Why Interactionism is not Defeated by Objections from the Law of Conservation of Energy

Guidelines for Models of Dual-Substance Mind-Body Interaction

LOUIS J. SWINGROVER
lswingrover@zagmail.gonzaga.edu | *(562) 631-9531*
Gonzaga University, Spring 2015

Abstract: Philosophers continue to debate the metaphysics of the mind, dividing over even such fundamental questions as whether the mind is physical, and if so, in what sense is it physical? Does it causally interact with the body? If so, how? The view that a substantial, non-physical mind causally interacts with a physical body is called "Interactionism". "The Interaction Problem" heads a class of objections to Interactionism that take aim at the nature of the relationship between mind and body on the Interactionist account. The most general objection is that Interactionism lacks a fully-explicated mechanism of mental causation. However arguments that a phenomenon such as interaction occurs need not explain how the phenomenon works in order to be successful. A more forceful objection is that any interaction between a physical and a non-physical substance would violate the Law of Conservation of Energy, a fundamental tenant of physics. However the laws of physics, even if properly described by scientists, are not true by necessity and therefore may not be universal, our current understanding of physics is provisional anyway, and mind-body interaction can be modeled to be consistent with the Law of Conservation of Energy. I propose two models: Discrete Spatial Transitioning, which posits mental control of the locations of physical components, and Physically Underdetermined Routing, which posits mental control of the behaviors of physical components.

1. Introduction

In this paper I outline some defensive strategies for what is currently a minority position in the philosophy of mind, *Interactionist Dualism*,[1] against a particular class of objections often levied against it under the banner of "The Interaction Problem". It is not necessary to assume, even for the sake of argument, that the position I am defending is the correct position. The only matter under investigation is whether it is vulnerable to the objections in view.

I start with a brief introduction to Interactionism and a few remarks about why it matters so much, then turn my attention to the Interaction Problem. I argue that questions about the mechanism of interaction are not defeaters, and ought not count against Interactionism. Then I weigh a more specific objection that asserts that interaction between physical and non-physical substances *could not* occur on the grounds that it would violate the Law of Conservation of Energy, and find it wanting. In the course of doing this some groundwork is laid for models of dual-substance mind-body interaction.

1.1. What is Interactionism?

The landscape of theories in the philosophy of mind can be divided into two mutually exclusive but non-exhaustive categories: *Substance Monism* and *Substance Dualism*. According to Substance Monism there is only one kind of substance. *Materialism* and *Idealism* both fall under this category. According to

[1] According to the 2009 survey documented by Bourget and Chalmers (2014), 105 out of 414 (25.4%) of target faculty members and PhDs with areas of specialization in the philosophy of mind reported accepting or leaning toward non-physicalism about the mind. It is likely that only a fraction of those respondents affirm Interactionism. By contrast, 248 out of the 414 (59.9%) reported accepting or leaning toward physicalism, a view that precludes all varieties of Dualism.

Substance Dualism (henceforth "Dualism" in this paper[2]) there are two kinds of substances, least controversially referred to as "physical" and "non-physical".

Psychophysical Parallelism is the doctrine that while the mind and body might seem to be in uncannily perfect agreement with each other they are nevertheless causally isolated, like two clocks wound up at some point in the past that still keep time flawlessly (not *linked* but *synced*).

Occasionalism holds that while mind and body are causally isolated, God treats events in the mind as occasions to cause corresponding events in the body in realtime (mind and body are *indirectly* linked).

"Epiphenomenalism" is typically used to describe a Property Dualism in which mental states supervene on physical states, however a Substance Dualist could similarly posit unidirectional causality between the body and the mind.[3]

Interactionism is the most radical of the Substance Dualist theories of mind, positing full bidirectional causality between the non-physical mind and the physical body. In this paper I am especially interested in a kind of mind-body Interaction that underwrites libertarian free will. An Interactionism that treats the mind as a nonphysical but deterministic cog in the intracranial machine seems unable to deliver anything Interactionists are concerned about grounding. Just what those concerns are will be tersely summarized in the following subsection.

[2] "Dualism" describes many views, including varieties of Substance Monism such as *Property* Dualism.

[3] The intuitive version of this would posit that the mind is a substantial epiphenomenon of the body (not merely a property), (cf. Searle, 2004a, pp. 53 & 67).

1.2. What's at Stake?

> Freedom, however, is the only one of all the ideas of the speculative reason of which we know the possibility a priori (without, however, understanding it), because it is the condition of the moral law which we know.
>
> *Critique of Practical Reason*
> Immanuel Kant

Whether or not things no less important than moral responsibility, divine benevolence, immortality, rationality, or true love are metaphysically possible just might turn on whether there is a nonphysical, somewhat self-determining mind that can causally influence the body. Philosophers divide over the necessary conditions for each of these things.

If one is philosophically aligned with the tradition reaching a high watermark in Immanuel Kant that maintains that moral responsibility is conditioned by free will, and if free will is conditioned by Interactionism in turn, then this debate has profound implications for one's ethics.

If creatures are not morally responsible their evil actions due to the fact that their behavior is the inevitable and exclusive result of deterministic laws established at the moment of creation, it becomes difficult to see how it would not then be the case that the Creator is evil. Therefore if one is already committed to one of several popular metaphysical and ethical frameworks the question of mind-body interaction bears significant theological ramifications.

Throughout history a large contingent of philosophers have, for various motivations and on various grounds entirely unrelated to physics or neurobiology, maintained the natural or possible immortality of the human soul. Answering scientific objections to Dualism runs interference for systems of thought that

postulate immortality by strengthening the plausibility of a metaphysics that makes immortality possible.

If one is convinced along with Lewis (2000, ch. 3), Searle (2003) and (2004b, p. 10 ff.),[4] Plantinga (2011), and others that a belief is not rational if it is the inevitable result of deterministic cause-and-effect relationships operating within its noetic agent rather than the free adoption of a conclusion on the basis of the apprehension of ground-consequent relationships among propositions, then Interactionism ought to be considered a necessary condition of rationality.

Finally, if one maintains that a free will incompatible with the causal closure of the physical world is necessary for one to exhibit true love, then the possibility of love itself has a critical stake in this debate.

1.3. The Goetz-Moreland Argument from Self-Awareness

While the purpose of this paper is essentially defensive, it might help to summarize at least one current supporting argument for Dualism. Moreland (2011) lays out a modified version of Stewart Goetz' argument from self-awareness and responds to three objections. Goetz and Moreland look to the way a range of data may be theoretically unified by positing an entity causally responsible for that data. They offer up the electron as an example of such an entity, which unifies a wide range of empirical data by characterizing them as effects of its causal powers. Moreland provides a short catalogue of intuitions like the following:

1. I am an individual and not a composite. If I lose a limb, I am not any less of a person.
2. Pairs of persons are not conscious subjects.

[4]Searle's account links a free will–conditioned rationality with ethics, arguing that without rationality one cannot make sense out of the idea of an obligation. He also takes free will to be required for speech acts and a range of other social phenomena. Menuge (2013) argues that Searle's account of rationality fails without recourse to a nonphysical self.

3. My mental states are deeply unified. That is not to say that my perceptual field is continuous and gap-free, but that it belongs to me and is unified with my own thoughts and sensations into a single stream of consciousness. *I have no difficulty in determining which mental states are mine.*
4. As I walk from place to place I intuit myself to be the same person despite the change in location. It is the same person that endures through and owns each moment.
5. I am fully present throughout my body.
6. My own memories, character, and personality traits are neither necessary nor sufficient for the continuity of my identity through change.
7. I and my body have different persistence conditions.
8. My mental capacities are internal to myself and essential to my identity.
9. I think. My mental properties are *kind-defining* properties whose instances are substances constituted by those properties.

Moreland argues that there is an adequate, unifying explanation of the ubiquity of these intuitions: the direct awareness of the self, which lies at the most primitive level of experience. He develops his theory of mind in careful detail and explores its ethical implications with Scott B. Rae in *Body & Soul* (2000).

Obviously arguments like the above do not go unchallenged in the literature. Objections to Dualism range from undercutting defeaters of specific arguments advanced in support of Dualism to positive arguments developed in favor of competing theories of mind. To address them all would be infeasible. This paper is concerned with objections aimed at the scientific plausibility of mind-brain interaction on Substance Dualism.

2. Objection From the Missing Mechanism

> But how the purer spirit is united to this clod, is a knot too hard for our degraded intellects to untie.
>
> *Scepsis Scientifica*, or *The Vanity of Dogmatizing*
> Joseph Glanvill

Western scientists and philosophers are driven by the desire to understand the causal mechanisms at work in the universe, and for many the question immediately raised by the prospect of mind-body interaction is ''*How does it work?*". Calef (2015) articulates it like this:

> Since the mind is, on the Cartesian model, immaterial and unextended, it can have no size, shape, location, mass, motion or solidity. How then can minds act on bodies? What sort of mechanism could convey information of the sort bodily movement requires, between ontologically autonomous realms?

According to Calef, the questions "involved in mind-body causality are commonly considered *decisive refutations of interactionism*." (emphasis mine)

3. Arguments *That* Need Not Explain *How*

What can the Interactionist say on occasions at which questions about mind-body interaction are raised as objections against Interactionism? Here is one possible way to reconstruct such an objection:

1. An argument A for a proposition P is only successful if A explains the mechanism of P.
2. Arguments for Interactionism do not explain the mechanism of mind-body interaction.
3. Therefore arguments for Interactionism are unsuccessful.

The most obvious and decisive rebuttal to the above is to point out that (1) is simply false. An argument might justify one to believe that a particular aircraft flies without explaining the fundamentals of aeronautics, or that a particular bridge is reliable without also providing an introduction to structural engineering, "the prior question is not how, but simply *is*—is there causal action?" (Roelofs, 1955). An argument for the occurrence of a particular phenomenon that lacks an explanation of the mechanism of that phenomenon ought to be

called a "hypothesis" if not a "research program". Any progress made in the theoretical development of a mechanism consistent with the hypothesis should then serve to strengthen its plausibility and guide empirical research.

4. Objection From the Law of Conservation of Energy

A critic could strengthen the objection above by developing it from a mere question about how interaction could work to an argument that it could not work in principle. The objection from the Law of Conservation of Energy is one attempt to do exactly that.

4.1. What is the Law of Conservation of Energy?

The belief that energy (or something like it) is conserved through events may go as far back as Thales or Empendocles. However Rankine (1853) may have been the first to attempt to articulate the principle in a manner that reflects the intertransformability of the various forms of energy, and he may have been the one to give it the name it currently goes by. Here is one way to define the law:

> The Law of Conservation of Energy $=_{def}$ The total energy of a physically isolated system never changes.

This principle can be formalized in many different ways.[5] The following formula relates kinetic energy (E_k), and momentum (mass m multiplied by ve-

[5]Note that what follows is a gross oversimplification of a complicated subject. For example, it does not account for the intertransformability of matter and energy and the regularity with which physicists insist such exchanges occur. Nevertheless it should suffice for the purposes of this paper, as there is no reason why any of the details that would be included in a more thorough treatment would affect the dialectic. According to proponents of universal conservation, even if matter or energy changes form or mutates into the other, all transformations occur according to stable, mathematically describable laws, and the total amount of matter and energy together always remains constant.

locity v): $E_k = \frac{1}{2}\sum_i m_i v_i^2$. This says that the kinetic energy of a group of objects is equal to half of the sum of each object's mass multiplied by the square of each object's velocity.

In addition to the energy an object possesses in virtue of its motion, it also possesses energy in virtue of its position in a field of force or due to the configuration of its parts. Rankine (1853) creatively terms this "potential energy" (E_p), the Newtonian formula for which is mgh, where g is gravity and h is height. The Law of Conservation can thus be formalized: $E_k + E_p = c$ where c is a constant (not the speed of light in a vacuum).

4.2. Why Is Conservation a Problem for Interactionism?

The objection to Interactionism from the Law of Conservation of Energy has roots that go all the way back to Princess Elisabeth of Bohemia, who expresses her concerns with Descartes' Interactionist Dualism in a letter to him in May of 1643 (cf. Garber, 2001, p. 172). Kim (2010, p. 188 ff.) explains that for...

> ...anything to cause a physical object to move, or cause any change in one, there must be a flow of energy, or transfer of momentum, from the cause to the physical object. But how could there be an energy flow from an immaterial mind to a material thing?

One way to formalize this is as follows:

4. For any object to causally operate on any physical object there must be a transfer of energy from the agent to the patient.[6]
5. If Interactionism is true, the mind causally operates on the body.
6. Therefore if Interactionism is true, there is a transfer of energy from the mind to the body.

[6] $(\forall x)(\forall y)(Cxy\&Py \rightarrow Exy)$ where C = causally operates on, P = is a physical object, and E = transfers energy to. Note that there is rarely, if ever, only one patient. Consider a case in which one billiard ball strikes another. Some energy carried by the first ball is lost in the form of heat, vibrations in the the pool table, etc. In the end however, all of the patients—the second ball, the atmosphere, the table, etc.—receive energy from the causal agent (the first ball).

7. A transfer of energy from the mind to the body would violate the Law of Conservation of Energy.
8. Therefore Interactionism violates the Law of Conservation of Energy.
9. If a doctrine violates the Law of Conservation of Energy then the doctrine is false.
10. Therefore Interactionism is false.

Why think that (4) is true? Within the current context, 'energy' refers to the ability of a system to perform 'work', where 'work' occurs when a body is displaced in the direction of an applied force.[7] For example, when an apple falls from a tree it moves in the direction of the force of gravity, and therefore work is done on the apple. Work is measured in units of force and distance; one *joule* is the amount of work done on a body that is displaced under the force of one Newton through a total distance of one meter. If a body at rest is put into motion it necessarily gains kinetic energy it did not possess previously, and if a body's motion is accelerated its kinetic energy increases. Changing a body's direction also transfers kinetic energy by causing motion that would not have been there otherwise, and slowing a body down transfers energy from the body being slowed into the object causing it to decelerate (for example, the tailhook of a plane accelerates the arresting gear on the aircraft carrier that slows it down after landing).

(5) seems to be true by definition. Interactionism explicitly affirms the causal operation of the mind on the body.

(6) follows from (4) and (5) by modus ponens. Note that (6–7) only concern the reference frame of mind-body interaction. During mind-body interaction, energy may flow from the body to other physical things and vice versa. However such events lie outside the considerations of (7). In other words, the frame

[7] This is, again, a biased oversimplification of a topic a fairer and more detailed treatment of which should not affect the outcome of the dialectic.

is *physically isolated*. That is not to say that the physical components of the body upon which the mind causally operates are physically isolated *in fact*. It is only to say that with the exception of the energy transferred in from the mind, all energy input and output is "accounted for".

(7) should now be glaringly obvious, as the Law of Conservation of Energy prohibits any change to the energy level of a physically isolated frame of reference. (8) follows from (6) and (7) by modus ponens. Finally, (10) follows from (8) and (9) by modus ponens.

There are two viable defensive strategies open to the Interactionist. One option is to dispute (9), undermining support for (10). This will be considered in § 5. The other strategy is to reject (4), undermining support for (6), (8), and (10). This will be pursued in § 6.

5. Energy May Not Be Universally Conserved

One way to defend Interactionism against this objection is to reject (9), and there is good reason for doing so. While Interactionists have a responsibility to support their claims, critics advancing arguments like the above that conclude that Interactionism is false must shoulder their own burdens of proof. In the case of (9) the critic bears no less a burden than to establish the universality of the Law of Conservation of Energy. Yet the Law of Conservation of Energy is no a priori truth. It is an inductive generalization based on empirical observations that ought to be regarded in light of the fact that, relative to the great size, density, complexity, and age of our universe the breadth and detail of the phenomena observed and recorded by human beings is infinitesimal.

In addition to the weakness of evidence in favor of (9) there are good reasons

for thinking that (9) is false. Consider the following argument. Either energy is past-finite or past-infinite. If it is past-finite, there is a first moment at which all matter and energy came into existence, rendering *every joule in the universe* a counterexample to the Law of Conservation of Energy.[8]

If energy is past-infinite there must be a fountainhead of energy somewhere in the universe to account for its current density, as without the addition of new energy the expansion of the universe would have resulted in heat death an infinite number of moments ago. The history of 20th Century cosmology is testament to this problem and the rational viability of such a solution due to the temporary flourishing of Bondi's, Gold's, and Hoyle's Steady State theory. Although unlikely, if the universe turns out to be like that the "Law" of Conservation of Energy is *excepted constantly*.

Would it be all that surprising if it turned out that what takes place in the human brain involves a phenomenon only otherwise known to occur at the origin of the universe? The rich, structured complexity of the brain has been compared to the heavens more than once.

Micheva et al. (2010) engineered and employed a synaptic imaging model, *array tomography*, with new analysis software designed to construct easily navigable three-dimensional models of the brain. When speaking to a reporter about their work a senior author of their paper says that the complexity of the brain was revealed to be far beyond what they had imagined, with approximately 125 trillion synapses (roughly the number of stars in 1,500 Milky Way galaxies), where each synapse appears to be...

> '...more like a microprocessor—with both memory-storage and information-processing elements—than a mere on/off switch. In fact, one synapse may contain on the order of 1,000 molecular-scale switches. A single

[8]The Law of Conservation of Energy may be in important respects superseded by a law describing the conservation of energy-momentum or energy-momentum-matter, etc. Nevertheless, if the universe has an absolute beginning as the mainstream interpretation of the standard hot Big Bang model predicts, conservation and linearity laws or their successors must all be broken at least once.

> human brain has more switches than all the computers and routers and Internet connections on Earth.' (Moore, 2010).

Thus, in addition to the complex and subtle behaviors we observe in each other and the qualitatively rich internal experiences with which we are directly acquainted, the astronomical biological complexity of the brain also suggests that something truly exceptional occurs there. When faced with the objection to Interactionism from the Law of Conservation of Energy, J. P. Moreland himself appears to reject (9), essentially positing what could be called miracles in the brain that mediate the volitional activity of the mind (1997, p. 144).

Where does this leave the dialectic? Despite the weakness of evidence in favor of the universal affirmation in (9) and the reasons to believe it is actually false, it may be the case that energy *is* conserved *in the brain*. The matter could be settled by empirical enquiry, either by a direct observation–based demonstration that energy is in fact conserved, or by the discovery of the conditions according to which energy is conserved and the demonstration that the brain operates within or manifests such conditions. Therefore the enquiry is advanced from the pessimistic philosophical implications of the Law of Conservation of Energy for mind-body interaction to an optimistic empirical research project.

Nevertheless there is another strategy for defending Interactionism against objections based on conservation laws in physics that remains available to proponents of Interactionism worth pursuing.

6. Interaction May Be Consistent With Conservation

> Cartesian Dualism isn't quite so outlandish and conceptually problematic as tends to be supposed.
>
> *How Cartesian Dualism Might Have Been True*
> David Chalmers

Another way to defend Interactionism against objections such as the argument in § 4.2 is to reject (4). If a causal agent can produce an effect in a physical object without transferring energy to it, it would be possible for an immaterial mind to causally operate on a physical body without affecting the amount of energy the body possesses.

There are two ways to model Interactionism consistently with the Law of Conservation of Energy. One is to model the mind as altering the *location* of components of the brain without altering the brain's energy level, which will be explored in § 6.1, and the other is to model the mind as altering the *behavior* of components of the brain without affecting the brain's energy level, which will be developed in § 6.2.

6.1. Discrete Spatial Transitioning

There is a simple reason why energy is usually transferred to a physical body that is causally operated on: to effect something, typically it must be *moved*, transferring kinetic energy. The movement is obvious in cases where the effect produced is an overall change in the location of a body large enough to be visible to the naked eye. It is less obvious when other changes are made. For example when one stands in front of a warm fire, the fire changes one's temperature but not one's overall location relative to the earth. However a body's rise in temperature is reducible to an increase in movement on the molecular level.

If it were possible to make a change to a body without having to move it (or its constituents) through space it would be possible to causally operate on it without increasing its energy. Consider the case of an apple with a mass of .003 kilograms hanging from a height of 3 meters. The apple possesses .08829 joules of potential energy: .003 kg x approximate standard gravity of 9.81 m/s^2 x 3 m. While the height of the apple matters, its potential energy is latitude and longitude–independent. If the apple were relocated to another limb at the same height, its potential energy at the new location would be exactly the same. If this spatial transition were discrete—if the apple were not pushed through the space in between the two points—its energy would never change.

If the mind were able to discretely relocate components of the brain it could regularly restructure regions of it to affect the outcome of its operation without ever altering energy levels. This kind of interaction would most likely occur at a microscopic level, at junctions of specified biological complexity, and would be governed by complex psychophysical parameters. This mechanism would underwrite a true, ground-level multifinality: If there is a system in which discrete spatial transitioning is possible at time T_0, a complete description of the locations and trajectories of every particle in the universe, together with a completed physics, would be insufficient to determine, with completeness and precision, the locations of all the particles in the universe at T_1. The constraints imposed by the psychophysical parameters at play would result in strictly-bounded ranges of outcomes for relevantly similar states of affairs, which would in turn be describable according to a probability distribution. However this would not result from causally prior probabilistic forces. It would be a posterior description of the free mental activity of multiple minds on their respective bodies.

The broad theoretical possibility of Discrete Spatial Transitioning demonstrates the consistency of Interactionism with the Law of Conservation of Energy, and the dialectic is therefore advanced again by this new model from the speculative to the empirical. Nevertheless Discrete Spatial Transitioning is not the only plausible theoretical mechanism of mind-body interaction underwriting the disputation of (4).

6.2. Physically Underdetermined Routing

> . . . if the two motions were of equal strength, there would be no movement either way. . .
>
> *On the Heavens*
> Aristotle

Rather than changing the configuration of the parts in the brain, the mind might effect the activity of the brain by supplying the final conditions necessary to determine which of the physically underdetermined routes an event sequence through a neural pathway will follow. This could be achieved by a causal chain of mechanical, electrical, chemical, or other activity at a much smaller scale that reaches a logic gate whose output at T_1 is not sufficiently determined by the antecedent physical conditions (at T_0). That is not to say that the output is not determined simpliciter. The physical and mental conditions at T_0 together would sufficiently determine which of the available physical outputs obtain T_1. Such a system would be similar to a railroad network with trillions of switches: the rails form the neural pathways, the cars represent signals or event sequences, and the mind operates the switches. The operation of these switches is transparent to the consciousness so that it "automatically" mediates mind-brain interaction according to psychophysical laws connecting certain kinds of

mental activity to certain kinds of brain activity.

What would happen in the absence of the mental conditions that typically supply what is necessary to sufficiently determine the state of the brain at T_1, as may be the case during certain kinds of unconsciousness? One possibility is that this would leave the brain signal or event sequence in the same state as Buridan's ass, *viz.* metastability. A system is metastable when it persists in a state of unstable equilibrium. A system assumes a state of equilibrium when it does not change states for more than one moment. The equilibrium of a particular system state is *stable* if its values constitute an attractor, a set of values describing a state toward which a system tends to evolve for a wide array of initial conditions and toward which a system tends to return after slight disturbances, e.g. the state of a ball settled into a valley. The equilibrium of a particular state is *unstable* in case the reverse is true, and the system does not tend to evolve toward it from a wide array of initial conditions, and tends to move away from it after slight disturbances. A ball balanced on a hill is in a sate of unstable equilibrium because balls do not tend to roll themselves up and balance on hills, and when bumped such a ball will tend away from its position at the top of the hill. If this state is prolonged it is metastable. Similarly, a neural signal or event sequence whose route is underdetermined by its physical conditions that lacks mental input would thereby lack what is required to proceed along one route or another; it would become metastable.

This sets up the quest to identify physical underdetermination and metastability in the brain. To empirically rule out the possibility of Physically Underdetermined Routing in the brain would require demonstration that the features of the brain responsible for action potentials operate deterministically (or nearly

so).

One of the more popular strategies for finding indeterminacy is to look to quantum mechanics. Searle (2003) and (2004a) sketches a model of mind-brain interaction that makes recourse to quantum indeterminacy as a means of making room for free will. However according to (Wilson, 1999, p. 185) the known or suspected mechanisms by which features of the brain produce action potentials "...including the direct opening of sodium channels in membranes, the triggering of release of neurotransmitter at synapses, the opening of postsynaptic, ligand-gated channels, and the control of neuromodulation" require a "...magnitude of ...disturbance...significantly greater than allowed for under quantum-mechanical uncertainty." While Wilson's case against models like Searle's may be substantive, his conclusion seems hasty. He concludes on this basis "that violations of fundamental physical laws, such as energy conservation, would occur were a non-physical mind able to influence brain and behaviour." However Discrete Spatial Transitioning, Physically Underdetermined Routing, and other models are theoretically possible at scales larger than what is possible at the quantum level.

7. Conclusion

Objections to Interactionism based on general questions about how mind-body interaction could occur fail because arguments that a phenomenon such as interaction occurs need not explain how the phenomenon works in order to be successful. Objections based on the Law of Conservation of Energy are not fatal to Interactionism because energy cannot be universally conserved and might not be conserved in the brain. Furthermore mind-body interaction can

be modeled consistently with the Law of Conservation of Energy by postulating Discrete Spatial Transitioning of neural components or Physically Underdetermined Routing of neural pathways. Whether these mechanisms are scientifically viable given human neuroanatomy must be explored empirically. Tse (2013) reminds readers that the mind-body problem has already been solved by nature, and it only remains for humanity to discover the solution. Perhaps the solution involves a combination of the models sketched above.

An interesting feature of these models is that they seem to be falsifiable but not verifiable. For example, to falsify the theory that bits of matter throughout the brain are discretely relocated by the causal powers of the mind would require one to confirm that the physical arrangement of the material bits of the brain universally follow deterministic laws. On the other hand however, even if 1. one has good reasons for thinking one knows how to verify that a system is functioning deterministically and 2. one runs through those checks and confirms there are brain states that are underdetermined by their antecedent conditions, it does not prove there is a conscious mind causally engaging the brain. There could be an unconscious force emergent from, or activated by, specific biological conditions that behaves probabilistically. This would result in a distribution of outcomes empirically indistinguishable from those predicted by Discrete Spatial Transitioning. Establishing the possibility of these mechanisms serves a defensive purpose only, by showing the consistency of Interactionism with the Law of Conservation of Energy. For positive arguments in support of Interaction one must look to metaphysics and phenomenology.

References

Harald Atmanspacher. "Quantum Approaches to Consciousness". In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Summer 2015 edition, 2015.

Edward Averill and B. F. Keating. "Does Interactionism Violate a Law of Classical Physics?". *Mind*.

David Bourget and David J. Chalmers. "What Do Philosophers Believe?". *Philosophical Studies*, 170(3):465–500, 2014.

Scott Calef. "Dualism and Mind". In *Internet Encyclopedia of Philosophy*. 2015. URL `http://www.iep.utm.edu/dualism/`. Retrieved 14 December 2015.

Tim Crane. *The Mechanical Mind: A Philosophical Introduction to Minds, Machines and Mental Representation*. Routledge, New York, second edition, 2003.

Christopher M. Danforth. "Chaos in an Atmosphere Hanging on a Wall". In *Mathematics of Planet Earth*. 2013. URL `http://mpe2013.org/2013/03/17/chaos-in-an-atmosphere-hanging-on-a-wall/`. Retrieved 5 December 2015.

John Foster. *The Immaterial Self: A Defence of the Cartesian Dualist Conception of the Mind*. Routledge, New York, 1991. International Library of Philosophy.

Walter J. Freeman and Mark D. Holmes. "Metastability, Instability, and State Transition in Neocortex". *Neural Networks*, 18(5–6):497–504, 2006.

Karl J. Friston. "Transients, Metastability, and Neuronal Dynamics". *Neuroimage*, 5:161–171, 1997.

Daniel Garber. *Descartes Embodied: Reading Cartesian Philosophy Through Cartesian Science*. Cambridge University Press, New York, 2001.

Joseph Glanvill. *Scepsis Scientifica, or The Vanity of Dogmatizing*. Ex-Classics Project, 2011.

Max Jammer. *Concepts of Force: A Study in the Foundations of Dynamics*. Harper & Brothers, New York, 1957. Originally published by Harvard University Press.

Jaegwon Kim. *Mind in a Physical World: An Essay on the Mind-Body Problem and Mental Causation*. MIT Press, Cambridge, MA, 2000.

Jaegwon Kim. *Philosophy of Mind*. Westview Press, Boulder, CO, third edition, 2010.

C. S. Lewis. *Miracles: A Preliminary Study*. Harper Collins, London, 2000. First published in 1978.

Arthur O. Lovejoy. *The Revolt Against Dualism: An Inquiry Concerning the Existence of Ideas*. Open Court Publishing Company, La Salle, Illinois, 1960. Carus Lectures.

E. J. Lowe. "The Causal Autonomy of the Mental". *Mind*, 102(408):629–644, October 1993. New Series.

E. J. Lowe. *The Four-Category Ontology: A Metaphysical Foundation for Natural Science*. Oxford University Press, New York, 2006.

William G. Lycan. "Giving Dualism Its Due". *Austalasian Journal of Philosophy*, 87(4):551–563, December 2009.

Angus J. L. Menuge. "Neuroscience, Rationality, and Free Will: A Critique of John Searle's Libertarian Naturalism". *Philosophia Christi*, 15(1):81–118, 2013.

Kristina D. Micheva, Brad Busse, Nicholas C. Weiler, Nancy O'Rourke, and Stephen J. Smith. "Single-Synapse Analysis of a Diverse Synapse Population: Proteomic Imaging Methods and Markers". *Neuron*, 68(4):639–653, 2010. URL `http://doi.org/10.1016/j.neuron.2010.09.024`.

W. P. Montague. "Professor Lovejoy's Carus Lectures". *Journal of Philosophy*, 25 (11):293–296, 1928.

Elizabeth Armstrong Moore. "Human Brain Has More Switches Than All Computers on Earth". URL `http://www.cnet.com/news/human-brain-has-more-switches-than-all-computers-on-earth/`, 2010.

J. P. Moreland. "Science, Miracles, Agency Theory, & the God of the Gaps". In R. Douglas Geivett and Gary Habermas, editors, *In Defense of Miracles: A Comprehensive Case for God's Action in History*, pages 132–148. InterVarsity Press, Downers Grove, IL, 1997.

J. P. Moreland. "Substance Dualism and the Argument from Self-Awareness". *Philosophia Christi*, 13(1):21–34, 2011.

J. P. Moreland and Scott B. Rae. *Body & Soul: Human Nature & The Crisis in Ethics*. InterVarsity Press, Downers Grove, Illinois, 2000.

Ulrich Morhhoff. "Interactionism, Energy Conservation, and the Violation of Physical Laws". 10(4):651–665, 1997.

Ulrich Morhhoff. "The Physics of Interactionism". *Journal of Consciousness Studies*, 6(8–9):165–184, 1999.

Alvin Plantinga. *Where the Conflict Really Lies: Science, Religion, and Naturalism*. Oxford University Press, New York, NY, 2011.

William John Macquorn Rankine. "On the General Law of the Transformation of Energy". In *Proceedings of the Philosophical Society of Glasgow*, volume 3, pages 276–280. 1853.

Howard D. Roelofs. "A Case for Dualism and Interaction". In *Philosophy and Phenomenological Research*, volume 15, pages 451–476. International Phenomenological Society, 1955.

Jeffrey M. Schwartz, Henry P. Stapp, and Mario Beauregard. "Quantum Physics in Neuroscience and Psychology: a Neurophysical Model of Mind-Brain Interaction". *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360:1309–1327, June 2005.

John Searle. *Rationality in Action*. MIT Press, Cambridge, MA, 2003. Jean Nicod Lectures.

John Searle. *Reflections on Free Will, Language, and Political Power*. Columbia University Press, New York, third edition, 2004a. Columbia Themes in Philosophy.

John Searle. *Freedom & Neurobiology*. Columbia University Press, New York, 2004b. Lectures presented in French in 2001 at the Sorbonne.

Henry P. Stapp. "Quantum Theory and the Role of Mind in Nature". *Foundations of Physics*, 31(10):1465–1499, 2003.

Peter Ulric Tse. *The Neural Basis of Free Will*. Cambridge, MA, 2013.

David L. Wilson. "Mind-Brain Interaction and Violation of Physical Laws". *Journal of Consciousness Studies*, 6(8–9):41–52, 1999.

J. O. Wisdom. "A New Model for the Mind-Body Relationship". *The British Journal for the Philosophy of Science*, 2(8):295–301.