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REALISM THROUGH MANIPULATION, AND BY HYPOTHESIS

1. INTRODUCTION

Metaphysical, or ontological, realism with respect to the unobservables of science is the view that unobservable objects, properties of objects, events and processes exist independently of what we believe, perceive or say there is in the world, or what linguistic framework we use to talk about the world. Thus there are electrons, and they do have charge, spin and mass, they are involved in emission events during neutron decay, and enough of them moving in the right way constitute the workings of computers. Under this heading can be found the scientific entity realism advocated by Ellis, Devitt, Hacking, Cartwright and Hellman amongst many others.¹ Arguments will be canvassed in this paper in support of this kind of robust scientific realism. Such a realism stands opposed to varieties of anti-realism ranging from constructive empiricism (which remains sceptical, not only about the truth or verisimilitude of our theories even though the theories do have truth values, but also claims about what exists), to the constructivism of many sociologists of science.

This paper develops an argument for ontological realism with respect to those unobservable items that we manipulate in experimental and technological processes. This is called 'realism by manipulation'. Often items are manipulated in experimental setups in order to detect other items that are not manipulated. This will be called 'hypothetical realism' with respect to what is allegedly detected through the manipulation of something else. In arguments for both kinds of realism appeal will be made to hypotheses or theories about the manipulated and the detected. But there is a difference. In the case of realism by manipulation often only a single causal law or a claim about the causal power(s) of the manipulated need be invoked. In contrast any argument for the detection of items not manipulated may require much theory which is highly speculative or untested. Thus hypothetical realism about unobservables may often be less

secure than realism based on manipulation because of the 'hypothetical' character of the theory about what is allegedly detected. But this is merely an epistemic matter that does not affect the ontological realism of either the manipulated items or the items merely detected. On the whole, support for a claim about the existence of some item based on manipulation is often stronger than support based on evidential considerations for hypothesised items. So, even though two kinds of realism are spoken about in the course of the paper, the division is between two kinds of evidence and argument for realism. This distinction is epistemic and is logically independent of ontological realism.

2. EXPERIMENTAL AND TECHNOLOGICAL PRAXIS AND A ROBUST REALISM

Most practicing scientists are involved with the experimental manipulation and the use, in technological applications, of not only observable items but also unobservable items postulated in scientific theories. Hacking is an advocate of realism with respect to unobservable entities, saying of positrons and electrons 'if you can spray them then they are real' (Hacking 1983, p. 23). In his 1983 book (pp. 22-4 and Chapter 16) Hacking describes two experiments in which an unobservable is manipulated to detect another alleged unobservable. In the first, electrons and positrons are sprayed onto a niobium ball suspended in a gravitational field at a temperature close to absolute zero. The point of the experiment is to detect the presence of hypothesised fractions of the charge e of electrons, such as $\pm 1/3e$, which would also indicate the presence of a free quark. There is some dispute amongst physicists as to whether the experiment does provide sufficient evidence for free quarks with fractional charges, as opposed to something else. Let us simply suppose that there is some evidence (Hacking cites some purported evidence for their existence (*ibid.*, p. 23). The point to be made is that the manipulated entities are the electrons and positrons; and in constructing the experimental apparatus appeal is made to just one of their simple causal properties, that of being able to neutralise any opposite charge. What could serve as a better mark of the real than such manipulability?

In contrast neither the fractional charges nor the quarks are manipulated; so no such strong mark of the real can apply to them. If there is some argument for their existence then it will be 'hypothetical' in that it appeals to, amongst other things, the speculative theory of fractionally charged quarks and evidence based on the frequency of their alleged detection (available theories of quarks suggest that the chance of their free occurrence

will be very low, and so their detection involves dealing with very low probabilities). Such a hypothetical realism with respect to quarks and fractional charges is grounded, not only in experimental practice, but also in theoretical considerations and special modes of inference from which the existence of quarks can be inferred. Given a set of rival theories about the subatomic, including our best current quark theory, and the evidence gathered in detection experiments, inference to the best explanation might tell us that our best current quark theory, with its presupposition that quarks exist, provides the best explanation of what is observed. However such argumentation is of a quite different character from considerations based on experimental manipulation.

Hacking provides a second example — the building and use of a polarising electron gun, which was given the acronym PEGGY II (see Hacking 1983, Chapter 16). The task was to investigate weak neutral currents which were hypothesised to be carried by neutral bosons (a particle detected only much later than the introduction of PEGGY II). The job of PEGGY II was to produce left-handed and right-handed polarised electrons and to investigate the relative frequency of their scattering. Hacking's argument for realism with respect to (polarised) electrons is based directly on manipulability. Given these two different experimental manipulations of electrons, the grounds for realism with respect to electrons becomes even more epistemically secure. In contrast there is at best only a hypothetical realism with respect to bosons and the weak neutral current postulated in theories of physics. The hypothetical or tentative realism towards, say, the neutral bosons investigated using PEGGY II, would become more robust if we were able, in turn, to manipulate them for various experimental purposes. In such a stepwise manner we build up our increasingly realist picture of the universe.

Hacking does not argue that we first build an experimental apparatus and then later become realists about electrons because the apparatus is a reliable producer of electrons. Rather because scientists are realists about electrons and the causal powers that are attributed to them, they build the apparatus they do (e.g., PEGGY II) and then use it to investigate other phenomena:

We are completely convinced of the reality of electrons when we regularly set out to build — and often enough succeed in building — new kinds of device that use various well-understood causal properties of electrons to interfere in other more hypothetical parts of nature (Hacking 1983, p. 265)

We need to investigate what reasons there are for being 'completely convinced' about the prior existence of electrons and their casual powers. And unlike Hacking's argument, it will be argued in Section 4 that the manipulation of electrons can be parlayed into an argument for their reality.

In the initial discovery of electrons by J. J. Thompson in the late 1890s, electrons were not manipulated but merely detected as they came off the cathode (i.e., negatively charged plate) in cathode-ray tubes. The cathode ray tubes were elongated, and at the end opposite the cathode there was a fluorescent screen that would brighten when electrons struck it. However it became possible to indirectly manipulate electrons. Thompson placed charged plates surrounding parts of the tubes to create an electric field in order to deflect the beam of 'cathode-rays' or electrons (as they were subsequently called). Depending on the amount of deflection, as measured by means of the fluorescent screen, he was able to determine the mass/charge ratio. Here what is directly manipulated includes the cathode from which electrons were discharged and the electric field between the charged plates. It is this field which interacts with the electrons as they pass along the tube. It was previously well known that electric fields existed and could deflect charged particles; their use as manipulators is a mark of realism with respect to such fields (whatever their nature be, something of which we might know little). The electrons passing through the field are affected by it, and so are deflected from their straight line path down the tube (by an angle that can be measured on the fluorescent screen). So indirectly, the electrons can also be manipulated by the electric field. But since they are not directly manipulated in order to detect some other item, at best the electrons have, in Thompson's apparatus, a hypothetical realism. Latter when they can in turn be directly manipulated their realism becomes more robust.

Manipulation occurs not only in the physical and chemical sciences but in most other sciences as well. Perhaps the most recent spectacular example of manipulation is in biochemistry, where genes, or more accurately sequences of DNA molecules, are manipulated for a host of ends in a growing gene technology. Here the goal of manipulation need not always be more experiment; in the case of gene technology the ends are increased productivity of crops or greater disease management. We can adapt Hacking's remark to say, in the case of genes: 'we are completely convinced of the reality of genes when we regularly set out to devise — and often enough succeed in devising — new kinds of techniques that use various well-understood causal properties of genes for a range of desired ends, from health to food production'. Such manipulability of the unobservable remains within the realm of pure science (or 'blue skies' research) when it occurs in furthering successful experimentation; but it reaches outside pure science when it enters into technologies that require reliable means for the production of items that are either individually or socially desired. Another technological example is the use of lasers in our CD players. Lasers are a product of laboratory experiments that can now be

manipulated by investigators in all sorts of experimental investigations. And their manipulable features can be 'encapsulated' as when they are built into our ordinary homely CD players.

At best manipulability is a mark of the real and not a criterion for the real. Manipulation is a success term (one cannot manipulate the unreal), and is a sufficient condition for realism; but it is not a necessary condition. The free quarks or fractional charges mentioned in the above experiment are (at this time) not manipulable by us (rather than, say, merely detected by us). If we are to argue for their realistic status, then we will have to do that by other means — unless, of course, we find a means of manipulating them. However not everything that is real is manipulable by us, e.g., pulsars, galaxies and black holes. And if current quark theory is correct and quarks do exist, then they may never be manipulable by us. Nor can we manipulate tectonic plates even though they have devastating effects upon us as they grind against one another around the surface of the planet. The realism associated with manipulability arises from the realism with respect to the relata which stand in causal relations; but only in some cases can the causal relations be exploited by us through manipulation. In the next section this will be explored further.

Note that we need not have full knowledge of what we manipulate in order to bring about a desired end. Perhaps we have only knowledge of a few of the causal powers of the items manipulated to bring about some effect. This is the case with the electrons used in the fractional charge experiments and in PEGGY II; and it is also the case with the electric fields used in Thompson's early work on the electron. We do not know, yet, what is the full nature of electrons, or electric fields, or what might be all the laws which apply to them. Related points can also be illustrated in the case of Semmelweis' discovery of 'cadaveric particles'.

Semmelweis was able to reduce the incidence of death by childbed fever in the Vienna hospital in which he worked by getting the student doctors, not merely to wash their hands, but to wash them in a chloride of lime solution. He hypothesised that 'cadaveric particles', as he called them, remained on the hands of doctors who examined corpses before they examined women about to give birth, thereby infecting the women with childbed fever. Through the new hand-washing procedures Semmelweis was able to manipulate the frequency with which 'cadaveric particles' were present on the hands of doctors, largely reducing it to zero. In turn he was able to manipulate the frequency with which 'cadaveric particles' affected women, and thus manipulate the frequency with which death by childbed fever occurred. It was the spectacular lowering of the incidence of childbed fever that lead people to believe that Semmelweis had made an important

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