Recovering the Experiment

ROM HARRÉ

Introduction

The current popularity of anti-science has many roots and takes many forms. But there is one for which we ourselves, as philosophers of science, have been in part responsible: the dethroning of the experiment as the touchstone of truth. Again there are several ways in which this has happened, with different putative effects. I want to focus on those that could roughly be grouped together as 'post-modern'.

It seems to me that the authors of the post-modernist account of science, from Fleck to Latour, have been animated, in part, by the need to account for the disparity between the weak *logical* power of empirical propositions reporting the results of experiments and observations with respect to the assessment of the belief-worthiness of hypotheses and theories and the actual effectiveness of descriptions and observations in forming and changing people's beliefs, their *persuasive power*. How is this gap to be filled? In order to assess the post-modernist attempts to close it, and perhaps to supersede them, it will be necessary to set out the classical account of the experiment in some detail. I shall set out this account as simply as possible, using the Aristotelian square of opposition as a format.

The classical account of the experiment

Inductivists and fallibilists discussed the relation between the World and our theories of it in a logical framework which privileged a pattern of propositional relations that is already found in Aristotle's *Posterior Analytics*. The epistemologies of both Mill and Popper can be expounded, for instance in undergraduate lectures, by the use of the traditional 'square of opposition' in which universal affirmative and negative propositions (A and E forms) were juxtaposed to particular affirmative and negative propositions (I and O forms). The latter, as reports of empirical studies were supposed to carry the disciplinary force of the experimental method. Within this simple framework we can see that both inductivists, such as Mill, and fallibilist or provisionalist philosophers, such as Bacon and Popper, treat experimental apparatus and informed

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

observation as a devices for generating I (Some S and P) and O (Some S are not P) propositions by which the epistemic 'value' of A (All S are P) and E (No S are P) hypotheses are to be assessed. There are several accounts of how these propositions are arrived at from experiments but there are few, if any, accounts of how the relevant experimental apparatus is related to the world, to Nature. Both classical epistemologies took for granted that the I and O forms could be peeled off experiments in such a way that they could be taken to represent Nature herself.[1] Thus Popper's realism was expressed propositionally in terms of a sequence of applications of *modus tollens*, and the rival Hempelian covering law thesis is *modus ponens* in modern dress. Bayesian treatments of the relations are refinements of the Aristotelian scheme but seem to me to leave the 'peeling off' assumption untouched.

The basic lay-out of the relationships assumed in the classical account, looks something like this:

> Scientific discourse describes experiments [and observations] which reveal Nature, the World.

The main working assumption of traditional accounts of the empirical aspect of science is that we can simply delete the middle term 'experiment' and take the statements describing the experiment as descriptions of the World. '30°C on the Centre Court' is a report not of the state of a thermometer but of the temperature of the air. In this way we arrive at the Mill/Popper view of the structure of empirical discourse.

Problems for science as discourse

Traditionally the problems that have attracted philosophical attention have been centred around the relation between general and/or theoretical hypotheses and descriptions of experiments and reports of observations, rather than around the relation between experimenting as a material practice and the world. The traditional scepticism that infects all discursive accounts of the empirical aspects of science could be summed up as follows:

The internal logical relations of the discourse of science are not strong enough to support the knowledge claims made on its behalf. Confirmation alone no more rationally enforces acceptance of a hypothesis than falsification alone rationally enforces rejection. So by the standards of the logicism of the Enlightenment, scientific methods, as the privileging of the results of experiments and obser-

[1] Popper's conventionalist account of 'basic statements' takes the apparatus/World relation for granted.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

vations, are flawed. How is the gap between the 'logic' of the square of opposition and the role of experimental reports in supporting or undermining the beliefs of scientists to be closed?

The external semantic relations of the discourse of science to the world are equally problematic. Notoriously, there is a need for a correspondence account of truth which has never been met, while 'degrees of truth' remains a stubbornly intractable notion.

Post-modernism offered resolutions to both problems. The explanation of the way beliefs are strengthened or weakened is to be found in features of discourse other than its logical structure, for instance its rhetorical tropes and the social positions of those who speak and write it. The second, and even more thrilling post-modern critique of the Enlightenment project, was the assertion that Reality, the World, does not enforce belief via scientific method, since it is not an essential component in experiments. This point was not so much that experiments and theories are internally related, a claim derived from a strong generalization of the theory ladeness of the observations and readings of the states of experimental equipment, but that the World, 'Reality' is not an essential component of the working of the apparatus or the making of observations.

Both of the problems of the traditional account are resolved. The gap between logic and belief is filled with literary theory and sociology. The failure to find an acceptable account of the discourse to World relation is by-passed since the World has no part to play in science.

Debatable assumptions behind the neglect of the role experimental apparatus

Why is the material practice of experimenting and the needful apparatus 'bracketed' in the classical account? For the purposes of the discussion to follow the answer can be found in tacit adherence to two principles:

> THE PRINCIPLE OF TRANSPARENCY: experiments reveal some aspect of the natural World, as it is, *ceteris paribus*. It follows that the analysis of experimental procedure itself can be omitted from the epistemology of natural science.
>
> THE PRINCIPLE OF ACTUALISM: experiments reveal occurrent aspects of the natural World. It follows that the results of experiments can be described in indicative propositions.

Though both of these assumptions have been queried in discussions that seem to me to have been independent of the advent of post-

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

modernism in philosophy of science, as seen from the perspective of post-modernism, they represent the Achilles heel of the classical account.[2]

The Principle of Transparency

The Principle of Transparency entails a Detachment Corollary, that phenomena can be described by what, at first sight, appears to be a description independent of the apparatus that gives us access to them. Take a very simple experiment: to use a mercury thermometer to measure the boiling point of a liquid, say alcohol. The state of the liquid causes the thermometer to come into a certain state, which is then taken as the measure of the state of the liquid. To make this move we must assume a tight and tidy causal relation, from World state to apparatus state. But the apparatus is itself a material thing and part of the World. It is assumed that the tight and tidy causal relation can be investigated like any other causal relation. If it 'holds up' the apparatus drops out of the story. Does the World state pre-exist the thermometer state and is it independent of it? The tight and tidy relation is causal, and causes are materially and conceptually independent of their effects. The apparatus, in this case the thermometer, is transparent, and provided care is taken to allow for the differential expansion of the glass, and that parallax errors are eliminated from the taking of the reading, and so on, the state of the thermometer represents the state of the liquid. Note that it is assumed that there might be, and students of calorimetry worked to provide, other ways of representing the same state of the liquid. This makes sense only under the Detachment Corollary. If criteria of identity for states of the liquid were derived from the nature of the measuring apparatus then they would not be measuring the same state.[3]

[2] The Principle of Transparency has been brought into question in popular discussions. However the Principle of Actualism came under attack as early as R. Bhaskar, *A Realist Philosophy of Science* (Leeds: Books, 1978), an analysis of experimental activity in terms of a distinction between the actual and the real, the latter consisting of natural powers and tendencies. More recently N. Cartwright, *Nature's Capacities and their Measurement (*Oxford: Clarendon Press, 1989) develops an argument in favour of natural tendencies and can also be read as opposed to actualism, though it is not exorcised as a critique of experiment. Ironically it will emerge that one of the taken-for-granted assumptions that 'powers' post-modernist critiques of the experiment is adherence to a form of actualism.

[3] This was perhaps the most serious problem that operationalism encountered.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

The Principle of Actualism

Traditionally, science has been taken to be about actual states of the World. For both Hume and Mach laws of nature are summaries of repeated sequences of actual states.

The Principle of Actualism expresses a choice of ontology. The main alternative realist ontology of tendencies, dispositions and powers has an equally long history. If we take experiments to be attempts to find out the powers of material things, then experimental results are not adequately analysed in an actualist framework. But the classical account of the experiment seems to be strongly actualist. General ontological considerations are germane to the interpretation of the practice of experimenting. However, as we shall see, post-modernism involves a rejection of the Principle of Transparency while preserving a commitment to an actualist ontology.

The correspondence theory of truth fits in to the traditional point of view as the alleged link between I and O propositions and the relevant state of an apparatus, *and* between the aforesaid state of an apparatus and some state of the world. There are two correspondences in the traditional account. Both have been interpreted actualistically. The basic statements of a scientific discipline describe occurrent states of apparatus, say the length of a column of mercury, while the states of the apparatus are in one to one correspondence with states of the World, namely the state of motion of the molecules of the substance the temperature of which is being measured. This is in keeping with the Detachment Corollary above, and indeed could have offered as a premise from which to derive it.

The upshot

I believe that both the Principle of Transparency and the Principle of Actualism are false as having general application to experimental natural science. But it will my task in what follows to try to show that the anti-science position, associated with post-modernism, is equally unsatisfactory. Experiments play all sorts of roles in the natural sciences, some of which I catalogued and illustrated in my study[4] of apparatus and its uses, and we all agree that some account of the apparatus cannot be eliminated from the description of experiments. I intend to show that neither can Nature. To show this I must set out, in some detail, the most recent line of argument in support of the post-modernist case. The recovery of the experi-

[4] R. Harré, *Great Scientific Experiments* (Oxford: Phaidon, 1981).

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

ment will not be a return to either the Transparency Principle or to the Principle of Actualism.

The argument to be developed is intended to show that while post-modernists reject the Principle of Transparency, they still adhere to the Principle of Actualism, a strong and disputable ontological thesis. The 'third way' is based on a rejection of the metaphysics implicit in the Principle of Actualism. An alternative ontology will permit the recovery of the traditional disciplinary role of the experiment without a return to the Principle of Transparency.

Post-modernism

I will first present some characteristic but general post-modernist theses, and then show how they lead to an equally characteristic philosophy of science.

General principles

The catalogue of theses that I will present is not exhaustive, but highlights those insights that seem to me to have been of the greatest importance in the post-modern movement as a philosophy of science. Let me set out the post-modern position first of all as it has appeared in the philosophy of the human sciences, and then modulate to the treatment of the natural sciences within this framework. Summarized rather brutally the position can be expressed in four main theses:

THESIS ONE: CONTEXTUALITY: Every intentional act, be it linguistic or accomplished in some other symbolic medium, derives at least part of its meaning from the context in which it is produced. The boundaries of contexts are variable and negotiable. There is no universal context, which would endow intentional acts with trans-situational meanings.

THESIS TWO: MULTIPLICITY: In any context there is an indefinite multiplicity of readings available for any sequence of intensional actions. No reading has precedence over any other.

THESIS THREE: POSITIONALITY: Actors occupy 'positions' in relation to one another in episodes of meaningful engagement, that is each assumes a set of rights and obligations as actor, which may or may not be conceded by the interactor. Positions are essentially contestable. Multiple contexts and multiple readings derive in part from multiple positions.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

> THESIS FOUR: REFLEXIVITY: Any explanatory or descriptive account of any aspect of human life is itself a reading and so a fit subject for a discursive analysis, and subject to the above principles, in particular there is no universal and/or privileged account of human activities including giving accounts and readings.

It is not too difficult to reformulate these principles to deny any privilege to scientific discourse as an account of our experience of Nature. Experiments are context bound and their interpretations are legion, depending only on the relative positionings of the interpreters.

Post-modernism as a philosophy of science

At the core of the post-modernist resolution of both the internal and external sources of scepticism in the traditional situation there are two alleged insights, remedying what is evidently missing from the traditional account. Neither microsocial nor macrosocial relations and structures. nor experimental equipment and using it are mentioned in the traditional account. The post-modernist move is to introduce both. From that standpoint the traditional account is no more than an obscure way of analysing the conventions of a certain kind of agonistic discourse, of the rhetorical devices used in offensive and defensive moves in controversies.

This sounds interesting, perhaps at the level of superior gossip, but then something quite thrilling is proposed: that Nature has nothing or almost nothing to do with the assessment of the value of scientific discourse as a repository of knowledge. The experiment, which, we prided ourselves, gave us access to Nature, and which we took for granted, in the transparency of experimental *apparatus*, is reconstrued either as a rhetorical device, an ally in some local controversy, or, though less frequently, as a pilot plant to be realized, perhaps, in some large-scale industrial process.

Detailed discussions and analyses of the relation of the experimental apparatus to the material world were rare in classical philosophy of science. What is the relation between the members of one class of material things, experimental setups, and the members of another class of material thing, physical structures and processes in the (or 'an') independent world?

According to Latour[5] and Hacking[6], there is no such relation, or if there is, it is of marginal importance in understanding the pro-

[5] B. Latour, *Science in Action* (Milton Keynes: Open University Press, 1987).

[6] I. Hacking, 'The self-vindication of the laboratory sciences', in *Science as Practice and Culture*, A. Pickering (ed.) (University of Chicago Press, 1992), 29–64.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

duction of scientific knowledge. The laboratory is a closed system, and outside it is the wild, forever *terra incognita*. Unlike the classical philosophers of science Latour and Hacking focus in interesting ways on the role of experimental apparatus in the generating of scientific discourse. If these insights could be sustained the outcome would be thrilling. In the absence of an apparatus to world relation, there would be alternative but a wholesale rejection of any correspondence theory of truth in all contexts, including that of the experimental results themselves. What seemed to be a transparent material relation turns out to be intratextual, social and discursive.

According to Latour, Pickering[7] and others, even the technical standards upon which the power of an experiment to convince rests, are a function of the social power of the group performing them. Therefore, it is argued, the explanation of why some accounts are believed and become authoritative, some rejected and others are not even formulated, will have a wholly sociological-historical explanation, probably in terms of social and institutional 'power'. There is no role for the experiment as a reflection of Nature or the World in explanation of why one account is preferred to another.[8] That certain experiments are regarded as authoritative is a status created by the members of the relevant community.

The post-modernist critique of the experiment

The post-modern critique of the experiment amounts to the seemingly thrilling claim that Nature or Reality has no place (or a very limited place[9]) in the work of the natural sciences. It amounts to an exclusion of Nature/World/Reality from philosophy of science. For example Gergen and Gergen make the position very clear in the following quote:

> the confirmation (or disconfirmation) of hypotheses through research findings are achieved through social consensus, not through observation of the 'facts'. The 'empirical test' is possible because the conventions of linguistic indexing are so fully shared ('so commonsensical') that they appear to 'reflect reality'.[10]

[7] A. Pickering, *Constructing Quarks: A Social History of Particle Physics* (Edinburgh University Press, 1984).

[8] For an excellent summary of arguments against a microsociological reduction of the epistemology of the natural sciences see K-M. Kim, *Explaining Scientific Consensus* (New York and London: Guildford, 1994).

[9] How limited is 'limited'? Hacking's account, to be discussed later, sounds thrilling because of the implication that 'limited' is vanishingly small.

[10] K. J. Gergen and M. Gergen, 'Towards reflexive methodology', In F. Steiner (ed.) *Research and Reflexivity* (Cambridge, Mass.: Harvard University Press, 1991), 81.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

There are three versions of this position. There is the 'textualist' version, in which all is discourse. There is thus a closed cycle between empirical and theoretical discourses and apparatus and the World are themselves texts to be read with no privileges as permanent bases of the assessment of discourse in general. The second version admits a categorial difference between discourses and material setups, say in laboratories, but excludes Nature, non-human Reality, from a role either in the creation of the laboratory or in the way the apparatus works in that laboratory, though 'society', perhaps as the client for the scientific entrepreneur is not excluded. In the third version, advocated by Latour neither Nature nor Society penetrate the walls of the laboratory nor the community within. In all three versions the Principle of Transparency is implicitly rejected. But all three are strongly actualist.

GOODMAN: THE CLOSED CYCLE OF DISCOURSE

For an example of a strong actualist and post-modernist philosophy of science we can go to Goodman's several presentations of his Ways of World making argument. The 'multiple versions' argument, is implicit in Goodman's earlier and well known study.[11] Here is Goodman's latest and perhaps strongest exposition of his view:

> Worlds are version dependent (that is vary with different versions) with respect not only to *what* they are but also to *that* they are. The answer to the question, 'Version and what else?' is 'Nothing.' The non-versional auxiliary, thought to be needed, is all encompassed within the versions.[12]

The difficulty of grasping Goodman's thesis is exacerbated by the immediately following qualification: 'Such version dependence does not imply that versions make their Worlds but only that they have Worlds answering to them'. But in the illustrative example we are back to making rather than answering to. If each version reveals an aspect of the World, I have no quarrel with Goodman, but as his argument unfolds it discloses a much more radical thesis. Goodman asks us to consider two versions, D and T, descriptions of the sky at night. In D we describe a section of sky with a star B at its centre. In T we assert that B is million light years away and what we see is how B looked a million years ago. T 'puts the life of B in the far past; while for D, B still sparkles.' 'T', says Goodman, is typical of versions that distribute things over time and space, and in doing so

[11] N. Goodman, *Ways of Worldmaking* (Indianapolis: Hackett, 1978).

[12] N. Goodman, 'Conditional plurality of pluralisms', *Dialektic* **3** (1996), 69–80.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

make time and space'. Neither version has priority nor subsumes the other. However, all depends on Goodman's implicit actualism. According to the alternative dynamicist ontology, B, the real star, has the power to cause us to see a light in the sky a million years after it was in a certain state. The appearances of the night sky are actual. The World is a complex structure of powers and dispositions. How the sky looks now enables us to ascribe powers to distant stars as material things. It took a lot of hard work to reach a version that conformed to the requirements of a science, capable of accounting for the widest range of appearances. The science of astronomy clearly distinguishes between the powers of things that could be displayed in observation and experiment and the actual appearances. Versions in cosmology no more 'make time and space' than do versions that one uses to explain to a child why the woodcutters axe on the other side of the Mississippi is seen to strike the log before it is heard to do so.

If the project is explanatory, that is, is a part of natural science, then version T subsumes version D. But notice that version D is necessary for version T since version D is nothing other than the observational/experimental basis for version T. The grammar of 'D-type versions' includes dispositional concepts, while the grammar of 'T-type versions' includes causal power concepts. A 'T/D' science is created by a supergrammar in which the explanatory relation is created by the generic ontological (grammatical) relation 'powers/dispositions'. Goodman's refusal to privilege the 'scientific version' is surely a consequence of prior adherence to an actualist ontology. In the dynamicist framework T subsumes D, while in the actualist framework D is robust and T scarcely more than a sci-fi speculation.

In his recent article, cited above, Goodman tries to make time version dependent, and thus defend and strengthen the 'Versions make Worlds' thesis. In his example there are three stellar explosions, say K, L and M. According to one version, V_1, the cosmologist's, they occur in the order L > M > K. According to an observer on the earth, V_2, they are seen in the order M > K > L. According to Goodman V_1 and V_2 are both true and so they are of different Worlds if of any. But this is absurd. There is one World such that stellar explosions ordered as L > M > K are observed on Earth, which is in that one World, in the order M > K > L. The versions can be ranked in that while one explains the other, the latter includes the description of supporting observations.

The moment we shift our metaphysical basis from actualism (occurrent states) to dynamism (natural powers and dispositions) the thrill of Goodman's argument is dispelled.

There is a very simple rebuttal of the 'equal standing of versions'

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

argument if we think in less intellectualist terms and pay attention to the role of discourse in the management of human projects, some of which will be practical, others political, others social and so on. Relative to a well defined project, versions can be ranked. If the project is to land a robot on one of the moons of Jupiter, the Newtonian version of the Solar System Story is better than the astrological. However if the project is to give some sense of a place in the universe to people not deeply versed in the physical sciences, the astrological version of the cosmos might do a better job. Versions are competitors only relative to projects, and in the absence of projects they are neither of equal standing nor ranked in some preference order. In some project environments there are uses for 'true', while in others different forms of assessment are appropriate. So the post-modernist claim that all versions are equal can only be made in a project vacuum. But in that context the contrary claim that some versions are better than others can make no sense. If a counter-claim makes no sense in a context, then neither does the original claim.

Since each version 'creates' its own world there is no place for experiments, as transparent windows giving on to one World, enabling us to rank versions with respect to their quality of representing aspects of that World. Goodman's position seems to lead to a denial of the Principle of Transparency. However, returning to his account of the world making power of versions it seems to me that that claim rests in part on a tacit and prior rejection of the Principle, together with a strong actualism. So his argument cannot be taken as a disproof of the Principle of Transparency since among its grounding premises is a tacit rejection of that very principle.

RORTY: THE CLOSURE OF THE LABORATORY TO NATURE

In both his major essays on the topic Rorty bases his philosophy of science on three principles:

1. 'A repudiation of the very idea of anything [social or material] having an intrinsic nature to be expressed or represented.'[13] So, 'Water is an oxide of hydrogen' would not express the nature of water, since it seems, according to Rorty, it has none.
2. Truth is confined to sentences which 'cannot exist independently of the human mind', though 'the world contains the causes of our being justified in holding a belief'[14]. But this does

[13] R. Rorty, *Contingency, Irony, and Solidarity* (Cambridge University Press, 1989), 4.

[14] op. cit. p. 5

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

not support a correspondence theory of truth since there are no facts in the world.

3. We should not look for criteria for adopting a certain vocabulary, for instance that of Newtonian physics, even though adopting this vocabulary lets us predict the world more easily.

Rorty's extrusion of Nature from its traditional role in the epistemology of the natural sciences seems to depend on the thesis that concepts like 'knowledge', 'essence' and so on are wholly explicable within a discourse genre. If facts are propositional and it is facts that are juxtaposed to hypotheses then natural science does not reach into the World. From the point of view of this analysis Rorty's position can be seen as a rejection of the Principle of Transparency, but in discursive form. The three-step structure, hypothesis-fact-World is not uniformly linked. The second pair are linked causally, while the first pair are linked semantically.

Presumably, as human constructions, experiments are sited within the discourse of science, not in the World. World to experiment relations are causal, but experiments, as interpreted phenomena, Rortian facts, must be discursive. One can see how this is a tacit denial of the Principle of Transparency. The Rorty scheme is really four-step. Hypothesis—experimental result as fact—experimental result as material state—World.

The treatment of these issues is more or less the same in Rorty's earlier and well known work.[15]

At the same time as he admits that the world causes us to entertain certain beliefs Rorty denies that it is the natures of world stuffs that does this useful work. The experiment, for example a manipulation to decompose water into hydrogen and oxygen, and to reconstitute it from them, seems to be forgotten. It is not Nature that causes our beliefs, if we can use that notion for a moment, but Nature as domesticated in the experimental apparatus. Only having forgotten the materiality of experimental apparatus could he say that 'physics fits the world' is an empty compliment, not an explanation of its success.

To restore the role of the World, while steering clear of the Principle of Transparency, will require a thorough analysis of the nature of experiments and the status of apparatus. My final commentary on Rorty's pragmatist account of science must await the detailed discussions of experiments. The point to be established is that though the relation of apparatus to World is a material correspondence it is not analysable in simple cause/effect terms. In a cer-

[15] R. Rorty, *Philosophy and the Mirror of Nature* (Oxford: Blackwell, 1980).

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

tain sense apparatus is Nature domesticated. In so far as Rorty's position depends on a causal analysis of the Nature/apparatus relation it is flawed.

LATOUR: THE ISOLATION OF THE LABORATORY AND ITS INHABITANTS FROM BOTH NATURE AND SOCIETY

Latour's post-modernism like Rorty's, is based upon the intuition that science is a wholly discursive activity. But his position is stronger than Rorty's in that he pays close attention to the importance of experimental apparatus and its skilful manipulation in the genesis of bodies of knowledge. But he goes further than Rorty in denying the World or Nature any role in the genesis of science either as discourse or as practice. This step beyond Rorty's modest position is driven by his account of experimental apparatus. People make it and people use it, adjusting it to get the results that will serve to settle some controversy in accordance with their beliefs and in their favour. In taking part in a controversy a scientist needs allies. He or she finds these both among the human inhabitants of the laboratory and the non-human, the apparatus. Fact builders have to 'enlist and interest the human actors ... and ... the non-human actors too so as to hold the first'[16] Once the controversy is settled the winners redescribe the results of their work by deleting the role of the apparatus and the local character of their manipulations, and presenting their results as the face of Nature itself. But this is a discursive or rhetorical transformation, achieved by deleting all indexical markers from the text. Seen clearly Nature does not penetrate the walls of the laboratory.

Sokol, following up his famous hoax with a philosophical criticism of post-modernist interpretations of the natural sciences, is intent on getting rid of the thrill of the post-modernism take on the natural sciences. In a recent paper[17] Sokal examines the structure of a key principle in Latour's argument. Latour condenses the post-modernism aspect of this analysis of laboratory work into a list of rules. The most thrilling is Rule 3, which runs as follows:

> Since the settlement of a controversy is the *cause* of Nature's representation, not its consequence, we can never use this consequence, Nature, to explain how and why a controversy has been settled.

[16] Latour, op. cit., 172.

[17] A. Sokal, 'Correcting the excesses of post-modernism', *Symposium on Consciousness*, May 2, (New York: New School, 1997).

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

The thrill is, of course, the implication that the explanation must be wholly sociological-political. But as Sokal points out, in the quotation there are two 'nature' expressions, namely 'Nature's representation' and 'Nature'. They are not synonyms, and in the course of the paragraph the latter is substituted for the former, and that is what generates the thrill. Suppose one insisted on semantic uniformity. Using 'Nature' in both places we get an absurdity, 'the settlement is the cause of Nature ...'. But if we substitute 'Nature's representation' for 'Nature', we get the banal truism that if the settlement is a cause of Nature's representation we can never use that to explain how the controversy was settled. The thrill is the consequence of semantic slack, readily dissolved. If we take 'Nature's representations' to be propositional, stories, narratives, accounts or versions, then, if we bought into the general post-modernist account of discourses about any subject matter whatever, Latour's cross substitution would make sense. But one cannot justify the general post-modern account by claiming support from an analysis of natural science that presupposes that account.

It is by his construal of pieces of apparatus as allies that Latour tries to close the laboratory to Nature. So it is to the role of apparatus that our analytical efforts must be directed.

The analysis of the role of apparatus in experimental practice

The deep point behind the whole treatment I am proposing is that the important forms of Nature's representation in natural science are material, namely experimental set-ups, that by isolating fragments of nature, we domesticate it, making it available for material manipulation. The discursive style of Nature's representation flourished *prescientifically*. The significance of the invention of the experiment in the late Middle Ages, by such as Theodoric of Freiborg, was not so much a check on discourse, the logicist tradition that has persisted to the present day, but as *an alternative form of representation*. For example it is not hard to treat Gilbert's Terrela, or model earth, a 10 cm sphere turned from loadstone, as a material representation of the earth as Gilbert believed it to be. Instead of saying, 'the earth is a sphere' and drawing inferences from it, we make a microworld spherical mini-earth, and see what it will do, and how things behave on its surface.

We can accomplish our escape from the locked laboratory by looking more carefully at the nature of experimental apparatus. I shall try to show that the most general characterization of a large

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

number of pieces of equipment, an 'instrumentarium', to pick up Ackermann's elegant phrase[18] in use in laboratories would be as bench-top models of the World or parts of the World. As such they come under the general logic of models be they cognitive or material. But since experimental apparatus is material an instrumentarium is also part of the World. Let me illustrate the point with two examples:

Faraday, Crookes and the discharge of electricity in attenuated gases

With the ready availability of a source of high voltage electricity, the Ruhmkorff coil, and developments in the technique of implanting electrodes in glass, the discharge tube became a popular 'toy' in mid-Victorian London. With after dinner demonstrations of the 'electric light' one had one's own aurora borealis in the drawing room. The discharge tube is a model (a domesticated version) of the unreachable but visible spaces of the upper atmosphere, and the glow a domesticated version of what can be seen in the wild. The drawing room shades into the laboratory. Faraday records visiting J. P Gassiot (Vice President of the Royal Society) to see a demonstration of the 'electric' light. He notices the 'dark space' near one the electrodes, spotting something not perceptible in the wild. Later he manipulated the glow by moving a magnet along the tube. He and others ask themselves 'How is the electricity transmitted in a near vacuum?'. Eventually Crookes begins to pay attention to what might be happening outside the tube. And so the familiar research programme leading to the discovery of alpha, beta and gamma rays gathered momentum. According to the logic of model building, the aurora and the glowing discharge tube are sub-types of the same super-type. The discharge tube in the laboratory does contain an attenuated gas and a miniature 'solar wind' passes through it. A little bit of Nature is reproduced in the laboratory in a domesticated version, and so represented in material and manipulable form.

Theodoric of Freiborg and the rainbow

Theodoric used an illuminated rack of water filled urine flasks as a model of a curtain of water droplets. Thus he recreated in the laboratory the familiar pattern of differing refractive colours in a domesticated and familiar form, wonderfully well described by Wallace.[19] The whole set-up is a material analogue in the laboratory

[18] R. Ackermann, *Data, Instruments and Theory* (Princeton University Press, 1985).

[19] W. A. Wallace, *The Scientific Methodology of Theodoric of Freibourg* (Fribourg University Press, 1959).

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

of the rain and the rainbow in Nature. One could say that the flasks are a domesticated version of the rainbow in the wild. And by the same logic the apparatus/colours is a sub-type of the same super-type as the rain-drops/rainbow. Water filled urine flasks *are* spherical masses of water.

The distinction I wish to make is not so much between the artificial and the natural, in which experimental apparatus as artefact is detached from any but an accidental relation to the World, rather that between the domesticated and the wild. The laboratory is like a farm. It is like neither an art-gallery nor a zoo—neither wholly artifactual nor wholly wild. The material setup has been tamed, rather than represented or caged.

A refinement in the 'logic' of models

Let us look again at the experimental equipment and what happens when a Stern-Gerlach apparatus is switched on; or when a reagent is poured into a test tube; or a bunsen burner is ignited under a retort, or a population of drosophila are left to breed in a suitable enclosure. We have certainly created models of certain aspects or portions of the World. But we have also done something else, since the apparatus is made of material stuff and fruit flies are flies. We have domesticated, and so brought partly under our control, certain aspects of the wild. Experiments are not just discursive representations of Nature in a material medium. They are natural phenomena.

In so far as models are treated as representations of reality they are in no better case against the post-modernist critic of science than propositions, but if they are taken as miniworlds, they are part of nature, bench-top apparatus, that belongs within the same type-hierarchies as some wild/naturally occurring mechanisms. Models, bench top, not cognitive, are domesticated portions of the wild World. Just like cows are domesticated versions of the aurochs, primeval wild oxen.

Treating ontologies as type-hierarchies makes clear several aspects of natural science. For the purposes of this discussion the authentication of a type-hierarchy is achieved through the demonstration that among the sub-types are one or more that are discernible in Nature. In this way the representational power of a laboratory model is established, if it is sub-type of a type-hierarchy some of the sub-types of which are known in Nature. Domestication permits representation. This is not the simple causal relation that Rorty takes it to be.

Pieces of experimental apparatus are artifacts and the stuffs they are used to manipulate are selected and often reprocessed from raw material. However the types instantiated in apparatus and the sam-

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

ples are material, and as such must have a place in some type-hierarchy along with other material sub-types, of some of which they could be models. Pieces of apparatus are made, not discovered. But the 'logic' of their placement in the natural sciences must be the same as the classification of new sub-types, members of which have been stumbled across in empirical investigations. For example Thagard's analysis of the discovery of the bacterium *helico pyloris*, as the cause of stomach ulcers, required the adjustment of two type-hierarchies.[20] A new sub-type was added to the bacterial type-hierarchy, authenticated over centuries, and, in this case, importantly established by comparison (in relevant respects) with the syphilis bacterium, already having a place as a sub-type. At the same time the type-hierarchy of diseases was revamped, so that the sub-type <gastric ulcer> was relocated under the type <infections> and deleted from the type <psychosomatic conditions>.

The performances of experimental apparatus are natural phenomena, though domesticated. What can we ascribe to Nature on the basis of these phenomena? The Principle of Actualism would counsel the ascription of these actual phenomena. This ties in with the traditional logicist move of using the I and O forms as the raw material of scientific knowledge. The post-modern critic is quite right to point out that these phenomena exist only in the laboratory settings, created and interpreted by a scientific community. However, the performances of experimental apparatus are open to another non-actualist interpretation. They display what Nature is capable of in conjunction with apparatus. In so far as the apparatus is a bench-top model of some Natural state of affairs, it displays real possibilities.

The argument shows that despite the falsity of the Principle of Transparency a proper understanding of the status of experimental apparatus and so of the process of experimenting coupled with a non-actualist ontology, scientists do have access to Nature. The crucial step is the abandonment of the Principle of Actualism. In consequence the Principle of Transparency can be rewritten. Apparatus is not transparent to the actual states of the World, but to its powers and tendencies.

Tests of this interpretation

Hacking's disjunction of apparatus and world

One must be struck by the relative stability of certain branches of the physical sciences. Geometrical optics, Newtonian mechanics,

[20] P. Thagard, 'Scientific Change: the Discovery and Acceptance of the Bacterial Theory of Ulcers'. Address to *The British Society for the Philosophy of Science*, London: 10 March, 1997.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

the 'nineteenth century' parts of inorganic chemistry, and so on have been stable, in some cases for four centuries. Within certain limits, defining appropriate ranges of environments, processes and substances, there appears to be not the slightest prospect of their being upset. How is this stability to be explained? The traditional explanation is that the laws of nature expressing what is known about the relevant phenomena are true *ceteris paribus*. This simple explanation collapses in the face of the philosophical assault on propositional truth, together with the problems of all logicist accounts of science.[21] According to Hacking, there is a quite different explanation, essentially a post-modernist one. Experiments are not simple displays of correlations of observables. They are many-way manipulations. The aim is to achieve a stable mutual adjustment of theory, discourse conventions, data collection and analysis and practical techniques. When these are nicely adjusted this bit of science is stable. There is thus a near perfect discourse/apparatus circle.

Hacking claims[22] that ' ... [as] a laboratory science matures, it develops a body of types of theory and types of apparatus and types of analysis that are mutually adjusted to one another. ... They are self-vindicating in the sense that any test of a theory is against apparatus that has evolved in conjunction with it ... and in conjunction with modes of data analysis.' And he goes on to say 'our preserved theories and the World fit together so snugly less because we have found out how the World is than because we have tailored each to the other.'[23] Hacking points out, quite rightly, that experimenting produces phenomena.

But Hacking draws a strong post-modernist conclusion.

> When [we have brought matters into consilience] ... we have not read the truth of the World. There usually were not some preexisting phenomena that experiment reported. It made them. There was not some previously organized correspondence between theory and reality that was confirmed[24].

By opting, tacitly, for an actualist account of the science/World relation Hacking misses the crucial point about experimentation, namely that a large class of experiments are directed to making natural

[21] For instance the underdetermination of theories by data (Clavius' paradox), the paradoxes of confirmation, and so on.

[22] op. cit., 30.

[23] It is difficult to grasp what 'tailoring the world' could be. It sounds rather like another example of the thrill-inducing slip Sokal discerns in Latour's Rule 3.

[24] op. cit., 58.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

affordances available for human contemplation and use. In some cases there were preexisting phenomena, such as moulds producing a secretion that killed hostile microorganisms, the Aurora Borealis, rocks falling from cliffs, and so on. We create material models of these setups in the laboratory and call them apparatus.

We are now set up for the post-modern. We thought that Nature must have a place, however humble, somewhere in this symbiotic relationship but according to Hacking (1992: 56) 'in referring to nature I do not imply that nature causes or contributes to such symbiosis in some active way. I do not invoke nature as an explanation of the possibility of science ...' And more of the same.

But there is a third explanation of the stability of well established science that is neither traditional nor post-modern. It is not at all thrilling. It does involve a quite different emphasis on the goings on in the laboratory from its rivals. The third explanation is that the apparatus, the instrumentarium consists of a set of material models of certain parts of the material World. The science derived from the use of an instrumentarium is stable, not because the laws of nature describing the behaviour of the apparatus are true of the World, but because the apparatus materially resembles that aspect of the World of which it is a model. An Atwood's Machine is like a cliff from which a loose rock can fall. A sealed tube of attenuated gas is like a layer of the upper atmosphere. A Petri dish is like an open wound. (Of course, in the relevant respects!). If the bits of apparatus in an instrumentarium are domesticated chunks of nature, then the general outline of Hacking' account of the stability of some parts of science is a consequence. The phenomena are in the laboratory, but the powers to produce them, in these circumstances are the powers of Nature, and they are very much present in the laboratory. In many cases the phenomena of the laboratory are domesticated manifestations of affordances. Sometimes, however, we may suspect that some apparatus/world complexes permit the display of affordances that are never realized in nature.

Apparatus not modelled directly on Nature

The discourse-experimental set-up that manifests 'Hackerian closure' does so because the apparatus is a good material model of something in the World. But not all instrumentaria are so simple. Some other cases need to be looked at to defend the thesis of this paper in full generality.

Many of the ways cows behave are pretty much like the ways aurochs behave, but not all. Cows are a reasonable model for an ethology of the auroch, but there are some things they do that are

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

not very auroch like, for instance standing around while someone other than a calf milks them with a machine which taps all four teats at once. Working with material models requires good judgement and sometimes meta-experimentation to get the similarities and differences between apparatus as model and its natural analogue clear. But there are instruments that are not simple models in the sense I have been discussing so far.

David Gooding[25] has described a nice case, Faraday's demonstration of the mechanical effect of electromagnetism, that requires an apparatus that is highly unlikely to find an analogue in nature. The apparatus of mercury bath, rotating wire and so on is created for a somewhat different purpose. It is a demonstration of a natural affordance, but not by the construction of a material model of a naturally occurring setup. More about that below. This needs careful qualification. Compare the analysis of an experiment to make electrons available to people as phenomena and one which is designed to make bacteria available to people as phenomena. How much of each is a product of the technique? In the electron case we can choose to make 'them' available as particles (using a cloud chamber to create tracks) or we can choose to make 'them' available as waves (using a double slit to create diffraction patterns). Whatever 'they' are, even if there is a 'they', is indeterminate given just these experiments. Nature has these powers relative to these material setups. But making bacteria available optically, with different stains, and making them available electronically by exploiting the wave-like properties of electrons, leaves robust criteria of identity in place. We have no conceptual difficulty with the idea of 'aspects of' or 'properties of' or 'internal fine structure of' bacteria.

Chemistry is rich in examples of Goodingesque 'makings available' to people of yet another kind. I became hooked to science the night my father and I, using a simple retort, isolated bromine. He assured me that this 'stuff' never appeared in Nature as the dark brown liquid we had brought to light. Faraday's electro-mechanical phenomena do not exist in Nature, even as analogues. The apparatus does, however, reveal a natural tendency. Bromine atoms nowhere exist in liquid form but even when locked into molecular combinations they do possess that capacity.

There is more to the requirements for 'making something available'. We need apparatus but also stuff for it to work on. Rothbart[26] has discussed the question of the preparation of pure samples. Thus all chemistry, biochemistry, metallurgy etc. is based on the idea of

[25] D. Gooding, *Experiments and the Making of Meaning* (Dordrecht: Kluwer, 1990).

[26] D. Rothbart, *Scientific Progress* (Lampeter: Mellen, 1997).

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

the pure/impure distinction. Once again we have a version of the domesticated/wild distinction. The specimen is domesticated in that it is designed to enable the experimenter to access some its natural dispositions. But there are complications. The experimenter prepares samples for manipulation. At the very least the dispositions of raw samples are rearranged in the processes of purification, unmasking some that impurities obscured. In breeding cats and dogs, cows and horses, farmers and their like enhance, suppress and indeed sometimes create dispositions. Natural powers can be enhanced and deleted, while new powers are created.

Part of the art of experimental science is to devise apparatus that enables us to manipulate something perceptible, and so to manipulate something imperceptible. For instance the Stern-Gerlach experiment and many experiments in thermodynamics, purport to achieve this. A Stern-Gerlach apparatus makes the nuclei of silver atoms manipulable, in that we can use it to sort them into two classes, depending on a certain quantum number. But they are not rendered perceptible in that apparatus. The tie between the two kinds of availability is loose. Sometimes perceptibility facilitates manipulability, for instance cloning by 'surgery' on the blastosphere. Sometimes techniques that make something perceptually available do not facilitate manipulability (for instance what the Hubble reveals) as in astronomy.[27] But to justify this claim the above argument based on the creation of bench-top models by domesticating part of the wild World needs supplementation. Nor are these cases so simple as the use of a novel experimental setup to display a natural power for a human audience, as in the wonderful demonstrations put on in the Christmas Lectures at the Royal Institution. Like the Stern-Gerlach, the Joule experiment on the mechanical equivalent of heat trades on a huge amount of theory, stories about reaches of nature unavailable to anyone however well equipped. Rotating the paddles by a falling weight (twenty descents of 63 inches) increases the velocity of water molecules, which in turn, increases the velocity of molecules in the thermometer which in turn caused the level of the mercury to rise. Assuming proportionality among all these processes, we reach the mechanical equivalent of heat, via manipulation of the imperceptible. Joule's apparatus has a pedigree, starting from Rumford's studies of the heat produced in solids by mechanical action, through Meyer's qualitative

[27] Surprisingly Hacking was once a leading exponent of the manipulability thesis. But now he says such things as 'those fantasists called scientific realists sometimes invoke nature or underlying reality to explain the 'success' of science' (op. cit., 56). And this from the man who declared that if you can spray them they are real!

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

demonstration that mechanical action on liquids also warms them. That the claim to have speeded up the water molecules is legitimate can, I believe, be justified. But it requires a long historical/inductive argument which would not be germane here. In Joule's paper of 1843 the molecular story is not mentioned. Still, the link with Nature, though tenuous, is not broken. The water at the foot of Niagara is warmer than the water above the falls.

For the adherent of a dynamicist ontology the actual phenomena of the laboratory, created in apparatus built by human beings, are *not* the building blocks of scientific knowledge. Rather they enable us to display the powers and tendencies of the World in a domesticated form. The final step in the argument will be to offer a general account of the dynamicist interpretation of experiments.

Bohr's philosophy of experimentation

For the full development of the dynamicist interpretation of a large class of experiments we must turn to the philosophy of science of Niels Bohr[28]. Philosophers and physicists took a long time to digest Bohr's point of view, perhaps because it was so very radical that it did not fit into the positivist/realist dichotomy, within which philosophy of science was then conducted.[29] The point of Bohr's interpretation was to acknowledge the ineliminability of the instrument/apparatus, the constructed character of laboratory phenomena, and at the same time to avoid eliminating the World. We can read Bohr as pointing out that the Principle of Transparency is false, that therefore the Detachment Corollary fails. The World is made manifest only in interaction with apparatus (and people). What range of powers and capacities can be made available for human beings is relative to the method of exploration. But this does not mean that the World plays no role in the outcome of experiments. To bring out Bohr's insights we need a non-actualist ontology. The basic distinction at the heart of dynamicist ontologies is that between dispositions and powers. Expressions for perceptibles can be related by truth functional connectives in a variety of ways, such as conjunction, disjunction and conditionality. A disposition is an observable because in the 'if A then B' form with which it is

[28] N. Bohr, *Atomic Physics and Human Knowledge* (New York: Wiley, 1958).

[29] Not surprisingly, many commentators interpreted Bohr's views as some kind of Berkelian idealism. The subtlety of his position, and the debt it owed to Kantian influences, did not begin to emerge until the commentary by J. Honner, *The Description of Nature* (Oxford: The Clarendon Press: 1987). It might even be said that the so-called 'Copenhagen Interpretation' was not true to the deep aspects of Bohr's insights.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

ascribed to a material set-up both 'A' and 'B' are expressions for perceptibles. The notion of an affordance drawn from J. J. Gibson's psychology[30] of perception is just that of a disposition the second term of which involves some human activity. Thick ice affords walking. The concept of 'causal power' is reserved for the unobservable property of at least some of the material entities in the set-up that accounts for its observable dispositions.[31] The Bohrian line, in Gibsonian dress, goes as follows:

> Apparatus 1 x the World manifests phenomenon P1 to a human observer, and this shows that the apparatus/World complex affords P1.
>
> Apparatus 2 x the World manifests phenomenon P2 to a human observer, and this shows that the apparatus/World complex 2 affords P2.

The World appears in both the above condensed sets of instructions for bringing some of the powers of Nature to light. Move the Atwood's machine to the moon, say in the form of a golf ball and golf club and the machine/World complex differs by Worlds. The new set-up affords a different motion from the earth-bound one.

Experiments cannot be interpreted without paying attention to a metaphysical scheme. The apparatus alone would not have afforded either P1 or P2 or anything else. Nor would the World. One or the other is made manifest by the use of the apparatus to explore the World. However, what the World affords is relative to apparatus. The Bohrian answer, I believe, would have been that the World/apparatus complex has certain dispositions to display certain states thus affording human beings such phenomena as tracks and interference patterns. Of course if one were a committed actualist, it could look very well as if Bohr had been some kind of positivist, since what we read off is 'on the surface' of the apparatus. Apparatus is not transparent. But these dispositions are explained by reference to the causal powers of the world. How the causal powers of the World are manifested is relative to the apparatus or technique employed. Nevertheless its use allows us to make the World display its powers in so far as this apparatus and not that calls them

[30] J. J. Gibson, *The Senses Considered as Perceptual Systems* (Boston: Houghton Miflin, 1966).

[31] If someone were to press for an analysis of the concept of 'causal power' in actualist terms, to what state of a material substrate does the term 'power' refer?, they would have missed the point of dynamicist ontologies. These have been offered from Kant to Cartwright as alternatives to actualism. To explicate a dispositions/powers ontology one can only offer examples.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

forth. What has the power, the World or the apparatus/World complex? In dynamicist terms the World has the power, but while it is the apparatus/World complex that affords the display, that is to which dispositions are ascribed.

Plainly there is an ontology immanent in Bohr's philosophy of experimentation. It is certainly not actualism. According to the dynamicist point of view, from which this paper is written, observed dispositions are explained by the causal powers of the beings or clusters of beings to which they are ascribed. In the particular case of sub-atomic physics, in which apparatus manifests certain phenomena, the apparatus/World complex displays the appropriate surface appearances, just in so far as the World has the power to afford them when conjoined with apparatus. According to the Honner-Brock interpretation of Bohr's point of view, natural science, and in particular physics, is the attempt to explore the powers of Nature through the exploration of the dispositions of a special class of material things, apparatus locked into a system with Nature. It is apparatus/World complexes that afford perceptible phenomena.

To defend the possibility of using experiments and experimental equipment as a source of reliable knowledge I need to defend the ontology within which and only within which experimentation makes sense, namely the depth ontology of real causal powers as opposed to the surface ontology of actual appearances and manifestations. According to the ontology of dispositions and powers the Principle of Transparency is false. Since this was also claimed by post-modernism, a defence of the experiment that does not depend on that principle is not vulnerable to criticism on the basis of the accusation of adhering to a naive correspondence theory of truth. However post-modernism does seem to make use of the Principle of Actualism, which is at odds with a dynamicist ontology. Post-modernism, at least as it is exemplified in the writings of Gergen, Latour and now Hacking, seems to be a close relative of the positivism to which it seemed at first to be opposed. It is certainly deeply at odds with any account of Nature in terms of observable dispositions and deep causal powers.

The basic particulars of classical physics are not so much Newtonian mechanical atoms, but charges and their spatio-temporally distributed fields of potential. Experiments in the physical sciences are concerned with isolating and making manifest in phenomena the powers of basic particulars as observable dispositions.[32]

[32] The human sciences are similar in a general way in that they are explorations of the powers and capacities of social entities to undertake joint tasks in accordance with norms of correctness, but, unlike the physical sciences, the basic particulars are already known, namely persons. People

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press

The simple charge/field physical scheme, mapping so nicely on to the dynamicist ontology of powers/dispositions[33] that has persisted from the eighteenth century, has been further refined in quantum field theory, and general relativity, in which charges have dissolved ontologically into fields. These developments do not, I believe, affect the argument, since they are even less actualist than was the classical field theory. It is not my purpose in this paper to defend a dynamicist ontology in detail, but to show how Bohr's philosophy of experimental physics shows us how to escape from Latour's laboratory to an engagement, of a sort, with Nature.

Linacre College, Oxford

[33] Hume's actualism should be seen against the background of a general adherence among leading philosophers of the time to dynamicist ontologies. These have never been better summed up than by Thomas Reid in his *Essays on the Active Powers of the Human Mind* (Edinburgh: Bell and Bradfute, 1788 [1819]), Chapter One.

1. 'Power is not an object of any of our external senses, nor even an object of consciousness.
2. 'There are some things of which we have a direct, and others of which we have only a relative conception, power belongs to the latter class.
3. ' ... power is a quality, and cannot exist without a subject to which it belongs.
4. 'We cannot conclude the want of a power from its not being exerted; nor from the exertion of a less degree of power, can we conclude that there is no greater degree of power.
5. 'There are some qualities that have a contrary, others that have not; power is a quality of the latter kind.'

---

have powers that engender fields of potential (meanings) with others. Corresponding to distributions in space there is distribution over a human population and there is corresponding distribution in time. Complexes of people have emergent powers. Experiments are useless in the human sciences because the isolation procedures necessary to conduct experiments destroys the psychological character of the symbols in use. I have no quarrel at all with those who find fault with experimental psychology.

https://doi.org/10.1017/S003181919800014X Published online by Cambridge University Press