I. Introduction

A. Hacking’s negative claim

Debates about scientific realism/antirealism mistakenly focus on whether explanatory and predictive success provides good reason to believe that theories are approximately true.

B. Hacking’s positive claim

Instead, debates should focus on whether experimental success provides a good reason to believe that the entities posited by scientific theories exist.

More precisely, Hacking holds the following:

• If experimental scientists manipulate entity \( x \) to produce new phenomena and investigate other aspects of nature, then (probably) \( x \) exists.

II. Kinds of realism

A. Realism about theories vs. entity realism

Realism about theories: science aims to form true theories of the world, and is (partly) successful in achieving this aim.

Entity realism: science is generally successful in positing existent unobservable entities.

• “Entities” include “processes, states, waves, currents, interactions, fields, black holes and the like.” (72)

B. Entity realism without theory realism

Experimental scientists believe that many unobservable entities exist.

Experimental scientists attribute many properties to these entities.

These properties can be embedded in “plenty of inconsistent theories about which the experimenter is agnostic,” some of which are useful for making calculations about one part of an experiment may be useless for making calculations for the other part of the experiment (72).

C. An argument for entity realism: first pass

1. If experimental practice is coherent, the experimenters are realists about the entities that they manipulate in order to produce new phenomena and investigate other aspects of nature.

2. Experimental practice is coherent.

3. ∴ Experimenters are realists about the entities that they manipulate in order to produce new phenomena and investigate other aspects of nature. (From 1,2)

III. Our debt to Hilary Putnam

A. Putnam’s (1975) referential theory of meaning

The meaning of a word consists of its:

• Syntactic marker (is it noun, verb, adjective, etc.)

• Semantic marker (what kind of thing is signified by the word? Animal? Mineral? Vegetable? Etc.)

• Stereotype (clichés about the word; descriptions that change over time)

• Referent (what is the specific stuff/thing in the world that the word denotes?)

Stereotypes can change over time while still referring to the same thing.

B. Putnam’s (1981) Internal Realism

Holds that everything (scientific or otherwise) depends on our minds and conventions.

Unlike his theory of meaning, this won’t really figure in what follows.
IV. Interfering & making
A. Interfering & observing
“Microscopes carry conviction because of the great array of interactions and interferences that are possible. When we see something that turns out not to be stable under such play, we call it an artefact and say it is not real.” (76)
1. If a microscopic object is either not manipulable or not robust, then it is not real.
2. If a microscopic object is manipulable and robust, it is real.
3. ∴ A microscopic object is real if and only if it is manipulable and robust. (From 1,2)

B. The experimental argument for realism
1. If scientists frequently succeed in building new kinds of devices that use various well-understood causal properties of electrons to interfere in other more hypothetical parts of nature, then (probably) electrons exist.
2. Scientists frequently succeed in building new kinds of devices that use various well-understood causal properties of electrons to interfere in other more hypothetical parts of nature, [probably]
3. ∴ Electrons exist. (From 1,2)

C. An interesting statement
“…the experimental argument for realism… is not that we infer the reality of electrons from our success. We do not make the instruments and then infer the reality of the electrons, as when we test a hypothesis, and then believe it because it passed the test. That gets the time-order wrong. By now we design apparatus relying on a modest number of home truths about electrons to produce some other phenomenon that we wish to investigate.”

V. A case study
A. Parity & weak neutral currents
In the 1960s, there were thought to be four fundamental forces in nature:
  o Gravity
  o Electromagnetism
  o Strong forces: 100 times stronger than electromagnetism, but very short range; act only on hadrons.
  o Weak forces: much weaker than strong forces, and even shorter range than strong forces; act on both hadrons and leptons. (Ex. radioactivity)
General idea: there is a unique kind of particle that is the “vehicle” for each of these forces (bosons for weak forces).
Weinberg-Salam (‘electroweak’) model predicts a very small parity violation in weak neutral currents.
  o Weak current: current resulting from interactions involving weak forces
  o Charged (i.e. non-neutral) currents were known to exist; conjectured to be result of charged bosons.
  o Parity: particles will exhibit the same properties, regardless of the direction in which they are spinning; parity is violated when spin makes a difference.

B. PEGGY II
Problem: in early 1970s, scattering experiments did not generate enough electrons to provide sufficient evidence for the Weinberg-Salam prediction.
Gallium Arsenide (GaAs) generates lots of electrons when struck by circularly polarized light.
Using a lot of technological know-how, PEGGY II was created, and could generate the data needed to test the Weinberg-Salam prediction, which was confirmed.
VI. Hacking’s interpretation of PEGGY II

A. The absence of theory

Scientists did not work out a theory for how to develop PEGGY II in advance; there was a chance encounter with the properties of GaAs in an optics journal. Many things about GaAs were unknown, e.g. why it polarizes only 37% of electrons. Experimenters need not have a theory for how everything hangs together, e.g. how the GaAs works with the cesium-oxide paint.

B. Inference to the Best Explanation

IBE is most reasonable to adopt when a theory is in its infancy, but this is precisely when it is also reasonable to deny IBE. (Millikan on the electron) This is why IBE is inconclusive.

C. When hypothetical entities become real

If experimental scientists manipulate entity \( x \) to produce \( y \), then (probably) \( x \) exists, but the existence of \( y \) is still up for grabs.

- We should be realists about \( y \) when \( y \) can be manipulated to produce some other phenomenon \( z \).

D. Hacking’s argument: final pass

1. If scientists can build reliable machines by using their knowledge of the causal properties of \( x \), then scientists understand the causal properties of \( x \).
2. If scientists understand the causal properties of \( x \), then \( x \) is (probably) real.
3. \( \therefore \) If scientists can build reliable machines by using their knowledge of the causal properties of \( x \), then \( x \) is (probably) real. (From 1,2)