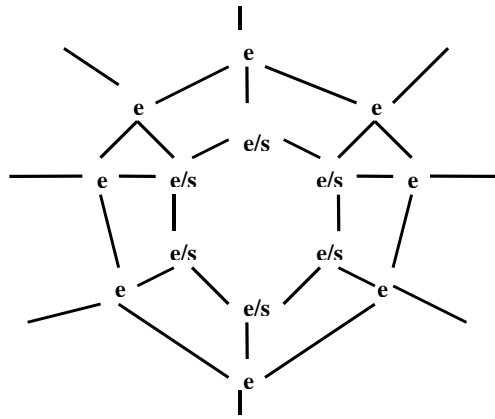
*Ernst Mach's "causal map" conception of psychophysics is compared with G.T. Fechner's and with contemporary problems of mind-brain identity and psychophysical parallelism.*

Psychophysics, since its official inception in the work of G.T. Fechner, whom we celebrate today, has always been about more than the mere correlation between subjective reports of sensations and brain processes. Fechner described the relation as being like the inside and outside of the same circle, one aspect hiding the other. The Austrian physicist, psychologist and philosopher Ernst Mach (1838-1916), broke with his mentor Fechner and proposed his own answer to the riddles of mind-brain identity and psychophysical parallelism.

As Michael Heidelberger (1993) has shown, Fechner thought the "inner" mental and "outer" physical aspects were functionally related to one another into a whole, as the different shapes of a coin are related as a function of the angle of view. There is no need for a "penny in itself" underneath; the penny *is* the sum of all its aspects.

Mach's mature scientific world-view, his theory of elements and functions, first appeared in the 1872 Pamphlet *History and Root of the Principle of the Conservation of Energy* and was deepened in subsequent works (see Banks 2003). An "element" is a quality, like a color, pressure or sound. But Mach held that there are also physical elements in nature outside of minds. These physical elements and their functional relations of intensity would form a dynamical physics with which Mach sought to replace the mechanical philosophy of matter and motion. Hence his deep-seated hostility to mechanical physics, which was so influential on Einstein and others. Mach's dynamical elements were like forces, pressing on, and constraining one another, as in the metaphysics of that other great philosopher-psychologist of the nineteenth century J.F. Herbart, Mach's other great influence. But whereas Herbart employed force-qualities bound up in simple substances or monads, Mach simply allowed the elements to abut upon one another with no underlying substrate.

Thus the peculiar subjectivity of sensations, or their psychophysical dimensions of quality and intensity, rather than mass, space and time, in no way distinguish them from physical elements, such as energy fluxes in an axon, for example. For Mach, a sensation is simply an element that participates totally in the events of the physical world, but also in certain specialized functional connections, such as those which govern the dimensions of sensory spaces of color, sound, touch and the like. Hence, Mach thinks we should cut through all the metaphysical difficulties and simply graph physical elements alongside sensations in a multidimensional "causal map" of the mind-brain suitable for psychophysical investigations (see figure below) including all the physiological-physical structures of the brain in three spatial dimensions, indicated by the 'e' variables, and the psychological manifolds, which also vary in their additional sensory dimensions, indicated by the 'e/s' variables:



There is thus no special Fechnerian “inner side” of nature for Mach because there is no reasonable distinction in kind between “inner” and “outer” elements, between sensations and physical elements. Likewise in causal maps of the mind-brain, sensations do not end up spatially inside the axons of neurons, or within matter at some micro-level; nor are they “emergent” at a spatial macro-level. They are placed alongside, causally or functionally attached to their concomitant physical energies in a multidimensional matrix or graph. The functionally defined matrix has both a three-dimensional physical projection, the brain, and other projections for the sensory manifolds, of color, of touch, of balance, sound, which only appear to be separate spaces. For example, in the *Analysis of Sensations* Mach remarks that one will thus not be able to find actual sensations of green *spatially* contained in the brain:

When I see a green leaf (an event which is conditioned by a certain brain process) the leaf is of course different in its form and color from the forms, colors, etc. which I discover in investigating a brain although all forms, colors etc are of a like nature in themselves, being neither physical nor psychical. The leaf, which I see, considered as dependent on the brain process is something psychical, while the brain-process itself represents, in the connection of its elements, something physical. ( p.62)

When I speak of the sensations of another person, those sensations are, of course, not exhibited in my optical or physical space; they are mentally added (*hinzugedacht*) and I conceive them causally, not spatially, attached to the brain observed, or rather, functionally presented. (p.27)

### Identity or Parallelism?

As a philosopher I have some interest in whether these ideas are any use, so I shall now examine Mach’s causal maps as problem solving devices, showing how they help to reconcile our two conflicting intuitions about the psychophysical relation: (1) that sensations and brain processes are identical, and (2) that populations of cells and their electro-chemical signals are not at all like phenomenal colors and pains, but are distinct yet parallel entities.

The doctrine of psychophysical parallelism states, roughly, that there is no feature of a phenomenological manifold, such as color or sound spaces, that does not correspond detail for detail to *some* isomorphic structure in the nervous system that varies in the same dimensions. To use one of Mach’s own discoveries, for example, the three independent sensations of tilt needed to orient the visual field correspond to processes in the three semi-circular canals orthogonal to one another in space. In Mach’s causal map, the

physical elements and the corresponding manifold of sensation-elements will be related by identical functions. But the elements making up the neurons, ion gates and all of their molecular components are not the same elements as the sensations of color and sound. The parallelism requires mapping the phenomenal space next to the physical space of the brain elements, but it does not require introjecting phenomenal spaces into or onto physical space, for example by spatially superimposing the sensation-manifold onto the spatial interiors of nerves, not even onto some supervenient macro-level, as if the overlaid sensation space had “emerged” at some given spatial scale from the physical elements and their microproperties.

Mach points out above that the physical structures of the investigated brain never contain within them the sensation of green. This is because the physical elements we investigate in space and time are, like all physical phenomena, indirect, and represent mediate effects of that single individual erg of nerve energy on measuring instruments, the direct presence of which however we experience as our sensation of green. The physical description is far better and more robust for describing the effects of the sensation element on measuring devices, photography, exterior observers and the rest of the physical universe while the sensation is a better description of what the individual, irrepeatable and irreproducible physical energy of the nerve *actually* looks like. (This idea goes back to the “specific energies” doctrine of Johannes Müller.)

Notwithstanding, the supporting physiological and electrical processes in the nerve *are* the physical cause of the individual energy that appears in the phenomenal space as the sensation of green. We can prove this by diverting the whole energy flux into a wire, whereupon the sensation disappears. Hence sensations are legitimate physical entities in their own right, identical with the individual energies generated in the nervous system, while not identical with the mediately observed elements of their supporting physical causes, the elements making up the physical nerve, the electrolytes and so on, which we observe and study in neuroscience. An *experimentum crucis* to establish this someday could be the generation of vivid sensations in substrates other than the human nervous system. This would be conclusive proof that although the sensations are in *our* case the directly apprehended physical energies supported by the nervous system, they can be caused in other ways and are not identical but parallel with their causes in any given case. (The logical possibility of such an experiment is why the principle of parallelism is so awkwardly worded above.)

The thesis that a sensation is the raw look of energy, has been revived recently by the philosopher of mind Galen Strawson (2006) and is part of his claim that physical naturalism, in the full-blooded sense, requires the recognition of human sensations as real alongside physical events: “this red-experience, this thing with whose essential nature I am in certain respects fully acquainted just in having it, is just this patch of complex neural activity.” (pp. 275-276)

Strawson also endorses the thesis that sensations are the interior, “intrinsic nature” of physical processes the *exterior* nature of which we are acquainted with in the nervous system. For Strawson, when a set of physical molecules and cells is assembled, the proto-qualities in the interiors of those constituents (at some spatial micro-level) join to an interior nature, or sensation. This “intrinsic nature” argument goes back to Bertrand Russell, who argued that physics described only external, structural properties, leaving the interior nature of matter unknown. Why then, said Russell, should we not think that the physical world is at bottom composed of physical qualities similar to sensations, such as his own unsensed sensibilia? Thus a collection of structurally-described entities would at the same time be a collection of their interior natures, giving them a Fechnerian “inner side.”

The virtues that philosophers like Strawson and others see in Russell’s “intrinsic natures” position are what makes the position unacceptable on a Machian view, so let’s look closely at it. For Strawson, sensations as the intrinsic nature or filling of matter add

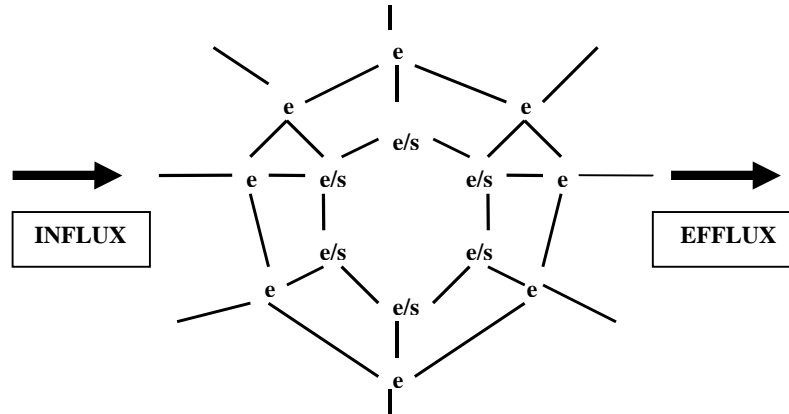
*nothing* to the physical description of those natural energies. Rather, the interior natures of the physical world are inert *endo-phenomena*, ghosts inside matter with no push or pull; no causal role whatever to play in the physical universe. The reason why this complete inertness is actually considered a virtue by Strawson and others is so that sensations are prevented from exerting causal forces and thus interfering in the “causally-closed” chain of physical events.

This position thus seems to bring back all the old dualisms of inner and outer which Mach banished. There is a physically efficacious exterior to nerve energies, including their dispositions to interact with the rest of the natural world, measuring instruments, etc. And then there is this parallel “inner-side” of sensation which, although directly apprehended by us, is outside the causal nexus and contributes nothing to the physical description of events. Sometimes the intrinsic qualities of a thing are said to “support,” “ground” or “realize” a set of efficacious relations to other things. But according to their proponents, these intrinsic qualities do not cause the dispositions they ground. The dispositions “follow” from them, in a way I am unable to imagine, except as a circular “disposition to produce dispositions.” Nor can I see anything scientifically useful in distinctions between “intrinsic” and “extrinsic” properties (are “mass” and “charge” intrinsic or extrinsic? Do we even know?) Indeed these arguments have encouraged some philosophers to say it is “dispositions all the way down” and that intrinsic natures are mere *flatus vocis*. Others have questioned how anything so inert as an intrinsic nature could even appear in the natural universe—if, as seems self-evident to me, “appearing” means exerting the force it takes to *make* something appear in the real world.

More likely, the philosopher’s notion of the “causal closure of the physical” introduces the pseudo-problem that the intrinsic natures argument is designed to solve. Mach addresses the point already in his *Conservation of Energy* pamphlet by saying that the closure of a system says *nothing* whatever about the specific transformations taking the system from state to state. He points out that it is perfectly conceivable, for example, that a system might form little closed subsystems or islets of isolated activity, shut up in themselves. (Incidentally, autonomous laws of formation of such islets are also conceivable without violating any physical laws.) And in the *Analysis of Sensations*, (p 55n.) Mach the physicist dismisses the notion that efficacious sensations would violate the conservation of energy.

I cannot refrain from here expressing my surprise that the principle of the conservation of energy has so often been dragged in in connexion with the question of whether there is a special psychical agent. On the assumption that energy is constant, the course of physical processes is limited but not necessarily determined with perfect uniqueness. That the principle of conservation of energy is satisfied in all physiological cases merely tells us that the psyche neither uses up work, nor performs it. When the philosopher asks a question..., he usually misses the point of the principle of the conservation of energy and the stock reply of the physicist has no intelligible meaning in a case so far removed from the scope of his ideas.

The conservation laws make a statement about the initial and final states of a process, but do not prevent one from interpolating, between a chain of events ABCD, an intermediary set of events AB(XYZ)CD which neither absorb nor export any net work. Thus the question of causal closure is uninteresting if the sensation manifolds are such intermediate islets among the mediately-measured events in physical space that surround them (see figure below). Hence the way is clear for the full-blooded notion of dynamical Machian elements and his thoroughgoing identity between sensations and efficacious physical energies absent any make-believe.



### The Diagonal Problem

The final issue I call the “diagonal” problem. Why do sensational nerve energies ‘s/e’ appear in consciousness, while the ‘e’ elements do not? What accounts for the unity of the sense manifolds or the ego? Why not pick a diagonal cluster of e’s and e/s’s instead and call that an ego? To meet the objection, Mach himself often used the argument of thought economy, that the complexes of elements suitable for sensations are economically beneficial and stable against a changing and chaotic background. But mere thought economy seems far too subjective a principle of individuation. Besides, how to account for an enduring instinct for forming economical wholes? Would that require an economy of the instinct for economy?

Let us skip to what I believe the answer to be, one which I think reveals important inner ties between Mach and Kant. For Kant, a diagonalized collection of mere functionally related elements would not suffice to make for conscious experiences. Rather consciousness requires a prior ordering of elementary experiences into a spatio-temporal framework. Conscious sensations tend to be supported by mechanisms of memory and imagination, filling in an imagined time-line around them, and a corresponding representation of spatially distant realities. Thus you *could*, in principle, diagonalize a spatio-temporal object from sensations and some extra physical elements, it is just, I suspect, that the elements that have such additional spatio-temporal structure are exactly those that do end up being the sensation-manifolds.

I myself think there are two kinds of functional connections between qualities that are *sine qua non* for an intuition of space. First there must be memory images of past and future states to complete an imagined time line around present states. As Kant points out, we cannot count to three by making identical strokes unless we store up and reproduce images of one and two and adjoin them to a present stroke of three. There must also be a combinatorial means of associating and dissociating relations between states. The points along a wire seen head-on look like a point until we turn them through an independent or dissociating dimension that separates or dissociates one associated point from another. Likewise, a temporal series of states or points needs another series associated with and dissociated from the first.

All of these conditions—memory, reproduction, association, dissociation—it seems to me can be satisfied by a population of cells arranged in the brain, generating further sensory manifold extensions among the irreducibly individual sensations in addition to the more robustly reproducible three-dimensional extension of the cells. The intracranial reconstruction of sensory spaces—acknowledged for example by Kandel et al. (1996) as one of the major tasks to be performed by the central nervous system—is also perhaps the brain’s cleverest counterfeit of different, maximally informative features of the external world within

a single three dimensional skull. The overall dimensionality of the several mock-ups achieved by the brain and its various different sensation manifolds of sight, sound, touch, motion, is greater than if the nervous system's representations were confined to a single three-dimensional representation, thus, I think, conveying a distinct evolutionary advantage to the having of extra inter-coordinated sensation spaces.

I cannot resist pointing out a last feature of Machian causal maps I find intriguingly suggestive. Consider the mysterious property of psycho-physical relations noted by Fechner, namely that the inner and outer aspects mutually obstruct each another. This occurs also in higher dimensional manifold relations, such as a four dimensional hypercube, whose eight, right-angled, cubic faces obstruct one another in the same manner, only one cubic face appearing at a time in three space. Mach's work suggests that the seemingly insuperable barrier between brain and mind may be just such an artifact of our limited representations.

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