

What Is Observation?

IDE-023 · Fundamental Ideas

Concept essays for *The Universe and Its Observers*

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Scale / context: From the unaided eye to detectors that record what no sense can reach

Boundary: Observation as an epistemic and physical act: what counts as observing, what theory contributes, and what the quantum measurement problem is. The operational machinery of measurement, from measurand to uncertainty budget, belongs to IDE-014

Related works: IDE-024, IDE-014, IDE-019

Epistemic profile: Established knowledge with interpretive boundaries

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Article Abstract

Observing is not looking. It is an interaction that leaves a record, together with an inference from that record to a claim about the world, and the inference always uses theory. Hanson's point that what one sees depends on what one knows is often taken as a claim that evidence is arbitrary; it is not, and Hacking's answer, that we believe in what we can manipulate to produce new effects, shows why.[1,2] Quantum theory adds a genuinely distinct problem, which is not instrument error and cannot be reduced by better calibration: Bell argued that the word measurement should be banned from the formulation because it disguises where the difficulty lies.[3] This article separates the epistemic, physical and sociological components that the single word observation runs together.

In 60 Seconds

An observation begins with a physical interaction: something couples to an apparatus or an environment and leaves a record, whether a count, a voltage, a track or a mark. This article treats that record as evidence only once it has been interpreted through models of the instrument and the process, which is what makes observation theory-laden in the modest and correct sense.[1] Theory-ladenness does not make evidence arbitrary: independent techniques and cross-checks can help distinguish phenomena from method-specific artefacts, and instruments can be used to intervene rather than only to look.[2] Quantum theory poses a separate difficulty. It is not that instruments disturb what they measure, which is also true classically, but that the theory as usually stated divides the world into a quantum system and a classical apparatus without saying where the line falls; Bell called this a fundamental ambiguity rather than a technical one.[3] Decoherence explains why the environment destroys the interference between the states that survive it, which is why the world is effectively classical, and does not resolve why one outcome is obtained.[4]

Why This Question Matters

The word observation covers three different things that get confused constantly. There is a physical process, which is what a detector does. There is an inference, which is where theory enters and where the interesting errors live. And there is a social process by which a community comes to accept that something was observed, which is where replication and calibration do their work. Popular arguments about whether observation creates reality, or whether scientists just see what they expect, mix these up; keeping them apart makes both questions tractable.

1. An Interaction That Leaves a Record

Physically, observation is coupling. A photon is absorbed, a charge is deposited, a molecule binds, a grain is developed, and afterwards some part of the apparatus is in a state correlated with the system. That correlation is the record, and it is what makes the event available for inference.

Nothing in that description requires a person. A photographic plate exposed in a locked room has observed in every sense that matters physically, and the record waits until someone reads it. The role of a scientist begins at the reading, not at the interaction, which is why appeals to consciousness in the physics of measurement are misplaced.[4]

Evidence, in the sense this article gives the word, is a record that has been interpreted. A voltage becomes a temperature through a calibration and a model of the sensor; a track becomes a particle identification through a model of the detector and of how such particles behave in it. The chain from record to claim is where the work is, and IDE-014 treats its metrological form.[6]

Where That Leaves Us

Observation is physically a coupling that leaves a record correlated with the system, and no observer in the mental sense is required for it. This article calls that record evidence only once models of the instrument and the process have been applied to it. That dependence on theory is what makes the next question unavoidable: whether it leaves evidence hostage to expectation.

2. Theory-Ladenness, Correctly Stated

Hanson argued that observation is not a neutral registering of sense data: what an observer takes themselves to see depends in part on the concepts and expectations they bring, so trained scientific observers can report seeing different things in the same observed preparation.[1] The claim is about the organization of perception and it is well supported.

It is regularly overread into the claim that evidence cannot adjudicate between theories, and that does not follow. Independent experimental techniques and cross-checks can help distinguish phenomena from method-specific artefacts.[2]

Hacking's contribution was to shift the ground from seeing to doing. What convinces us that an entity is real, he argued, is not that a theory says so but that we can manipulate it to produce new phenomena: if you can spray electrons at something and observe a designed effect, the entity has become a tool rather than a hypothesis.[2] Intervention gives observation a check that passive looking cannot.

Where That Leaves Us

What an observer takes themselves to see depends on the concepts they bring, which is well supported; independent techniques and cross-checks can help distinguish phenomena from method-specific artefacts, while intervention tests what looking alone cannot.[1,2] Quantum theory, though, raises a difficulty that no amount of cross-checking removes.

3. The Measurement Problem Is Not Instrument Error

It is common to hear that in quantum physics observation disturbs the system. Disturbance is real, and it is also entirely familiar classically: a thermometer changes the temperature of what it measures. If that were the whole story there would be no problem, only a correction to apply.[6]

Bell's objection is sharper. The standard formulation of quantum mechanics gives one rule for undisturbed evolution and another for what happens on measurement, and it does not say what physically counts as a measurement or where the boundary between quantum system and classical apparatus is drawn.[3] Since apparatus is made of atoms, the theory as stated applies its two rules without specifying when to switch, and that is an ambiguity at the foundations rather than a practical inconvenience.

This is worth keeping separate from metrological uncertainty, which is a parameter characterising the dispersion of the values attributed to a measurand on the basis of the information used.[6] Improving calibration reduces the latter and does nothing to the former, and conflating them makes the actual problem invisible.

Where That Leaves Us

The quantum measurement problem is not that instruments disturb systems, which is classically familiar, but that the standard formulation applies two different rules without saying where the boundary between system and apparatus lies. That is a foundational ambiguity, not a calibration issue. Decoherence is the most substantial physical response, and it is important to say what it delivers.

4. What Decoherence Settles

When a system interacts with an environment of many degrees of freedom, the environment monitors certain of its observables, and the information distinguishing its alternatives is selectively lost into correlations with that environment. The interference between the states that correspond to those observables is therefore destroyed, and a particular set of states, the ones that stay stable under that interaction, is singled out.[4]

That is a real physical result. It explains why the interference between those states is destroyed and why the states that survive the interaction are the ones they are. The everyday world is therefore effectively classical: the process rules out the vast majority of the states the formalism allows, and superpositions of macroscopically distinct states especially.

What it does not do is explain why one outcome rather than another occurs. The formalism yields a set of alternatives with probabilities and an explanation of why they no longer interfere; the transition to a single realized result is what the main interpretations answer differently, and that boundary is stated explicitly in the review literature on decoherence.[4,7] Treating decoherence as a solution to the whole measurement problem overstates a good result.

Where That Leaves Us

Decoherence explains why the environment destroys the interference between the surviving states and why those particular states are singled out, but not why one outcome rather than another occurs. Presenting it as the whole solution overstates it. Beyond the physics lies the question of how a community decides that an observation was made at all.

5. How Communities Settle What Was Observed

Deciding whether a result is real usually means replicating it, and Collins pointed out a difficulty in that procedure. To know whether an attempted replication was competent, you need to know whether the effect is real; to know whether the effect is real, you need competent replications. He called this the experimenter's regress, and documented it in cases where the existence of the phenomenon was genuinely in dispute.[5]

The regress is real. In Collins's documented case, calibration against a known effect is one community practice used to establish experimental competence, although a disputant can refuse the calibrating effect as a surrogate for the effect in dispute.[5] Two other laboratory practices bear on the same difficulty without determining how communities settle it. Independent techniques and cross-checks can help distinguish phenomena from method-specific artefacts; building an apparatus that produces the phenomenon is what Hacking calls the creation of phenomena.[2]

Taken together, the three components give a workable account: observation is a physical interaction producing a record; models turn that record into evidence and can be checked by independent techniques; and, where competence is disputed, community practices include calibration, which a disputant may refuse.[2,5]

Where That Leaves Us

Judging whether a replication was competent can require knowing whether the effect is real. In Collins's documented case, calibration is one community practice used to establish competence, and a calibration can be refused.[5] Independent techniques and cross-checks can help distinguish phenomena from method-specific artefacts.[2] Observation is physical, inferential and social. IDE-024 takes up what must be present: a variation distinguishable from background.

What We Know, and How

- Observation is physically an interaction leaving a record correlated with the system, and requires no observer in any mental sense.[3,4]
- What an observer takes themselves to see depends on the concepts they bring; independent techniques and cross-checks can help distinguish phenomena from method-specific artefacts, and intervention provides an additional test.[1,2]
- The quantum measurement problem is that the standard formulation applies two different dynamical rules without specifying the boundary between system and apparatus, which is distinct from instrument disturbance and from metrological uncertainty.[3,6]
- Decoherence explains the destruction of interference between the states that survive the interaction and the selection of those preferred states, but not why a particular outcome occurs. [4]

What We Still Don't Know

- Why a particular outcome is realized in an individual quantum event, which the main interpretations answer differently.[3,4]
- Where, if anywhere, a principled boundary between quantum and classical description should be drawn, which Bell identified as unspecified in the standard formulation.[3]
- How much of the resolution of disputed observations in practice depends on evidence rather than on extra-evidential factors, which is contested in the study of scientific practice.[5]

What Could Change Our Minds

- An experimental demonstration restoring interference between macroscopically distinct detector records, after entanglement with an environment of many degrees of freedom, would contradict the decoherence account of why that interference is destroyed under such coupling, which is what the account claims; it would not bear on why one outcome is obtained, which the account does not address.[4]
- A formulation of quantum mechanics that specified a physical boundary between system and apparatus and made testable predictions differing from the standard theory would resolve the ambiguity Bell identified, and could be checked.[3]
- A documented class of cases in which independent instruments with genuinely different systematic errors converged on results later shown to be artefacts would weaken agreement across instruments as evidence against an artefact.[1,2]

If You Remember Only One Thing

Observing is an interaction that leaves a record, an inference that uses theory, and a community judgement that it can be repeated; conflating the three makes it look mysterious.

Related Articles

- IDE-024 — What Is a Signal?
- IDE-014 — Measurement
- IDE-019 — What Is Light? Wave, Quantum and Observer

References

- [1] Norwood Russell Hanson. Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science. Cambridge University Press (1958).
- [2] Ian Hacking. Representing and Intervening: Introductory Topics in the Philosophy of Natural Science. Cambridge University Press (1983).
- [3] John S. Bell. Against 'Measurement'. Physics World 3(8), 33-40 (1990). DOI 10.1088/2058-7058/3/8/26.
- [4] Wojciech H. Zurek. Decoherence, Einselection, and the Quantum Origins of the Classical. Reviews of Modern Physics 75(3), 715-775 (2003). DOI 10.1103/RevModPhys.75.715.
- [5] Harry M. Collins. Changing Order: Replication and Induction in Scientific Practice. University of Chicago Press (1985).
- [6] JCGM 200:2012. International Vocabulary of Metrology: Basic and General Concepts and Associated Terms (VIM), 3rd edition. BIPM (2012).

[7] Guido Bacciagaluppi. The Role of Decoherence in Quantum Mechanics. The Stanford Encyclopedia of Philosophy, first published 3 November 2003, substantive revision 23 January 2025. <https://plato.stanford.edu/entries/qm-decoherence/>