

Peer Review

Review of: "The Interaction Problem and Mental Causation: A Quantum Field Theoretical Perspective"

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This paper addresses the question of how an immaterial or unphysical mind can causally interact with a physical body or its brain states. The primary part of the paper is an For the most part, the author discusses quantum field theory as an example of what physicists regard as physical causal interactions. Unfortunately, the discussion of QFT is confused at best, and often wrong. I sympathise with the author's confusion. Even physicists struggle to explain what QFT, or quantum theory in general, is about.

QFT results when we combine special relativity with quantum mechanics. The central problem is Einstein's equivalence of mass and energy. Photons, corresponding to light of a fixed frequency, have energy proportional to their frequency, but no mass. The energy of a photon can be converted into particles with mass, and vice versa. This makes QFT necessarily a quantum theory of many particles.

In the early part of the last century, we discovered there were ways of intervening in the world to change things in a way that could not be explained by classical physics, the physics of Newton, Maxwell, and Einstein (in his theory of gravitation). Intervention means causation. Every experiment that has ever been done in physics is about interventions that lead to a change in the results of measurements. QFT is no different. It is how we explain interventions using collisions between very high-energy particles. In low-energy settings, it explains how we make laser light sources and quantum computers. Quantum theory started out by explaining how natural quantum stuff responds to our interventions but is now much more about how to engineer stuff fully controllable using quantum principles. In QFT, we discovered that the world affords more levers to move it than we had expected, but the central problem remains.

Causation is central to the meaning of 'physical' for physicists, and causation means intervention by humans acting in the world. All interventions require doing thermodynamic work on the world. And all

measurements require that the world does work on us. Interventions require access to a low-entropy source of energy, e.g., a battery. Seen this way, it might be better to think of the meaning of 'unphysical' as any explanation that violates the laws of thermodynamics. For example, being able to change the world without having to buy a battery.

Nonetheless, we have to explain what kinds of thermodynamically constrained machines can have 'mental' features. We are apparently back to mental events of 'learning agents' causing changes in the physical world. Since the discovery of effective learning algorithms running on physical stuff (silicon CMOS devices), no one should be in any doubt that 'mental activity' costs energy if by mental activity we mean learning and control. This begs the question: are human agents any different from learning machines, with levers attached to move the world?

Let me now correct some errors in the paper regarding QFT. Most people are confused by Feynman diagrams. They look like cartoons of particles bouncing off each other. They are not. They are a graphical device for keeping track of terms in a power series expansion of functions used to compute probabilities of events seen in the laboratory, usually counting particles of one sort or another. Feynman diagrams are a convenient graphical trick to save writing down lots of equations. To be fair, the author does acknowledge this in saying, "we should not interpret these graphical representations as having any ontology other than fictions that serve our naive intuition".

In QFT, a particle is something you count because it collides with a detector of some sort that changes in a fixed way for each particle. It is not

"visualized as traveling-wave perturbations of the respective particle field parameterized over a spacetime manifold (sort of localized excitation or fluctuation, just imagine vibrating 'bumps'), with interactions occurring when these excited states couple with one another."

In other words, 'particle' refers to a particular kind of measurement. In QFT, ultimately all measures are costing measurement. It is incorrect to claim that "our observations are limited to the detection of point-like interactions impacting detectors rather than waves or fields." There are no point-like measurements. All physical measurements take place over some non-zero volume and non-zero duration. Attempts to make these externs as small as possible will result in such huge energy fluctuations that the device will vanish behind an event horizon and become dually disconnected from the rest of the universe.

It is a simple mistake to claim that “quantum field operators act at a given point in space”. They are mathematical operations. If they happen anywhere, they happen on the pads of theoretical physicists. It is that word ‘operator’ that catches everyone. It is true that the theory books all write operators as if they are functions of space and time, like the classical electric and magnetic fields. But this is misleading. Ultimately, the ‘x’ and ‘t’ parameters refer to the detectors and sources that are used in the experimental interventions.

The authors’ claim that : “QFT provides a stronger foundation for constructing models of interactive dualism that are more consistent with current scientific knowledge.” is based on a misunderstanding of what QFT is about. QFT does not offer any hope in trying to find an analogy for mental causation.

Declarations

Potential competing interests: No potential competing interests to declare.