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Article

Cause, Effect, and the Nature of Mind

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Abstract

What is causation, and how do mind and matter fit within the causal structure of reality? This paper argues that conventional reductionist causation — the view that causal influence flows *only* upward from microphysical constituents to larger and larger structures — is both metaphysically incomplete and inadequate to the facts. After surveying standard accounts of causation in Western philosophy and science, I argue against epiphenomenalism and the emergentist denial of genuine mental causation. In their place, I develop the concept of *radial causation*, according to which every actual entity exerts causal influence outward in all directions, with no privileged bottom-up priority. Building on Whitehead's process metaphysics, I propose that causation has two inseparable aspects: an internal or mental aspect constituted by each entity's own perspective and subjectivity, and an external or material aspect available to outside observers. Radial causation allows top-down as well as bottom-up causation (and "sideways causation") and explains how higher-level conscious entities can be genuinely causally efficacious without violating physical principles. The paper concludes with a brief examination of how General Resonance Theory and contemporary electromagnetic field theories of consciousness provide one empirically grounded implementation of radial causation at the neural level, offering a mechanistic picture of how mind and matter interact as genuinely co-equal aspects of a single causal web. This is a radically participatory and collegial view of the universe.

Keywords: causation; mental causation; radial causation; panpsychism; epiphenomenalism; emergence; process philosophy; Whitehead; consciousness; electromagnetic field theories

1. Introduction

What causes things to happen? How does one thing affect another? Does the mind affect the physical world, or is it a helpless bystander to the real action — a mere whistle on a locomotive engine, as Thomas Huxley memorably put it? What is causality itself, and how does it relate to the nature of mind and consciousness? These questions are among the most persistent and precious gems in the philosopher's goody bag of perennial problems.

This paper offers some answers that I believe are logically coherent, parsimonious, and adequate to the facts. These are the traditional criteria for philosophically sound ideas, and I will try to hold to them throughout. The central claim is this: all "things" are actually processes that are continuously and necessarily interconnected to all other things and processes through a universal web of causal influence. To be is to be causally influenced and, in turn, capable of exerting causal influence on other processes. The common view of physical objects as isolated and discrete entities is inherently incomplete. All physical objects include both a locus of solidity and a practically infinite web of causal emanations.

From this observation I develop a conception I call radial causation. Reductionist causation, which allows only bottom-up causation from the level of fundamental physical entities upward, is replaced in this framework with a model in which all entities are capable of exerting causal influence either up or down or sideways in the physical scale, and in which top-down causation is just as real and legitimate as bottom-up causation. This has deep consequences for the philosophy of mind: if mind is genuinely causally efficacious, and if radial causation is correct, then mind occupies a natural and non-mysterious place in the causal structure of the universe.

The paper proceeds as follows. Section 2 clarifies key terms: “physical,” “material,” “mind,” and “consciousness.” Section 3 surveys Western accounts of causation and offers a response to the Humean skeptical challenge. Section 4 argues against epiphenomenalism. Section 5 considers what the universe looks like when we take seriously both the mind and the causal web framework. Section 6 examines and rejects emergentism. Section 7 develops the concept of radial causation in detail. Section 8 addresses the question of whether wholes can be more than their parts. Section 9 draws out the dual-aspect or panpsychist implications. Section 10 considers how consciousness arises as a whole through field coherence and resonance. Section 11 treats free will in the context of radial causation. Section 12 briefly surveys relevant empirical considerations. Section 13 examines how General Resonance Theory and electromagnetic field approaches provide a contemporary mechanistic implementation of the philosophical framework developed here. Section 14 concludes.

2. Defining Our Terms

In talking about causality and its relation to mind, clarity about terms is essential. Let us start with “physical.” The most obvious, comprehensive, and natural definition of “physical” is “that which is causally efficacious” — that which does something in the world. Whitehead (1929) similarly argued that the best definition of “to exist” is to be causally efficacious. “Physicalism” is thus the philosophy that all things are physical or supervene on physical things, and it denies that there is any separate realm of spirit or mind entirely disconnected from the causal order.

“Material” is a narrower category than “physical.” In the modern era, “material” refers to matter and, since Einstein, to matter/energy as a single category of stuff. Materialism holds that all things are comprised of combinations of matter and energy existing in the container of spacetime. It thus narrows physicalism by asserting that nothing other than matter/energy in spacetime is causally efficacious.

“Mind” and “consciousness” refer to subjectivity: the “what it is like” quality that we each know first-hand as experiencing beings in the world (Nagel, 1974). To have a mind or to be conscious is to have mental qualities such as feelings, desires, intentions, and perspectives. Matter/energy, as conventionally defined, is generally held to lack any such mental or subjective component. The standard materialist view is that mind somehow emerges from matter when the requisite structure and complexity is achieved.

Here is my first key point, which motivates everything that follows. If we accept that mind is causally efficacious — and I will argue below that we should — and if “physical” means “that which is causally efficacious,” then mind, insofar as it is embodied in human and other bodies, should be considered physical. This may at first seem strange: is not the mental realm the opposite of the physical realm? Not under the definitions I am advocating. The apparent strangeness reflects the deeply embedded Cartesian dualism that still structures much of Western culture and philosophy, but it is not an entailment of careful analysis. We can be physicalists in Griffin’s (1997) sense while still taking the mental realm seriously, because the physical includes the mental. Causation and mind are not separated realms; they are two aspects of the same underlying reality.

3. Causation in Western Philosophy and Science

Causation is the generic label we give to the idea of influence or connectivity in the universe. Something “here” causes an event “over there” if we can reasonably infer a direct or indirect physical chain of events between the two. Western philosophy from Aristotle onwards has recognized multiple senses of cause: material, formal, efficient, and final. The modern scientific tradition, following Bacon and Descartes, has largely restricted itself to efficient causation — the push-pull of mechanical force — and has been deeply skeptical of final causes or teleology in nature.

The deepest philosophical challenge to our concept of causation came from Hume (1748), who argued that we never directly perceive causation itself, only constant conjunction: A regularly follows B, but we cannot observe the “necessary connection” that would make B the cause of A rather than

merely its predecessor. Causation, on Hume's view, is a habit of mind rather than a feature of reality, an inference we project onto the succession of events rather than something we detect.

The appropriate response to Hume's challenge is not to abandon causation but to acknowledge that we can never know true causes with metaphysical certainty. We can only infer them. But inference from strong and recurrent correlations is precisely what good science consists in. The sun has risen every day of human history; we cannot prove with absolute certainty that it will rise again tomorrow, but we are entirely reasonable in concluding that it will. Similarly, any strong and recurrent correlation licenses a reasonable causal inference, even while remaining open to revision.

Contemporary philosophy of causation has moved well beyond Hume's purely epistemic skepticism. Counterfactual accounts (Lewis, 1973) define causation in terms of what would have happened otherwise: A causes B if, had A not occurred, B would not have occurred. Interventionist accounts (Woodward, 2003) define causation in terms of what happens to B when we manipulate A. These accounts have proven enormously productive in scientific contexts and provide the working framework within which most empirical causal claims are assessed. Neither approach requires knowledge of metaphysically necessary connections; both are fully compatible with the inferentialist response to Hume. For present purposes, I will adopt a broadly interventionist conception while arguing that this account must be embedded in a richer metaphysical picture to accommodate mental causation adequately.

One natural but potentially misleading idea about causation is what we might call microphysical priority: the assumption that the most fundamental causal work is always done at the smallest scale, and that higher-level causal descriptions are merely convenient shorthand for what is "really" happening at the microphysical level. This idea is closely connected to reductionism and to the doctrine of causal closure. I turn to both below, after first addressing the question of epiphenomenalism.

4. Against Epiphenomenalism

Some philosophers hold that minds are causally inert epiphenomena: byproducts of brain activity that have no causal influence on the physical world. Huxley's image of the steam whistle captures this idea perfectly. Each of us, under this view, thinks we have a role in the universe — that our choices, intentions, and deliberations matter — but we are mistaken. Our brains have a role, but not the minds those brains produce. Epiphenomenalism is a form of materialism that takes seriously the existence of consciousness while denying it any causal power.

There are compelling reasons to reject this view. First, there is the argument from common sense. Each of us has an extraordinarily strong and persistent first-person impression of being causally effective in the world. We choose where to direct our attention, what words to type, what actions to take. Common sense is common because it generally makes sense, and the burden of proof lies with any view that overturns it. We should only reject strong and universal common-sense intuitions in the face of compelling evidence and the absence of viable alternatives. Epiphenomenalism meets neither condition.

Second, there is what we might call the asymmetry argument. Epiphenomenalism holds that causation can be a one-way street: physical processes can affect mental states, but mental states cannot affect physical processes. We do not observe any other case in the physical world where something can receive a physical signal without also being capable of sending one. To be physically susceptible is, it seems, always also to be physically efficacious. This does not logically rule out exceptions, but it gives us strong *prima facie* reason to doubt that one exists in the case of consciousness.

Third, epiphenomenalism faces a serious evolutionary problem. If consciousness has absolutely no causal consequences, it is entirely mysterious why natural selection would produce it, or allow it to proliferate, or associate it with complex cognitive systems that demonstrably enhance survival. An adaptively inert byproduct that consumes neural resources and is universally associated with flexible, goal-directed behavior requires a great deal of explaining. Theories that attribute genuine

causal efficacy to consciousness have a much smoother evolutionary story to tell (Griffin, 1997; Strawson, 2006).

The Libet (2004) experiments are sometimes cited as evidence for epiphenomenalism: they appear to show that brain activity predictive of an action precedes the conscious intention to act. However, Libet himself explicitly denied that his results undermine free will, and later work by Schurger and Dehaene (2012) has shown that the relevant neural patterns are better explained by stochastic accumulator models that are fully compatible with conscious agency. The pre-movement potential is better understood as neural noise that eventually crosses a threshold, with consciousness playing a real role in shaping the trajectory toward and beyond that threshold rather than being a mere post-hoc observer of it.

5. The Universe as a Web of Causal Flows

Let us take a step back and think large. The universe is everything that we can perceive or could, in principle, perceive. Perception is only achieved through causal influence: an object “over there” influences me “here” in such a way that I can detect it with one or more of my senses. The “universe” may therefore be defined as that which is included in the causal web that we can, or could in principle, access. Universe and causal web are co-extensive.

Now, if “physical” means causally efficacious, and if mind is causally efficacious (as we have argued), then the entire universe may be described as a vast web of causal flows in which both mind and matter participate. This vast web of causal flows just is both mind and matter changing in time. It is all there is. But mind and matter are not two different kinds of stuff in this picture; they are best viewed as two aspects of a single thing, two sides of the same coin.

That coin may be described simply as an event, a happening. Each event is, for itself — from the inside — mental and subjective. The same event is, from the outside as perceived by outside observers, material and objective. This dual-aspect structure holds for every level of reality, from the most primitive subatomic particle to the grandest structures of the universe. Everything has both an inside and an outside. This is the fundamental ontological claim of the panpsychist tradition, and it is, I will argue, the only metaphysical picture that does full justice to both science and experience.

The deeper question, of course, is at what level of organization — in any given complex system, such as a bacterium, a plant, a rock, a planet — we find mind or subjectivity in any meaningful sense. We do not know, and perhaps never will, because we can never directly access any consciousness but our own. But we can develop a science to tackle such questions by focusing on the mechanisms by which unitary minds are created. I have suggested elsewhere (Hunt, 2011) that the key to the arising of a unitary mind in each instance is field coherence achieved through shared resonance. I return to this suggestion in Section 10.

6. Emergentism and Its Problems

The most prevalent position on the mind–body problem in contemporary philosophy and science is some form of emergentism: the view that mind simply emerges from matter in certain complex forms, just as wetness, solidity, and color emerge from matter under certain conditions. Goldstein’s (1999) definition captures the idea well: emergence is “the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems.”

I believe emergentism, in its standard form, is inadequate as an account of consciousness, and for a reason that is worth stating precisely. Consider liquidity. Liquidity is a genuine emergent property: hydrogen and oxygen are not themselves liquid at room temperature, yet they combine to form water, which is. But this emergence is in principle explicable by examining how the constituent molecules interact with each other; we are dealing with the outsides of things at every step. The emergence of a new relational property of outsides from other outsides presents no deep mystery, even if its details are complex.

Consciousness is entirely different because we are not talking about relational properties of outsides. We are talking about insides — experience, subjectivity, qualia, the felt quality of what it is like to be something. And when we define our physical constituents as wholly lacking in any inside, as wholly non-experiential, it becomes not just unexplained but deeply implausible that mind should “emerge” from this wholly mindless substrate. This is what Strawson (2006) calls “radical emergence,” and he makes essentially the same argument for its impossibility: the emergence of insides from what previously consisted only of outsides would be the spontaneous creation of an entirely new category of reality.

Sewall Wright (1977) stated it well: “Emergence of mind from no mind is sheer magic.” Colin McGinn (1991) is, if anything, more emphatic. He writes that sentience appears to have sprung from “pulpy matter” in a way that introduces “a sharp break in the natural order,” a break that looks less like science and more like miracle. One might be tempted to invoke divine assistance, he suggests — but that is precisely what naturalism is designed to avoid.

It is worth acknowledging that philosophers in the emergentist tradition have sophisticated responses to this line of argument. Frankish (2016) argues, on illusionist grounds, that qualia as we ordinarily conceive them are a cognitive illusion, so the hard problem is dissolved rather than solved. Chalmers (1996) acknowledges the explanatory gap but seeks to close it through “natural psychophysical laws” connecting physical and phenomenal facts. Goff (2019) argues for cosmopsychism rather than panpsychism as the preferred panexperientialist alternative. These are serious positions that deserve careful engagement. But my own view is that the Strawsonian argument identifies a genuine and deep problem for any account that begins with wholly non-experiential matter and attempts to derive genuine experience from it. The most parsimonious and principled response is to deny the starting point: matter is not wholly non-experiential at any level.

7. Radial Causation: The Core Model

We are now in a position to develop the conception of causation that the foregoing analysis demands. Conventional physicalist causation is reductionist in a specific sense: it permits causal influence to flow only upward from fundamental microphysical entities to higher-level structures. This is enshrined in the doctrine of “causal closure,” which holds that every physical effect has a sufficient physical cause at the microphysical level (Vicente, 2006). Under reductionist causation, a cell is simply the sum total of its constituent causal interactions, working from the smallest scale upward; no additional top-level causation needs invoking.

The idea of top-down causation allows for two-way traffic in causation. Influences flow both upward from parts to wholes and downward from wholes to parts. A simple example: when I move my head through the air in a circular motion, the decision to do so — presumably stemming from my mind in association with my brain — exerts an influence over all the cells and molecules in my head and brain as they move through space. And yet my mind is itself a product of my brain and its associated biological structures. Top-down causation does not eliminate bottom-up causation; it supplements it.

But if causation goes both ways — upward and downward — which level wins when conflicting influences are imposed? Does top-down causation trump bottom-up, or vice versa? I want to propose a more radical solution that dissolves this conflict rather than adjudicating it. The solution turns on the rejection of the picture in which causal forces flow past distinct and separated things, either upward or downward in a hierarchy.

Causation is not, in my proposed framework, a matter of forces flowing past distinct and separate physical things either upwards or downwards. Rather, each physical entity, by virtue of its being physical, exerts its own radial causation in its process of becoming physical. It shakes the web of causation that surrounds it in every direction. That same web constitutes the entity in question: any specific entity can only be identified as a portion of the unbroken web of causation that is the universe. All boundaries are fuzzy and perpetually changing.

I call this concept *radial causation* because the appropriate image is not arrows moving up or down a hierarchy but ripples moving outward in all directions from each entity in three-dimensional (really four-dimensional) space. Where reductionist causation is one-way and only upward, and top-down causation allows two-way traffic, radial causation allows causal influence to flow in all directions at all scales, with no microphysical priority or hegemony other than the sheer numerical fact that microphysical entities far outnumber more complex entities. Rosenberg (2005, p. 157) articulates a related notion when he writes that causal entities can “exist at any level of nature” and there is no “pride of place given to microphysical individuals.”

I will use Whitehead’s (1929) term *actual entity* to refer to a generic physical entity in illustrating this picture. Actual entities are, for Whitehead, “the final real things of which the world is made up” (PR p. 18). Whitehead’s notion of causation rests on each actual entity oscillating between potentiality and actuality in a process he describes as concrescence — the process of becoming concrete. Each moment of concrescence involves “prehension,” or felt taking-account-of, the causal influences from surrounding entities. The entity then achieves “satisfaction” — a moment of actualized unity — before perishing and becoming data for the next round of concrescences. This process is eternally iterative: each moment of the universal clock implies a new set of prehensions and concrescences.

Odin (1982) has described Whitehead’s notion of causation as “cumulative penetration,” and the phrase is apt. Causal influence does not arrive in discrete isolated packages but accumulates from all surrounding actual entities simultaneously. The total causal history of the universe converges on each moment of actualization, though of course the vast majority of it arrives attenuated beyond practical detection. In principle, however, each actual event is the product of the entire causal history of the universe up to that point — which is why Nagarjuna’s Buddhist analysis of causation, anticipating some aspects of this view by two millennia, concluded that “the entire universe actually causes each event.”

The contemporary philosophical literature on causation provides additional support for this picture. Hoel’s (2017) work on causal emergence is particularly relevant. Hoel argues that macro-scale descriptions can have strictly higher “effective information” than their microphysical substrates, meaning that causal power is genuinely higher at higher levels of description in some systems. This is a direct challenge to microphysical priority and provides formal tools for articulating why top-down (and more generally radial) causation is real rather than merely conventional. Aaronson (2016) has raised objections to Hoel’s specific measure of effective information, and the debate continues, but the general principle that macro-scale causal descriptions can be irreducible to micro-scale ones has substantial independent support from the literature on scientific reduction and multiple realizability.

We habitually focus on the central locus of any entity and forget the causal web that is the more accurate totality of that entity. This fixation on the center — the “simple location” that Whitehead identified as the fundamental error of substance philosophy — obscures the radial, web-like nature of physical reality. Once we correct for this fixation, the notion that higher-level entities (including animal minds) have genuine causal power becomes not just plausible but expected and natural.

8. Is the Whole Greater Than the Parts?

What does it mean for something to be greater than its parts? When we consider “parts” under the causal web framework developed above — parts as processes rather than cogs or discrete things — the whole is indeed greater than the parts because new causal structures are created through the combination of the parts. If we separate the parts of any particular entity, the causal web that connected the parts is, by definition, lost, no matter what collection of parts we are considering.

The key distinction is between viewing things as wave-like or web-like rather than cog-like. Cogs have no connections once separated from each other. Webs maintain a connection even when pulled apart, though the strength and nature of that connection changes and generally weakens when constituents are separated. Processes are like webs in this respect: they are defined partly by their relational connections, and those connections are partially constitutive of what each process is.

This has direct bearing on the combination problem that faces panpsychism: how do micro-level experiential entities combine to form a genuinely unified macro-level experiential entity, rather than just a collection of micro-experiential entities stuffed into a shared container (James, 1890; Chalmers, 2017)? The combination problem dissolves, I suggest, once we recognize that the relevant entities are not discrete bounded things but process-webs defined by their causal relationships. Combination is not the addition of pre-packaged experiential atoms but the creation of new causal structures — new causal webs — with genuinely novel experiential properties. This is precisely Whitehead's "the many become one and are increased by one."

9. Causation as Dual-Aspect: Mental Inside, Physical Outside

Given the difficulties with emergentism, epiphenomenalism, and substance dualism, the most parsimonious available alternative is some form of panpsychism: the view that all things and processes have both mental and physical properties. Placing this in the context of the previous discussion, we may say that all causes have an internal mental aspect and an external physical aspect. These two aspects are complementary and necessarily go together, like two sides of a coin.

Every cause, under this approach, has an inside that is mental in terms of having at least some tiny amount of subjectivity, and a physical outside that has at least some tiny amount of matter/energy associated with it. This does not mean that everything has rich human-like consciousness. The mental aspect of a subatomic particle is presumably vanishingly rudimentary compared to the rich subjective experience of a human being. But it does mean that consciousness is not the miraculous product of wholly non-conscious matter; it is, instead, a fundamental aspect of physical reality that becomes progressively richer and more complex as physical structures become progressively more organized and integrated.

This dual-aspect conception has a distinguished philosophical lineage. Schopenhauer argued that the world is will (inner aspect) and representation (outer aspect). Fechner proposed that mind and matter are inner and outer views of the same reality. Whitehead (1929) developed the most comprehensive modern process version, in which every actual entity has both a "physical pole" (its receptive relation to past actualities) and a "mental pole" (its creative response to those actualities). In the contemporary literature, Rosenberg's (2004) "natural individuals" framework similarly argues that causation and consciousness are internally linked. Strawson's (2006) "realistic monism" defends essentially the same dual-aspect position on independent grounds.

The dual-aspect view is sometimes objected to on the grounds that it is mere relabeling: instead of solving the hard problem it simply asserts that the mental aspect is always there and calls it a day. I think this objection confuses what a metaphysical account should provide. Metaphysics does not eliminate the hard problem any more than physics eliminates the mystery of mass or charge. What it does is locate consciousness appropriately within the causal order, show that it is not anomalous, and open the door to a scientific research program for understanding how and why different kinds of physical organization are associated with different kinds and intensities of experience. Radial causation combined with dual-aspect ontology provides exactly this framework.

10. Consciousness as a Whole: Field Coherence and Resonance

Under the view of causation as internally mental and externally material, the combination of parts into a new whole should produce a new and higher-level consciousness, due to the new causal web that is formed by such combination. But if this is the case, why does not every motley collection of parts, when heaped together, form a new consciousness? A pile of rocks does not seem to be conscious in any meaningful sense, and a bucket of neurons separated from their connections is similarly not a mind.

The answer, in the ontology proposed here, is that not just any connection results in a new consciousness. What is required is genuine causal integration: the formation of new causal structures that are not reducible to the sum of the pre-existing causal structures of the parts. And the mechanism

I have proposed for this integration is field coherence achieved through mutual resonance. Systems that achieve field coherence through shared resonance possess a unitary mind in each moment that field coherence is achieved and maintained (Hunt, 2011; Hunt and Schooler, 2019).

This is structurally similar to, but distinct from, Tononi's (2012) Integrated Information Theory (IIT). Both approaches require that consciousness be associated with integrated information that exists over and above the sum of its parts. My approach differs from IIT in two key respects. First, I rely on a process notion of time — time as constituted by the iterative actualizations of actual entities, rather than as a container within which events occur — as the ontological basis for the integration framework. Second, I embrace the panpsychist implications of the view, whereas Tononi has at various points been reluctant to follow IIT to its panpsychist conclusions. Both Tononi's approach and mine acknowledge that quantifying consciousness in complex living systems is extremely difficult in practice; this is expected for any nascent science of consciousness and is not in itself a mark against the approach.

In this framing, in which the universe is nothing but a vast web of causes, we realize that causation itself must have a mental component because at least some causes — specifically, those that comprise each one of us — have a mental component. And since there is no principled reason to restrict this insight to human causes, the most parsimonious conclusion is that all causes, at every scale, have at least a rudimentary mental component.

11. Free Will in the Context of Radial Causation

Einstein famously remarked, in expressing his discontent with Bohr's interpretation of quantum mechanics, that God does not play dice with the world. The framework I am developing charts a middle course between the dice-playing that Bohr advocated and the strict determinism that Einstein favored. Rather than supposing that the universe is either entirely deterministic or governed purely by chance, we can find a middle ground in which genuine self-determination is a real but constrained feature of every actual entity.

Under radial causation combined with dual-aspect ontology, all entities/events have at least some capacity for self-determination. This capacity is ontologically built into entities, but in most cases it is extremely rudimentary. This is why we can call the laws of physics laws: they almost always hold up under examination. Many physical laws, however, acknowledge the possibility of exceptions, albeit extremely rare ones. For this reason, Whitehead described the laws of nature as more like habits of nature — extraordinarily stable habits, to be sure, but habits nonetheless, capable of change over evolutionary time.

The evolution of life is also the evolution of consciousness and free will. As physical systems become more complex, more integrated, and more capable of field coherence, their capacity for self-determination grows. The human feeling of being a free agent in the universe is shown, under this ontology, to be accurate — not an illusion but a genuine feature of reality, though one that comes with important qualifications.

We are not infinitely free beings. We are free within the context of our own history. We are each the leading edge of evolution in our particular slice of space and time, but we cannot escape our history entirely. We cannot choose to appear on the surface of Mars in the next second, or sprout a new pair of arms. We are free to choose a particular future out of a projected set of possible futures — but within the habits of physics and the constraints of our accumulated history. This is compatibilism in a rich metaphysical sense: freedom is not the absence of causation but the exercise of self-determination from within a causal web that one both inhabits and partially constitutes.

12. Empirical Considerations

The framework developed here is primarily philosophical rather than empirical, but it is not empirically inert. Several experimental research programs bear on its plausibility. I briefly mention two.

First, there is the tradition of random number generator (RNG) experiments. Beginning with the PEAR lab (Princeton Engineering Anomalies Research) and continuing with the Global Consciousness Project, researchers have investigated whether human mental states can influence the output of electronic random number generators beyond chance. The results have been contentious: some studies report small but significant deviations from randomness correlated with human mental intentions, while critics have raised methodological objections and replication concerns. If upheld, such results would represent a major challenge to conventional materialism, which flatly denies the possibility of mind influencing matter beyond the strict confines of the body. They would also constitute direct empirical evidence for radial causation and the genuine efficacy of human consciousness as a causal force in the physical world. The evidence is currently far from decisive, but the research program is precisely what one would expect to be pursued if radial causation is correct.

Second, there is the growing literature on top-down causation in biology. Noble (2012) and others have argued that gene expression and even mutation rates are regulated by higher-level biological processes in ways that cannot be captured by purely bottom-up genetic models. Epigenetic inheritance provides another case: heritable changes in gene expression occur without changes to the underlying DNA sequence, mediated by higher-level cellular and organismal processes. These phenomena suggest that top-down causation is not merely a convenient shorthand but a real feature of biological systems — exactly what the radial causation framework would predict.

13. General Resonance Theory and Electromagnetic Field Approaches as One Implementation of Radial Causation

The philosophical framework of radial causation and dual-aspect ontology developed above is, by design, theory-neutral at the level of specific mechanisms. It does not presuppose any particular account of how consciousness is implemented in biological systems; it requires only that some form of field coherence and integration underlie unified conscious experience, and that this integration involve genuine bidirectional causal influence between different levels of physical organization. The framework is consistent with IIT, global workspace theory, higher-order theories, and others, even if it sits most naturally with panpsychist and field-theoretic approaches.

It is nonetheless worth sketching, briefly and without arguing for it at length here, one contemporary research program that appears to provide a compelling mechanistic implementation of the philosophical picture. General Resonance Theory (GRT), developed by Hunt and Schooler (2019) and elaborated in subsequent work, proposes that consciousness arises from resonant interactions among oscillatory systems at multiple scales, enabling the combination of simpler experiential entities into more complex unified wholes. GRT is panpsychist in its foundations, embracing rather than avoiding the implication that consciousness is a graded and universal feature of physical reality.

GRT rests on three core conjectures. The Shared Resonance Conjecture holds that resonance is the mechanism by which micro-conscious entities combine to form macro-conscious systems: through shared oscillatory patterns, constituent entities achieve coherence and create a unified field of awareness. The Boundary Conjecture specifies the spatial and temporal extent of any particular conscious entity using the equation $x = v/f$, where x is boundary size, v is the propagation velocity of resonant signals, and f is frequency. The Nested Consciousness Conjecture holds that lower-level experiences are preserved within higher-level integrations rather than extinguished: “the many become one and are increased by one,” in Whitehead’s formulation.

The electromagnetic field implementation of GRT is developed most fully in Hunt and Jones (2023) and the related SEFH (Strong Electromagnetic Field Hypothesis) papers. The central proposal is that consciousness resides primarily in the brain’s endogenous electromagnetic fields rather than in the spike code of neural firing patterns. Neural firing, on this view, serves primarily as an energetic input and modulator for field-based computation, rather than as the computation itself. The electromagnetic fields generated by neural activity propagate at speeds orders of magnitude faster

than synaptic transmission (ephaptic field effects at up to 47 km/s versus spike velocities of 0.1–120 m/s), enabling the kind of rapid global integration that characterizes unified conscious experience.

The relevance of this framework to radial causation should be clear. Electromagnetic fields are inherently radial: they propagate outward in all directions from their sources and interact with all charged matter in their vicinity. They do not respect the hierarchical boundaries that reductionist causation assumes. When neural activity generates an electromagnetic field, that field immediately influences all other charged structures in its vicinity — not just those “above” or “below” the source in some notional hierarchy, but in all directions simultaneously. Top-down effects — from global field configurations to local neural activity — are just as real and measurable as bottom-up effects from neural firing to field generation. Anastassiou et al.’s (2011) experimental work on ephaptic coupling and Pinotsis and Miller’s (2023) findings on field-to-activity causation ratios both support this bidirectional picture.

Crucially, the EM field framework also illuminates how mental causation avoids violating physical causal closure. The objection to mental causation based on causal closure assumes that mental events are non-physical events that would have to inject “extra” causal power into a physically self-contained system. But on the dual-aspect view, mental and physical descriptions refer to the same underlying events under different modes of description. The electromagnetic fields that constitute consciousness just are physical events, measurable with standard instruments. Mental causation — the influence of one’s intentions on one’s actions — is simply the causal efficacy of those electromagnetic field configurations on subsequent neural and motor processes. No violation of physical closure is required because mind and matter are not two different things but two aspects of one thing.

The reader should not conclude that accepting radial causation requires accepting GRT or the EM field hypothesis. The philosophical argument of this paper stands independently. But GRT and EM field theories of consciousness do illustrate, in concrete mechanistic terms, how the abstract philosophical picture can be cashed out in scientifically tractable form: as a research program investigating how electromagnetic resonance across multiple scales produces the field coherence that, on the present account, constitutes unified conscious experience.

14. Conclusions

I have argued for a conception of causation that departs from the reductionist orthodoxy in two related ways. First, in its ontological structure: radial causation replaces the one-way upward flow of reductionist causation and the two-way vertical flow of top-down causation with pan-directional causal influence at all scales, with no microphysical priority. Second, in its relationship to mind: causation has an internal mental aspect as well as an external physical aspect, and this dual structure holds at every level of organization, not just at the level of complex biological systems.

These two claims are deeply connected. The reason reductionist causation looks plausible is partly that it tacitly assumes the mental realm is anomalous and needs special pleading. Once we recognize that the mental is a fundamental feature of causation at every level — as the inner face of the outward causal reality that physicists and neuroscientists study — the pressure to restrict causation to upward-only flows largely evaporates. Causation flows radially because actual entities are not isolated billiard balls exchanging impacts but process-webs embedded in a universe that is itself a vast web of causes, each with its own inside and outside.

Several important implications follow. Epiphenomenalism is false: consciousness is genuinely causally efficacious, not because it is some extra non-physical ingredient but because it is the inner face of the physical processes that constitute neural activity, electromagnetic field dynamics, and all the rest. Emergence in the radical sense — the appearance of genuine insides from wholly inside-free matter — does not occur, because there are no wholly inside-free entities in the first place. The hard problem of consciousness, insofar as it rests on the assumption that we must explain how mind arises from wholly mindless matter, is dissolved at the root.

Free will, under radical causation, is neither an illusion nor a mysterious exemption from physical law. It is the exercise of genuine self-determination by an actual entity whose self-determination is constrained but not eliminated by its physical history and context. Evolution, on this picture, is the progressive increase in the complexity, integration, and self-determination of physical-mental process-webs over cosmic time.

The universe, in sum, is nothing but causation — a vast web of causal flows that is simultaneously and inseparably a web of experience. It is radically participatory. To be causal is to be physical is to be actual. And to be actual is to have, however rudimentarily, an inside as well as an outside. That inside is mind. That outside is matter. And the causal web that connects them in every direction at every scale is the universe itself.

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