The Lenses of Perception Interpretation of Quantum Mechanics

Doug Marman[1]

Abstract: A new interpretation of quantum mechanics (QM) shows that all of the baffling behavior of fundamental particles that make QM so hard to comprehend are consistent with the behavior of biological lifeforms involved in receptive-responsive relationships with one another and their environment. This raises a radical possibility that fundamental particles possess a form of sentience and this sentience enables them to form relationships that create all of the tangible matter and energy and the spatiotemporal dimensions of our universe. This paper proposes a set of underlying principles to explain how this works at the quantum level. These principles are shown to be consistent with quantum formalism. Further, this paper shows that these principles offer an intuitive explanation for why the formalism of QM takes the form that it does.

Quantum formalism tells us that quantum states cannot be measured directly in their natural "coherent" form, and that quantum states must evolve gradually and linearly until a measurement occurs. Why? And why is all matter and energy quantized into packets that behave like particles when they are measured, but act more like waves when they are not being measured? And why do entangled particles act as if they "know" and "respond" to each other's state no matter how far apart they are?

This paper proposes that *if sentience is the cause* of this strange behavior, then the irrational nature of human relationships that we experience every day *can* offer insights that directly relate to the strange behavior of quanta. This opens the door to an intuitive understanding of QM.

This paper shows that there are three fundamental lenses of perception (sentient ways of sensing and responding) that appear to guide the behavior of all quanta and living organisms: first-person, second-person, and third-person perception. Quanta and life forms use these three lenses to form different types of relationships, and these relationships are what create the natural universe. These principles reveal an intangible aspect to sentient relationships, represented by quantum states that shape everything happening in the tangible, measurable world.

However, the main value of an interpretation of QM is its ability to offer potential solutions to existing problems in science. Two speculative proposals will be reviewed briefly. The first offers new insights into how the field of space may emerge at the quantum level. This has the potential to resolve the problems with developing a

[1] **Doug Marman** has been lecturing, writing, and leading classes on the exploration of consciousness for more than forty years. His recent book, *Lenses of Perception: A Surprising New Look at the Origin of Life, the Laws of Nature, and Our Universe* (http://lensesofperception.com), outlines the path he took to arrive at the ideas in the current paper. His work has led him through a wide range of successful professions, including: chief technology officer and corporate executive of a $1.7B division of General Electric, co-founder of a technology start-up based on artificial intelligence, inventor (with more than thirty patents), journalist, marketing manager, editor, and engineer. He lives with his family in the United States Pacific Northwest.
doug.marman@lensesofperception.com

quantum theory of gravity. However, the most startling prediction of the Lenses of Perception (LoP) Interpretation is that quantum behavior must be involved whenever living creatures engage in relationships with each other and their environment. This prediction is unavoidable if the interpretation is right. It also offers a simple way to test the theory. If this interpretation is sound, it has far-reaching implications for biology, psychology, and other social sciences because it shows that quantum effects play roles in all of those fields.

Keywords: Conscious access, dark energy, dark matter, decoherence, entanglement, panpsychism, quantum formalism, quantum gravity, quantum states, superpositions, wave collapse.

Table of Contents

Introduction

Quantum mechanics has proven itself to be one of the most important scientific breakthroughs in history. The astounding accuracy of QM now displaces classical physics, especially when working on small scales near the sizes of atoms. However, the philosophical problem with QM is that it also displaces a number of important concepts of classical physics, such as the principle of cause-and-effect; the meaning of forces; the solidity of matter; and the ability to position ourselves as independent outside observers when running experiments.

The observer problem has serious ramifications: It means that there is no accurate third-person perspective for quantum interactions. This goes to the heart of what makes QM so baffling.

The impact of the observer cannot be avoided in quantum experiments because trying to measure or observe fundamental particles alters the outcome. This is not just due to the fact that shining a light on subatomic particles means hitting them with photons that carry a force. No, the problem goes much deeper. There is no way to gain direct information about fundamental particles without entering into a quantum state with those particles.

This limitation of observation is directly related to "the measurement problem" in QM, which will be discussed in more detail later. This is the biggest issue that interpretations of QM try to resolve.

There are more than a dozen interpretations that are consistent with the mathematical formalism of QM (Schlosshauer, Kofler, and Zeilinger, 2013). They each try to expand our understanding of the natural world and the meaning of QM. However, in many cases they contradict each other, which means that these interpretations cannot all be valid.

Two recent papers give a good example. Both offer excellent insights into QM, and both are fully consistent with QM formalism. Yet, they paint very different pictures of what the puzzle of QM is really about. The reason for this is that they each focus on different parts of the puzzle.

The first paper, "Relational Quantum Mechanics," by theoretical physicist Carlo Rovelli (2008) tries to get at the core of the difficult "sense of unease that quantum mechanics communicates" (p. 1). In his paper Rovelli offers two ideas: First, that there are no such things as observer-independent states of quantum systems, and there are equally no such things as observer-independent values of physical qualities (p. 1). In other words, in quantum mechanics there are only relational states and relational measured values. Second, he says that "quantum mechanics will cease to look puzzling only when we will be able to *derive* the formalism of the theory from a set of simple physical assertions ('postulates,' 'principles') about the world" (p. 2).

The second paper is "Taking Heisenberg's Potentia Seriously," by physicist/philosopher Ruth Kastner, biochemist Stuart Kauffman, and philosopher of science Michael Epperson (2017). This paper proposes that "quantum mechanics evinces a reality that entails both actualities…and potentia" (p. 8), where the later are invisible, intangible, quantum possibilities that exist outside of space-time dimensions and yet influence all tangible actualities within space-time. Both actualities and potentia are, therefore, "ontologically significant." This perspective "accounts naturally for the counter-intuitive features of quantum mechanics such as nonlocality, entanglement, and instantaneous collapse" (p. 15). Interestingly, this paper also makes a point to argue for using a "constructive theory" (p. 8) that offers a model for how quantum processes work, rather than a "principle theory," as the best way to gain insights into physical processes underlying quantum phenomena.

Later I will return to these papers in more depth to show that they both offer valuable insights. But the point I want to illustrate here is that these papers present two very different pictures, and neither picture naturally leads to the conclusions of the other. How does the relational nature of quantum states and properties lead to the conclusion that actualities work differently from quantum potentia and both are real? Or how does the dual nature of physical reality lead to the conclusion that all quantum states and measured values are relational; none are observer-independent? At the same time, each paper argues for opposite approaches in how best to understand quantum phenomena.

More importantly, Rovelli's paper still leaves us with the question of why all quantum systems exist only as observer-dependent states. This seems just as unsettling and hard to comprehend as the puzzle of quantum mechanics that it hopes to help us understand. And if we take Heisenberg's potentia seriously, we are still left asking: What does it mean to say that quantum possibilities exist as a form of reality when those quantum possibilities are not actualities? In both cases, the baffling nature of quantum mechanics remains, as if to remind us that although we seem to be taking steps in the right direction, we are still no closer to making sense of it all.

In this paper, I hope to show that both a theory of principle and a constructive theory are needed to find an interpretation that is comprehensive enough to allow us to see how all these puzzle pieces fit together. Using both approaches can then show us why "Relational Quantum Mechanics" falls short of solving the measurement problem, while "Taking Heisenberg's Potentia Seriously" does offer a working model that helps us understand the measurement problem, but does not go far enough to identify the underlying principles that explain why our physical world is composed of a duality of actualities and quantum possibilities in the first place.

If I was going to summarize the central issue that makes quantum mechanics so baffling, I would say that it begins with the scientific desire to establish quantum theory only on the tangible results of repeatable experiments and the attempt to reduce those results to a formalism that accurately predicts what will happen in the real world under any conditions.

There is nothing wrong with this desire except that it is limited solely to a third-person perspective, as if we are independent observers. Unfortunately, using this lens makes it impossible to see what is happening at the quantum level. We will never understand the full meaning of quantum interactions from an outsider's perspective because, as Rovelli shows, there are no observer-independent quantum states or values. Only relational states and measurements appear to exist. This means we need a relational lens to understand what quantum behavior means. However, this still leaves us with questions: Why does the physical world behave this way? And what does it mean?

Albert Einstein, one of the founding fathers of quantum theory, could not bring himself to accept the whole picture of QM. He felt something important was missing. QM didn't make sense as a complete theory. Rovelli (2017) tells the story:

> On the one hand, Einstein proposed Werner Heisenberg and Paul Dirac for the Nobel Prize, recognizing that they had understood something fundamental about the world. On the other, he took every opportunity to grumble that all this did not, however, make much sense.
>
> The young lions of the Copenhagen group [Heisenberg, Neils Bohr, and others] were dismayed: how could this come from *Einstein* himself? Their spiritual father, the man who had the courage to think the unthinkable, now pulled back and feared this new leap into the unknown – the very leap that he had himself triggered? How could it be the same Einstein who had taught us that time is not universal, and space bends; the same person now saying that the world could not be *this* strange? (pp. 137-138)
>
> [Einstein] refused to accept the relational aspect of the theory, the fact that things manifest themselves only through interactions… Ultimately, Einstein accepts that the theory represents a gigantic leap forward in our understanding of the world, and that it is coherent. But he remains convinced that things could not be as strange as this theory proposed – and that "behind" it there must be a further, more reasonable explanation. (p. 139)

This paper suggests that Einstein was right to reject the idea that things manifest *only* through interactions, and he was right to think that something more is going on behind those interactions that can offer an explanation that makes more sense. As will become clear, the missing element is an intangible aspect of reality called the "quantum state," that cannot be seen directly by third-person perception but plays a vital role in everything that happens in the tangible world. What we need is a way to understand this quantum state. What is it and what does it mean?

Although quantum states, as described by physicists, seem baffling and bizarre, because we cannot see them directly, they are, in fact, something that biologists, psychologists and social scientists should recognize as familiar, because they run into a similar situation when trying to study living creatures. They know that there is no way to see how organisms or human beings live in their natural state (when they are not being observed), because it is only possible to study how they behave when scientists observe them.

Or to put this another way: Organisms naturally respond to being measured because, whether we realize it or not, the act of measuring and observing creates a relationship with living things that alters how they behave. When marine biologists study the feeding and breeding behavior of fish, or zoologists study the social interactions of gorillas, they know that they are not just observing, they are also being observed. This suggests that if there is a possibility that quanta are sentient then a relational lens *is* needed to unravel the meaning of quantumness and where it comes from. It also suggests that there *is* something more going on with receptive-responsive relationships between quanta that *does* make sense of their behavior.

While this paper explores the possibility that quanta themselves might in some way be related to sentience, it does not start with this proposition. It begins in section 1 with a long list of similarities between the behavior of quanta and the behavior of living organisms. These behaviors represent the most puzzling aspects of QM. The list of remarkable similarities is so long and comprehensive that it begs the question: Do quantum entities possess some form of consciousness?

This leads to a quick, informal test of this interpretation in section 2, just to see if it holds any merit. If sentience is responsible for quantumness, then it leads to an inescapable prediction: We must see all of the seemingly inexplicable behaviors of QM at the level of sentient organisms as well. If this is true, it contradicts one of the most widely accepted tenets of QM theory: that some quantum behaviors are visible only on small scales. More importantly, if this conjecture is right, it sheds an important light on the meaning of quantum behavior, and it shows that quantum behavior must play a fundamental role in biology and all of the social sciences, especially psychology.

The fact that observers can no longer be ignored, that they are always involved in the measurement process, has led some physicists to propose that the consciousness of the observer might be the key to solving the measurement problem (von Neumann, 1955, & Wigner, 1961). However, those interpretations have fallen out of favor for good reasons, because recent experiments show that the measurement problem still exists even when test configurations are altered randomly and no person observes the results until long after the data are collected. This does not rule out the involvement of consciousness, but it does suggest that any influence on measurements by human observation does not resolve the underlying questions about the measurement process.

This raises one of the most significant criticisms that can be aimed at this current paper: whether it has the rigor necessary for a formal interpretation of QM. There is a good reason to raise this question because this paper is dealing with the notoriously difficult-to-define nature of consciousness.

This paper argues that complete analytical rigor is not necessary or even desirable when looking for a way to interpret and understand QM. Where rigor is needed is in testing theories. For this hypothesis to be testable, therefore, it must offer clear descriptions and models for what quantum states are and how they change. Therefore, this paper needs to explain how consciousness is involved in relationships between quanta in a way that is clear enough to be rigorously tested. This is dealt with in section 3.

After passing the informal test in section 2 – to assure that this approach is worth exploring – and finding a way to work with sentience in a scientific manner, in section 3, the paper presents the underlying principles that govern quanta in section 4. These principles also lead to a constructive model that is consistent with Heisenberg's potentia. Section 5 then shows that these principles are consistent with the mathematical formalism of QM. Further, it shows, as Rovelli suggests, how quantum formalism can be derived from a set of underlying principles.

In section 6, the paper discusses implications, challenges, and opportunities for further research.

1. Similarities between Quanta and Living Organisms

Before looking at the similarities between quanta and living organisms, there are two lessons from classical physics that can help guide our way to a more comprehensive understanding of QM.

The lens of perception used by classical physicists, which is based on the third-person perspective, grew largely out of Isaac Newton's approach to studying the force of gravity. He developed the mathematical tool of calculus to understand motion and changes in motion (acceleration). From this he drew startling conclusions about the laws of motion in general. For example, unless an external force acts on an object, the object will never change its speed or direction. And the acceleration of an object is determined by the force that is driving it.

However, a closer look at Newton's calculus, as in Marman (2016) shows that analyzing generalized changes in motion produces a far more complex picture. The equation looks like this:

The distance an object moves over time = $V + ba_1^2 + ca_2^3 + da_3^4$... (p. 23)

The three dots at the end tell us that the formula is infinite. It never ends. Newton simplified the equation by using a powerful device: studying one force at a time. If we look at only one force acting on an object, then calculus reduces the above equation to this:

Force = (mass) x (acceleration)

That makes changes in motion manageable, and this is the basis of Newton's second law of motion. But few physicists realize how much has been lost to achieve this simplicity: It only applies to cases where an external force acts on an object, and it only applies to forces that act independently. It does not include the possibility of multiple *internal* influences being involved in the dynamics. As a result, it no longer gives us a general description of changes in motion.

This turns out to be crucial when studying living creatures because biologists have clear evidence that even the simplest organisms initiate changes from within, as biologist Martin Heisenberg (2009), son of the physicist Werner Heisenberg, explains:

> The idea that animals act only in response to external stimuli has long been abandoned, and it is well established that they initiate behaviour on the basis of their internal states, as we do. (p. 164)
>
> Evidence of randomly generated action – action that is distinct from reaction because it does not depend upon external stimuli – can be found in unicellular organisms…. What this tells us is that behavioural output can be independent of sensory input.... The physiology of how this happens has been little investigated. But there is plenty of evidence that an animal's behaviour cannot be reduced to responses. For example, my lab has demonstrated that fruit flies, in situations they have never encountered, can modify their expectations about the consequences of their actions. They can solve problems that no individual fly in the evolutionary history of the species has solved before. Our experiments show that they actively initiate behaviour. (p. 165)

Newton's approach cannot be used to explain the sentient behavior of living things because his second law only applies to singular external forces acting on objects. If we cannot use Newton's second law, then we need a different lens to understand biological life because the principle of cause-and-effect and Newton's laws do not apply to changes in motion originating from within.

It turns out that this same issue exists in QM as well. Physicists do not see external forces directing the behavior of individual quanta. Instead, what are interpreted as forces emerge from invisible quantum exchanges between particles. In other words, forces emerge from relationships. (More on this later). This is why QM sees the forces of classical physics more as outcomes than causes.

Here is a second interesting insight from classical physics that might help explain the seemingly bizarre world this paper is exploring. Physicists have struggled with trying to understand why human beings experience time flowing only in a forward direction (Penrose, 1989, p. 302). If we use the traditional third-person lens of classical physics, time looks as if it is spread out from past to future like a separate dimension. This third-person view of time shows no reason for time to flow in only one direction. In fact, it does not even suggest that time flows at all.

It is not just our experience of the forward flow of time that presents a problem for physics. Our first-person perceptions give us a clear experience of time that we call the moment "now." In fact, our experiences suggest that "now" is a continuously flowing passage between past and future. Hence, the *experience* of "now" appears to be the only moment of time that exists. The past, as well as future possibilities, do influence all sentient creatures, but organisms experience directly only what is happening now. Classical physics, on the other hand, has no way of determining any special meaning for "now" (Mermin, 1998); it is just a point on a line like any other point.

Our experiences also show that our perceptions of time can vary dramatically from one situation to another. For example, time may seem to speed by when we are having fun with friends, while it drags when waiting in line at a store. Because of these widely varying experiences of time, our perceptions are often considered subjective and then discounted. However, this misses the fact that these experiences with time are not happening solely within ourselves. They come from relationships with others in the world. Or, to make this point clearer, time appears to vary depending on our relationships. Experiences with relational time do not follow the tick of an externally imposed time-frame. They are context-dependent and personal.

This shows that although the third-person lens may be ideal for understanding mechanical cause-and-effect reactions, it does not show us everything that is happening. We face the exact same challenge with quantum behavior; we appear to be missing some vital aspect beneath the surface of tangible phenomena. And, as we will see later, what we are missing may have everything to do with the intangible dynamics of relationships between sentient agents.

Now, let's turn to the resemblances between quanta and organisms.

1.1 Indeterminacy

Quantum theory says that an individual particle's actual behavior is unpredictable. Equations can accurately determine the probabilities of where photons might hit a screen, for example, but there is no way of knowing where a single photon will actually land before it does.

This suggests that the landing spot is not determined by outside influences alone. External forces only shape the probabilities of what will happen, they do not determine individual outcomes. This is one of the strange realities of quantum mechanics. This was also one of Albert Einstein's biggest problems with QM. He felt that it was an indication that quantum theory is incomplete, leading to his famous comment, "God does not play with dice." In other words, he felt that there needed to be some kind of explanation for the indeterminate behavior of quanta.

Exactly where a photon lands can be compared to a swimmer in a sea of shifting currents reaching out to helping hands on a rocky shore.[2] Which hand will the swimmer grab? Indeterminacy shows us that photons and other particles are not actually "forced" into position by forces. They are only influenced. If this is true – and physicists have proven this over and over again – then what determines the end result?[3] This is one of the unsolved mysteries of QM.

Many interpretations of QM have proposed possible answers. For example, the von Neumann-Wigner Interpretation (n.d.) suggests that the quantum wave-function, which describes how quantum possibilities evolve, "collapses" down to one actual outcome through the consciousness of the observer. But, even if this were true, it offers no insight into how or why one possibility is selected over another. Therefore, it does not solve this problem.

The Many-Worlds Interpretation (n.d.) tries to get around this issue by suggesting that all possible outcomes take place in different universes. Unfortunately, these parallel universes are beyond our reach, so we have no way to test this. But even if this interpretation were right, it still wouldn't explain why the photon in our universe arrives where it does. It simply says that we are living in a world where it lands on that spot. This does not help us understand what is happening or why.

The Copenhagen Interpretation does not recognize the "wave collapse" as real because the wave equation cannot show how it happens. This is one of the reasons why Bohr said that the quantum realm is impossible to understand (Kastner, 2016, p. 1 and p. 14).

The "Taking Heisenberg's Potentia Seriously" paper offers a model that does a good job showing that the wave collapse is real and how it works (pp. 6-12). However, it still cannot explain why, only that specific one possibility out of many becomes an actuality. (More on this later).

The "Relational Quantum Mechanics" paper suggests that, somehow, the actualized state emerges from relationships with the environment through a process called "decoherence," but even if this were true (and, as we will see later, there are good reasons to suggest that it is not), this approach offers no good explanation for why the quantum state instantaneously and irreversibly "collapses" to one actuality and not another.

Yet, when we look at the behavior of living things, we see this exact same trait of indeterminacy. Why? Because they can initiate behavior. Yes, they are clearly influenced by external forces and constraints, but they also possess a degree of internal agency. They do not function like clockwork machines that follow programed trajectories determined solely by outside forces. They respond to the environment based on their relationships with their habitat.

When studying the behavior of single-celled bacteria, biologists can predict how a cell will act *on average*, but they have no way of knowing what one will do in any single case. This is the nature of living things.

---

[2] My thanks to Alan Rayner for this graphic metaphor.
[3] For an overview of the science behind this, see my discussion in Marman, 2016, pp. 239-247.

Animals behave as if they possess "free will." The problem is that outside observation cannot determine where this autonomous ability comes from. And the term "will" is equally problematic, since it suggests causative action that is also impossible to observe by outsiders. But some form of internal agency is evident in all living creatures. Thus, the homily of biologists that dead fish are the only fish that *only* swim with the current.

1.2 The Quantum Nature of Energy and Matter

Here is another fundamental resemblance between quanta and living things: They both behave as individual agencies.

A central principle in QM theory is that energy and matter must always be quantized. Individual particles (or wave-fronts, if you prefer that model) are needed to carry energy and mass. These packets cannot be reduced to fractions of a packet: There is no such thing as half a photon.

Why? No interpretations even try to explain this. It is simply accepted as a necessary postulate of quantum mechanics. However, cells and living organisms also act as individuals. In fact, their individual nature becomes clear by the way they carry energy and mass. In other words, it comes down, once again, to their intrinsic agency.

You can, of course, cut creatures in half, but if you do they will either die or regenerate from one or both segments into individual functioning bodies once again. On the other hand, if you kill them, they stop acting as individuals. Their bodies settle into equilibrium with the environment.

This shows clearly where the nature of their individuality and identity come from: their internal agency. It does not come from their energy or mass, but what they do with energy and mass.

1.3 Individuality and Internal Agency Does Not Mean Independence

This leads to a surprising resemblance: Fundamental particles cannot exist independently of their environment any more than living creatures can.

We know that all animals, plants, and organisms need air, food, and water to thrive. If you prevent them from making exchanges with their habitat, they will die. This dependence on the environment is well accepted by biologists. But it is startling to find similar behavior in quanta.

According to quantum theory, electrons, by themselves, are dimensionless points. When they are measured, however, electrons act as if they contain space and possess a body (Cartlidge, 2011).

Physicists have learned that, in order to get accurate results that describe the observed behavior of electrons using quantum field equations, each electron must be treated as if it is surrounded by a cloud of invisible "virtual" particles. This mathematical adjustment is called "renormalization." Without this cloud, the electron would act as if it contains no physical space. In other words, virtual particles appear to give electrons their bodies. The same is true for all matter particles, including all types of neutrinos, muons, and quarks.

However, the dependence of particles on their environment goes further. Every matter-type particle must also belong to a particle field. For example, electrons are members of a universal collective called the "electron particle field." Particle fields give particles their properties of mass, charge, and spin – their uniform, if you will. This is why every electron has a single negative charge, along with the exact same spin and mass. This means that if you take an electron from its particle field it will "die" and no longer exist as an electron.

This description might seem like a bit of a stretch until we see how the "weak nuclear force" affects electrons: It causes them to decay – which means they cease being electrons. They stop carrying energy and mass the way that electrons do. And after an electron decays from the weak force, a new particle is born that suddenly starts wearing the uniform of neutrinos instead.

However, this neutrino is not an unrelated new particle because there is a clear continuation of agency from the electron to the neutrino. In other words, it appears as if the electron dies and is then reborn as a neutrino.

The point of this is that a particle must belong to a particle field. In fact, many physicists say that it is impossible to separate fields from particles. Rovelli (2017) put it this way: "Fields and particles are the same thing" (p. 126). In other words, particles cannot live without fields. The lives of organisms similarly depend on their relationships with members of their species and their habitat.

1.4 Entanglement

One of the clearest resemblances between quanta and organisms comes from the baffling nature of quantum entanglement. Experiments prove that this is an outwardly strange but intrinsic property of reality. When particles become entangled, they share a quantum state that aligns them.[4] They can stay aligned to the same shared state even after flying miles away from each other.

For example, take two entangled electrons that have opposed reciprocal spins. Their spins remain reciprocal indefinitely. Even if the spin of one is altered by an outside influence, such as a measurement of their spin, the other will reciprocate. Even stranger, it does not matter how far apart the two electrons are in terms of distance.

How do they know how to stay aligned when they are miles apart? More importantly, why and how do particles become entangled in the first place?

Neils Bohr's advice was to stop asking these questions because it is impossible to see what is happening at the quantum level; this is just the way particles behave. Bohr said: "There is no quantum world. There is only an abstract physical description. It is wrong to think that the task of physics is to find out how nature is" (as cited in Petersen, 1963, p. 12).

As other physicists have pointed out, this had a "chilling effect" (Kastner, 2013, p. 8) on the pursuit of comprehending quantum behavior. Before Bohr's comments, it was the job of physicists to search for a deeper understanding. Afterwards, it was generally considered to be a waste of time (Mermin, 1990, p. 198).

[4] For an overview of the research on this, see Quantum Entanglement (n.d.).

However, if we use relational lenses, rather than taking a third-person perspective, we see that quantum entanglement looks quite similar to what we experience in human relationships. Adesso (2007) and many other physicists have used the same comparison. For example, the physicist, John Bell (as cited in Bernstein, 2009) used the following way of explaining entanglement to others:

> identical twins who had been separated at birth. Bell discovered that there were a number of pairs that had been reunited later in life to find that they had a remarkable number of things in common, including smoking the same brand of cigarette. (p. 172)

This does not mean that these physicists are suggesting that human relationships and quantum entanglement are the same. Not at all. They are simply offering human relationships as examples because it gives people a reasonable way of relating to what entanglement entails.

For example, if we look at our own friendships, we feel an affinity and sense of rapport that aligns us with our friends. We complete each other's sentences. We laugh at the same jokes. We feel their pain when they are suffering, and their thrills of success, as if they are our own.

We feel the influence of this intangible alignment with others no matter how far away we might be from them. We think of them during the day because this invisible affinity seems to tug at us inwardly. We feel the possibilities of our relationships as if we share a kind of private emotional space with others, even when we cannot talk with them or send messages.

If we put on our third-person lenses and look at entangled electrons, if we position ourselves as outside observers, the thought that they could be emotionally involved seems preposterous. They are just electrons, tiny bits of matter. How could they feel emotions?

That is a perfectly understandable viewpoint. But, if third-person perspectives are the final word, we will not even try to explore this similarity. We will rule it out because it makes no sense to us.

This is how lenses of perception can blind us. They can prevent us from learning and seeing new possibilities simply because we have not yet learned how they make sense through another lens. As a result, it is easy to unconsciously reject perspectives that seem alien to our way of seeing.

However, the unexpected nature of reality keeps forcing scientists to look at the world in new ways. This is why we need to keep trying on new lenses, to see where they take us, no matter how uncomfortable they make us feel. This means crossing through a zone of confusion that can be unsettling before it starts to make sense. We should not let this hold us back if we really want to understand. This, in many ways, describes the present challenge we face with quantum mechanics.

What if entanglement *is* the result of relationships with some kind of inner dynamics similar to emotions? Can this help explain the mysteries of quantum mechanics? Honestly, the only reason to ask these questions is because there is such a long list of resemblances and similarities, all pointing to the same possibility.

1.5 Attraction and Repulsion

Here's another interesting resemblance: At the quantum level, electrons are not repelled by all other electrons, and they are not always attracted to every proton (Kastner, 2015, pp. 84-87).

Yes, we know that like charges repel and opposite charges attract, but this does not always happen between individual particles.

It is true that if you have two foam balls charged with billions of added electrons, they will *always* repel each other. But on the quantum level it is hit or miss. This sounds a lot like the emotional nature of relationships; they are unpredictable. We never know for sure who is going to hit it off.

We all know at least two friends who are not attracted to each other, even though we like them both. Yes, we see a general sense of attraction between men and women, but this certainly isn't true in all cases. The experience of emotional attraction between human beings is actually rare, which is what makes it special.

As I will show later, physicists have determined that attraction and repulsion between charged particles is also rare and that these responses are triggered by invisible quantum exchanges between them. This is mathematically described as virtual particles passing back and forth between charged particles. Virtual particles are intangible – there is no way to detect them directly. The process of attraction and repulsion can also be described mathematically as invisible wave functions that either add together or cancel each other out.

But why does one pair of particles hit it off when another pair does not? No other interpretation of QM offers an explanation. The third-person perspective has not been able to explain this mystery. In fact, it suggests that there is no way of knowing. But we know how it feels to be attracted to another person. It is often unexpected. If the other person confirms that they feel the same way toward us, then the experience of "chemistry" between us is reinforced and grows stronger. With validation, a relationship feels substantial and real.

So, this behavior of charged particles makes some sense if we compare it to the receptive-responsive exchange that we see in relationships between life forms. This, of course, still leaves the question about how this works. (A model that explains this will be explored in detail later).

1.6 Wave-particle Duality

Particles are notorious for displaying two different types of behavior: They show both particle-like and wave-like properties (Penrose, 2016, pp. 133-138). For example, photons look like particles when they light up one spot on a screen. They look more like waves when they create interference patterns. (More on this later).

We see a similar dual behavior with organisms. Their particle-like nature stands out when they act as individuals. Their wave-like nature, on the other hand, shows up when they are involved in the back-and-forth exchanges of relationships. This is especially noticeable when they are involved in collective group relationships.

Look at the shape of a rose: Its beauty arises from the delicate folds and ripples of its petals formed by countless living cells working in concert. All life forms are involved in continual exchanges with the world – the rhythmic breathing in and out, beating of hearts, and the inflow and outflow of material exchanges with their habitat. Wave-like behavior is easy to see.

All creatures are affected by the groups they are involved in. This raises the question: Does the wave nature of quantum states derive from dynamic relationships?

1.7 The Uncertainty Principle

Werner Heisenberg (1927) published his famous paper on the Uncertainty Principle which says that the more accurately we determine the location of a particle, the less accurately we can determine where it is going, and the more accurately we determine where a particle is going, the less we can know about its location.

As Bowman (2008) says, for many years this unexpected discovery was so at odds with classical physics that it was seen as describing the defining trait of quantum mechanics itself (p. 82).

A complete explanation for why this inherent uncertainty exists is not known. However, physicists know that there is a relationship between measuring the position of a particle and measuring where that particle is going. As a result, if you measure where a particle is located first, and then measure where it is going, you will get a different answer than if you measure where it is going first and then measure its position. This is equivalent to saying, in mathematical terms, that "*A*" times "*B*" is *not* equal to "*B*" times "*A*".

To get a better sense of the impact of the uncertainty principle, let's look at two examples. First, if you create a very narrow slit for photons to pass through, then when the photon is in the slit, the location of that photon is well defined. This means that we should see an increase in the uncertainty of where that photon is going. This is exactly what happens: photons head off in all sorts of directions when exiting the slit. This is called "diffraction." Feynman (1985) describes the result this way: "So when you try to squeeze light too much to make sure it's going in only a straight line, it refuses to cooperate and begins to spread out" (p. 55).

Here is a second example: Electrons do not orbit the nucleus of an atom. Their location is more like a cloud. The reason for this is that the electrons are in stable, clearly defined momentum states, called electron shells. For example, when an electron is in the lowest energy state in a hydrogen atom, the electron has no angular momentum at all. If the momentum is in a stable and fixed state like this, then the electron's *position* must be highly uncertain. This is why physicists describe the possible locations for an electron to be like a cloud, because they have no clear position. It turns out that this is what creates the hard shell around atoms that gives matter its appearance of solidity:

> Now, suppose you tried to squeeze that electron cloud down to a smaller cloud. This would decrease the uncertainty of its position by confining it to a smaller region. The HUP [Heisenberg Uncertainty Principle] then dictates that its momentum – in this case, momentum straight inward or outward from the nucleus – would become more uncertain. With increasing uncertainty in momentum comes a greater likelihood of a larger momentum, which corresponds to more energy of motion. More energy of motion means

> a greater resistive force pushing outward. Therefore, the tighter a space you try to cram the cloud into, the more energetically it will resist. (Kastner, 2015, pp. 81-82)

In both of these examples, the more we try to nail down where quanta are or where they are going, the more they push back. We see this same trait when trying to control animals. Living organisms resist being forced to obey completely because it denies their ability to move and act. They need freedom to find food and form relationships – in order to live. The only way to completely stop a creature from moving is to kill it. Thus, the natural ecology on our planet can never be fully forced or controlled because life has a way of its own that springs from sentience.

The only way to stop a particle from moving is to annihilate it, because if a particle ever did become perfectly still, it would have a fixed position and no momentum. The uncertainty principle forbids this. Therefore, every particle must always be in motion (Smolin, 2017, p. 83).

Even Werner Heisenberg's son, biologist Martin Heisenberg, wrote about the relationship between the uncertainty principle and the "free will" behavior of biological organisms (Heisenberg, M., 2009). A number of physicists have also seen this relationship between the uncertainty principle and free will. For example, experimental particle physicist Bruce A. Schumm (2004) wrote this:

> The uncertainty principle is one of the striking revelations of quantum mechanics, and it pervades the theory as a fundamental tenet that cannot be violated.... More interestingly, it is a revelation that seems to address questions of deep philosophical import. With the advent of the uncertainty principle, determinism, the notion that the laws of nature set forth an inextricable course of events from which no deviation is possible, becomes indefensible. According to the uncertainty principle, the exact course of events is fundamentally unknowable. There is always some uncertainty in the physical properties of any given object; not even nature herself knows how this uncertainty will resolve itself.... It's not just a matter of building a better instrument for determining these properties. The exact value is simply unknowable, even in principle. Many have gone on to conjecture that Heisenberg's uncertainty principle is the very source of human free will, but this remains to be demonstrated. (p. 42)

It is a fundamental trait of sentient agents to resist attempts to completely limit and control them. Dead bodies, on the other hand, do not push back. They reach equilibrium with the environment and stop opposing external forces. If this is right, then perhaps Heisenberg's uncertainty principle is *not* the source of free will. Perhaps the opposite is true: The need of quanta to act as sentient agents is the source of the uncertainty principle. (A model for how this works will be offered later).

1.8 Exchanging Energy

Here's another similarity: Kastner (2013) shows that real particles continually circulate and exchange energy. If they ever stop circulating and exchanging energy, there is no way of knowing if they exist in the space-time dimensions of our universe because they can no longer be detected. In other words, particles only become tangible through transactions of energy (p. 16).

Later, we will see that this circulating and exchanging of energy comes down to emission and absorption.

We see similar behavior with organisms: They can only live in this world if they continue gathering and expending energy. This means consuming (absorbing) food and eliminating (emitting) waste. In other words, life forms must engage in continuing work with the world to live here.

1.9 The List of Similarities

To this list we can add a ninth item, the similarity noted in the introduction: We cannot directly see how quanta behave in their natural state. We can only observe how they act when they are being observed. Trying to study living creatures runs into the same difficulty. It is as if a wall exists that obscures our ability to see what makes organisms alive. Taking creatures apart to study their organs gives us a clearer idea of their anatomy, but it can also bring an end to their life. In the same way, as soon as we try to study a quantum state by measuring it, it temporarily loses its quantumness. (More on this in the next section).

And we can add tenth and eleventh items to this list: quantum superpositions and the wave-function collapse, both to be discussed in the next section.

Clearly, some of these resemblances are more compelling than others. But, taken overall, they raise the question of why so many similarities exist. At a minimum, we should be asking: Is there something to be learned from this?

To explore these questions, the Lenses of Perception (LoP) Interpretation proposes that these are more than superficial resemblances: They imply that quantum particles have some intrinsic element of sentient awareness. Can this explain why quanta become entangled and form relationships with some but not others?

This possibility offers an intriguing perspective on many of the biggest mysteries of quantum mechanics. And sometimes just looking at problems in new ways can lead to new solutions. It may seem like an outlandish hypothesis, but that should not dissuade us. As Neil's Bohr said, "We are all agreed that your theory is crazy. The question is whether it is crazy enough to have a chance of being correct" (Bohr, n.d.).

Fortunately, the LoP Interpretation offers more than a new perspective, it also gives us a clear way to test whether it is wrong.

2. The Inescapable Predication of the LoP Interpretation

The LoP theory differentiates itself from every other interpretation by predicting that we should see quantum behavior wherever living organisms form relationships. This is a necessary conclusion if the LoP Interpretation is right. It cannot be avoided.

If quantumness is caused by sentience, then we should not just see these seemingly irrational behaviors at the microscopic level. We should find the same exact patterns of entanglement, superpositions, uncertainty, the quantization of energy and matter, and the wave-function collapse, at every level where life forms relate to each other.

Quantum theory states that quantum effects disappear as you move from the microscopic level to the world of big things. If this is true, then the LoP Interpretation can be proved wrong by showing one principle of quantum behavior that is not at work at the level of organisms and human beings. Even one example of a true quantum effect is enough to disprove the LoP theory.

That should be easy, but it isn't. I have not been able to find a single case. All of the behaviors that we observe with fundamental particles that give us the "sense of unease that quantum mechanics communicates," as Rovelli put it earlier, can be seen in our lives as human beings and in the behavior of all organisms, even single-celled amoebas.

We have just reviewed the similarity between entanglement and human relationships. We know that both particles and organisms are carriers of energy and matter. Therefore, they both act as if they are individuals, and this means that the energy and mass of life forms is always quantized, the same as with quanta. In other words, there is no such thing as a living entity that is half alive. Biologist Alan Rayner and I wrote a paper on this exact subject (Marman & Rayner, 2016).

We also saw above how the indeterminate and unpredictable behavior of quanta is similar to the willful behavior of living creatures, and how particles and organisms display both a particle-like and wave-like nature.

This leaves us with two quintessential quantum principles: Superpositions and the wave-function collapse are both considered unique to QM. Both of these functions clearly occur at the quantum level, and there is nothing in quantum theory to suggest that we should see either of these at the level of human beings or single-celled organisms. This is especially true for superpositions because they quickly disappear when we move from the subatomic realm to the macroscopic world.

Therefore, it should be startling and unexpected to find these two principles at work in the lives of human beings and other creatures. But, if they do not play crucial roles in relationships between all life forms, the LoP Interpretation fails.

2.1 The Wave-Function Collapse

Of these two, the wave-function collapse is easiest to show because physicists have already written about this happening at the level of human beings. The reason human observation was proposed to be the cause of the wave-function collapse, as mentioned in the introduction, was because, according to quantum theory, the wave-function evolves in a linear, continuous manner, which means that there should be no way for it to change instantaneously. However, when a measurement is made, the quantum state makes a sudden, non-linear collapse to a single actual result.

The physicist, John von Neumann, explained this in 1932, when he published the first fully rigorous formal analysis of QM.[5] What he showed was that the wave collapse appeared to be completely different from the natural, gradual evolution of pure quantum states.

Up until then, the most popular explanation, based on the Copenhagen Interpretation, suggested that the collapse occurs when a quantum state "mixes" with the measurement

[5] It was first published in German, then translated into English in 1955 (von Neumann, 1955).

equipment that is in a classical state. However, von Neumann showed that the equipment needs to be treated as a quantum system as well. This means that any equipment involved in a measurement becomes entangled with the quantum state being tested, according to the formalism. As a result, the equipment is no longer independent; it is now in a shared quantum state. If this is true, then this shared state should continue to evolve gradually and linearly.

Then when does the wave collapse occur? He looked at the overall process and could only see one place where something distinct and sudden happens: when the observer of the test recognizes the results. For the observer, this recognition creates an instantaneous shift in information. In that moment, the results become the knowledge of the observer (von Neumann, 1955, pp. 418-421).

As a result, the quantum leap that takes place with a wave collapse, according to the Copenhagen interpretation, does not represent an actual physical process, but merely a sudden change in the physicist's knowledge (Penrose, 2016, p. 144).

We have to remember that QM experiments in the early twentieth century were not nearly as advanced as today. When they ran the famous experiment where photons are fired one at a time through two slits, they were surprised to see an interference pattern build up over time from where the photons hit the screen. How do single photons going through these slits create this wave-like interference pattern? Did each photon go through both slits at the same time, like a wave?

To answer this question, they set up detectors near the slits, to see if any photon went through both slits. When they ran the test this way, every photon was detected passing through only one of the two slits, not both. At the same time, however, the interference pattern suddenly disappeared. Somehow having detectors near the slits stopped the wave-like behavior of the photons.

They ran the experiment again, leaving the detectors in place next to the slits, except they turned the detectors off. The interference pattern returned. Photons regained their wave-like properties.

This is why physicists began to ask if the act of observation could be causing the photons to lose their wave-like "coherent" quantum state. But in the last thirty years, experiments have become far more sophisticated. There is now strong evidence that "decoherence," which causes the interference pattern to fade, is gradual and is not the result of measurements.

In fact, decoherence theory says that decoherence happens when particles become entangled with their environment. The more a particle becomes entangled with other particles in the environment, the more information about the particle becomes known by the environment. This information causes the loss of interference patterns because a particle can retain its coherent quantum state only when it is not being observed by other particles, according to decoherence theory.

This tells us that decoherence is the result of the linear evolution of quantum states. And this suggests that decoherence actually has nothing to do with the collapse of the wave function.

This development has caused a great deal of confusion. Many physicists originally felt that for all practical purposes the measurement problem was solved and no collapse is needed. The founders of the science of decoherence stepped forward to make it clear that this is not true (Joos, E., *et al.*, 2003. pp. 4-5 and p. 357).

Decoherence only explains the interference pattern, not why a photon hits one point on the screen and not others. And decoherence cannot explain why each photon chooses one slit and not the other. These are not gradual changes. Photons do not gradually begin moving through one slit. They do not gradually select one spot on the screen over others. These are discontinuous selections that result in singular actual results.

The LoP Interpretation can add more clarity to what all this means, and we will get into more detail about decoherence later. But for now, let's look at how the wave-function collapse of QM is similar to what happens at the level of human beings.

At the quantum level, a collapse is not deterministically caused by outside forces. This is why quantum equations can only predict probabilities, not individual outcomes. We see something surprisingly similar in relationships between people. No one, not even the people involved, can know for sure which relationships will develop into lasting friendships or marriages.

Outside influences, such as friends, family, and society in general, do indeed have an effect on the outcome, but the fate of a relationship is largely determined by what develops between the people involved. Still, when it comes to a couple that decides to move in together or get married, a shared decision must be made. In that instant, the gradual evolution of their friendship makes a sudden shift. In other words, this is an instantaneous leap that is irreversible. Even if the couple later decides to go their separate ways, there is no going back to the relationship they had before they decided to live together.

This is why the photon landing on a screen can be compared to a swimmer in a turbulent sea, where the hands of friends are reaching out from the rocky shore. Which hand will the swimmer (the photon) grasp? It all comes down to choosing one relationship over another, in a moment when the sea is rising and falling.

This example suggests that the wave function collapses when a single possibility emerges, out of all the possibilities, as the one worth acting on in that moment. One relationship stands out. The hand of that friend becomes the one the swimmer grasps. At the human level, it is easy to see, in a similar way, how intangible emotions and feelings become triggers for tangible choices.

This description is virtually identical to what physicists call "symmetry breaking," which describes a sudden shift that happens within a field (Kastner, 2016, p. 16). Symmetry is a shared common property across a field, such as the relationship between gaseous water molecules in the air. They all keep about the same amount of distance from each other. However, if the air temperature drops, some of those water molecules start creating stronger bonds with each other as they come closer together. Which molecules make this change first? Once again, it comes down to choosing the relationships that align the closest. As soon as some water molecules start joining, the field of water vapor makes a phase change and water droplets start falling from the air as rain. Crystals, such as salt, emerge out of a solution of brine in the same way. When symmetry in a field breaks, it happens spontaneously within the field. The "Taking Heisenberg's Potentia Seriously" paper says that a wave collapse occurs in the same way as quantum symmetry breaking; they both describe the same process (Kastner, Kauffman, & Epperson, 2017, p. 6).

Here is how physicist Lee Smolin (2007) describes symmetry breaking:

> Physicists … say that the symmetry between us at birth is broken by the situations we encounter and the choices we make. In some cases, it would be hard to predict the way the symmetry will be broken. We know that it must break, but looking at a nursery full of infants we are hard-pressed to predict how. In cases like this, physicists say that the symmetry is *spontaneously broken*. By this we mean that it is necessary that the symmetry break, but exactly how it breaks is highly contingent. This spontaneous symmetry breaking is the second great principle that underlies the standard model of particle physics.
>
> Here is another example from human life. As a faculty member, I've sometimes had occasion to go to receptions for new undergraduates. Watching them meet one another, it has occurred to me that over the next year some will become friends, others lovers, a few will even marry. At this first moment, when they encounter one another as strangers, there is a lot of symmetry in the room; many possible couples and bonds of friendship could be forged in this group. But of necessity the symmetry must be broken as the actual human relationships develop out of a much larger space of possible relationships. This, too, is an example of spontaneous symmetry breaking. (pp. 59-60)

Smolin's examples illustrate that symmetry breaking and the wave collapse, at the level of fields and quanta, are clearly similar to events that happen at the level of human relationships. Partnerships and marriages form, creating a new form of order in what was once a uniformly symmetric field. Water drops and crystals emerge as new visible forms in the same way. In other words, we see what appear to be new visible forms emerging from the invisible relationships between them. Something tangible emerges from the intangible inner dynamics of relationships between sentient agents. Later we will see how this works in detail.

For now, this passes the goal of this first informal test to see if wave-function collapses might also occur with living creatures. This test, of course, is far from convincing. But, for a first step this shows that, as radical as the suggestion is that quanta behave as if they possess sentience of some kind, there is no immediate reason to reject the possibility. Now, let's explore this in more depth.

2.1.1 Wigner's Friend and Third-Person Observers

Before we move on to the far more interesting case of superpositions, which will also be more controversial, I would like to take a moment to point out something that is becoming clearer from these comparisons between the behavior of particles and the behavior of organisms. This goes directly to the question of whether it is worth the time to pursue this line of inquiry.

When physicists use the term "wave collapse," or the term "spontaneous symmetry breaking," there is a great deal of vagueness about what these terms actually mean. How and why these events take place is hard to nail down.

Smolin says above that symmetry breaking is "highly contingent." But, even if we can analyze all of the factors influencing an outcome, that will not tell us enough to determine exactly how and when the symmetry will break. The reason for this lack of clarity, I believe, comes from the fact that we are talking about processes that display a form of internal agency, but we are trying to look at this as outside observers by focusing entirely on the tangible results of experiments, while ignoring the intangible aspects of relationships.

However, when we talk about human relationships and how two people make a decision to live together or get married, we can relate to what this change means because we know what it feels like to be on the inside of relationships. As a result, a decision that couples choose together makes far more sense to us than changes that spontaneously emerge between quanta. Thus, it is easier to understand why relationships suddenly leap to a new phase between people.

This raises the key question of this paper: Can the insights we learn from human relationships, that we gain through experiences, help us understand the behavior of quanta? I believe the answer is yes, and it can lead to new insights that are testable.

For example, the physicist, Eugene Wigner, wrote a controversial paper (1961) that gained a lot of attention, especially outside of physics. In this paper, quoted below, he starts by summarizing von Neumann's discussions about the way that human consciousness seems to be involved in the measurement process:

> When the province of physical theory was extended to encompass microscopic phenomena, through the creation of quantum mechanics, the concept of consciousness came to the fore again: it was not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness. All that quantum mechanics purports to provide are probability connections between subsequent impressions (also called "apperceptions") of the consciousness, and even though the dividing line between the observer, whose consciousness is being affected, and the observed physical object can be shifted towards the one or the other to a considerable degree, it cannot be eliminated. (p. 172)
>
> The important point is that the impression which one gains at an interaction may, and in general does, modify the probabilities with which one gains the various possible impressions at later interactions. In other words, the impression which one gains at an interaction, called also the result of an observation, modifies the wave function of the system. The modified wave function is, furthermore, in general unpredictable before the impression gained at the interaction has entered our consciousness: it is the entering of an impression into our consciousness which alters the wave function because it modifies our appraisal of the probabilities for different impressions which we expect to receive in the future. It is at this point that the consciousness enters the theory unavoidably and unalterably. If one speaks in terms of the wave function, its changes are coupled with the entering of impressions into our consciousness. If one formulates the laws of quantum mechanics in terms of probabilities of impressions, these are *ipso facto* the primary concepts with which one deals. (pp. 175-176)

Most physicists have good reasons for disagreeing with the way that von Neumann and Wigner describe the role of consciousness in QM, as we will see soon. Even Wigner himself abandoned this way of thinking when the science of decoherence was introduced, because it was entanglement with the environment, not human observers, that cause the interference pattern to disappear.

The mistake that Wigner and von Neumann make is that they confuse the wave collapse that happens at the human level (when the results become clear to the observer running the experiment) with the wave collapse happening at the level of quanta. Wave collapses, according to the LoP Interpretation, do indeed happen at both levels, but the levels should not be confused. Seeing quantumness as the result of sentience can help clear up this significant point of confusion.

However, what is important in Wigner's (1961) article that I want to look at now is that he took this discussion further and asked what happens in the case where he himself is not directly involved in a measurement experiment, but he has a close friend who is. This is famously called the problem of "Wigner's Friend," which is almost as famous as "Schrödinger's Cat." Wigner then analyzes the situation using the quantum formalism established by von Neumann:

> It is natural to inquire about the situation if one does not make the observation oneself but lets someone else carry it out. What is the wave function if my friend looked at the place where the flash might show at time *t*? The answer is that the information available about the *object* cannot be described by a wave function. One could attribute a wave function to the joint system: friend plus object, and this joint system would have a wave function also after the interaction, that is, after my friend has looked. (p. 176)

The reason that Wigner says the information available about the object cannot be described by a wave function is because he is relying on his friend for information about what happened. Wigner has no information of his own about the object except what his friend tells him. And what his friend tells him about the object is colored by his friend's entanglement with the object. We see the same thing when we listen to a friend tell us about someone they met – we know that their description of the person they met is going to be colored by their personal experiences with that person. (More about this later). Now back to the rest of Wigner's comment.

> I can then enter into interaction with this joint system by asking my friend whether he saw a flash. If his answer gives me the impression that he did, the joint wave function of friend + object will change into one in which they have separate wave functions (the total wave function is a product) and the wave function of the object is ψ_1. If he says no, the wave function of the object is ψ_2, i.e., the object behaves from then on as if I had observed it and had seen no flash. However, even in this case, in which the observation was carried out by someone else, the typical change in the wave function occurred only when some information (the *yes* or *no* of my friend) entered *my* consciousness. It follows that the quantum description of objects is influenced by impressions entering my consciousness. (p. 176)

If this is confusing to read, it is largely because Wigner is using the formalized approach for analyzing quantum interactions. The main reason this approach seems confusing is because it spends only a little time talking about the test itself and spends almost the whole paragraph talking about how to think about the information that we learned about the test and how we got that information. Wigner is saying above that if his friend reports that he saw a flash, then, the moment Wigner hears this, the state of two possible outcomes collapses down to one, for him. If his friend saw no flash, then the possibilities collapse down to the other option.

This formalism is necessary because we cannot see directly what is happening with unobserved quantum states, the same way Wigner could not see the test directly. All the information we gain comes from mixed states, and this means that we need to always remember that our information is colored by the observers who give us that information. We will get into more about this later.

For now, I want to focus on how vague the role is that consciousness plays in this description. It is easy to see why most physicists want to leave consciousness out of the discussion. Is Wigner suggesting that his hearing about the test from his friend played a role in the flash of light?

We can now add some clarity to this discussion by using the similarities between quanta and organisms that we looked at above. For example, later in his paper, Wigner (1961) says that if his friend is someone he knows, and his friend tells him that he saw the results of an experiment, then it would be "unnatural" to reject what his friend says. Few "people, in their hearts, will go along with" taking such a radical position (pp. 180-181).

Trusting his friend, therefore, allows him to accept information about the experiment without being directly involved. Wigner suggests that accepting information from his friend causes a sudden shift in what he knows about the test and this describes a wave-function collapse.

I think Wigner is making a good point, *if* we are talking about what is happening at the human level. There *is* a sudden shift in his perception of the test results when he accepts what his friend tells him. However, this sudden shift is only possible if he trusts his friend. This trust is the result of their history together. In other words, trusting his friend means that they are entangled. This shows us that a shared wave-function between him and his friend is what allows him to accept the word of his friend, and this acceptance is a spontaneous act that causes a shift in his awareness.

Wigner accepts what his friend tells him because they are closely entangled. If someone he never met before tells him the results of a test, he will probably reserve judgment until he knows more. This offers us a valuable insight into how entanglement is involved in the wave collapse process. And this can help give us an intuitive understanding of what is going on at the quantum level. (We will also see how this applies to the process of decoherence later).

In fact, we can take this further. Wigner is probably not going to feel much weight if he hears an unknown person telling him the result of a test. He will feel even less weight if the person says they did not actually see the test results themselves; they were just passing along what they heard from another person.

On the other hand, a lot more weight would shift Wigner's scales if he hears from fifteen people and they all report the same results, especially if they each say that they witnessed the test directly. And the weight will increase significantly if these fifteen people are well-known physicists, even if he does not know them personally. But the most weight will come from fifteen physicists that he knows and trusts. This shows how information passed along by a number of entangled relationships with others makes the outcome clearer to a third-person observer.

However, there is no way to predict when exactly the scales will shift to the point where Wigner accepts the information that he is hearing third-hand. We only know that when Wigner reaches that tipping point, and accepts the outcome of the experiment, that his realization does hit him suddenly. The shift in his perception happens all at once. He now feels confident that he knows what happened. This shows us clearly that this wave collapse is describing a shift in his perception. It is easy to see why this happens suddenly, because we all know what it means to “get” an idea. It hits us all at once like a light turning on. On the other hand, the influence from third-hand information grows gradually and, thus, describes a different process (decoherence).

This insider perspective is valuable for understanding human experiences. However, the scientific value we gain from this all depends on how similar human entanglement is to quantum entanglement. If they are identical processes, insights from human relationships can offer us a powerful way to make sense of the quantum world.

To illustrate this point further, imagine you are at a party when a physical knock-down fight starts between two people in another room. You are too far away to hear or see anything about what happened, but people soon start coming into your room and you overhear them talking about the fight. After a while, a few of your friends come by and pass on what they heard. Pretty soon some of the details become clear. You now have a sense of what happened.

This story is similar to Wigner’s Friend, except there are a number of friends and quite a few strangers as well. This shows how third-hand information spreads and how a consensus story of what happened emerges. This is the process of decoherence. However, looking closer, we can see that only certain types of information consolidate to form a clear picture, such as who the fight was between and where it happened. This is objective information. Subjective information, on the other hand, remains vague, such as why they were fighting and who may have started the fight. QM faces this same problem.

It is easy to see why this happens at the human level: No observers actually saw who started the fight, and there was no way that observers could see why they were fighting because intentions and motivations are invisible to outsiders. Some of the words that the two fighters yelled at each other, after the fight started, may have been heard, but people could only guess at what those words meant because they were personal exchanges. Each observer guesses differently about the meaning and thus passes on a differently “colored” interpretation. These different interpretations conflict with each other – they do not converge, making it hard to consolidate them into a clear account.

The cause of the fight and the words that the fighters yelled at each other sprang from a personal relationship – from a shared space and history between them. Outside observers cannot see the inner dynamics of this relationship. That is why third-person observation forms no clear consensus about the motivation behind the fight. The public never really knows the emotions and feelings between close friends and lovers – or sworn enemies – in private relationships.

If this insight applies to quantum interactions, it changes the story completely. It suggests that the reason we cannot see quantum states directly is because these shared dynamics between sentient quanta are private, knowable only to those involved. This is why those dynamics are intangible, because no third-person view of them is possible. We will never get the full story with only outsider accounts. We can only guess. This allows us to relate to the behavior of quanta and understand their seemingly irrational behavior because human relationships are equally irrational when viewed from the outside. We know from personal experience that there is no definitive logic, and there are no fixed laws determining the outcome of relationships.

2.1.2 The Third Person Problem

The question being raised here is whether the lessons we learn about relationships at the human level directly relate to quanta. The only way to find out is to see how far these similarities go. And this is where Wigner's Friend gets interesting, because we find a similar story at the center of Rovelli's paper on "Relational Quantum Mechanics." He calls it "the third person problem." The difference is that Rovelli is talking only about what happens at the quantum level, while Wigner was describing the human level. Rovelli (2008) writes:

> By using the word "observer" I do not make any reference to conscious, animate, or computing, or in any other manner special, system. I use the word "observer" in the sense in which it is conventionally used in Galilean relativity when we say that an object has a velocity "with respect to a certain observer". The observer can be any physical object having a definite state of motion. For instance, I say that my hand moves at a velocity *v* with respect to the lamp on my table. Velocity is a relational notion…and thus it is always (explicitly or implicitly) referred to something; it is traditional to denote this something as the observer, but it is important in the following discussion to keep in mind that the observer can be a table lamp. Also, I use information theory in its information-theory meaning: information is a measure of the number of states in which a system can be – or in which several systems whose states are physically constrained (correlated) can be. Thus, a pen on my table has information because it points in this or that direction. We do not need a human being, a cat, or a computer, to make use of this notion of information. (p. 3)

In other words, Rovelli is using a purely third-person perspective for his analysis. Using this perspective means that he cannot see anything about the inside dynamic of what is happening. (Later we will see why his "Galilean observer" analogy falls short of what is needed because it is lacking the inside dynamics. It works fine for classical physics, but is not enough to represent the dynamics of quantum interactions). Next, Rovelli (2008) takes us through a formal analysis of what happens when an observer "*O*" makes a measurement on a system "*S*."

> For the moment we may think of *O* as a classical macroscopic measuring apparatus, including or not including a human being. Assume that the quantity being measured, say *q*, takes two values, 1 and 2; and let the states of the system *S* be described by vectors (rays) in a two (complex) dimensional Hilbert space H_S. Let the two eigenstates of the operator corresponding to the measurement of *q* be $|1\rangle$ and $|2\rangle$. As it is well known: if *S* is in a generic normalized state $|\psi\rangle = \alpha|1\rangle + \beta|2\rangle$, where α and β are complex numbers and $|\alpha|^2 + |\beta|^2 = 1$, then *O* can measure either one of the two values 1 and 2 – with respective probabilities $|\alpha|^2$ and $|\beta|^2$. (p. 3)

This will sound like gobbledygook if you are not familiar with quantum formalism. Later, I will explain why this method is used. For now, let me summarize what Rovelli is saying: If *O* makes a measurement of *S*, and there are only two possible outcomes of the test, $|1\rangle$ and $|2\rangle$, then quantum formalism says that system *S* is in a state where two possibilities exist at the same time (more about this in the next section). There is also a statistical probability associated with each of these possibilities, α and β, and if you add the squares of these probabilities together it will equal 1.

Rovelli then describes what happens when the measurement is taken (p. 3). First, system *S* is clearly affected by the measurement process, because after the measurement *S* is no longer in a state of two possibilities. There is now only one actual outcome. Therefore, the possibilities have collapsed down to one actuality.

Rovelli goes on to describe the same sequence of events, but this time from the perspective of a second observer "*P*" who does not perform any measurement. In other words, *P* is a third-person observer. This is where "the third person problem" comes from. This is like the story of Wigner's Friend, where Wigner was the third person.

The first thing that *P* observes is that *O* and *S* have formed an interaction with each other due to the measurement that *O* made on *S*. Rovelli says that *P*, as an outside observer, can see that *O* has a quantum state of its own and *S* has a quantum state of its own, and when they interact they form a joint quantum state. Another way to say this is that *O* and *S* become entangled through the process of measurement.

P also sees that *O* is influencing the outcome of the measurement. This means that the probabilities of the two outcomes are altered because *O* is now involved. This is important because it shows us that something is happening between *O* and *S*. They are affecting each other. But if we use only an outsider's perspective, we cannot see why this happens or what it means. An insider perspective suggests that the relationship between *O* and *S* influences the outcome of the measurement.

Rovelli then gets to the key point that he is trying to show: Because *P* is not directly involved in the measurement, *P* cannot see which of the two outcomes becomes the actuality. To *P*, the shared quantum state of *O*-*S* is still in a state where two possibilities exist at the same time. *P* does not know the outcome of *O's* measurement. Therefore, *P* only sees that the joint *O*-*S* state has changed.

Rovelli (2008) concludes:

> Thus, I come to the observation on which the rest of the paper relies.
>
> **Main observation:** In quantum mechanics different observers may give different accounts of the same sequence of events. (p. 4)
>
> If different observers give different accounts of the same sequence of events, then each quantum mechanical description has to be understood as relative to a particular observer. Thus, a quantum mechanical description of a certain system (state and/or values of physical quantities) cannot be taken as an "absolute" (observer-independent) description of reality, but rather as a formalization, or codification, of properties of a system relative to a given observer. Quantum mechanics can therefore be viewed as a theory about the states of systems and values of physical quantities relative to other systems…. Therefore, I suggest that in quantum mechanics "state" as well as "value of a variable" – or "outcome of a measurement –" are relational notions in the same sense in which velocity is relational in classical mechanics. (p. 6)

Rovelli concludes that quantum states and measured values are relative. None exist as *observer-independent* realities. But, why is this true? The reason, that we just saw with Wigner's Friend, is because there are inner dynamics taking place in private relationships between quanta that no third-person perspective can see. An outside observer cannot see the same thing as those who are directly involved. This is why different observers arrive at different conclusions about what has happened. Thus, reality is *observer-dependent*.

The only way *P* can find out the result of a measurement made by *O* is for *P* to interrogate *O*. This means that *P* has to make a measurement of *O* and *S* to find out what transpired between them. But, as soon as this happens, *P* is no longer a third-person observer. *P* is now directly involved. This means that *P* is also entangled, and this affects the relationship between *O* and *S*. Thus, a measurement means a wave collapse, and this is different for those involved than it is for outsiders.

All of this is perfectly consistent with the insights gained from the human level examples given above. Everything that happens is *observer-dependent*. Once again, the similarities between human experiences and the behavior of quanta go deep and appear to hold up under formal analysis.

2.2 Superpositions

The most important reason that physicists say quantumness does not extend much further than the realm of subatomic particles is because superpositions quickly disappear as particles interact with their environment. It is virtually impossible to find quantum level superposition states at the level of biological organisms. Thus, superpositions are the toughest test for the LoP Interpretation.

To understand superpositions, let us return to the two-slit experiment. If photons are sent through one at a time, and there are no detectors near the slits, then we have no way of knowing which slit the photons go through. If we run the experiment over and over, we will see an interference pattern develop from where the photons hit the screen. This tells us that the photons are not just going through one slit or the other. Something else is happening. It appears as if the wave-like nature of the photons allows them to go through both slits at the same time.

This is not just true for photons. Electrons and other fundamental particles will display the same phenomenon. Even atoms produce interference patterns. But as objects become bigger, the interference quickly fades. It becomes virtually impossible to see superpositions when objects are big enough to be seen with our eyes.

Quantum formalism says that we must treat the two slits as two possible paths to the screen and that both possibilities exist at the same time. In other words, it is as if the two possibilities are super-imposed on top of each other.

As Roger Penrose (2016) explains, we must not think of this as if there are two photons and each one goes through a different slit. If that is the case, we can apply the logical term "and" to describe what is happening. We cannot use "and" because there is only one particle. Also, we cannot apply the logical term "or" either. The photon does not simply go through one slit *or* the other, because we will not see an interference pattern if that is what is happening. Superposition is a unique state. This is not just because multiple possibilities exist at the same time, but because all those possibilities actually influence the outcome at the same time. This influence is what creates the interference pattern (p. 24).

If you roll a six-sided die, it will end up on one of its six surfaces. These six possibilities *do* exist at the same time before the die settles onto one surface, but the possibilities *do not* influence the outcome. The die simply lands on one of the six surfaces *or* another.

The idea of superpositions is so illogical that physicists needed a long time before they could accept them as real. The evidence now seems indisputable. Here is how Heisenberg (1959) explained this strange quantum behavior:

> This concept of the probability wave was something entirely new in theoretical physics… [It] meant a tendency for something… It was a quantitative version of the old concept of 'potentia' in Aristotelian philosophy. It introduced something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality. (p. 42)

This is the concept of potentia that the "Taking Heisenberg's Potentia Seriously" paper is referring to. Let's look at some examples of superpositions.

Quantum theory says that an electron can exist in many different places as it moves through a conductor. The probabilities usually decrease with distance. This means that, from time to time, the possibility exists that an electron can appear on either side of an impermeable wall, if that wall is thin enough. One moment it can be on one side, and the next moment it can be on the opposite side without going through the wall. This is exactly what happens, and the principle is used to make transistors work. The process is called "tunneling" because it is as if the electron tunnels through the silicon wall. However, it does not actually tunnel, it just appears on the other side.

Or take the case of atoms. An electron does not orbit the nucleus like a planet orbits a sun because that would mean the electron is traveling a distinct path around the nucleus. It is not, and physicists know that it is not, because if it is, it would lose orbital energy and eventually descend into the nucleus. Instead, electrons are suspended in a stable energy state in relation to the nucleus, as I mentioned earlier. Quantum theory says the electron is in a superposition state of all possible positions in an electron shell around the nucleus. You can think of this as if the electron is a droplet of water that does not exist in one place because it is suspended as a gas in a cloud that surrounds the nucleus, except this cloud is a cloud of possibilities.

Why do quanta act this way? Why do superpositions exist at the quantum level? Quantum theory does not know, but suggests that it has something to do with quanta being wave-like when they are not observed. This means that an electron can literally be spread out across a region of space. It does not have to move through space to get to another location. It can leap there. The problem for this paper is that we never see organisms or human beings leaping around this way.

However, the story changes once we understand what superpositions are and why they exist. An insider lens, rather than an outsider lens, can help us gain insights into what superpositions mean.

The LoP Interpretation says that superpositions are not just possibilities – potentia: They are the possibilities that exist in relationships. For example, consider trying to choose which friend you should to go out to lunch with. You have two possibilities. Both options influence you and weigh on you. You can go to lunch with one friend or the other, or you might even consider taking them both to lunch at the same time, but a joint lunch date creates even more complications (interference patterns) because your two friends might not even like each other. The point is that, before you make a decision, all of the possible options influence you because you anticipate the way your relationships will be impacted by the choices you make. This is how possibilities in relationships influence us and shape our decisions.

Relationships are complex because they are open-ended, they are not deterministic. But as soon as we act on one of these possibilities – as soon as we choose one – the possible outcomes collapse down to one actuality. This is what is happening when the wave function collapses.

The reason we never see people in different locations at the same time is because we are looking at their bodies. Bodies are assemblies of billions upon billions of particles. Remember, according to the LoP Interpretation, quantum behavior only exists at the level where internal agents are involved in relationships. Quantum effects fade away when we look at huge conglomerates, such as a mound of dirt, because conglomerates have no ability to act as sentient agents. As a result, all of the possible relationships between particles in a mound of dirt cancel each other out.

For example, there are billions of electrons jumping around in the electron shells of the atoms of our bodies. What difference does this make to the position of our bodies? To make a detectable difference, billions of electrons would all have to leap in exactly the same direction at the same time. But this never happens because each leap is determined by one-on-one relationships, making it statistical. This is why bodies of organisms never appear to leap from place to place.

If superpositions do not exist at the level of human beings and other organisms, then the LoP Interpretation fails. Is this the death knell? Look closer. We never actually see electrons in multiple places at the same time either. Whenever we measure the location of an electron it is always in one place. Yes, we can detect the presence of an electron as it surrounds an atomic nucleus like a cloud, but we cannot see its specific location until we measure it directly.

Using this new understanding, the story changes when we look at human beings – not their bodies, but the intangible internal agents who inhabit their bodies. Can we, as internal agents, be in different places at the same time? Yes, we can, because we inhabit all of our body.

When we are upset by bad news, we feel it in the pit of our stomach. We cheer ourselves up by singing a song. Songs and emotions can move us. Where do they move us? To a different place than the pit of our stomach. Perhaps our heart center?

We also become aware of our heart center when we are with our lover. But when we think about the world, it seems as if we are looking at a screen in our heads. Sensations and sounds and feelings ripple through our bodies. At any moment, we can be anywhere in our body or be associated with our whole body at the same time. We are not limited to one place until we specifically move our attention there. Then we make a quantum leap to that place.

This might sound like nothing more than subjective impressions, but Roger Sperry's experiments (1968) with people who had the nerves cut between the left and right hemispheres of their brain (to prevent convulsions), prove that each hemisphere of the brain processes sensory information independently from the other. Sperry also showed that these people still used both the right and left hemispheres of their brain, depending on the situation. And when using one half, perceptions from the other side simply faded into the background, the same way we ignore sounds coming from another room when we are engaged in a conversation. In other words, we leap back and forth between the two hemispheres of our brain whenever we shift our attention (pp. 723-727). Sperry (1964) also showed that these people never felt as if they were split in two, and their families noticed no changes in their behavior. They and their families experienced them as the same single individuals they were before their operations (p. 46). Sperry won the Nobel prize for his research. (For a more complete review on this topic, see Marman, 2016, pp. 307-311).

Recent experiments have taken this further. They show that, when we consciously use what we see through our left eye and through our right eye to create a three-dimensional picture, our attention oscillates back and forth. We never consciously see through both eyes at the same time. Our attention can only be on one eye at a time. If our brain is just a computer, it should process the data from the left eye and right eye in parallel. In fact, it does exactly that in the early stages. But this process radically changes when vision becomes conscious, as Dehaene (2014) explains:

> [These experiments prove] that what matters to consciousness is not the initial stage of peripheral visual processing (where both [left and right eye] alternatives are still available) but a later state (at which a single winning image emerges). Because our consciousness cannot simultaneously apprehend two objects at the same location, our brain is the seat of a fierce competition. Unknown to us, not just two but countless potential perceptions ceaselessly compete for our conscious awareness – and yet at any given time, only one of them makes it into our conscious mind. Rivalry is, indeed, an apt metaphor for this constant fight for conscious access.
>
> Is this rivalry a passive process, or can we consciously decide which image will be the winner of the fight? When we perceive two competing images, our subjective impression is that we are passively submitted to these ceaseless alternations. That impression is false, however: attention does play an important role in the cortical competition process. (p. 30)
>
> But most important, the very existence of a single winner depends on our giving it our attention; the fighting arena itself, as it were, is made up of the conscious mind. (pp. 30-31)

In other words, conscious seeing is different from what happens in the early stages of processing visual data. The moment we consciously see, we view images from only one eye at a time. Visual data is processed in parallel before then, just like superpositions that exist at the same time. By moving our attention, it is just as if we are making a measurement. That is when only one of the two possibilities exists. Why one eye and not the other? It may be something seen through our left eye that catches our attention, or there might be something in the right eye's field of view that intrigues us. Or we go back and forth because we want to compare the two. In other words, images are not actually "competing" with each other, as if this is some kind of fight. These are relationship possibilities. Images from both eyes are unconsciously processed at the same time, but only one makes it to conscious perception. This appears to describe the wave collapse process. It shows us that only one possibility emerges and becomes tangible to our awareness at a time.

We are venturing into controversial territory here. Neuroscientists, including Stanislas Dahaene, whom I quoted above, generally see consciousness as something that emerges from the brain. On the other hand, many philosophers argue that this avoids the hard problem of consciousness, which is that there is an internal aspect of conscious experiences – the sharpness of a pain, the feeling of the warmth of the sun, or the yellowness of a lemon. First-person perception has an inner side to our experiences that is not easily communicated through verbal description. We cannot explain what the sourness of a lemon is like to someone who has never tasted it before. Dahaene (2014) writes:

> I disagree [with the philosophers], and I will argue that the notion of a phenomenal consciousness that is distinct from conscious access is highly misleading and leads down a slippery slope to dualism. We should start simple and first study conscious access. Once we clarify how any piece of sensory information can gain access to our mind and become reportable, then the insurmountable problem of our ineffable experiences will disappear. (p. 10)

When Dahaene says "conscious access," he is talking about when the processed information in our brain crosses over into our conscious awareness. I call this the "threshold of perception," and it plays a vital role in how spontaneous symmetry breaking and the wave collapse work, according to the LoP Interpretation. Dahaene says that studying how unconscious sensations cross over to become conscious has caused a revolution in cognitive neuroscience over the last 30 years. I believe that physics can gain the same benefit by applying this understanding to how quanta cross over from intangible possibilities to tangible actualities.

However, when Dahaene (2014) says that he disagrees with philosophers, it is not because he thinks that we should ignore the inner aspect of experiences. On the contrary, he says that accepting subjective reports as valid data has created "a revolution for psychology" (p. 11).

Once again, this is exactly in synch with the LoP Interpretation. Third-person measurements and observations will never be enough to understand the inner dynamics of relationships between sentient agents. This remarkable similarity between the unpredictable nature of the wave collapse and the indeterminacy with how living organisms make choices can be seen as evidence that there is an internal aspect to quantum mechanics that is remarkably similar to what psychologists have learned to accept.

Brushing such evidence away and saying that we simply live in a statistical world adds no value or meaning. It offers no insights leading to a deeper understanding. On the other hand, look at the amazing similarity between the way quantum superpositions collapse down to one actuality and the way countless sensations are processed in our brain in parallel and then reduced down to one relationship that is selected by our attention and then emerges into conscious awareness. If these two processes are not just similar, but the same, it opens new doors for neuroscience and physics.

Dahaene's main disagreement with the philosophers is his concern that it leads down a slippery slope into dualism. He need not worry. The "Taking Heisenberg's Potentia Seriously" paper (Kastner, Kauffman, and Epperson, 2017) shows that invisible quantum states do not exist tangibly because they cannot be observed directly. This means we should not treat them as objective facts. However, they are still ontologically real and have a measurable impact on the tangible actualities that make up the space-time dimension. Thus, the philosophical duality is no longer a problem because there is no gap between mind and body (pp. 3-4). The LoP Interpretation agrees with this.

We will get into more about all of this later. I have included this aside about neuroscience now only to show that once again we see a direct relationship between how the “countless potential perceptions ceaselessly compete for our conscious awareness” (Dehaene, 2014, p. 30). This describes the same way that superpositions reach out with open hands to become actualities. Only one can be grasped, and this is what happens when the wave function collapses or the symmetry breaks. One of the intangible possibilities crosses the threshold to become tangible.

For example, think about the relationships we have with our cells and organs. It is easy to forget about them, as they are unconscious until we get hungry or need to go to the bathroom. Then they cross the threshold of our perception. Our attention shifts suddenly if our heart beats erratically or we feel short of breath. In other words, the relationships between us and the cells of our bodies influence us with possibilities all the time. This is what it means to inhabit a living body.

Electrons appear to inhabit an atom the same way. They can be everywhere in an energy shell that surrounds an atom. They can also leap from one shell to another. They can spread out like a cloud, or they can be in just one place when they are engaged in a measurement.

Do we not experience this same bizarre quantum behavior in our lives? Where do we, as internal agents, sit in our bodies? As Dahaene (2014) points out, ancient philosophers asked where the seat of soul is, and they offered a wide range of answers: Hippocrates and Hierophilus said the seat of soul is in the brain. Democritus and Aristotle said that soul exists throughout the body. Epicurus put the seat of soul in the stomach, the Stoics within and around the heart. Strato placed the seat of soul between the eyes (p. 7).

They all seem to disagree. Now we can see why. They are all correct because we as an internal agent can move our seat of attention to any place in our body, or we can live everywhere in our body if we stop focusing our attention on any one spot. This is consistent with quantum behavior.

However, the most noticeable experience of superpositions, for human beings, comes from our relationships with other people. All of our relationships with others influence us at the same time. They are always there in the background shaping our lives, whether we realize it or not.

Should we move to another country to take a promising job if it means leaving our lover? Will we take time from a busy work day to buy a gift for our child’s birthday? Which friend should we go to lunch with today? In other words, superpositions represent the possibilities in relationships – the “potentia” of what our relationships can become.

Therefore, it is valid to say that we live with the possibility of taking a job in another country, and we live with the possibility of not moving because living with our lover is too important. We live in both of these *states* at the same time. And it is clear that these possibilities *interfere* with each other. Both possibilities weigh on us until our scales tip one way or another. They do not force us. This is not about cause and effect. They only influence us. And the moment we act on one of the two possibilities, it becomes tangible and the other choice disappears – it is no longer an option.

This describes exactly what happens when the wave function collapses. It collapses only when one of the intangible possibilities is selected. It then becomes an actual, tangible event. An insider perspective shows us how relationships give birth to the objective phenomena of our natural world.

This passes the informal test of the LoP Interpretation's prediction that quantum effects should exist wherever we see living creatures forming relationships with each other. This test is by no means conclusive. However, as unexpected as this prediction is, there seems to be enough evidence to suggest that it might be worth investigating further. In other words, this interpretation might just be crazy enough – as Bohr put it – to be right.

All of the bizarre behaviors of quantum mechanics appear to exist in the relationships between life forms. If this is true, then biology, sociology, and psychology will never be hard sciences like Newtonian physics, because they are too close to the relationships between sentient organisms. Quantum effects may play a more important role in these fields than anyone has realized. This shows how a new interpretation of QM could revolutionize our understanding of these fields.

However, the devil is in the details, as the saying goes. Before we can rigorously test this interpretation, we need a much clearer model for how quanta behave. And before we can formulate a model, we need to deal with the nebulous subject of consciousness. So let's dive in.

3. The Problem of Consciousness in Quantum Mechanics

In the last section, we informally looked at the similarities between quanta and organisms from the bottom up. All of the bizarre behaviors of quanta appear to be present in relationships between life forms as well. This opens the door to a potentially deeper understanding of QM.

In this section, I want to informally consider this from the top down. If the relationships between quanta and living things are more than resemblances, if they are governed by the same principles, then top-down similarities need to hold up to scrutiny as well. And looking at this from the top down leads to a number of additional insights that help clarify the underlying principles involved.

As Wigner (1961) said, ever since the first fully rigorous formalism of QM, the problem of consciousness has dogged QM (p. 172). With all the latest experiments – and there are quite a few (such as Ma *et al.*, 2012, Jacques *et al.*, 2006, and Yu, S. & Nikolic, D., 2011) – that strongly suggest human observation is not the cause of the wave collapse at the quantum level, there still has been no finding that eliminates the possibility that consciousness is involved. For an overview of this situation, see Nauenberg, 2011.

The case is quite strong that human observation is not the cause of the wave collapse at the quantum level. But this does not mean that consciousness is not involved at the quantum level, and it does not mean that there is no collapse of superpositions taking place at the level of human observation.

Here is the problem: When two photons become entangled, each photon somehow "knows" the spin state of the other, even when they are miles away. How do they know?

An experiment by Dumé (2007) shows that if the path an electron takes through two slits becomes "known" by even one other particle, such as a nearby electron, the interference pattern fades by a measurable amount. If two or more particles "learn" the path of the electron, the interference pattern fades even further (pp. 3-9).

If there are enough particles near the slits that it is possible for equipment to learn the path that an electron takes with a high degree of accuracy, then the interference pattern disappears completely.

In other words, the real reason that the specter of consciousness looms over QM is because the spread of information is crucial to how quanta respond. However, most physicists wave away the role that consciousness plays by taking the same position that Rovelli (2008) took in treating information according to the principles of information theory, by saying that "information is a measure of the number of states in which a system can be – or in which several systems whose states are physically constrained (correlated) can be" (p. 3).

Unfortunately, this avoids the real problem. The issue is not about "the number of states in which a system can be," but how the information of those states spreads and alters quantum states. Why do quanta alter their behavior when they gain information? For example, why do photons hit different places on a screen depending on whether the environment "knows" which slit they pass through? The assertion that information is no more than "the number of states in which a system can be" does not make this problem at the heart of QM go away.

Further, Fields (2012) shows that to assume a "Galilean" observer (as do Rovelli and most physicists) makes the observer too "informationally impoverished" to work in quantum physics. A quantum observer must, at a minimum, be able to alter its state in response to information that it receives. Acting as a passive reference point is not enough (pp. 92-119).

Physicists know these issues well, but as soon as the "c" word is raised, their hands go up and they say: "Stop! Before going any further, define consciousness. If you cannot define it, it has no place in science." This is an understandable response because there is no consensus on how to define consciousness.

This normally leads to a highly contentious philosophical discussion, but I am going to avoid this quagmire because it is not necessary. All that we need to understand is what impact, if any, consciousness has on quantum interactions. I do not mean the impact of human consciousness on quantum interactions, but the impact of *sentience* on how *quanta* respond. Clarifying the way that consciousness affects the relationships between quanta offers us a path to finding a testable way of verifying or falsifying the role of consciousness.

3.1 How to Work with Something That Cannot Be Measured Directly

Isaac Newton faced a similar problem when he studied time. As Rovelli (2017) explains, Newton realized that there is no way to measure time directly. We can only compare the rhythmic timing of one process, such as the swinging of a pendulum, with the rhythmic timing of another process, such as the ticking of a watch, or the pulse from a heartbeat. Rovelli asks,

> Is this not somewhat circular? What does it mean?
>
> It means that we, in reality, never measure time itself; we always measure the physical variables *A*, *B*, *C*, … (oscillations, beats, and many other things) and compare one variable with another, that is to say, we measure the functions *A(B)*, *B(C)*, *C(A)*, and so on. We can count how many beats for each oscillation; how many oscillations for every tick of my stopwatch; how many ticks of my stopwatch between intervals of the clock on the bell tower….
>
> The point is that it is *useful* to imagine that a variable *t* exists, the "true time," which underpins all those movements, even if we cannot measure it directly….
>
> It was Newton who understood all of this: he understood that this was a good way to proceed, and clarified and developed this schema. Newton asserts explicitly in his book that we can't ever measure the true time *t*, but if we *assume* that it exists, we can set up an efficient framework to describe nature. (pp. 180-181)

We are in the same situation with consciousness because there is no way to measure it directly. However, not being able to measure consciousness – just like time – does not mean that it does not exist. After all, we know consciousness is real from our own experience. So, what if we *assume* that it exists? Can we use Newton's trick and observe the results of consciousness by comparing one function of consciousness to another?

3.2 Conscious Perception and Intentional Action

There happen to be two specific functions that are ideally suited for this comparison: perception and action. These two functions describe the receptivity and responsiveness of everything alive.

The reason these two functions are ideal is because they both play such central roles in the lives of organisms. And both are functions of consciousness that appear to be completely dependent on each other: Intentional actions are only effective when guided by conscious perception, and the accuracy of conscious perceptions can only be calibrated with intentional actions (through trial and error). No act of internal agency, such as the ability to hunt for food or avoid threats, is possible without both conscious perception and intentional action working together.

We cannot measure consciousness directly. There is no way to detect it with any equipment. But when we throw a bird up in the air and it does not fall to the ground, but flies away, we see the evidence of a sentient internal agent. Every display of internal agency in creatures is directly tied to the use of conscious perception with intentional action – receptivity with responsiveness.

The relationship between perception and action goes surprisingly deep. Roger Sperry (1952) describes it as the single most important lesson that he learned from his first studies of the brain. Listen to what he says about how difficult it is to find *any* way of explaining how thinking (mental activities) can move muscles (motor behavior):

> An analysis of our current thinking [about the relationship between mental activity and the brain] will show that it tends to suffer generally from a failure to view mental activities in their proper relation, or even in any relation, to motor behavior. The remedy

> lies in further insight into the relationship between the sensor-associative functions of the brain on the one hand and its motor activity on the other….
> Only after we have attained some understanding of the way in which the sensory and thought processes become transformed into motor activity, can we hope to comprehend their meaning and plan of organization….
>
> Utilization of this motor approach immediately helps us to view the brain objectively for what it is, namely, a mechanism for governing motor activity. Its primary function is essentially the transforming of sensory patterns into patterns of motor coordination. Herein lies a fundamental basis for the interpretation, direct or indirect, of all higher brain processes including the mental functions….
>
> Further support for this point of view may be found in the study of brain architecture. One searches the cerebrum in vain for any structures that seem to be designed for the purpose of forming, cataloging, storing, or emanating copies or representations of the outside world. If any scheme or plan at all is evident in the complicated fiber associations and nuclear interconnections of the brain, it is a design patterned throughout for governing excitation of the "final common (motor) pathways." …
>
> To the neurologist, regarding the brain from an objective, analytical standpoint, it is readily apparent that the sole product of brain function is motor coordination. To repeat: *the entire output of our thinking machine consists of nothing but patterns of motor coordination.* (pp. 296-298)

Coordination between perception and motor activity is not only a valuable way of understanding the function of the brain; it is just as central to the lives of the simplest cells with no brain at all. They need sensory perception to guide their movements, and they need movement to create a feedback loop with perception. Without both conscious perception and action working together, repeated intentional behavior is impossible.

In fact, perception and action – receptivity and responsiveness – play key roles at every level of biological life. For single-celled slime mold to work as a group when hunting for food, individual cells need to act in synchrony with each other, without a brain, while specializing their roles at the same time (Marman, 2016, pp. 358-362). How is this possible without perception? Clearly it is not. Perception is just as vital to the activity of bee hives and all forms of social activities.

If perception is so important in guiding the actions of living creatures and life forms, and actions are just as necessary for guiding perceptions and making them meaningful, then perhaps this relationship can offer insights into how quanta would behave if they are sentient. In other words, any sentience an electron possesses would be meaningless if this sentience did not guide it to respond in some way. Can this help us understand why receiving information (which is simply another way of describing the act of perceiving) alters the behavior of quanta? Yes, perhaps, but only if the top-down comparison holds up. We need a more detailed description of how this works.

The approach I am taking here is similar to recent developments in cognitive science that have produced encouraging results, as Dehaene (2014) explains:

> Throughout the nineteenth and twentieth centuries, the question of consciousness lay outside the boundaries of normal science. It was a fuzzy, ill-defined domain whose subjectivity put it forever beyond the reach of objective experimentation. For many years, no serious researcher would touch the problem: speculating about consciousness was a tolerated hobby for the aging scientist. In his textbook *Psychology, the Science of Mental Life* (1962), George Miller, the founding father of cognitive psychology, proposed an official ban: "Consciousness is a word worn smooth by a million tongues…. Maybe we should ban the word for a decade or two until we can develop more precise terms for the several uses which 'consciousness' now obscures."
>
> And banned it was. When I was a student in the late 1980s, I was surprised to discover that, during lab meetings, we were not allowed to use the C-word. We all studied consciousness in one way or another, of course, by asking human subjects to categorize what they had seen or to form mental images in darkness, but the word itself remained taboo: no serious scientific publication used it… With a few major exceptions, the general feeling was that using the term *consciousness* added nothing of value to psychological science. In the emerging positive science of cognition, mental operations were to be solely described in terms of the processing of information and its molecular and neuronal implementation. Consciousness was ill-defined, unnecessary, and passé….
>
> In the past twenty years, the fields of cognitive science, neurophysiology, and brain imaging have mounted a solid empirical attack on consciousness. As a result, the problem has lost its speculative status and become an issue of experimental ingenuity….
>
> The word *consciousness*, as we use it in everyday speech, is loaded with fuzzy meanings, covering a broad range of complex phenomena. Our first task, then will be to bring order to this confused state of affairs. We will have to narrow our subject matter to a definite point that can be subjected to precise experiments. (pp. 7-8)
>
> What counts as genuine consciousness, I will argue, is conscious access – the simple fact that usually, whenever we are awake, whatever we decide to focus on may be conscious… When we are fully awake and attentive, sometimes we can see an object and describe our perception to others, but sometimes we cannot – perhaps the object was too faint, or it was flashed too briefly to be visible. In the first case, we are said to enjoy *conscious access*, and in the second we are not (and yet, as we shall see, our brain may be processing the information unconsciously). (p. 9)

Conscious access is something that can be tested. Experiments have made it clear that unconscious processes play an important role in influencing what crosses the threshold of perception, but the act of attention is still needed to select the one possibility that crosses the threshold to conscious awareness. In other words, something more is going on than just the processing of information in the brain.

3.3 Three Levels of Human Cognition

To compare quanta with human beings from the top down, I need to describe three levels of human cognition. Each level displays a unique relationship between conscious perception and intentional action. Do these same three levels of behavior exist in physics? If they do, what does this tell us?

3.3.1 Level 1: Analytical Conscious Thought

At level 1, we see perception as something that we can think about. Intentional action is also something we can think about. As a result, we see a gap between perception and action, as if they are two independent processes. This is why we have the ability to think before we act. We can choose consciously when and how to act, and we can choose consciously which perceptions to ignore and which to use to accomplish an intentional goal.

This first level is what most people associate with consciousness and free will. And this is why the idea that quanta could be conscious sounds so absurd, because it seems ridiculous to suggest that quanta can think. And if they cannot think, how can they use perceptions to guide their actions? This would be a problem for the LoP Interpretation, if the top-down comparison between human beings and quanta does not hold up. However, as you might guess, analytical conscious thought is not as simple as it seems.

The problem is that when we approach conscious thought this way we run into the mind-body problem that philosophers have struggled with for centuries. This is exactly the slippery slope into duality that Dehaene was trying to avoid because it is fraught with all sorts of problems.

For example, how do we move our muscles by thinking about moving them? Do we direct the specific muscles that we want to move? Do we even know which specific muscles are needed to stand up and wave our hand? Even if we were able to figure out the exact order and timing sequence to go for a jog, do we actually direct our muscles this way?

Thankfully, the answer is no. Experiments show conclusively that even if we could find a way to consciously control each muscle in the right order, we would look like a broken-down machine jerking its way forward, because our thinking processes are way too slow. Fortunately, we do not control our muscles this way. In fact, the only reason we are able to run and move fluidly is because we do not analyze our individual actions. Analysis is paralysis, as the saying goes.

The same is true with our perceptions. As Wilson (2002) shows, our brain is flooded with sensory messages from nerve cells throughout our body (p. 24). Can you imagine how long it would take to sort through the millions of messages our brain receives every second? It would be impossible, because we simply cannot think about more than one thing at a time.

There is no way we can sort through and think about all of our sensations any more than we can consciously control every action of our body. That picture is a myth. However, it is a useful story that we tell ourselves because when we decide to raise our hand, our hand *does* go up. We *do* have the ability to choose between vanilla and chocolate ice cream. We know that on some days we clearly need to get ourselves up out of bed to go to work. We *do* need to make it happen.

Yes, we have some control and we can make choices. We also use perceptions to guide our actions, but exactly how do these things happen if it is not through conscious thought? I believe that understanding how the wave collapse works at the quantum level can help us understand how this works in our brains. We will get to that later. For now, the question is: Do we see this pattern of Level 1 behavior when looking at particles?

Yes, we do. In fact, this is directly related to the way classical physics sees the world. Just as we imagine that the actions of our bodies are caused by intentions and will-power, classical physics pictures material bodies as objects moved by outside forces. In fact, this is why the classical idea of forces makes so much sense to us. It is the same as pushing a cart with our body. We do that.

Newton's laws of motion are based on a cause-and-effect relationship. In the same way, analytical thinking sees perception as independent of action for the same reason – because we see ourselves as the cause. We think before we act. We use reason and logic to make intelligent choices. But we cannot see how we move our muscles or our body, and physicists cannot see forces directly either, only the results of forces.

Classical physics pictures particles, atoms, and material bodies as independent things with external forces acting on them. In the same way, analytical thinking pictures the organs of our body as separate from each other, with our mind controlling them and telling them when to act.

However, physicists now know that the classical view of the world is largely an illusion. Quantum mechanics shows us that this view is only an approximation. As soon as we look closely, this lens of perception falls apart. There is no definitive cause-and-effect process at the quantum level. Two quanta that appear to be separate can be entangled. They become coupled together in one quantum state. Even atoms that seem like hard bits of matter from a distance are only fuzzy balls of energy when seen at the subatomic level.

Neuroscientists have run into the same issue. There is no clear cause-and-effect process between thought and action. This is why they often say that free will may be an illusion (Harris, 2012). A convergence of brain activity peaks hundreds of milliseconds before we think we decide (Libet, Gleason, Wright & Pearl, 1983), suggesting that even a simple decision is far more complex than we realize, and our choices are influenced in significant ways by unconscious processes.

When it comes to conscious thought guiding actions, we never actually see this in brain activities or in living creatures. This is why Sperry said above that research suffers from "a failure to view mental activities in their proper relation, or even in any relation, to motor behavior." Conscious actions do not actually work this way. Thus, the resemblance to classical physics holds up, because classical forces and the idea of particles as bits of matter do not actually work this way either.

3.3.2 Level 2: Skilled Actions and Relational Learning

Psychologists now know that learning new skills involves a different process than the type of conscious analytical thought used in academic learning. Skills are learned through *doing*. Thinking often impedes the learning of new skills, showing that this is a different process.

John Flach, Professor of Psychology, and Fred Voorhorst a design engineer, (2016), illustrate skill-based learning by describing the process a child goes through when first learning how to walk, then how to skate on ice, next how to do a handstand, and finally how to walk on stilts. Each skill requires a "different type of coordination pattern," a different series of actions to achieve control. In other words, they each require a different relationship between perception and action to click into place. And the only way to truly master these skills is through trial and error (pp. 104-105).

Skill-based learning uses a loop that starts with a directed action. The child must try something. This leads to perceptual feedback, such as the child falling on their face or flipping over on their back. Then they try again, using a new approach. With each loop of trial and error, they gradually learn how to balance and how to move. Errors, in this process, are essential tools for calibration (pp. 76-86).

Skill-based learning, in the early stages, happens without analytical conscious thought. This is easy to see because children cannot explain how they balance on stilts. They have no clear conscious idea about how they walk on their hands or skate on ice. They just know how to *do* it. Acquiring new skills is all about learning how to *do* something. This is how intentional actions are learned (pp. 185-188).

Thought processes are not involved in this learning process, but they still play an important role. Each directed action, for example, when children initiate each trial and error loop, are directed by thoughts. They think, "What if I try this?" before making another attempt. However, the way they learn to balance on their hands is different from anything they have learned before, so they have no way of thinking that can tell them what they need to do or how to do it. They just "get the hang of it." This is clearly not the same process as analytical thinking.

Skill-based learning has three major characteristics, according to Flach and Voorhorst (2016):

1. It is learning by *doing*. A teacher might help illustrate through examples, but learning comes from practice, practice, practice. In other words, it needs action.

2. It requires tight coupling between action and perception. It is only loosely coupled to abstract cognitive processes. This explains why the best athletes are often not the best teachers.

3. Skill-based learning is even more crucial in situations that are highly dynamic, such as walking on your hands while on a boat swaying in the ocean, or trying to walk on a high wire. Extremely rapid corrections are needed in these cases to maintain stability. There is not enough time to think about each correction. You need to know how to respond instinctively without thought. Professional athletes excel at this (p. 187).

Tight coupling between action and perception is the key point here. When learning new skills through trial and error, perception and action are so tightly coupled that there is almost no gap. It seems as if perception flows directly into action. Trying to insert conscious thought into the process will seriously impede early stages of skill-based learning. This is why children are faster at learning new languages and other skills; they do not think as much about the process.

People have used skill-based learning for thousands of years – long before the third-person lens of science prevailed – because it was the best way to learn new crafts and professions. If you want to learn how to become a blacksmith, a carpet weaver, an artist, or you want to know how to raise a family, you need practice and experience. And it helps to work with masters of a trade.

In fact, if we trace back all the aspects of knowledge that we teach in schools today, we will find that they all began with skill-based learning. For example, rational and logical thought emerged only after people learned how to write with linear words and sentences. And written language came from spoken language. And spoken language grew out of non-verbal communication.

No one teaches a baby how to talk. Toddlers learn it themselves by making sounds and hearing the sounds they make. They get to know their bodies the same way: They form working relationships with their muscles and cells through trial and error.

Jean Piaget (1929, 1930, 1955), the psychologist, documented the way babies, in their first year, start recognizing the difference between their bodies and other things. They learn what it feels like when they grab their toes. Grabbing and sucking on their toes, over and over, shows them that this feeling is different from someone else grabbing their toes, or from them grabbing something else, like a rattle, that is not their own body. Thus, an understanding of what belongs to their body, and what does not, emerges from the experience of doing things – all without thinking about it.[6]

In other words, everything that we consciously think about is built on a framework of skills. At the base of every thought, every idea, is a skill-based way of relating to things. For example, our sense of "grasping" an idea is directly related to our experiences with grasping objects.

Therefore, this second level of cognition underlies everything that happens at the level of analytical conscious thought. However, it is hard to picture quanta going through a process of skill-based learning. So, we need a simpler way of understanding this second level of cognition. Fortunately, the answer comes from what I said above: Babies get to know their bodies by forming working relationships with their muscles and cells. In other words, we learn new skills the same way we learn how to work with others: through the dynamics of working relationships.

Skill-based learning is, in fact, the way we learn to form working relationships with other people. Remember point 3 above: Skill-based learning is crucial whenever situations change rapidly. People are also highly dynamic. They change continually from moment to moment and day to day. So we must learn to keep changing how we see them if we want to work together effectively. As our partners evolve, our responses need to adapt as well. Logical rules will not help. We need to continually learn from our errors to keep our working relationships running smoothly.

Musicians playing in orchestras are a good example. They must coordinate their actions precisely. There is not enough time to think before responding (Baumeister, Masicampo, & Vohs, 2011, pp. 352-353). Tests show that they play best when they focus on the flow of music, not the notes. The same type of synchronization is needed for professional athletes playing as a team. They must learn to respond fluidly to each other, without thought. Contrived actions cause the delicate dance between perception and action to break apart. Actions then become stilted, not natural.

---

[6] By the age of two, most babies learn to walk and speak. Through games of "peek-a-boo," they discover that people and objects continue to exist, even when they are hidden from sight. They acquire visual depth perception through experience, and how to move their arms and legs. They recognize family members, and they learn that crying brings food. The amount of learning in their first two years is extraordinary, but it all happens unconsciously from actions they make, years before they understand how to think analytically.

Any attempt to use the process of cause-and-effect interferes with the dynamics of working relationships, because, for a team to be effective, responses need to be spontaneous and natural. People need to learn each other well. Breaking the tightly coupled loop between perception and action in order to control a team interrupts the flow of effective teamwork. In fact, trying to control working groups, rather than leading them, often limits their potential. Learning how to work together through practice, by doing things as a team, builds stronger teams.

At the human level, it is easy to see the difference between analytical conscious thought and the flowing receptiveness and responsiveness in healthy working relationships. For example, if we want to learn how to work with another person, should we dissect them to study their organs and brain cells? Of course not, because this could kill the person we are trying to work with. Taking people apart will never reveal the secrets of what makes them alive. Reductive analysis can teach us how clocks and machines work, but it will not explain how to work with other human beings.

We run into the same problem if we try to psychoanalyze a person or categorize their traits (such as education level, male or female, skin color), or if we try to study their behavior patterns. Third-person observations, like these, are poor choices if our goal is to learn how to work with them.

We learn far more by spending time with them, asking them how they see things, doing things together, working as a team, and seeing them as friends. Those are the best ways to know a person. Objective analysis is not much help. In fact, it gets in the way of relationships.

However, using a relational approach has a consequence: We are now involved. We have lost our objectivity. More importantly, what we learn is not who another person is by themselves. We only see and experience who they are when we are working with them. This is the same wall physicists run into when studying quantum mechanics. This is not a coincidence. It is a clue that we are on the right track. This is the paradox we are trying to solve.

The best way to form working relationships is by doing things together, not by reading books or logical deduction. We absorb a sense of others when working toward a common goal. It happens without analytical thinking. In other words, working with others teaches us how to let our actions and perceptions flow fluidly with them, without thinking about it. This is what makes relationships so difficult to describe with words.

Skills are learned by forming working relationships. All skills are based on a tightly coupled loop between perceptions and actions, and so are healthy relationships. Therefore, what this second level of cognition is showing us is how actions are carried out in synchronized ways. Skill-based learning is needed before analytical conscious thought is possible.

Do we see this same process in physics? Yes, this is similar to the wave collapse process at the quantum level – the process where tangible actions emerge from intangible quantum possibilities. As we will see later, actualized events, where the wave function collapses, requires the coupling of perfectly matched quantum wave functions. This means synchronization between quanta. Only then is an exchange of energy possible. The resemblance to working relationships is remarkable.

An important lesson to learn from our human experiences, at the second level of consciousness, is that actions and perceptions still seem different from each other, but they are so tightly coupled together that they form a receptive-responsive flow from one to the other. This suggests that quanta should be responsive to relational perceptions leading up to a wave collapse. No thought should be involved because that is not how consciousness displays itself at this level.

Another lesson is that both working relationships and learning new skills begin with sporadic actions. To an outside observer such actions can seem random and chaotic. But, to those involved, they are trials and errors. In other words, actions at this level are initiated to learn how to form a working relationship. As soon as a relationship forms, sentient agents are able to change the state of how they work together. The flow of water is a good example of this, because the on-going sharing of electrons – known as covalent bonds – allows water molecules to flow fluidly.

It is also interesting to note that with more intelligent organisms we see fewer apparently random actions. For example, if a grown person picks up a bow and arrow for the first time, their aim will probably be poor, but they will still draw on countless similar actions to guide them. Not so with a baby, who will just aimlessly throw the arrows around. However, as you look at less intelligent life forms, uncoordinated actions become much more common.

For example, Heisenberg, M. (2009) describes the way amoebae use their flagella to spontaneously change their direction until they find something of interest (p. 165).

Likewise, Rayner (2017) shows that fungi send out hyphae in many directions until a source of food is detected. *Circumspection* – looking around – precedes directional focus (pp. 53-54).

This suggests that we should see more spontaneous actions at the level of quanta. However, once relationships are formed, we should see clear patterns emerging from what appear to be apparently random acts. This, of course, is exactly what we see with interference patterns created by individual photons. This is a sign that relationships are guiding what is happening. (More on this later).

In summary, we do not see clear cause and effect at this level, the way we do in classical physics, because we are *not* dealing with conglomerates. This second level shows us how sentient agents work together to bring about the actions and events that define our tangible world. We see this with cells working together in organisms, and with organisms working together as teams. And the same process appears to take place at the quantum level as well.

3.3.3 Level 3: Embryonic Perceptions and Emerging Emotions

Before sensations and urges to act can emerge into conscious perception, they exist in a form that is too subtle to describe with words. For example, the moment we walk into a room filled with people, we unconsciously sense the consciousness in that room. Before we have a chance to notice details, we often feel something that draws us in or repulses us. We form impressions of strangers the same way, even before we see them speak or act.

Our first impressions are not distinct. They are vague and amorphous before they become clear enough perceptions that we can consciously think about them. We can picture first impressions as being on their way to becoming comprehensible, but they have not yet arrived at a state where they are distinct enough for our conscious mind to perceive. William James

(1899), the psychologist, gives us a glimpse into this process when he writes about the nature of apprehensions:

> The gist of the matter is this: Every impression that comes in from without, be it a sentence which we hear, an object of vision, or an effluvium which assails our nose, no sooner enters our consciousness than it is drafted off in some determinate direction or other, making connection with the other materials already there, and finally producing what we call our reaction. The particular connections it strikes into are determined by our past experiences and the 'associations' of the present sort of impression with them. (p. 157)

> A child will call snow, when he sees it for the first time, sugar or white butterflies. The sail of a boat he calls a curtain; an egg in its shell, seen for the first time, he calls a pretty potato; an orange, a ball; a folding corkscrew, a pair of bad scissors. Caspar Hauser called the first geese he saw horses, and the Polynesians called Captain Cook's horses pigs. Mr. Rooper has written a little book on apperception, to which he gives the title of "A Pot of Green Feathers," that being the name applied to a pot of ferns by a child who had never seen ferns before. (pp. 159-160)

Thus, when we see something for the first time, our unconscious makes associations with things that it knows. It looks for the closest match until it gets to know what it is actually sensing. It learns by forming a relationship with the new thing, whatever it might be. And it forms relationships by experiencing the impressions. It does not learn by thinking about it, like Level 1, and it does not learn by doing and acting, like Level 2. At Level 3, we learn from experience.

This is how children learn what an orange is when they eat one. They "get to know" what snow is by seeing, feeling, and tasting it. This is similar to learning a new skill, except the process at Level 3 is unconscious. There are no trials or errors because feelings and perceptions are still emerging. They are not distinct enough to act on or think about. We simply learn through experience – by being involved. Until they are clear, the meaning of oranges and snow cannot cross over into comprehension. We cannot make sense of them or relate to them. We cannot even frame what they are, which is why there is no way to consciously think about them or do something with them.

To get a better idea about how the unconscious works, we need to get closer to our raw experiences, by becoming involved in the experiences themselves, not by thinking about them. This process cannot be taught with words. However, reviewing a famous psychology experiment can help.

3.3.3.1 Cards that Play Tricks with Our Minds

Psychologists Jerome S. Bruner and Leo Postman (1949), from Harvard University, describe the results of an experiment that they ran on perception. Their experiment seemed simple: They asked subjects to watch a screen where they displayed images of playing cards.

At first, the pictures were flashed for such a short period of time that the subjects could not perceive what they were seeing. Gradually, the duration of the images was increased, until they were able to recognize the cards (pp. 209-210).

The subjects were told about this part of the experiment. What they did not know was that mixed in with the images of normal playing cards were cards that had the colors reversed: for example, a red six of spades and a black four of hearts (p. 209).

The first thing Bruner and Postman noticed was that normal cards were recognized much sooner than the reverse-color cards. Normal cards required about 1/36th of a second before they could be "seen." The cross-color cards needed more than 1/9th of a second – four times longer! (p. 210)

This makes sense, since the unconscious already knew what real playing cards look like from previous experiences (i.e., playing card games). Therefore, they already had a lens of perception – a way of seeing cards. That is why they could identify normal cards quickly. At the same time, they unconsciously sensed that something was strange about the six of spades and four of hearts. Their unconscious needed longer to figure it out, because it did not "know" those images. These wrongly colored cards did not just take longer to recognize, they also created odd distortions in perception before the subjects figured out what was happening (pp. 211-213).

Most of the people first "saw" the red six of spades as either a black six of spades or a red six of hearts. Some of them consistently saw the wrong color of the card, while others consistently misinterpreted the suits. In other words, their unconscious was trying to *associate* these cards with things that they knew. The unconscious sensed that it was seeing a distorted image. So it tried to correct the picture by substituting an image of what a real six of spades or six of hearts should look like. The appearance was so close to a real card that it guessed that it was a real card (p. 213).

However, the match was not quite right, and with experience the unconscious sensed this. It seemed to see that the traditional six of spades did not fit everything it was seeing, which is why it took so much longer to figure out what was going on with the mis-colored cards.

A number of people saw something stranger: The colors of the cards seemed to shift before their eyes. They could not understand what was happening, or how to explain what they were seeing. They described the cards as purple, grayish, rusty-black, or brown-black. Their words were often bizarre: "Lighter than black, blacker than red," "Black but redness somewhere. Blurred redness," "First black, then red, then black" (pp. 215-216).

Their unconscious was searching to find a way to relate to what they were seeing. It was weighing different *possibilities*. It moved from one possibility to another, switching back and forth. It was trying to *relate* to these cards. That is why the colors seemed to shift before their eyes.

This is when more than half of the subjects experienced a complete breakdown in perception. It did not usually last long, but they became so confused that they lost all sense of knowing what was happening. Here is what one person said:

> "I can't make the suit out, whatever it is. It didn't even look like a card that time. I don't know what color it is now or whether it's a spade or a heart. I'm not even sure now what a spade looks like! My God!" (p. 218).

Psychologists call this “cognitive dissonance.” The unconscious searches for a lens – a way of seeing – that it can relate to, but nothing fits. At this point, the conscious mind completely loses its ability to orient itself, making first-person perception impossible. This is the state of confusion. It happens when first-person perception breaks down and only the unconscious keeps working and looking for a way to relate. The person does not know what to *do* and they do not know what to *think*. However, the unconscious process of experiencing continues, so they continue to learn.

Remember, all of this was happening in fractions of a second, as the cards flashed by. Subjects could only think about what they saw after the cards disappeared. It was too fast for their conscious mind. Therefore, it was their unconscious that was shaping their perceptions, not their conscious mind. And the unconscious had not yet learned how to relate to these strange new cards.

Shortly after these breakdowns in cognition, the subjects started getting glimpses of a new way of seeing. One person reported, “What’s the matter with the symbols now? They look reversed or something.” Another said, “The spades are turned the wrong way, I think” (p. 221).

The upward pointing tip of a spade that they were looking for did not match the downward pointing tip of the heart that was there. Their unconscious could now see the mismatch, but their analytical thinking could not yet grasp the new lens to see what it meant. They needed to fully let go of their old way of seeing before they could find a new lens – a new way of relating. Can you see how bizarre and different the unconscious process seems compared to conscious thought?

Then, suddenly the shock of recognition hit them. Bruner and Postman calls this the “My God!” reaction, since they heard this over and over, at the moment it made sense. “Good Lord, what have I been saying? That's a red six of spades!” (p. 222).

The subconscious figured it out. No reasoning of the conscious mind was involved. Once the right way of relating is found to explain the strangeness, everything snaps into focus. This is the “Aha!” moment, when it crosses over into conscious access. A new lens of perception just formed.

This experiment gives us a glimpse of the unconscious process. It shows us that Level 3 works by forming relationships and associations, and it forms these relationships by getting involved in experiences. This is how embryonic perceptions and emotions emerge into clarity. First-person intentional actions and third-person conscious thought are not possible before this happens.

We are now entering into controversial territory. While psychology has made progress recently in better understanding the process of conscious access, the world of our unconscious that processes sensations and impressions before they become conscious, is hard to nail down because they are not yet conscious. As a result, we find a number of radically different theories on how to interpret the unconscious. This is similar in many ways to the radically differing interpretations of QM.

And the similarity does not end there. Emerging emotional feelings, before they are able to cross over into clear emotional responses, are not static. They evolve continuously, in a remarkably similar way to how quantum wave functions evolve. For example, if we walk into a bar, our initial impression brings an immediate sense of like or dislike, but these feelings change as soon as we start talking to the people there.

Physicists see coherent quantum wave functions acting the same: They continually evolve. There are no sudden transitions until there is a wave collapse at Level 2.

We often remember the sense of emotional attraction or repulsion that we felt when first meeting another person. The feeling might be strong or mild, but it begins to evolve as soon as we get to know them better. Our emotional response can change fluidly from dislike, to intrigue, to genuine interest, depending on what the other person says and how they respond to us.

These emerging feelings can also be marked by moments of conscious perception, such as when the person does something that surprises us. We then suddenly change the way we see that person. This is similar to a wave collapse. In other words, in that moment our half-formed feelings and perceptions cross over into Level 2. When this happens, the relationship possibilities shift suddenly and start evolving down a different path. This is the same pattern that physicists see when the wave function collapses.

Here is another interesting similarity: Our first impressions of an environment do not come from one or two specific perceptions. They actually seem to come from an overall impression from all of our unconscious senses, as if they all flood us at the same time. This is the same way superpositions work. They all influence us at the same time, often creating a range of conflicting feelings. First impressions affect us this way because they are still emerging; they are only the *possibilities* of perceptions. In other words, they are what Heisenberg called *potentia*.

Plus, each of the countless impressions influence us with a different weight, based on how close they are to being recognizable, the same way probabilities in QM are used to calculate the likely outcome of a measurement. Therefore, some unconscious feelings influence us more strongly than others, but all of these impressions add together. This way of describing our state of consciousness at Level 3 is remarkably similar to the behavior of coherent quantum states.

Embryonic emotions that have not yet emerged as clear feelings are often considered subjective, but they produce a real effect. When someone feels a sense of admiration for us, whether we are consciously aware of it or not, it changes our unconscious feelings towards them. If two people feel a sense of attraction to each other, it is far more likely that they will be drawn to each other, even if the feeling is unconscious.

Nothing that we see at this level is distinct or definitive. We only catch glimpses of what appear to be half-formed perceptions and feelings leading to a vague sense of attraction or repulsion.

Quanta experience attraction and repulsion in this same open-ended manner. It makes them more likely to move closer together or farther away. But, for tangible movement to occur, there must be an exchange of energy. That requires a Level 2 wave collapse. We see the same thing on the human level: We can only act intentionally when tangible perceptions emerge into consciousness.

How do we observe the inner dynamics of Level 3 if it is unconscious? Obviously, we cannot see it clearly. We can only sense it vaguely in the moments before it crosses over into conscious access. This is virtually identical to the issue that physicists face with coherent quantum states, because as soon as they measure a quantum state it is no longer coherent. In other words, how can we study the uncertain nature of quantum states when they change into something distinct as soon as we measure them? This goes to the heart of quantumness. This is why there are so many widely differing speculations and interpretations. The problem is the same for psychologists and neuroscientists who try to study unconscious processes before they become conscious.

As a result, physicists are divided into two groups: those who believe the quantum wave function represents something real and those who believe it is "merely a calculational tool for working out probabilities of the results of experiments…" (Penrose, 2016, p. 198).

The Copenhagen Interpretation, which is the most popular interpretation of QM, says that the wave function is just a mathematical tool. However, there is significant evidence suggesting that it does indeed represent something real, as Roger Penrose (2016) points out, because some experiments are 100% accurate (such as retesting the spin state of a photon after it was just tested) (pp. 198-204).

The "Taking Heisenberg's Potentia Seriously" paper also says that the wave function represents something real, and it offers a detailed model for how it influences every tangible and measurable event in our universe. This model, the paper claims, is what has been missing. The LoP Interpretation suggests that what has been missing is how closely quantum states resemble unconscious behavior. This explains why we see two states of reality: the quantum state and the visible, tangible world.

It turns out, as you might guess, that psychologists are also divided into two groups as well: those who see consciousness as simply a by-product that emerges from the brain, and those who see it the other way around – where consciousness shapes brain functions. Both sides face challenges.

For example, if conscious awareness emerges from brain activity, how do chemical and electrical interactions between neurons make the leap to consciousness? This question is not even close to being resolved. In fact, there is no good theory for how such a leap to consciousness could even be possible, as the neuroscientist, Sam Harris (2011), explains:

> Most scientists are confident that consciousness emerges from unconscious complexity. We have compelling reasons for believing this, because the only signs of consciousness we see in the universe are found in evolved organisms like ourselves. Nevertheless, this notion of emergence strikes me as nothing more than a restatement of a miracle. To say that consciousness emerged at some point in the evolution of life doesn't give us an inkling of how it could emerge from unconscious processes, even in principle....
>
> Consciousness – the sheer fact that this universe is illuminated by sentience – is precisely what unconsciousness is not. And I believe that no description of unconscious complexity will fully account for it.... Consciousness may very well be the lawful product of unconscious information processing. But I don't know what that sentence means – and I don't think anyone else does either. (Harris, Oct. 11, 2011)

Harris' readers were surprised by his comments. They asked him: Why does the emergence of consciousness pose such a problem? In a follow-up blog post, Harris answered: "Why is consciousness more perplexing than language or digestion? The problem...is that the distance between unconsciousness and consciousness must be traversed in a single stride, if traversed at all" (Harris, Oct. 19, 2011).

You cannot get to consciousness gradually. The step is immediate – it happens in one sudden leap. You are either conscious or you are not. There is no in-between. Nothing known to physics or chemistry can create a discontinuous leap like this, except for a wave collapse. But quantum effects have been ruled out by neuroscientists because they should not be visible at the level of evolved organisms. (See: Harris, 2012, pp. 29-30, and Dehaene, 2014, pp. 263-264).

The other side of the debate faces a similar challenge: How does consciousness influence our world of matter and energy? There is no evidence of other forces than those identified by physics. And why do matter and energy exist on one hand and consciousness on the other? This is the slippery slope into dualism that Dahaene mentioned earlier.

This certainly seems to be as difficult to solve as the emergence of consciousness. However, an explanation for how this is possible emerges from the LoP Interpretation. It will be explained in section 4.9. This is a benefit that comes from identifying underlying principles that can explain the formalism of QM. If the LoP Interpretation is right, then consciousness *does* come first, and quantum leaps *are* involved. This overturns the "compelling reasons" that Harris stated above: "the only signs of consciousness we see in the universe are found in evolved organisms like ourselves." This argument fails if we can now see signs of sentience everywhere, even at the level of quanta. Plus, wherever we see relationships between sentient agents we find quantum effects.

We will explore this in more detail later, but the point here is that we see, once again, a remarkable resemblance between unconscious processes that exist before conscious access, on the one hand, and pure coherent quantum states that exist before measurements, on the other.

3.3.3.2 Automatic Responses that are Not Automatic

Before we leave this third level of cognition, there is something I want to examine more closely. How do we explain embryonic unconscious feelings that are on the way to becoming distinct emotions? How should we treat first impressions on the way to becoming clear perceptions? How are we supposed to think about half-formed emotional feelings that are precursors to actions?

For those who believe that consciousness emerges from the brain, it is natural to describe these as nothing more than brain functions. In other words, they do not see these as results of consciousness. But this avoids the fact that at this level we see a display of half-perceptions and half-urges-to-act that are so close together that they, for all practical purposes, happen at the same time. In other words, we see receptivity and responsiveness – the very traits that are functions of consciousness.

Our first impressions arise immediately from a flood of sensations that permeate us when we enter a bar or meet a stranger. There is no time for analytical thought. There is not enough clarity to recognize one emotion to act on. This is what makes this third level unique and different from the other two states of cognition: Perception and action are inseparable because they are possibilities.

The receptivity and responsiveness that takes place at Level 3 has all the traits of being embryonic perceptions and emotional responses, both happening at the same time. Psychologists might call these “automatic” responses, the same way physicists see the behavior of quanta as automatic, but in both cases the term “automatic” *does not fit* because it implies cause and effect. In both cases, that is clearly what is *not* happening.

Physicists have proven this at the quantum level. Cause and effect requires an object to obey the force that is moving it. However, that is clearly *not* what happens at the quantum level, and that is clearly *not* what we see with unconscious processes before they cross over to conscious access.

In Newtonian physics, determination is possible because we can know the position and momentum of an object, and the forces being applied to inert objects appear to be separate. At the quantum level, however, the more accurately you know the position of a particle, the less you know about its momentum. If you know exactly where it is, then you have no idea where it is going. This uncertainty is inherent, making it impossible to predict what a single quantum will do.

For the same reason, we must abandon the idea of cause and effect when dealing with unconscious processes that lead up to and influence what crosses over into conscious access. Uncertainty rules over all of these half-formed perceptions and half-formed urges. More importantly, this third level of cognition shows us receptivity and responsiveness – two functions of consciousness – working together. This is how the unconscious learns to relate through continued experience.

Our first impression that we like someone is not automatic. It makes no sense to compare this to a mechanical reaction. The “chemistry” we feel with another person is not a chemical reaction because it is completely unpredictable. There is no evidence that chemistry in a relationship is the result of actual chemistry or external forces. Calling them automatic is simply avoiding the display of consciousness that we see at this level.

This is, of course, exactly the same thing that physicists do when they push aside consciousness. This is why Rovelli says that the “observer” does not need to be treated as conscious. A table lamp can be an observer, he says. But when we look at what is happening at the quantum level, we have no way of knowing how an individual quantum will respond to the information it receives. We can only make statistical predictions. This means that even the atoms of a table lamp form relationships with quanta in a way that suggests there are inner dynamics involved in the relationship. Quanta act as if they spontaneously choose one of the possibilities for no external reason.

All of this leads to a highly controversial conclusion, which is debatable and should be debated. However, if the LoP Interpretation is right, then unconscious processes must be considered an aspect of consciousness, just as the unpredictable behavior of intangible quanta must be seen as the result of sentience. We cannot see consciousness directly, but we can easily see the difference between automatic cause-and-effect reactions and the gradual evolution of relationships that develop through receptivity and responsiveness.

3.3.4 Comparing the Three Levels

Roger Penrose (2016) recently explained the problems with current interpretations of QM. His description so closely resembles the three levels of cognition discussed above that it is worth reviewing.

He starts by presenting a picture that can be seen as a simile of the physical world. In the picture, we see a mermaid sitting on a rock with half of her body above water and half below. He writes:

> The lower part of the picture depicts what is happening beneath the sea, as an entangled mess of activity involving many odd-looking creatures and alien entities, but with perhaps a kind of special beauty of its own. This represents the strange and unfamiliar world of quantum-level processes. The upper part of the picture depicts the kind of world that we are more familiar with, where different objects are well separated and constitute things that behave as independent objects. This represents the classical world, acting according to laws we have become accustomed to, and had understood – prior to the advent of quantum mechanics – as precisely governing the behavior of things. The mermaid herself straddles the two, being half fish and half person. She represents the link between the two mutually alien worlds. She is also mysterious and apparently magical, as her ability to form her link between these worlds seems to defy the laws of each. Moreover, she brings, from her experiences of the world beneath, a different perspective on our world above, appearing to look down upon it from a great height from her vantage point on the rock. (p. 138)

In other words, the classical world represents a world of definitive objects governed by cause-and-effect processes. The quantum world is an alien world to us because things are entangled, not clearly defined, and hidden from view. The mermaid embodies a third reality that in a magical way crosses from the undersea world into the visible world above the surface of the water.

This offers a great overview of the world as seen by our current understanding of physics. And it is easy to recognize that much of what makes the mystery so intriguing is that the mermaid's magic resembles so closely the mystery of how our unconscious crosses over into consciousness. However, the reason Penrose is using this simile is because he wants to help explain the underlying problem that QM faces. He goes on to say:

> It is the normal belief of physicists – and it is my own belief also – that there should *not* be fundamentally different laws governing different regimes of physical phenomena, but just *one* overriding system of fundamental laws (or general principles) governing *all* physical processes. (p. 138)

> Accordingly, the [classical and quantum] worlds…should not be thought of as really being alien to one another, but with our present understanding of quantum theory and its relation to the macroscopic world, it is merely a convenience for us to treat things as though they inhabited different worlds and thus obeying different laws. In practice, it is certainly the case that we *do* tend to use one set of laws for what I shall refer to the *quantum level* and another set for the *classical level*. The borderline between these two levels is never made very clear, and there is the common view that classical physics is, in any case, merely a convenient approximation to the "true" quantum physics that is

> taken to be satisfied *exactly* by its basic constituents. It would be taken that the classical approximation normally works extremely well when there are vast numbers of quantum particles involved. I shall be arguing later that there are, nevertheless, certain severe difficulties involved in holding too strongly to this kind of convenience viewpoint. (pp. 140-141)
>
> The classical world seems indeed to be extremely closely governed by the classical laws of Newton, augmented by those of Maxwell to describe continuous electromagnetic fields, and those being further augmented by the Lorentz force law which describes how individual charged particles respond to electromagnetic fields. If we consider matter in very rapid motion, we need to bring in the laws of special relativity, and when we involve sufficiently significant gravitational potentials, we need also to take into account Einstein's general relativity. These laws combine into a coherent whole, in which behaviour is governed…in a precise deterministic and local way. (p. 141)
>
> The quantum world, on the other hand, has a time evolution…described by a different equation, called the *Schrödinger equation*. This is still a deterministic and local time evolution…and it applies to a mathematical entity called the *quantum state*, introduced into quantum theory to describe a system at any one moment. This determinism is very similar to what we have in classical theory, but there are various key differences from the classical evolution process.... In fact, some of these differences…have implications that are so alien to our experiences of the actual behaviour of the world that it becomes totally unreasonable to try to continue to use [quantum laws] for our descriptions of reality after macroscopically discernible alternatives become involved. Instead, in standard quantum theory, we adopt a third procedure, called *quantum measurement*… performing this necessary link connecting the quantum world with the classical world of our experiences… [This] procedure is completely different from the deterministic evolutions of either [the classical or quantum levels], being a *probabilistic* action, and…it exhibits curiously non-local features that defy all understanding in terms of the classical laws that we are familiar with. (p. 142)
>
> However…there are some profoundly mysterious puzzles involved in the adoption of such a point of view, and it becomes very hard to accept that the strange [quantum]-rules, when directly applied to macroscopic bodies, can in themselves result in [collapse]-like or [classical]-like behaviour. It is here that the serious difficulties in "interpreting" quantum mechanics begin to loom large. (p. 144)

In other words, one of the fundamental unsolved problems of QM is why we see the world operating at three different levels. Most physicists realize that this does not seem right, that there should be a single perspective that makes sense of all three. The view we gain from psychology gives us an insider view that adds depth and meaning. But it still leaves us wondering why we see three levels.

I believe that this picture can be simplified.

1. The top level is defined by objective **third-person perception** of the world, where we see objects and actions as outsiders. Our analytical ideas and thoughts seem distinct and clearly defined, the same way that objects and forces appear distinct. However, a closer look shows us that nothing is as definitive as it seems. And this top level cannot explain quantum states or the states that allow creatures to be alive.

2. The most notable feature of the middle level is defined by **first-person perception**. This is what enables quantum states and unconscious processes to cross over into actualized events and conscious access, making them visible to third-person analysis. This is the source of all tangible activity. Internal agency originates at this level, allowing quanta and living organisms to act as individuals and exchange energy.

3. The bottom level is shaped by the influence of possibilities in relationships between sentient agents, whether they are quanta or living creatures. These possibilities are uncertain. They are never clearly defined, and they continue to evolve gradually. Attraction and repulsion emerge from the intangible dynamics of the relationships between agents. These dynamics are composed of wave functions, according to QM. At the human level we know them as receptiveness and responsiveness. They are the results of embryonic perceptions and urges-to-respond that are so close to each other that they appear to be two sides of the same coin. I call this **second-person perception** because, when writing a personal letter, we use the second-person voice to address the quality of "you" we sense in another being, forgetting ourselves in the process. This can also be called the relational lens of perception. This is why Rovelli was right to say that the quantum world is made up of nothing but relational states and values, but we must remember that these relationships are energized by inner dynamics that are intangible and invisible to outside observers.

This is a simplified summary of the lenses of perception that give the LoP Interpretation its name. All other lenses are composed of one or more of these three lenses. And from these three lenses, we can develop a model that is consistent with quantum formalism. It is also consistent with everything we know about psychology and neuroscience, as far as I can see.

The world forms and develops according to these three lenses because quanta are sentient. Thus, these three ways of seeing become the ways that sentient entities develop relationships with each other. This is why we see the pattern of quantum behavior at the level of human psychology and living organisms. Internal agency and the quantization of energy and matter is the result of first-person perception. The strange and irrational behavior of quantum and unconscious states comes from second-person ways of relating. And the classical view only sees the outside – the end result.

This represents an overview of the proposition presented by the LoP Interpretation. Next, we will study the underlying principles of perception that lead to these three lenses and quantum behavior.

4. The Creative Process of Perception – The Principles

In the last few sections, I have used an informal approach to compare quantum-level processes to organisms. The main purpose was to see if there was any obvious reason for ruling out the LoP Interpretation. I have found none, but of course all of these issues could be explored in far more detail. However, now is not the best time for debating these points. Once I lay down the underlying principles that allow a rigorous comparison with quantum formalism, then we will be able to do a much better analysis.

This section begins a more formal process. I will explain the fundamental principles of the creative process of perception that applies to both quanta and life forms, and I will explain how I arrived at them.

My goal is to show, first, how the sentience of internal agents naturally leads to embryonic perceptions and responses, and, second, how those emerging perceptions and responses lead to dynamic relationships. Then I will show how relationships can create the natural world of matter, energy, space, and time. In other words, we will see how the tangible universe emerges from nothing but consciousness – the same way that unconscious processes emerge to produce our conscious reality.

An even more rigorous process starts in section 5, where I show that the principles of perception explained in this section explain why quantum formalism takes the form that it does. Along the way we will see a number of additional insights emerge from these principles.

One of the lessons learned in previous sections is that comparing quanta with organisms gives us two different perspectives. At the level of quanta, where states and behaviors are simple, with only a few degrees of freedom, it is easier to see what makes quantumness so bizarre. From the level of living creatures, on the other hand, we see an insider point of view that offers a deeper understanding of what is happening to cause such irrational goings-on.

In this section, we are going to use this same process of going back and forth between quanta and organisms, but for a different reason: to identify key principles of perception. In describing these underlying postulates, we need to apply constraints from both ends of the spectrum, to make sure these principles work for both.

This should make it easier to find a way to invalidate the LoP Interpretation, if there is one, because more constraints need to be applied here than for any other interpretation. At the same time, these added constraints also make the LoP Interpretation more detailed in its explanatory power for what is happening at the quantum level.

There is an additional constraint that weighs heavily on the LoP Interpretation. If consciousness does indeed come first, before matter and energy, this means that these principles need to explain how mass and energy emerge, along with space, time, and everything else, for that matter. If the LoP Interpretation cannot show how our tangible world emerges from nothing but consciousness, then we will end up with a theory that still leaves us with a world of duality. It might offer added insights, but we will still be left with Roger Penrose's (2016) concern:

> It is the normal belief of physicists – and it is my own belief also – that there should *not* be fundamentally different laws governing different regimes of physical phenomena, but just *one* overriding system of fundamental laws (or general principles) governing *all* physical processes. (p. 138)

This additional constraint suggests that the LoP Interpretation must offer an explanation that starts before the world of matter, energy, space, and time emerged. In this simple starting point, only consciousness exists.

This is where I will begin, as I now introduce the first postulate:

4.1 Postulate 1: Consciousness Always Belongs to a Sentient Agent

This assertion, that consciousness always belongs to a sentient agent, can easily be debated. But there is no need to argue over this postulate, since it is nothing more than a starting assumption to develop a system of principles. As Bowman (2008) says in his book about quantum formalism,

> A postulate is, essentially, a statement made without proof or analytical justification – an underived statement. In physics, a postulate is, in effect, a proposal, and such a proposal must ultimately stand or fall not on *derivation*, but on *verification* in the physical world. It must be tested experimentally. Newton's laws of motion were such proposals. (p. 6)

The main reason for asserting Postulate 1 is because everything we have seen so far, at the levels of both quanta and organisms, suggests that sentience gives both particles and living creatures an ability to act as individuals through internal agency. This explains why matter and energy are quantized and why there is no such thing as an organism that is half-alive.

This is also consistent with Roger Sperry's (1968) research on people who have the connection between the two hemispheres of their brain cut: They retain their awareness as a singular person. And it is consistent with the discovery cited earlier that we must place our attention on something before it can cross over into conscious access.

Whenever consciousness plays a role, it does so through sentient agents whose actions are guided by perceptions. This is, therefore, stated as a starting assumption for the LoP Interpretation.

Another way of putting this is that consciousness always belongs to "someone." This means that consciousness does not float out in space on its own. Whenever we talk about consciousness we can always ask "whose consciousness?" As we will see later, this is an important constraint.

4.2 Postulate 2: Sentient Agents Can Experience Each Other

If, in the beginning, there is only consciousness belonging to one sentient agent, then how could it ever become aware of anything outside of itself? It seems absolutely necessary that there must be more than one sentient entity if relationships are going to create a world filled with material bodies and forces.

As soon as there is more than one sentient agent, then the possibility exists that they can experience and perceive each other, making it possible for relationships to form between them.

The experience of others leads to what might be called the first true perception. By perception, I mean an experience that is recognized. In this case, the first perception would come from the experience of something outside of the sentient agent's own consciousness.

What is the basis for this perception? The perception arises because there is a difference between self and others. If this difference is noticed, it can be perceived. If it is not noticed, the two sentient agents will pass each other like ships in the night and nothing will happen.

4.3 Postulate 3: Perception Begins with the Sensing of Differences

Psychologists say that all sensations that lead to perceptions are based on differences, such as the difference between hotter and colder. However, we need to be careful here. We do not want to base these principles on human perceptions because humans do not exist yet in the primordial world where there are only sentient agents who perceive each other.

Our human concept of differences comes from looking at the world as an outside observer. We sense that a pot is hot when we touch it because it is hotter than the countertop or the air. Unfortunately, outer perceptions do not exist yet in our fictional primordial world. This means that there are no such things as third-person perceptions yet. **The only perception that exists is first-person perception**, which comes from the experiences that belong to sentient agents.

Therefore, a sentient agent is able to recognize the presence of another sentient agent only because the experience of its own self is different in some noticeable way from experiencing the presence of others. This experience can lead to perceiving the difference between self and others.

Here is another place where we need to be careful. This first perception of the difference between self and others should not be seen as anything even close to a thought of any kind. At best, it will start out as an emerging perception. This is important because it means that the only level of cognition that exists up to this point is Level 3 – the unconscious – which is also what physicists call "the pure coherent quantum state." There are no measurements possible yet and there are equally no distinct states or perceptions either.

If the first embryonic perception arises from experiencing the presence of another because it seems different in some way from the experience of self, then, in some cases, this half-formed perception should evolve and grow. Why would it evolve? There are three reasons:

First, an agent that starts to perceive the presence of others may want to know more about what this half-formed perception means. In other words, their first impression of others may spark a half-formed feeling of attraction. This is a display of consciousness at its simplest form: half-formed perceptions leading to half-formed emotional responses.

Second, the perception will evolve when the experience of another continues. If the sense of otherness only exists for a moment and then disappears, the vague perception cannot evolve. Or if there is no interest – or feeling of attraction – in the experience of others, then nothing will happen. But, if the agent feels some emerging sense of attraction from an incipient perception of another, and if this experience continues, then the perception should grow, as the unconscious learns how to relate.

Third, the most important reason that the perception of another will evolve is because the moment a perception begins emerging, the experience becomes more vivid. In other words, recognizing a perception heightens our awareness of that perception. The moment you sense a distinction of any kind, it becomes clearer to you. Becoming aware of something actively changes your experience of it as you get to know that experience. This shows us the creative power of perception.

This creative property of perception is the key to all of the mysterious behaviors of quanta.

Notice that third-person perception does not work this way. The outside world appears to exist as an independent reality from us. We appear to be mere witnesses. Observing does not seem to change the outside world or create anything. However, this is not true for embryonic perceptions.

At the level of cognition (where perceptions are just emerging and our urges to know are only half-formed), the instant we sense a difference, it becomes clearer. Recognition energizes the sensation, you might say, awakening a stronger feeling of curiosity and attraction. As a result, perceptions continue to gather strength and become clearer at the unconscious level.

If this is true at the human level, then the same process should be true at the level of quanta. This creative property of perception needs to be stated as a postulate:

4.4 Postulate 4: Perceiving a Difference Strengthens the Awareness of that Difference

As I said before, in reference to the unconscious level of cognition, embryonic perceptions can immediately trigger half-formed responses, as if the perception and response are one and the same. Now we can see why: The first glimmer of perception strengthens our awareness of that perception because it triggers an incipient emotional response. This response heightens our awareness. And, when the perception is strengthened, this triggers the response to grow in a way that is inseparable from the perception. In other words, it creates an increased feeling of a need to know more.

I have described the evolution of this process as if it begins with perception and is followed by an emotional response. In other words, receptiveness leads to responsiveness. We can just as easily see this process beginning with an emotional urge that then energizes our awareness of that urge, awakening an emerging perception. For example, think about times when you react unconsciously without thinking about what you are doing. It can awaken you to a sense of attraction or repulsion that you are feeling but had not noticed before.

In none of these cases are we talking about anything even close to cause-and-effect reactions. It would be more accurate to say that emerging perceptions can awaken emotional responses and embryonic emotional responses can awaken perceptions. This is how consciousness displays itself at the quantum level, which is also the unconscious level.

This is why sentient agents alter their responses based on perceptions (information). If perceptions and responses did not awaken each other, there would be no sentient agency.

For example, let’s say you are trying to listen to someone over the noise of a crowd. You may be completely unaware that one of your friends is standing in the back of the room. However, at some point a vague perception grows, or perhaps a vague feeling emerges that continues to grow stronger as your eyes continue to catch glimpses, because the emerging perception and feeling strengthen each other. Things change the moment you consciously recognize your friend in the back of the room. That is when it grows strong and clear enough to cross over into conscious perception.

Therefore, this fourth postulate tells us that embryonic perceptions and urges strengthen each other. And as they grow stronger, first-person perceptions and emotional responses become clearer.

Look closer at what this means: The first glimmering perception and feeling of your friend grows and evolves because your friend is there in the back of the room. This is the only reason perception and feelings grow clearer and stronger. In other words, when perceptions and feelings relate to something real, our perceptions and feelings continue growing and evolving.

This strengthening process of perceptions and feelings falls apart if the sensed differences do not exist in the first place. In other words, there can be no positive reinforcement if a perception or feeling is about something that is not really there. So, the distinction, or at least the hint of a difference, must be based on something real for a perception to grow stronger and clearer. And there must be an "interest" – an internal sense of attraction or repulsion. The strength of this interest, therefore, acts as a weighting factor, determining how fast the perception grows clearer and stronger.

From the above four postulates, we can now describe how the inner dynamics of second-person relationships develop and how they influence sentient agents.

4.5 Postulate 5: Second-Person Relationships Are Created by the Reinforcement of Shared Perceptions and Feelings

Up until this point, I have only spoken about the emerging perceptions and incipient responses of a single agent. Therefore, no relationships have formed yet. There are only first-person perceptions and feelings.

However, as soon as two agents both sense a common interest in each other, a new dynamic arises. At first, the embryonic perceptions and feelings evolve on an individual basis as before, but now something new emerges: the perception or feeling that they both share an interest in each other. This is a very different type of perception and feeling. It awakens a new emerging awareness of their mutual interest in each other. As a result, two agents can reinforce each other's perceptions and feelings. Once this starts, the perceptions and feelings that they both share an interest in each other will grow stronger.

Thus, as soon as two agents begin sensing that they both share a common interest in each other, a relationship begins. The relationship continues to develop for as long as their interests are aligned. In other words, it is the reinforcement of each other's perceptions and feelings that makes the experience of the relationship real to them. Becoming aware of another person's interest in us, when it is a shared attraction, strengthens the relationship experience. This is how second-person perception emerges.

This process does not work when we are attracted to someone who feels indifferent to us. There is no reinforcement of perceptions about a mutual interest, so the relationship never becomes real. This process of coupling with another is a powerful experience. Perceptions and feelings of an emerging relationship stand out as special and distinct from any other type of experience, further strengthening the relationship. In other words, the inner dynamic of second-person relationships are driven by a process of positive feedback.

The moment we, as human beings, see and feel a distinction between self and others, we not only reinforce the experience of our self, we can also, at the same time – whether we realize it or not – sense others as "you." If this is what happens at the human level, the same process needs to happen at the quantum level. This means that quanta are drawn to form relationships with other quanta when the interest is shared and mutual. The relationship then takes on a life and reality of its own. This process of perception is so dynamic that it feels alive. This is what makes relationships special and why they lead into dramatically new types of experiences.

This process of positive feedback also happens unconsciously. Simply being with someone can trigger a desire to know them better. We call it "chemistry." According to this postulate, this sense of attraction also happens between quanta. We will see later that there is strong physical evidence that this is true. In fact, this attraction is the origin of the forces of physics. And mutual feelings of repulsion can emerge in the same way.

This means that both first-person and second-person perceptions grow from the difference between self and others. However, while both of these lenses of perception are sparked by the experience of otherness, they follow different paths. First-person perceptions heighten the distinctions we notice, making the differences sharper and clearer as they evolve. Relationships, on the other hand, grow into shared experiences.

From this postulate we can make an assertion: **A second-person relationship only forms when it is mutually reinforced by another sentient agent.** This means that the inner dynamics of relationships only activate when both agents reinforce each other's perceptions and feelings of the relationship. If one entity is an inert hunk of matter, like a rock, our first-person perceptions of the rock can grow because we like the beauty and color of the rock, but no second-person relationship can develop because the rock cannot return an interest in us. It never becomes a shared experience.

A second assertion: **Second-person relationships do not switch on or off instantaneously by themselves; they start from mere possibilities and continue to thrive and grow through possibilities.** We call them "possibilities" because they only become real when both agents reinforce them. Therefore, "potentia," as Heisenberg calls it, acts as "a strange kind of physical reality just in the middle between possibility and reality." This is why coherent quantum states are never definitive states.

Relationship possibilities continually evolve because perceptions and feelings continue to change. Relationships unfold. They are never certain. And a relationship starts dying when the shared interest flags. Thus, the inner dynamics of relationships are sustained by a shared interest.

From this, I can state the first postulate that directly applies to QM:

4.6 Postulate 6: Quantum Wave Functions Are the Back-and-Forth Reinforcement of Perceptions in Second-Person Relationships

Remember, at this point, there are still no third-person perceptions. No outside observations exist yet. The back-and-forth reinforcement of relationships is only experienced by the sentient agents involved. Second-person experiences stand out because of the highly dynamic nature of positive feedback. Outsiders can never perceive or feel what those involved in relationships experience – the feelings that are mutually reinforced and shared – because these inner dynamics are private and only exist between them. This is what makes the relationship special and real to them.

This explains why outsiders cannot detect quantum wave functions directly. Wave functions never exist as a part of the third-person world that we see outside of us. This goes to the heart of why QM is so difficult to understand when using only third-person lenses.

And from this we can make another assertion: **When physicists say that they are describing the wave function of a particle, they are wrong. Quantum wave functions only describe the inner dynamics of relationships. A particle has no wave function of its own. It is only involved in wave functions through relationships with other sentient agents.** This is consistent with Rovelli's statement that all quantum states and measured values of quantum states are relational.

Note: When physicists talk about the wave function of an electron, this is really describing the relationship between the internal agency of the electron and the electron particle field. This is a different type of relationship, as we will see later.

Another assertion: **Second-person relationships are the source of quantum entanglement.** This is easy to see because entanglement is nothing more than a shared quantum state, such as a shared spin state. Therefore, we can also assert that: **Entanglement is only possible between sentient agents.** Rocks cannot become entangled to each other, but living creatures can, and so can quanta.

Quantum states describe nothing more than the inner dynamics of second-person relationships. The possibilities in those relationships – what they can become – are the dynamics that drive them. These act as superpositions, and now we can see why, because: **the possibilities of what "might" happen next in a relationship do in fact influence what "will" happen next.** The influence of these possibilities is what makes quantum states so fundamental to everything that happens. This leads to an important insight:

For hundreds of years science has been teaching us the lesson of seeing things as they are. We should not let ourselves be fooled by imagination or beliefs. We need to verify and run tests to know the world as it is. This is a lesson learned from third-person perception and classical physics.

The importance of this approach has proven itself over and over in science and technology. Unfortunately, it hits a wall when trying to study living things because how we see and treat creatures affects how they respond. In other words, third-person perception is exactly the wrong lens for studying relationships.

Think about it: In a relationship, is it best to accept the way things are? Should we only try to see the relationship as it is currently? Or, should we actively engage with our partner in sparking the relationship to grow into something more? This is why, when we see and feel new possibilities, we breathe life into relationships. They take on a life of their own when we care and nourish them, the same way we water plants. We do that by seeing possibilities in our relationships. Friendships and families need to evolve, or they fade away.

This is what quantum mechanics is trying to teach us: **Perception – the way we see other living things – is creative because it changes our relationships.** Seeing things only as they are is death for relationships. It stops the process of positive feedback because the possibilities stop evolving. They can never grow strong enough to cross over and become objectively real. (More on this later).

Therefore, if this postulate is right and quantum states are wave functions, which are actually just the reinforced possibilities in relationships, then we can see why they will never obey the Principle of Non-contradiction (PNC) or the Law of the Excluded Middle (LEM), which are two first principles of logic that have formerly been considered self-evident. The paper on "Taking Heisenberg's Potentia Seriously" puts it this way:

> Together, PNC and LEM constitute a principle of exclusive disjunction of contradictories, wherein a proposition P is necessarily either true or false, with no 'middle' alternative. Russell presented LEM this way: "Everything must either be or not be" (Russell, 1912, 113). When interpreted classically, Russell's formulation implicitly only acknowledges one mode of 'being' – that which is actual. Thus, a tacit classical assumption behind LEM is that of actualism: the doctrine that only actual things exist. However, as will be demonstrated presently, in the context of quantum mechanics, PNC and LEM together evince the ontological significance of *both* actuality and potentiality, given that every quantum measurement entails the former's evolution from the latter by way of probabilities, which also satisfy both PNC and LEM. (Kastner, Kauffman, and Epperson, 2017, pp. 5-6)

In other words, quantum formalism is showing us that possibilities determine the probabilities of what will become actual. If quantum states by themselves are not actualities, but relationship possibilities, it is easy to see that they will still have a very real impact on sentient agents. They will play important roles in physics because relationship possibilities are highly dynamic in shaping everything that actually happens. However, they do not obey the laws of actual realities.

We should also remember that, beneath the surface of all relationships and wave-functions, first-person perceptions are always present and active. Yes, sentient agents reinforce each other's perceptions in a thriving relationship. But shared interests must arise from the interests of each sentient agent. This is why the behavior of quanta is unpredictable. Relationships shape everything that happens in the world, but they lead only to statistical laws because relationships ultimately depend on first-person perceptions as well. How two sentient agents respond to each other cannot be predicted, even by the partners themselves.

However, the quality of spontaneous and fluid aliveness that we see in relationships seems to be missing in the classical world of rocks, mountains, and planets. Inert "things" do obey the laws of PNC and LEM. Why do the creative powers of possibilities disappear in the classical world? From the principles described above, we now have the tools to start answering this question.

4.7 Postulate 7: Third-Person Perception Emerges from Experiences with Third-Person Relationships

We are on a journey to see how everything emerged from nothing but consciousness. How far have we come so far? We have agents with first-person perception, and we have a world filled with second-person relationships. In other words, we are still a lot closer to "nothing" than "everything." The tangible world does not exist yet. There is no matter or energy, and we have yet to see anything close to Newton or Einstein's idea of space.

However, there is a perception of time at this early stage: the experience of time flowing that comes from evolving relationships. Gradual growth in the back-and-forth reinforcements of perceptions, as relationships unfold, create the perception of time passing, but this is only experienced by agents in relationships. A recent quantum experiment validates that this is indeed a source of local time:

> Time is an emergent phenomenon that is a side effect of quantum entanglement, say physicists. And they have the first experimental results to prove it….
>
> [T]hey confirm that time is indeed an emergent phenomenon for 'internal' observers but absent for external ones. (The Physics arXiv Blog, 2013)

In other words: **Second-person perception leads to a relational experience of time that flows and varies with the intensity of the relationship.** Thus, time speeds by when we are having fun.

There is also a sense of space that exists in relationships. I call it relational space. For example, we feel a sense of closeness in relationships that reflects our level of interest and our involvement. However, this is nothing like the kind of third-person space that we experience in the world outside of us. Third-person space is a universal public space, you might say, not a private relational space that can only be perceived by those involved.

Fortunately, a sense of three-dimensional space began emerging as soon as the first third-person relationships started. And we now have the principles to see how this began.

If we go back to a point where the world had only two sentient agents, we find only first-person and second-person experiences and perceptions. However, as soon as more agents arrive, the story changes. Most of these agents form one-on-one relationships with each other. As a result, new perceptions start emerging that make all of these relationships more complex.

To illustrate, imagine transferring to a new university. You start making friends as you get to know people. After forming a few personal friendships, you notice that your new friends have friendships of their own with others. How do you feel about their friendships? What if some of their friendships are with people you do not like? Think of how it feels when your friend's other friendships seem stronger than the one you have with your friend? You notice these things, right? Why? Because these are outside influences that affect your relationship with your friend.

All of your friend's friendships have an influence on your friend. Those relational possibilities all affect your friend at the same time. In other words, they act the same as superpositions because this is where superpositions come from. So, when you become entangled with a friend, you also become entangled with your friend's friends, but this is a different type of entanglement.

I call these "third-person relationships." They are different from personal one-on-one relationships that you have with your friends. For example, you may know the names of your friend's friends and something about them, but you do not really know them. You know *of* them. If you meet a friend when they are having lunch with their friends, it can feel a bit weird at first, as if you are on the outside looking in. You see something going on between your friend and his or her friends that you are not involved in, except you *are* involved in a strange way through your friend.

In other words, third-person friends seem impersonal. They also act as outside influences affecting your second-person relationships. You notice things about them when you first meet them, such as how tall they are, the color of their hair, or the clothes they are wearing. These are the same types of first-person perceptions you would have when meeting a stranger, because they actually are strangers to you, until you get to know them better. You may feel entangled with them in a strange way, because they are your friend's friends, but relationships with your friend's friends feel far less personal and they seem more like outsiders to you. They only interest you because of the way they affect the second-person relationship that you have with your friend. This is the nature of third-person entanglement.

How does third-person entanglement work? We know that second-person relationships develop through dynamic back-and-forth exchanges that evolve through the reinforcement of two people's interest in each other. Second-person relationships take on a life of their own – a life that is shared only between the two involved. They are highly dynamic because of positive feedback that evolves and grows. The possibilities in second person relationships are the foundations of quantum states.

Third-person relationships, on the other hand, are quite different because there is no reciprocal positive reinforcement of possibilities. This is why third-person relationships feel impersonal. And yet we are still entangled with our friend's friends because they are entangled with our friend. In other words, third-person entanglement only exists because of second-person relationships.

Our lives are clearly expanded by our friendships. We meet countless people through our friends. Those third-person friends also have friends. And, of course our friends have families and their friends have families. And the members of our family, with whom we grew up, also have friends who have friends. We are in a strange way related to almost everyone in the world through friendships or families. Whether there are no more than six degrees of separation between us and anyone else, as one author suggested, the fact is that we are all entangled in a strange indirect way.

Why is this important? Because, as Wigner said, we listen to our friends, and because of that we also listen to our friend's friends as well. They become sources of information for us. We may not trust people we do not know, but when we hear information over and over from many third-person friends, the information compounds to take on a sense of reality.

This directly relates to the story I told in section 2.1.1, where you go to a party and a fight breaks out. You learn about what happened from the third-person perceptions of others. Now we can see what was happening: Third-person information comes to us through our friendships. This is why the relationship you have with a person passing information to you determines how much weight you give to the things they say. And, since everyone at the party is related through friendships to everyone else who is there, you listen at least partially to what everyone says.

The stories we hear become clear only when a consensus emerges about what happened. In other words, the third-person stories need to agree with each other. Only when a clear consensus emerges about what happened, such as where the fight happened and who was involved, will we have a solid feeling that the story is telling us something that really did happen. We gain this solid feeling not just because we feel the weight of agreement between all the stories, but also because everyone else feels this weight as well.

In other words, when stories agree with each other, those stories take on a sense of objective reality. When stories do not agree, they seem weak – not real. This is distinctly different from the reinforcement of feelings and perceptions in second-person relationships that grow from the one-on-one, back-and-forth exchanges between two people, making their relationship a private affair. With third-person relationships, it is third-person (outsider) stories that seem real when they agree.

This process is actually based on negative feedback, not on the positive feedback we see in second-person relationships that makes them so dynamic. Negative feedback is the way oscillating systems converge. For example, negative feedback shuts off the heater in your house when your house reaches the threshold temperature on your thermostat. Third-person stories converge for the same reason. History books are great examples of third-person stories converging from thousands of people. However, only the outsider stories converge. The personal experiences of people who lived during the same period of time vary so widely, from person to person, that they do not converge.

With second-person relationships, we see positive feedback creating relationships that have a life of their own. It is positive feedback that makes them dynamic. Third-person perceptions, on the other hand, reach consensus only when they agree. Differences weaken third-person stories. On the other hand, differences in second-person relationships often make things more interesting.

Therefore, third-person perceptions converge through a form of negative feedback from everyone, creating a consensus view. This is how our experience of a public reality emerges.

The third-person world – the world "out there" – is created by outsider perceptions that agree. Third-person relationships are also where "outside" forces come from.

Let's translate this back to the quantum world. The key elements are:

1. Second-person relationships, in a world of sentient agents, leads to outsider experiences. When it comes to relationships with third-person "friends," every agent is on the outside. These third-person relationships form only through second-person relationships.

2. Third-person relationships are sources of outsider perceptions. Third-person relationships also act as outside forces that influence personal relationship possibilities (quantum states).

3. When outsider perceptions agree from many sources, the consensus converges – producing a public reality. These perceptions consolidate through negative feedback, creating a norm. At the same time, differences in third-person perceptions fade away through negative feedback because they do not seem real. This creates an outside reality perceived by all of the agents related through third-person relationships.

4. **This third-person outside reality is what physicists call a "field."**

5. At the human level, fields are called "societies" or "communities." It is easy to see, at the human level, that these perceptual fields are formed by the perceptions of the people.

6. Most physicists think of fields as the driving sources of change in our world, with particles being merely the ripples on those fields. It is easy to see why third-person relationships act as if they are external forces, however, the LoP Interpretation says that sentient agents are the true source. Their outsider perceptions create and sustain all fields. It is easier to see this at the level of living creatures, but it is just as true for quanta.

I will now state this as a postulate and describe the results in detail:

4.8 Postulate 8: Fields Are Created by Third-Person Relationships

With this statement, we enter uncharted territory. This postulate tells us that fields are created by a special type of relationship. This is a different type of entanglement than the type seen in personal second-person relationships. And the results are dramatically different.

For example, second-person relationships are intense and highly personal. The inner dynamics are only experienced by those who are directly involved.

Third-person relationships, on the other hand, are impersonal. This is why third-person perceptions form the background of the world, not the dynamic foreground. Also, fields emerge unconsciously through negative feedback. This is why they seem automatic, not personal or dynamic.

A tapestry of third-person relationships creates our public reality. It is reinforced by everyone. This process of reinforcement spreads so far out across our web of relationships, and is reinforced by everyone so unconsciously, that the public reality seems to exist on its own. It seems to be a reality that is not altered by how we see it, because our individual perceptions are just one out of millions. However, the "real world out there" is simply a consensus of everyone's third-person perceptions.

We hardly notice the subtle ways that we accept and adjust to the social culture we live in until we visit a foreign land. Then the differences jump out at us. Social influences coerce us to go along with the crowd, even though people rarely force us overtly. Peer pressure is usually an impersonal pressure that seems to come from everyone. It pushes us all to conform. This is how fields act as external forces.

This postulate leads to a number of significant insights. However, no other interpretations of QM suggest that there are different types of entanglement, as far as I know. This means that this postulate faces a major challenge. We need to confirm that it is valid.

Fortunately, this postulate solves one of the biggest problems in the interpretation of QM: how quantum states create a macroscopic world that seems solid and objectively real.

> *The classical limit of quantum mechanics* refers to the belief that quantum mechanics is a more fundamental theory than classical mechanics, so that classical mechanics should emerge from quantum mechanics in some appropriate limit.
>
> Ideally, this emergence would result from some simple limiting procedure.... Alas, no generally applicable route to the classical limit has ever been found. Despite what some textbooks suggest, it is not clear how, or even if, the classical limit can be realized. It now appears that any resolution of the classical limit problem will require, at the least,

> *both* a limiting procedure *and* accounting for the interaction of quantum systems with the environment through a sophisticated approach known as *decoherence.* (Bowman, 2008, p. 31)

Third-person relationships offer a solution to this problem. Negative feedback creates the limiting procedure that has been missing because third-person perceptions converge when they align with the consensus. This is how the classical reality of an external world with external forces emerges. Societies and fields seem to exist on their own. They do not seem to be affected by how we see them because they are formed by countless outsider perceptions.

The process that forms fields and societies is a limiting procedure that creates a classical world for two reasons: First, the effect is weak when only a few sentient agents are involved in third-person relationships. The influence becomes significant only when the group grows large. This is why peer pressure is only noticeable in large groups. Small groups are far more influenced by personal second-person relationships because the effects of fields are small. Second, fields act as forces that resist change. In other words, they create stasis and conformity by converging toward a norm.

These two traits form a limiting process that creates the classical world at the macroscopic level.

This process is also consistent with the approach known as decoherence because the information that converges comes through entanglement with other particles in the environment. However, this new postulate needs testing, because, while the mathematical equations that model the process of decoherence are consistent with fields forming through third-person perception, the interpretation of how this works is quite different from the current theory of decoherence.

4.8.1 A New Interpretation for Decoherence

Since Newton's time, physicists have followed certain beliefs. For example, when an object is measured, and everyone finds the same results, this indicates that we have learned something about the object itself. And, if we want accurate measurements, we need to limit the interference of outside noise. In other words, isolating an object from the rest of the world is the best way to learn about an object's true properties and its state.

Physicists now know that this is impossible for quantum mechanics (Schlosshauer, 2008, pp. 1-3). Tangible and visible objects are always coupled (entangled) with the environment. The moment we make a measurement, we couple with the object being tested along with our equipment. More importantly, the process of entanglement, according to decoherence theory, is what appears to cause the “classical” tangible world to emerge from pure quantum coherent states.

> [O]ver the past three or so decades it has been slowly realized that the isolated-system assumption...had in fact been the crucial obstacle to an understanding of the quantum-to-classical transition. It was recognized that the openness of quantum systems, i.e., their interaction with the environment, is *essential* to explaining how quantum systems...become effectively classical: How their “quantumness” seems to slip out of view as we go to larger scales. (Schlosshauer 2008, pp. 3-4)

Decoherence theory says that the wave-like nature of quantum states spreads out and couples with the environment. This means that entanglement is ubiquitous. Classical objects, such as rocks and trees, appear to exist in specific places only because the particles are entangled with the world.

This is why, after a photon in a two-slit experiment becomes entangled with the environment, the interference pattern disappears, because the environment then learns information about which slit the photon goes through. When the path of the particle is not known by the environment, then each slit represents a possible path that the photon may take, and the possibilities of these two paths interfere with each other because they act as superpositions.

The theory of decoherence says that particles lose their "quantumness" when their superpositions "leak out" into the environment through entanglement. Do not worry if all of this seems difficult to picture. A number of physicists have problems with this explanation as well. And this theory does not agree with the LoP Interpretation. To understand this better, we need to take a closer look.

There are a few important facts that make decoherence easier to understand. (The following are from Schlosshauer, 2008). First, we need to know that there are degrees of entanglement:

> This raises the question of how to quantify entanglement, i.e., of how to measure "how much" a given state is entangled. This question is important to decoherence. As we shall see, broadly speaking, the higher the degree of entanglement between the system of interest and its environment, typically the stronger will be the decohering effect of the environment. (p. 32)

The key to measuring how much a given state is entangled comes down to this: If you measure one particle, and this measurement tells you a lot about the state of its entangled partner, then they are strongly entangled. For example, if you measure two entangled electrons and you learn that the spin of one is "up," and this tells you that the spin of the other electron is "down," then these two electrons are "maximally" entangled (pp. 32-33). Full entanglement like this means that you know everything about the spin state of the second electron by measuring the first electron.

On the other hand, if you measure the momentum of one electron and it only vaguely tells you anything about the momentum of the second electron, then the entanglement is weak. If it tells you nothing at all about the momentum of the second electron, then there is no entanglement of the momentum state at all.

The next thing to know is what defines how much entanglement is possible: The degree of possible entanglement is determined by how distinct the quantum states are in relation to each other. For example, in the case of spin, there are only two possible states when they are measured: "up" or "down." And entangled electrons must always be in opposite states when they are entangled. Thus, their spin states are perfectly distinct in relation to each other: They always have exactly opposite spin states. If the spin state of one is "up," the other must be "down."

The momentum of free electrons, on the other hand, can vary across wide ranges of speeds and directions, making it difficult to entangle momentum states because the differences are not black and white, but various shades of grey. (Momentum states of electrons in atoms are different; they are distinct. This, in fact, is usually how maximally entangled electrons are created. They come from electrons that share the same shell in atoms). This leads to an important conclusion: “[T]his distinguishability of the states of one system correlated with the states of another system lies at the heart of an understanding of the conceptual basis of decoherence” (p. 33).

In other words, entanglement needs distinctions. This is why distinguishability is a defining factor. This perfectly aligns with the principle of perception I outlined in section 4.3: **Perception begins with the sensing of differences.** Thus, distinguishability is the foundation of perception itself. And, remember, perceptions must be reinforced for entanglement to form. Therefore, the fact that distinguishability defines the strength of entanglement makes sense because distinguishability defines the strength of perceptions. Postulate three explains why entanglement works this way.

Now, based on what Schlosshauer says above, the current theory of decoherence then states (I will explain what the quote below means afterward) that information about a system being tested, such as a photon in a two-slit experiment, spreads out into the environment through entanglement, and the amount of information that spreads

> increases with the amount of system-environment entanglement, and thus also with the distinguishability of the relative states of the environment correlated with the different component states of the system. The larger the amount of this information about the system learned by the environment becomes, the more the system loses its individuality (in the sense of the inability to assign an individual quantum state to it). As a consequence, quantum coherence initially localized within the system will become a “shared property” of the composite system-environment state and can no longer be observed at the level of the system, leading to decoherence. (p. 33)

> Some states of the system are more prone to decoherence than others, and the sensitivity of a particular state is determined by the structure of the system-environment interaction. The preferred states of the system emerge dynamically as those states that are the least sensitive, or the most robust, to the interaction with the environment, in the sense that they become least entangled with the environment in the course of the evolution and are thus most immune to decoherence…. Similarly, we may say that the interaction with the environment “superselects” the observable states of the system: Some states are robust in spite of the environmental interaction, while other states are rapidly decohered and become therefore unobservable in practice. (p. 73)

The above three paragraphs are the best and clearest explanations I have seen in all the papers and books on decoherence that I have read. However, the details of how the classical world is supposed to emerge, according to this theory of decoherence, are still incredibly vague. Especially, the story about how the “preferred states” of a system emerge through a process that sounds a lot like a happenstance of interactions between the system and the environment.

I will get into more about preferred states later. For now, I want to show the problems in the above three paragraphs, in relation to the LoP postulates of perception.

First, saying that the system being tested loses its individuality when it becomes entangled with the environment is problematic. The first paragraph says that this refers to the quantum state of the system. Thus, the quantum state supposedly loses its individuality. The problem is that this treats a quantum state as if it is a thing. Third-person lenses would certainly like to see it this way, but if the LoP Interpretation is right, quantum states are possibilities in relationships, not things. Clearly, it does not make sense to say that a possibility in a relationship loses its individuality.

It also makes no sense to say that sentient agents lose their individuality when they become entangled because it is not even possible to become entangled unless they are different. Remember, distinguishability is the crucial factor in determining how strongly they become entangled. If this is true, then how can entanglement with the environment cause a loss of individuality? It cannot. The distinctiveness between one agent and another is why they become entangled in the first place.

This brings us to the second issue. According to the postulates I have outlined above, only sentient agents can become entangled. This constraint means that the environment cannot form entangled relationships. Rocks cannot become entangled either. Only sentient agents can couple.

This raises a question: How do we know which agents belong to the environment and which belong to the system being tested? In the case of the two-slit experiment, it is easy, because the photon is the system and everything else is the environment. However, it is not easy to draw this line when it comes to living organisms because they are continually making exchanges, back-and-forth, with their habitat. In fact, I question whether it is even possible to draw a line that separates any system from its environment, especially when we are talking about quantum states that are relationships themselves. For example, a simple electron gains its mass and spin characteristics from its relationship to the electron particle field. If this is true, then how can an electron exist separate from that field?

As soon as we look at entanglement through the LoP lens, a third, bigger problem becomes clear: One-on-one entanglement between sentient agents does not create a shared "system-environment state." It creates private one-on-one relationships. For the environment to form a shared state, third-person entanglement is necessary. However, third-person entanglement does not share the inner dynamics of private one-on-one relationships. This means that superpositions do not leak out from private relationships when particles become entangled to other particles in the environment. Only third-person outsider perceptions spread out. Second-person superpositions remain private.

As a result, the quantum coherence (or quantumness) of a quantum state is not leaked out into the environment when sentient agents become entangled with other agents. The only things that spread throughout the environment are third-person perceptions. This is easier to see with living creatures because they breathe in air molecules made by other organisms and breath out molecules that other organisms need. Losing their shared quantum state would mean death. So the idea that decoherence causes objects to become separate and independent from each other is a problem.

The second paragraph above is even more problematic. It says that some states of the system are more prone to decoherence, and the factor that makes a state more sensitive to decoherence is determined by the structure of the "system-environment interaction." This is quite vague. It then goes on to say that the "preferred states" of the system, which are the states that most clearly stand out to define how we see that system, emerge because they avoid becoming entangled with the environment. This is seriously mixed up, according to the LoP Interpretation.

First, there is no mystery about which states decohere and which do not, according to LoP. Only third-person perceptions decohere. This is what spreads throughout the environment. Consensus forms to create one public consolidated picture. When we measure a system, this third-person information is what we are gathering. We are not seeing "preferred states" of the system itself. We are seeing the public consensus of third-person information about the system. This is why a rock appears to be located in a certain place on the ground, and it looks the same way from all viewpoints. Everyone sees the same outer reality because these are third-person perceptions. We are not looking at the state of the rock. We are looking at the shared outsider picture of the rock. That is what we see with our eyes and instruments, making it look like an external reality.

The same thing happens at the human level. For example, consider people calling someone "a movie star." Star status is not a property that belongs to them by themselves. That is a consensus perspective seen by people in society. When a person becomes famous after playing major roles in a number of successful movies, we feel comfortable saying that it is a fact they are a movie star. However, star status is not clear if an actor has only a minor part in one movie. Their status as a star is then debatable. There is no consensus. Thus, the state of being seen as a movie star emerges as they play major roles in more movies. Therefore, according to the LoP Interpretation, "preferred states" emerge through a simple process: the consensus that forms from third-person perceptions.

The third paragraph, in the quote above, turns this issue into an even bigger problem by suggesting that the environment "superselects" the preferred states. This process, called "einselection" (short for environmentally-induced selection), is often compared to Darwin's theory of natural selection, where the environment selects the fittest creatures by killing off those that are least fit. There are two big problems with this comparison to natural selection. First, evolutionary fitness is nothing more than the ability of a creature to survive. This means that the whole concept of fitness is circular because a creature's survival is also how we measure its fitness.

Second, Darwin's theory is about the survival of living creatures. We do not see rocks or piles of sand evolving. More importantly, Darwin knew that lifeless properties in an environment, such as temperature or wind, only cause creatures to adapt to changes in the environment. No new species or abilities "emerge" through natural selection this way. The emergence of new abilities and new species requires life responding to life, such as through competition, where predators hunt for prey, or symbiotic cooperation between life forms. The reason Darwin said this is because dynamic, positive feedback is needed to create the directional power of evolution. Thus, the real driver of evolution is the relationships between sentient agents, bringing us back to the LoP Interpretation.

> Natural Selection, at the "bare bones" of its mechanism, only builds adaptation to changing local environments; the principle includes no statement about inherent directionality of any kind, not to mention progress.
>
> Darwin resolved this…by invoking a particular ecological context as the normal stage for natural selection. If most ecosystems are chock full of life, and if selection usually operates in a regime of biotic competition [living organisms competing with other living

> organisms], then the constant removal of inferior by superior forms will impart a progressive direction to evolutionary change in the long run. (Gould, 2002, p. 479)

Once we bring the discussion back to the relationships between sentient agents (the LoP theory), the picture becomes clearer. The dynamics driving the quantum-to-classical transition are based on the spreading and consolidation of third-person perceptions across a web of third-person relationships. This is how our experience of the world out there is created. On the other hand, the processes that create new species and new abilities depend on personal relationships between sentient agents.

Of course, it does *seem* as if the environment is selecting. The public can *seem* quite fickle in its love of movie stars. Harsh environments at work do *seem* to decide the fates of creatures. However, when we look at this from the quantum level, from the level of sentient agents, it becomes clear that sentience is needed to make true choices – to do any selecting. People choose, not the public.

With the above explanation, we can now compare decoherence theory against LoP theory. Let's take a look.

4.8.1.1 The Speed of Decoherence

We need to separate this discussion on decoherence into two parts. First, is the mathematical description of how interference patterns disappear as particles like electrons and photons interact with other particles in the environment. Second, we need to compare the interpretations about how this process works and what it means.

Starting with the first part, mathematical equations have been developed to predict the speed of decoherence. These equations have been validated by experiments. Countless tests have shown that the more interactions a particle has with other particles when passing through a two-slit experiment, the more rapidly the interference pattern disappears.

Interactions with the environment do not have to involve transactions of energy; they can be purely quantum interactions that arise from passing by or being close to one another. However, in most cases, energetic interactions are also involved, such as interactions with air molecules, photons from ambient light, background radioactivity, cosmic radiation, solar neutrinos, etc. (Schlosshauer 2008, p. 115). Very little interaction is needed to create a measurable amount of decoherence.

A full mathematical analysis of the equations that have been shown to predict the disappearance of interference patterns is quite complex and beyond the scope of this paper. However, the main factors driving those equations are based on the principles I described above, along with a couple additional factors. Let's review them one by one.

1. The degree of entanglement is an important factor, as I said above. According to decoherence theory, this is determined by distinguishability.

   The LoP Interpretation agrees. Distinguishability determines the strength of entanglement because distinguishability determines the strength of perception, and perception must be reinforced for entanglement to exist.

2. According to decoherence theory, the higher the degree of entanglement, the stronger the decohering effect will be.

   The LoP Interpretation places an equal weight on the importance of entanglement. The stronger the entanglement (meaning second-person relationships), the more it becomes a channel for information to flow out to other sentient agents in the environment, and for information to flow from the environment to the system being tested. Strong second-person entanglement increases the decohering effect because information carries more weight when coming from a trusted source (with a higher degree of entanglement). This is easy to understand at the human level. However, the LoP Interpretation says that it is third-person relationships that pass along the outsider information that provides the decohering effect. Nonetheless, the mathematical weight from second-person entanglement will be the same because all third-person relationships come through second-person relationships.

3. If the strength of entanglement is a factor in decoherence, then distinguishability plays a crucial role in deciding which quantum states will decohere the fastest, according to the theory of decoherence. This means that position and momentum states, which differ only in grey variations, not black-and-white distinctions, will not spread across the environment, but will remain behind as “preferred states” of the system being tested. Distinctly defined states (such as the two-slit options) will lose their superpositions as those superpositions spread out into the environment. For the same reason, it will not be easy to assign an individual quantum state to spin states, because they are also distinctly defined.

   The LoP Interpretation says that this is backwards, but the end result is the same. Position and momentum information is what spreads throughout the environment because this is third-person information. This is why the first information to decohere is the position and momentum of a system. If an electron does not interact with other sentient agents, there is no way of knowing where the electron is located or what its momentum is. However, when location information does spread, it suppresses the interference patterns in two-slit experiments because the path of the photon becomes publicly known. (More on this later).

   Entangled spin states are different. They are not weakened by third-person information because their shared spin state is the result of a second-person relationship. This is why entanglement between photons has been shown to persist when separated by more than a thousand miles, even when the photons go through fiber optic cables, bounce off mirrors, and pass through optical beam-splitters and prisms. This is why entangled spin-states are notorious for resisting decoherence.

4. The most important factor for defining the speed of decoherence, according to the theory of decoherence, is the number of particles that the system being tested becomes entangled with, and the number of other particles that those particles become entangled with.

   LoP theory agrees, because it is those “other particles” that receive and pass along third-person information, and each particle that becomes directly entangled with the system being tested opens up new channels of information that flow out to those “other particles.” The total number of particles involved play a defining factor because the more that third-person information is confirmed by others, the more influential it becomes. At the human level, this is easily seen by how peer pressure and the need to conform increases as the size of a company grows. Small start-up businesses experience far more freedom and spontaneity, while large institutions become strapped by red-tape and bureaucracy. This all happens so unconsciously that it seems mechanical and external.

5. The size of the system being tested can also be a factor, according to decoherence theory, because the larger the system is, the more likely it will interact with particles passing by.

   LoP theory agrees with this for the same reason.

These are the factors that have proven successful in predicting the speed with which interference patterns disappear through decoherence. As you can see, decoherence theory and LoP theory agree on the weighting factors determining the rate of decoherence. Perhaps a more detailed analysis can identify differences that are testable. More study is needed to see if that is possible. For now, I see no way to distinguish how these two theories predict the speed of decoherence.

Next, I compare the interpretations. Here there are clear differences that affect the outcome.

4.8.1.2 Interpreting the Process of Decoherence

According to decoherence theory, the process of entanglement causes the quantum coherence of particles to leak out into the environment. The environment effectively absorbs the superpositions that make quantum states so hard to nail down. This causes particles to become "classical" in their behavior. In other words, after decoherence, particles act as if they are located in clear positions, have clear trajectories when they move, and have clear momentum states. As a result, it is common for decoherence theorists to declare that the wave-like nature of coherent particles disappears, and their particle-like nature emerges through decoherence.

Another important claim is that these clearly defined "preferred states" that emerge through decoherence are selected by the environment through a process called "Quantum Darwinism" (Zurek, 2009). Thus, the theory of decoherence is often claimed as a solution to how the quantum world becomes classical.

However, there is a fundamental issue with the above interpretation: It all depends on a distinction between the system and its environment. Without a distinction, there is no entanglement between the system and the environment. And without this entanglement, the distinctiveness of the system cannot emerge. Therefore, the claim that decoherence explains the quantum-to-classical transition also requires the property of distinctiveness, in the beginning, that it claims to produce in the end. This is clearly a problem of circularity. If distinguishability is needed for entanglement to begin, then no one can claim that decoherence creates distinguishable states.

Schlosshauer (2008), quoted above, explains the matter this way:

> Note that decoherence derives from the presupposition of the existence and the possibility of a division of the world into "the system" and "the environment." (p. 101)

> This system-environment dualism is generally associated with quantum entanglement, which always describes a correlation between parts of the universe…. [T]erms like "observation," "correlation," and "interaction" will naturally make little sense without a division into systems. (p. 102)
>
> However, the assumption of a decomposition of the universe into subsystems (as necessary as it appears to be for the emergence of the measurement problem and for the formulation of the decoherence program) is definitely nontrivial… Zurek was one of the first to clearly point out this conceptual difficulty:
>
> In particular, one issue which has been often taken for granted is looming big, as a foundation of the whole decoherence program. It is the question of what are the "systems" which play such a crucial role in all the discussions of the emergent classicality (…) [A] compelling explanation of what are the systems – how to define them… – would be undoubtedly most useful. (Schlosshauer, pp. 102-103)

In other words, the question is: How do distinctions between systems come into existence in the first place? A reviewer of Schlosshauer's book, N. P. Landsman (2009), is more pointed about this issue:

> [D]espite Schlosshauer's insistence that "the decoherence program is derived solely from the well-confirmed Schrödinger dynamics" and that accordingly this program "attempts to explain the emergence of classicality purely from the formalism of basic quantum mechanics" (p. 337), in actual fact the whole program hinges on an interpretational move that cannot be read off the Schrödinger equation or any other ingredient of the formalism. The move in question is the assumption that…the einselected states form a basis,...this 'preferred' basis is taken to be the one over which the theory is interpreted.... Nothing in the formalism dictates this procedure. (p. 2)

This preferred basis is the set of properties that define the system. According to decoherence theory, this basis is formed by "the structure of the system-environment interaction," as Schlosshauer says above. This is why I said that this process is vague, because it is not defined by quantum formalism. It just somehow works out through happenstance. Other articles suggest that this problem goes much deeper. It is fatally flawed.

For example, Fields (2018) points out that "environmentally-induced superselection," known as einselection, is presented as an "observer-independent mechanism by which apparently classical systems 'emerge'" (p. 1). The assertion that this process is observer-free makes it an attractive idea to physicists because it fits the traditional lens of classical physics. As a result, it appears as if einselection converts the

> environment from a passive sink for quantum coherence into an active "witness" that continuously determines the observable states of the systems embedded in it… Quantum states that are continually "witnessed" by the environment are effectively classical; hence it has been proposed, under the rubric of "quantum Darwinism," that einselection provides an observer-independent physical mechanism for the emergence of classicality… If this proposal is correct, einselection answers one of the deepest questions in quantum measurement theory: the question of "how one can define systems…." In recognition of this, einselection has been called "the most important and powerful idea in quantum theory since entanglement."

> The present paper shows that a recognizably classical world of discrete, bounded objects acted upon by external forces only emerges via einselection if "systems" are defined in an observer-dependent way. It thus shows that einselection does not provide an observer-*independent* mechanism for the emergence of classicality. (p. 2)

Fields goes on to show that for einselection to work, it must first assume that subsystems exist. In other words, "the 'environment as witness' formalism implicitly assumes the effective classicality of the environment" (p. 3). If it has to assume the classical world exists to begin with, in order to make the theory of Quantum Darwinism work, it does not provide a mechanism for the observer-*independent* emergence of classicality. For that emergence claim to be true, according to Fields, "einselection must not only establish a preferred basis for *S* [the system], but also establish a boundary for *S* that separates and hence distinguishes it from all spatially-distinct systems" (pp. 3-4).

This is significant because there is no entanglement possible without this distinction. More importantly, as Fields points out, there is nothing in quantum theory that determines the choice of what the system is and what it is not (p. 6).

In other words, a particle-like property cannot emerge through einselection because the distinction between the system and the environment is needed for entanglement to take place. If only coherent wave-like properties exist to begin with, there are no boundaries, no clear distinctions, because wave functions spread out everywhere. After a lengthy detailed analysis, Fields continues:

> Einselection cannot, therefore, be viewed as an observer-independent mechanism for the emergence of classicality; doing so requires the assumption that the environment is effectively classical and is therefore circular. This circularity cannot be rescued by a bootstrap argument, since an effectively classical environmental fragment must be assumed for every emerging object, and such an assumption must be made independently for every observer. It also cannot be rescued by assuming a physical but observer-independent restriction on the choice of systems to be einselected. Any such restriction…also introduces circularity.... If einselection is to be considered a physical mechanism for the emergence of classicality, therefore, it can only be considered to be an observer-dependent mechanism. (pp. 8-9)

This explains why Bowman (2008) said (above) that decoherence alone cannot explain the emergence of the classical world. A limiting process is also needed (p. 31).

The point that Fields is making here is significant. It not only says that we must give up the idea of observer-independence when it comes to analyzing the processes that lead to decoherence. It also implies that only observer-*dependent* mechanisms are possible.

Even Rovelli, who shows that there are no observer-independent quantum states or values, does not seem to fully recognize what this means. Fields' point tells us that Rovelli's Galilean observer, a lamp, must be abandoned, because the lamp is a classical object. (See section 2.1.2 above).

We cannot start with classical objects. We must start with quantum states. Everything that Fields says here is in agreement with the LoP Interpretation.

The process that leads to entanglement starts with sentient agents perceiving distinctions between themselves. These agents possess clear properties that distinguish them as individuals because of their internal agency – their ability to act in response to perceptions. However, the spatial boundaries of these internal agents are not well-defined in any way because they are entangled with others in their "habitat," the same way that living organisms cannot be clearly defined without killing them. It is their individuality that is well defined by the way they carry mass and energy, but this only displays itself when they are measured, or when they actively exchange energy.

Fields asks, What are the "fragments" of "every emerging object" that grow to take on the classical properties that we see? The LoP Interpretation can answer this: Sentient agents are the fragments. The classical world emerges through the consensus of third-person perceptions. The environment emerges as a field, establishing an external world that appears to exist independently of observers. This third-person consensus forms the "basis" for how objects are seen. But, none of this is observer-*independent*. In fact, every step in the selection process requires first-person perception because only sentient agents can select, so, of course, it is fully and completely observer-*dependent* by definition.

If we want to explain the process of decoherence, we need to be able to start with the world's first observers and show how the third-person classical world emerges naturally. This is the only way to solve this problem. Decoherence theory cannot explain how this happens because it assumes an environment that is distinct from subsystems. LoP theory offers a solution. To illustrate how this works in more detail, let's look at how the three dimensions of space emerge as a field.

4.8.1.3 Decoherence and an Insider's View of Space

With the emergence of third-person entanglement, outsider information is shared and naturally converges by suppressing information that does not agree with the norm. This naturally reinforces the norm, strengthening our experience of an outer reality. This all happens unconsciously, so even primitive sentient agents should be influenced by the emergence of this outer reality, the same way living organisms are.

To see how this works on the quantum level, let's go back to the first sentient agents when they started sensing third-person perceptions. I will start with five sentient agents, named *A*, *B*, *C*, *D*, and *E*. Of course, these sentient agents form entangled one-on-one relationships with many, if not all of the other agents. We also know that all these relationships exist at the same time, and the possibilities in the relationships act as superpositions. We can say that all of the possibilities in the relationships that *A* has with other agents represent its full quantum state.

Now, let's say that *A* forms a second-person relationship with *B*, *C*, and *D*, when agent *E* comes by. We should expect *A* to sense responses from *B*, *C*, and *D* to agent *E*. For example, *B* might have the strongest response because it is closer to *E* than *C* or *D*. Or *C* or *D* might be closer. Whatever the arrangement, a sense of relative closeness should emerge from the differences that *A* senses between the responses of *B*, *C*, and *D* to *E*. Remember, these are all third-person perceptions, which means that they are all based on comparisons between others. And these perceptions come to *A* through its second-person relationships.

Of course, saying that *A* perceives a sense of relative closeness does not mean that agent *A* has a yardstick and measures how close *E* is to *B*, compared to how close *E* is to *C* or *D*. No, these are purely unconscious perceptions – the sense that *B* responds in such a way that it appears to be nearer to *E*, and that *D* is farther away, you might say. No analysis is involved. *B* simply seems closer to *E* than *C* or *D*, based on their responses to *E*.

These are relative comparisons that *A* senses. This is why they are grey. The distinctions are weak and not at all certain to *A*. Further, these differences only have meaning as comparisons: *B* seems nearer to *E* than the others. The perceptions that *A* has about this are impersonal because they come from the responses of *B*, *C*, and *D* to *E*. And from this third-person information, *A* forms a vague perception that one sentient agent, *E*, is responsible for all of these responses from *B*, *C*, and *D*, because they all seem to happen as *E* passes by. As a result, *A* gains a half-formed perception of a comparative arrangement between the other agents in relation to *E*. This shows why third-person perceptions are different. They do not act as superpositions because they use only negative feedback, not positive feedback, when they combine to form a consensus.

One-on-one personal relationships also exist at the same time, and the possibilities in these relationships do act as superpositions, but they do not combine, because they are privately shared perceptions between agents. This is why second-person possibilities interfere with each other when the phases of their wave functions conflict. The math that describes how this works in quantum formalism is based on treating quantum states not as "real" functions but as "complex" functions, meaning that one of its mathematical axes is located in an imaginary ($\sqrt{-1}$) domain. According to the LoP Interpretation, this imaginary domain represents the private one-on-one relationship state.

Third-person perceptions are different. They are impersonal. As a result, they have no axis centered in an imaginary domain. At first, there is no shared basis for third-person perceptions, but because they relate to things that exist and persist as real (not complex) functions, they naturally converge to form a common basis, creating a field. This is how third-person possibilities converge through consensus. This background reference becomes the basis that all measurements are made from.

If *E* is really there and is passing by gradually, then perceptions of *E* will continue. These will reinforce the perceptions that *E* is there. This will also reinforce *A*'s perceptions that all of these responses of *B*, *C*, and *D* are related to *E*. This strengthens *A*'s half-formed perceptions.

The argument might be raised that there is no way *E* could "pass by" before the field of space exists. This is true, but it is not important because the field of space only emerges from what *is* being perceived and what perceptions *are* persisting. Thus, the perception of *E* passing by emerges.

However, the above discussion is still only about *A*'s perceptions. If third-person information is naturally shared through entangled relationships, as I am describing here, then of course agents *B*, *C*, and *D*, will also gain a sense of *E* from responses of the others, including *A*'s responses to *E*. So, they each develop half-formed perceptions of an arrangement between the other particles through relative comparisons of their nearness to *E*.

When *A*, *B*, *C*, and *D* compare the third-person perceptions of others with their own, which are still only vague perceptions and subtle feelings at best, they will eventually notice that the responses of others seem related to the passing of *E*, but there are differences. They are not exactly the same. When these differences have no pattern to them and no consistency, they will be ignored because they do not appear to represent anything real. Those third-person perceptions perish, you might say. They disappear. However, even subtly agreeing perceptions will be reinforced and gain strength, especially if they persist. Thus, a shared consensus emerges.

It is worth mentioning here that every third-person perception of something real does not need to be strengthened. All that is needed is a general tendency to reinforce perceptions that persist and correlate with other perceptions.

With only five agents in the world, it is hard to imagine any more than a vague sense of an outsider arrangement between the nearness of the agents in relation to each other. However, as the number of agents in the world increases, the experience of a 3-D representation will naturally emerge, creating a spatial sense of a real world. Why three dimensions? Because this experience of an outer reality comes from third-person perceptions that are confirmed by other third-person perceptions.

Let me explain. Every sentient agent is an outsider when comparing others. If agent *A* is only looking at its own third-person perceptions, a two-dimensional map is enough to represent the relative closeness of *B*, *C*, and *D* in relation to *E*. Each comparison can be represented as a simple two-dimensional triangle, with *A* at the apex, and the other two points of the triangle being the two others being compared.

However, the experience of a 3-D spatial reality only emerges when third-person perceptions of everyone converge to form a consensus. This includes other agents' third-person comparisons of *A* to others. This means that every point on every triangle connects to every point on every other triangle. This is why the field of space that emerges is experienced as a three-dimensional reality.

This field of space, however, is not built on a grid of *x*, *y*, *z*, coordinates. It is only composed of consistent relative comparisons of the nearness and movements of sentient agents.

This experience not only creates the experience of an external spatial reality. It also brings to each agent a sense of their own place in that reality. Psychologists call this a "felt sense" of place, and it is well-known that this forms unconsciously (Marman, 2016, pp. 90-96). This experience of being in the world is a big part of what makes our experience of the world objectively real to us. This is one of the results created by third-person entanglement.

If LoP theory is valid, another assertion can be made: **Although the field of space emerges from a consensus of third-person perceptions, there can be no outsider perceptions of the field of space itself.** In other words, any agent who experiences the field of space is involved in that field, and any agent that is not a part of that field will feel no interactions with that field. This means that fields are invisible to outsiders, the same way that second-person relationships are invisible to outsiders, because fields are shared quantum states. Yet, fields have real effects on those involved.

This assertion has important implications, because it solves one of the stumbling blocks that has been getting in the way of developing a theory of quantum gravity. Lee Smolin (2017) explains:

> Among the things we had to struggle with were the implications of the fact that the observer in quantum cosmology is inside the universe. The problem is that in all the usual interpretations of quantum theory the observer is assumed to be outside the system. That cannot be so in cosmology. This is our principle and, as I've emphasized before, this is the whole point. If we do not take it into account, whatever we may do is not relevant to a real theory of cosmology….
>
> What is needed is an interpretation of the states of quantum theory that allows the observer to be part of the quantum system. (pp. 40-42)

This is clearly what postulate 8 accomplishes because it shows that the emergence of space must be *observer-dependent*. However, to see how well the LoP Interpretation fits, listen to how Smolin describes the new understanding of space that has emerged from research into quantum gravity:

> [T]here is no meaning to space that is independent of the relationships among real things in the world. Space is not a stage, which might be either empty or full, onto which things come and go. Space is nothing apart from the things that exist; it is only an aspect of the relationships that hold between things. Space, then, is something like a sentence. It is absurd to talk of a sentence with no words in it. Each sentence has a grammatical structure that is defined by relationships that hold between the words in it, relationships like subject-object or adjective-noun. If we take out all the words we are not left with an empty sentence, we are left with nothing. Moreover, there are many different grammatical structures, catering for different arrangements of words and the various relationships between them. There is no such thing as an absolute sentence structure that holds for all sentences independent of their particular words and meanings.
>
> The geometry of a universe is very like the grammatical structure of a sentence. Just as a sentence has no structure and no existence apart from the relationships between the words, space has no existence apart from the relationships that hold between the things in the universe. If you change a sentence by taking some words out, or changing their order, its grammatical structure changes. Similarly, the geometry of space changes when the things in the universe change their relationships to one another….
>
> The view of space as something that exists independent of any relationships is called the absolute view. It was Newton's view, but it has been definitively repudiated by the experiments that have verified Einstein's theory of general relativity. This has radical implications, which take a lot of thinking to get used to. (pp. 18-19)

The LoP Interpretation takes this further, making it even harder to get our heads around, especially if we are used to the idea of a physical world that only exists “out there.” Postulate 8 is saying that the field of space is intangible to outsiders because it is a quantum state. And the relationships are not formed between “things” or objects, but between sentient agents that are themselves intangible until they exchange energy. This means that there is a difference between the field of space and what physicists call space-time, which I will explain in detail, in section 4.9.

All of this shows the importance of seeing what is happening from an insider’s perspective, not just from an outsider’s point of view. This leads us to another interesting insight: The perception of a sense of place, according to the LoP Interpretation, only exists because sentient agents feel coupled to the field of space. This is similar to becoming the citizen of a country, which is an experience that only exists when we form a relationship with that country as a whole. The society we live in is a field formed by sentient agents, just as the field of space is formed. And to live in a society, we must be entangled in some way with that society. Otherwise, it has no effect on us.

This means that our experience of being here, in a place, is not a complete reality in itself. A sense of place only exists when we *also* have a relationship to the field of space. Therefore, there are two related perceptions that are inseparable: (1) Being in a place in space. (2) Being in a relationship with the whole of space. This is the result of two different lenses of perception.

The first of these two perceptions – a sense of place – comes from a sentient agent's first-person perception. This is their private experience of being "here." And first-person perception, as shown in section 4.5, evolves to make distinctions clearer. This is why our experience of being "here" becomes distinct and real.

On the other hand, our third-person relationship with space creates an experience of momentum. Our feeling of motion comes from being entangled to the whole world out there, not just one location. Therefore, position and momentum are products of two different lenses of perception, but both are related to an agent's experience with the same field of space. This reveals a deep relationship between position and momentum, and this gives us a deeper insight into the Heisenberg uncertainty principle. This is worth a closer look.

4.8.2 The Strange Message of Uncertainty

Measuring an object's position and momentum is not a problem with large objects, such as a car. We can measure its speed and location without noticeably impacting where it is or how fast it is moving. This is why we intuitively picture a car moving across a clearly defined path.

However, when it comes to quanta, everything changes. There is no way of knowing exactly where a particle is going when we measure its location. And if we plot our measurements, we see that the particle follows a fuzzy trajectory. It seems to jump around. Plus, if we measure its momentum, it is not clear exactly where the particle is located. There is an inherent uncertainty that can never be removed, suggesting that quantum mechanics itself is incomplete, as Bowman (2008) explains, because quantum theory states that

> perfectly well-defined values of the electron's position and momentum evidently *exist*: yet there is no experiment by which both can be perfectly *known*…. Taken at face value, then, [this] contradicts completeness, for if the electron's position and momentum are precisely defined, and exist, yet quantum mechanics cannot account for that fact, the theory must be *in*complete. (p. 89)

However, the cause of this issue is not our inability to measure both position and momentum at the same time. The real problem is that position and momentum are related to the same quantum state, and this joint state itself seems to be inherently uncertain for some reason:

> Whether or not simultaneous measurements are in fact possible has been a matter of some debate. Regardless, if one insists on the completeness of quantum mechanics, things become outright weird. If quantum mechanics is complete, then the [quantum] state must fully describe an individual system, say an electron. But all information about the

> electron must be contained in the state, and the state yields "blurry" distributions of x [position] and p_x [momentum]. Thus, the uncertainty relations evidently imply constraints on the *existence* of simultaneously well-defined properties of a single system – that is, not only are the *probability distributions* for x and p_x indistinct, so *are* x *and* p_x *themselves*. Again, this strange result arises from an insistence on the completeness of quantum mechanics. (p. 90)

The LoP Interpretation offers insights into this puzzle. First, we can now see why position and momentum are related: They share one common quantum state – the field of space. Second, this shared position-momentum state *is* blurry because it is nothing but a shared consensus of outsider perceptions. Remember, these are third-person stories. They will never give us a sense of absolute certainty, no matter how many stories agree, because it is all third-hand information.

However, this is not a full explanation. For that we need to include the impact of measurements, which require a wave collapse. In section 4.9.2.8, we will see that measurements disturb the field of space because they represent actual changes in second-person relationships. This is exactly the same point that Smolin (2017) made above when he said "the geometry of space changes when the things in the universe change their relationships to one another" (p. 19). The strange message of uncertainty, therefore, is that the quantum state of space *is* blurry because it is always shifting.

4.8.3 Energy Is Needed to Go Against the Norm

Returning to our previous discussion, if an agent has no experience of being in space, then it has no third-person relationship with that field of space. And, if it forms no third-person relationship with a field, then it feels no third-person ties to other agents in that field. This might seem strange when talking about particles, but we all know people who divorce themselves from their countries and communities, even their families. This shows us that first-person perception is involved in all relationships. Later, we will see why this is important.

Now, as the number of agents in a field grows, the experience of three-dimensional reality grows stronger as a perception. And the stronger this perception grows, the more it influences each of the agents in the field, because they each unconsciously conform to this perception.

What does this pressure to conform feel like? It feels the same way that we as human beings feel when we are in a group and try to go against the norm. It is an unconscious feeling that things will go easier if we go along with others. Why fight against the status quo?

This leads to a significant point: **When the number of agents in a field becomes large, going against the norm takes effort. In other words, real energy is needed.**

This is where it gets interesting. Going against the norm of the field of space does not mean moving from one location to another. It means a change in momentum. We know this from Newton's first law of motion: No force (no effort) is needed to keep an object moving at a steady pace. However, acceleration, which is a change in momentum, does require a force. A force is needed to go against the norm because being tied to a field is what creates inertia. If you push an object that is tied to a field, what happens? You feel resistance. Inertia is this resistance to change; it comes from third-person entanglement to a field.

Think about what this means: The field of space establishes a norm that includes particles staying in one location and particles that are moving steadily, but not particles that accelerate. Accelerating particles are going against the norm. We know this is true because acceleration requires a force, as Newton's second law tells us. Why do fields work this way?

There is a simple reason for this, according to LoP theory. Fields are only created by third-person comparative perceptions that persist. These are impersonal outsider perceptions. All forces, on the other hand, emerge from personal second-person relationships, such as attraction and repulsion. This is why forces disturb fields, creating ripples in those fields. (A detailed explanation for how this works is given in section 4.9). Therefore, we can say that the mass of a particle is created by the strength of that particle's third-person entanglement to a field. This is true because mass is nothing more than resistance to a force. And particles resist forces when they are tied to a field. All electrons have the same mass because they are all tied to the electron particle field.

If a particle belongs to two different fields that are independent of each other, such as the Higgs field and the electron particle field, then that particle will be pulled in different directions, even if the particle appears to be stationary, because the two fields move independent of each other. This is how fundamental particles gain "rest mass."

We experience the same feeling when we belong to two different groups, such as a scientific community and a political party. Each group pulls us in different directions. Thus, politics feels like an outside force to a scientific community.

So, our primordial world has grown. It now includes relational time, three dimensions of space, the need for energy when going against the norm of fields, the emergence of mass and inertia, and the foundation for Newton's laws of motion. Third-person fields bring us a lot closer to the classical world. However, we have not solved the whole puzzle yet because fields are still quantum states. We need space-time events and measurements to fully explain the classical world as we know it.

4.8.4 A New Look at the Two-Slit Experiment

Before we move on, we now have a new way of explaining the two-slit experiment, with what we have just learned about fields.

If there are no other agents nearby, when a photon goes from its source through the slits to a point on the screen, there will be no spatial information about which slit it went through. There is clear spatial information about where the photon hits the screen, and clear spatial information exists for the emitter, because the emitter and screen are both entangled with the world. But, if there are no other agents near the photon, then there is no way to pass along third-person information about the photon's path. This means there will be no clear idea of which slit the photon goes through.

As a result, the LoP Interpretation says that the photon does not pass through both slits as a wave. It passes only through one slit, but there is not enough third-person information to tell us which slit. Thus, the interference pattern has nothing to do with the photon changing from wave-like to particle-like behavior. There is simply no way to know the path that the photon takes.

Recent experiments validate this interpretation. Two recent experiments have shown that photons do appear to go through only one of the slits, not both. We simply cannot determine which path without making a measurement (reported in Francis, 2012, and Francis, 2011).

This lack of information about which path is taken affects the photon because it does not know its exact place in the world for that moment in time. It is as if the influence of the field of space is suspended and the photon is free to choose whichever path it likes. Thus, only second-person relationships determine what happens. This is why the two possible paths exist as superpositions and both possibilities influence the outcome. (More on this in section 4.9). But, as soon as other agents, such as particles, other photons, or cosmic rays pass through the equipment, a sense of the photon's path emerges. And as it does, the photon's choices decrease, because the field of space now gives the photon a clearer picture of the path it is taking. This is why the interference pattern fades.

This describes how the process of decoherence works, according to the LoP Interpretation. This does not yet solve the measurement problem, however. For that we need one more postulate.

4.9 Postulate 9: First-Person Perceptions Cause the Wave Collapse

We now get to the heart of the measurement problem in QM: Why are there always specific outcomes whenever we make a measurement and how are those outcomes determined?

This is a thorny problem for quantum theory because it cannot be explained by the gradual linear changes of quantum states that follow the Schrödinger wave equation. It is as if the wave function is bypassed or turned off for a moment, but only for the moment when the wave collapses.

> The measurement problem…is one of the most famous and stubborn in quantum mechanics. Often it is characterized as "the collapse of the wave function," indicating that when a measurement is performed, the result will be one of the eigenvalues of the measured observable. But this description fails to convey the depth of the difficulty. That the wave function (quantum state) collapses when a measurement is performed is indeed surprising, but it is not obviously inconsistent. The real crux of the measurement problem is not simply that collapse occurs, but rather how it occurs.
>
> It can be shown (without undue difficulty) that collapse cannot occur due to "regular" time evolution by the Schrödinger equation…. That is, we must suspend the Schrödinger equation during a measurement, so as to effect the collapse. But must not a measurement simply be a particular kind of physical interaction – different in details, but not in kind, from non-measurement interactions? What, then, can justify "turning off" the Schrödinger equation only during a measurement? As John Bell asked, "are we not obliged to admit that more or less 'measurement-like' processes are going on more or less all the time more or less everywhere? Is there ever then a moment when there is no [collapsing] and the Schrödinger equation applies?" This, more so than collapse per se, lies at the heart of the measurement problem. (Bowman, 2008, pp. 30-31)

We now have the tools to answer these questions. I already provided a story about how this looks from the level of human consciousness. This offers a degree of clarity that gives us added insight into what is happening from an insider's perspective. Here is what I wrote in section 3.3.4:

> The most notable feature of the middle level is defined by **first-person perception**. This is what enables quantum states and unconscious processes to cross over into actualized events and conscious access, making them visible to third-person analysis. This is the source of all tangible activity. Internal agency originates at this level, allowing quanta and living organisms to act as individuals and exchange energy.

The last sentence is the most important when applying this principle to the level of quanta. We indeed see "internal agency" displaying itself when events are actualized. For example, this is when we see a photon clearly hit one spot on a screen. All events that involve energy transactions also display this property of individual quanta because the energy must be carried in packets. The reason for this, according to LoP theory, is that internal agency requires first-person choices. In other words, we must place our attention on one possibility (out of many) and choose it, before it can happen. Everything leading up to that moment is the evolution of the possibilities that influence us. These possibilities happen purely at the quantum level – meaning at the level of personal relationships between sentient agents. When a choice, which is an act of perception, leads to an empirically detectable action, we see a wave collapse.

We now need to explain how this works at the quantum level based on the postulated principles of perception above. Fortunately, we have just learned a valuable new insight: It takes energy to go against the norm of third-person fields. Let's look at this in more detail.

Second-person relationships evolve in a linear way, the same way that quantum states evolve, as described by quantum formalism. The reason for this is that one-on-one relationships evolve in response to the sentient agents involved, because the perceptions of their relationship with each other continue to change. We naturally feel a loss of self when we are with our closest friends and become wrapped up in the relationship experience. This is why we see no sign of internal agency with quantum states and why they seem wave-like when they are not being measured or analyzed.

Third-person relationships, on the other hand, evolve through the decoherence process, producing the public field of space, and other fields as well, such as particle fields and the electromagnetic (EM) field. As the number of sentient agents in those fields grow, the fields grow stronger in the pressure they apply to follow the norm. Fields, by their nature, according to the LoP Interpretation, always push for stasis. The pressure is felt unconsciously and appears more as something in the background, not the foreground. This is why we see no signs of individuality in fields themselves, except when field particles interact as sentient agents.

While the evolution of quantum states (wave-functions) and the evolution of fields are both well defined by quantum formalism, the conflict between them is not. However, the fact that there is a conflict between them becomes immediately clear with the LoP Interpretation. This conflict can be illustrated informally (and surprisingly) by Shakespeare's story of Romeo and Juliet (adapted from Marman, 2016, pp. 225-226):

> Romeo grows up in one family, Juliet in another. Each family has its own perceptual field formed by generations of ancestors. The two families have been at war, hating and despising each other. Romeo and Juliet fall in love, against the laws that govern their

family behavior, and against everything they have been taught since they were children. They are suddenly thrust into an impossible conflict.

The power of tradition seems absolute, like a law of nature that must be obeyed. However, third-person fields cannot compete with love. The bond between Romeo and Juliet goes deeper. They love each other. So, they stop obeying the teachings of their ancestors. The laws of their families can no longer control them because they feel a strong desire to make different choices.

Suddenly, they find themselves in a situation with dangerous possibilities. These are superpositions. The outcome could take many different paths. Meanwhile, each family tries to force obedience to their laws. Their traditions must be followed. Romeo and Juliet break with tradition because they refuse to be parted, resulting in their deaths. The play ends with both families realizing the wrong that has been done. Their fields are forever changed by a boy and girl who fell in love.

Shakespeare was right: Second-person bonds are more powerful than third-person fields. Personal relationships are stronger than outer laws. And he was right that the two can be at odds. Our private lives are often in conflict with the public and political world we live in. And the lesson here is that our public world should recognize that, whether it likes it or not, it must adapt to the choices of people.

Fields define how particles should act, but third-person social norms cannot control what happens when people fall in love. Personal experiences affect them deeply. They find themselves involved in the back-and-forth dance of entanglement. They share a mutual relationship that is stronger than any field.

Second-person relationships have a significantly stronger influence over quanta than the norm of third-person fields. However, it takes effort – real energy – to go against a third-person field. Or, to put this another way, sentient agents can break with the norm and choose to form a new reality in the world – a new reality that is not dictated by external forces. However, they can only accomplish this through a concerted effort.

This is why a wave collapse requires energy to be exchanged, because the whole third-person field must be altered. And, just as we see in the story of Romeo and Juliet above, both agents in a second-person relationship must decide jointly to make this happen together. Since decisions are always first-person actions, this means that both agents must choose to act in concert. Their joint action changes the public world. This is how ripples in fields are created, as the fields are forced to adjust to the new reality.

The Schrödinger equation "turns off" because there are no longer any embryonic perceptions and half-formed feelings about the many personal relationship possibilities between the two sentient agents. Both agents have recognized and selected one of the possibilities together. In order to break with tradition, those perceptions must trigger an action strong enough to alter the external field. Only acts made jointly this way can create an event in the world. Such an act resets the wave function because the world changes in an irreversible way. The old possibilities no longer exist because the situation has changed. This also changes their second-person relationship irreversibly. As a result, a new story now begins to evolve based on new possibilities.

4.9.1 A Formal Model for Wave Collapse

This describes why and how the wave function collapses. But this is only an explanation suitable for the human level. We need to formalize this process in a way that applies to quanta. Fortunately, all the hard work has already been done. This was the surprising discovery I made, in 2015, when I ran across Ruth Kastner's formal interpretation of QM (Kastner, 2013), called the Relativistic Transactional Interpretation (RTI). Her approach is an off-shoot of the Transactional Interpretation of QM (TI) developed in the 1980s by John Cramer (1986).

Cramer was inspired by "Wheeler-Feynman absorber theory," developed by Richard Feynman and his thesis advisor John Archibald Wheeler, which offers an alternate model for EM energy. As explained by Kastner (2013), Feynman and Wheeler showed that the radiation of light can be viewed as waves sent out from emitters that move forward in time and waves sent out from absorbers that move backwards in time. When the two waves match and align exactly, the combination creates a transfer of energy from emitter to absorber. This process is called a "handshake." A handshake is the "coupling" of the two waves that create a transfer of energy (pp. 44-45).

Cramer realized that if this is a valid representation of how energy is transferred, then quantum formalism should include both the forward moving and backwards moving waves. To use only the wave that moves forward in time, which is the traditional method, is to only include the story of emission. This does not describe the process of absorption. It tells only half the story.

This idea that a wave function travels backwards in time is hard for many scientists to swallow, which is why the TI interpretation has not been widely accepted. However, Kastner solves this problem by saying that these waves do not exist in space-time. Only the transactions of energy take place in space-time. In other words, quantum wave functions (the possibilities) exist outside of the space-time dimensions.

Kastner shows that the "offer waves" that come from potential emitters, and "confirmation waves" that come from potential absorbers, are quantum wave functions. In other words, these exchanges represent a quantum relationship, and these are quantum states that do not exist in space-time.

> Offer and confirmation waves are physically real, but sub-empirical, possibilities. [Offer waves and confirmation waves] are interpreted ontologically in [RTI] as *physically real possibilities*. In this context, "real" means physically efficacious but not necessarily *actualized*…. [T]hink of [these waves as] the submerged portion of [an] iceberg…. [F]rom the vantage point of the deck of a ship (representing the empirical realm), we cannot see the submerged portion, but it certainly supports the visible portion and therefore cannot be dismissed as "abstract" or "unreal." In Bohr's words, these entities "transcend the spacetime construct"; however, rather than dismiss them as Bohr did, I allow that they are physically real, even if sub-empirical.
>
> [Offer waves and confirmation waves] are necessary but not sufficient conditions for an actualized event. The remaining necessary condition for an actualized event is that one particular transaction be actualized. (Kastner, 2013, p. 68)

I was stunned to see how perfectly this aligns with the LoP Interpretation. Kastner says that she does not claim to know the material nature of these quantum *possibilities* (p. 67). However, the postulates above tell us that these are relationship possibilities between sentient agents. They do not exist in space-time because they cannot be seen by outsiders. They exist only between agents.

The "coupling" of offer waves and confirmation waves also fits perfectly with the inner dynamics of relationships between sentient agents. Even the idea that wave functions pass back and forth between quanta fits with the postulates listed above. Only when they align with and complement each other can these *possibilities* be reinforced, and only when they are reinforced can the relationship evolve.

However, all possibilities do not create actualized transactions of energy. In fact, real transactions of energy are rare, and there is no way that outsiders can predict which relationship is going to produce an actualized event. Only a small percent of these quantum possibilities are actualized. Kastner (2013) points out that the coupling factor between individual photons and electrons, where an electron absorbs a photon, is about 1/137. The same coupling factor exists for an electron to emit a photon. Therefore, the probability that an actualized transaction will occur between two electrons is $(1/137)^2$, which is about 0.005% (pp. 65-66).

This example graphically illustrates why it is the square of the quantum possibility that gives us the probability of actualization – because the offer wave probability must be multiplied by the confirmation wave probability and both waves must be identical for them to couple. This is the exact condition required by the postulates of perception described above. Possibilities in a relationship must be agreed on exactly before they can act in concert.

Traditional interpretations of QM cannot explain why squares of probabilities are needed. It was determined empirically by Max Born and is now accepted as a postulate of quantum formalism. This is one of the significant advantages of the TI interpretation: It shows why "Born's Rule" exists. (For a detailed explanation see Kastner, 2013, pp. 53-55).

> [I]n most prevailing interpretations, the Born Rule is either simply assumed as part of the mathematical machinery…or it is given a pragmatic, 'for all practical purposes' account, which in my view, fails to do justice as the crucial link between theory and concrete experience. The Born Rule constitutes a deep mystery for all prevailing interpretations…other than TI. (Kastner, 2013, p. 35)

We can now add the LoP Interpretation to the list of interpretations that agree with this explanation.

The coupling between photons and electrons shows us something else as well. When second-person relationships form, according to LoP, attraction or repulsion develop, the same as we see in relationships between living creatures (Kastner, 2015, pp. 86-87).

Physicists model two electrons repelling each other as a virtual photon passing between them. However, as explained above, only 0.005% of the time will two electrons actually be physically repulsed away from each other. In those rare cases, the photon that passes between the electrons is said to be a "real" photon, because it carries real energy in space-time. The other 0.995% of the time, a static force of repulsion exists, but no actualized transfer of energy takes place. In those cases, the photon is said to be a "virtual" photon because it never exists in space-time.

In other words, static forces arise from relationship exchanges that exist only in the quantum world. Forces that accelerate objects are different: they exist in space-time. Static forces are different from actualized forces, but there is a clear relationship between them: Before energy can flow, there must be a buildup of static force. This is when virtual photons can pass between potential emitters and absorbers. Therefore, it all begins with attraction and repulsion.

When static charges grow strong enough, the story changes. Electrical sparks fly through the air or beams of light are created. Transactional events can only happen when emitters build up more potential energy than absorbers. This means that the relationship is no longer equal. That is why energy flows from the emitter to the absorber. This is what is needed to create an event that changes the EM field and the field of space. (More on this below).

What makes radiant energy different from static forces? Kastner (2015) offers a clear interpretation. She says that the mystery comes down to a simple fact: There is a threshold that a virtual photon must cross before it can move from being a mere possibility to a real photon.

> This number, 1/137, is a very well-known number in physics. It is called the "fine structure constant." The fine structure constant is important because it characterizes the strength of the electromagnetic interaction between charged particles… [I]n this book, the fine structure constant gains an interesting new physical meaning: it expresses the likelihood that a photon will advance from being merely "virtual" to being…actualized. (p. 101)

Feynman (1985) defines the fine structure constant in a similar way: "the [probability] amplitude for a real electron to emit or absorb a real photon" (p. 129).

This graphically illustrates the existence of an energy threshold needed to change the third-person EM field. This validates the LoP theory that energy is needed to go against a field. A quantum of momentum is also needed to change the field of space. However, LoP theory takes this further, because it predicts that the amount of energy needed to change a field will grow as more sentient agents join a field. In other words, the fine structure constant can change. This prediction comes from the fact that, as the number of charged particles in the EM field grows, so will its resistance against change. This idea of thresholds plays an important role with all of the four forces of physics, according to the LoP Interpretation (Marman, 2016, pp. 446-450).

Kastner (2013) says that the key advantage of the Transactional Interpretation over all other "collapse" type interpretations is that the meaning of "measurement" is clearly defined in physical terms, without having to appeal to the consciousness of an observer of the measurement. Once again, the LoP Interpretation is in agreement.

> How is this achieved? Very simply, by taking into account that *absorption is a real physical process*. This is certainly the case in relativistic quantum field theories: one cannot arrive at a correct empirical prediction without taking absorption into account. Indeed, absorption (i.e., annihilation) is a key element of the definition of the field operators used in any calculation of probabilities of empirical events. Such calculations routinely involve taking expectation values in which quanta are created and quanta are destroyed. If such calculations refer to anything physical (the basic realist assumption),

> both processes are physical processes. However, for the past century or so, interpretations of non-relativistic quantum theory have completely disregarded the absorption process, granting physicality only to emission processes … They have thus considered non-relativistic quantum mechanics – which is just a limiting case of quantum theory – only in a particular form (as applying only to emission) and in isolation from its relativistic application; and this, I suggest, is what has prevented the ability of such interpretations to account for measurement in physical terms.
>
> Specifically, a measurement or determinate event (i.e., it does not have to be a formal "measurement" conducted by an observer) occurs whenever annihilation of one or more free quanta occurs. In terms of relativistic quantum theory, absorption corresponds to the action of annihilation operators on free quanta, just as emission corresponds to the action of creation operators. (pp. 55-56)

What Kastner is saying here is that, first, QM needs to include the process of absorption, not just emission, and, second, a relativistic model of quantum theory is needed to fully explain what a wave collapse means. The difference between relativistic models and traditional non-relativistic interpretations is that relativistic models show how forces emerge from quantum interactions and obey Einstein's theory of relativity. Relativistic models describe quanta, such as virtual photons, passing between charged particles. Virtual particles are being created and destroyed all the time, even in the voids of space where no real particles exist. Quantum field theory describes this process in great detail, and it is necessary to include the effects of virtual particles to get accurate results. The process of calculating the impact of virtual particles is called "renormalization."

To put this in simpler terms, physicists already acknowledge that quantum states are being created and annihilated all the time. They are sometimes modeled as virtual particles, but they can also be treated as quantum wave functions that do not exist in space-time. Therefore, a wave collapse is actually and truly an annihilation of a wave function through the process of absorption.

When a photon is emitted from an atom, the photon is literally being created. When it is absorbed, such as when it lights up a point on a screen, the photon literally ends its life. The photon carries with it energy and momentum from an emitter to an absorber. This is an event that takes place in space-time. The photon is, therefore, the space-time manifestation of a quantum relationship.

This physical model is a perfect fit with the postulates of perception listed above. We now have a theory that starts with underlying principles (postulates) and includes a model-based theory as well. Combining these two, the LoP Interpretation can clearly explain the wave collapse process.

While Kastner's interpretation (RTI), offers a working model that has rigorously been shown to be consistent with quantum formalism, it still falls short of providing a full explanation for why and how one of the quantum state possibilities is selected to become an actualized event, although it comes closer than any other interpretation I have seen in describing what is happening. Kastner even comes closer than Cramer's Transactional Interpretation (TI) because she shows that the process begins outside of space-time, in what she calls "pre-spacetime" (PST).

> If we take the domain of transaction formation as PST rather than spacetime, then an account cannot be given in terms of any causal process within spacetime in the usual sense…since the latter are confined to spacetime. Instead we need to turn to a similar situation in physics in which there are apparently many possibilities but only one is realized: "spontaneous symmetry breaking" (SSB). (p. 76)

This makes perfect sense and is in agreement with LoP theory. There can be no causal processes behind the wave collapse. And SSB is a good model to turn to. Kastner then describes a number of examples of SSB, including a study of the pattern created by a drop splashing into a bowl of milk. The pattern of the splash is never exactly symmetrical. When the authors of a study on milk splashing ask why it is not symmetrical, they answer that it is because of imperfections. Nature is never perfectly symmetric. Kastner (2013) comments:

> Thus, the apparent answer of the authors to the question of what causes the system to end up in a particular state is: quantum fluctuations… It appears that, strictly speaking, when considering symmetry breaking in the classical domain, one could always point to some external cause of this type, even if only a random quantum fluctuation. So when the authors say that "the actual breaks the symmetry of the potential," they are not yet describing the quantum domain which [RTI] seeks to describe. (p. 81)

Kastner rightly points out that quantum fluctuations could indeed offer a valid explanation for why the symmetry is disturbed in the domain of classical physics. And she is right that this explanation does not work for the quantum domain where one quantum state is chosen over others. She then refers to a famous purely quantum case of symmetry breaking: the Higgs field. And here we can see that a full explanation falls short:

> If we want to try to follow the same procedure and to seek a specific cause…for the choice of one of the infinite set of possible vacuum states, we either have to suppose that it also stems from fundamentally indeterministic quantum fluctuations of the vacuum, or postulate fluctuations in some deeper realm that lies outside any current theory…. The only alternative is to postulate that SSB in the Standard Model requires a "many worlds" interpretation, in which SSB gives rise to many possible worlds.... But this is certainly not the usual approach. (p. 82)

To summarize, Kastner is saying that when there is a wave collapse, one way of explaining how one of the possibilities is selected could be the influence of quantum fluctuations. If this is not the cause, then it could come from "fluctuations in some deeper realm that lies outside of any current theory," or we need to invoke the Many Worlds Interpretation, which says that each of the possibilities is selected in a different parallel universe.

Unfortunately, quantum fluctuations cannot be the cause. It is fine to use this as an external force when dealing with classical events such as splashes of milk. Or you could use this to explain why a knife perfectly balanced on its point, in a complete vacuum, will always fall eventually. But this does not work as an explanation for a wave collapse because quantum fluctuations are nothing more than the fluctuations created by virtual particles being created and destroyed. These are the same quantum states that occasionally cross over to become actualized as real particles.

The question we are trying to answer is why one, out of the many possible quantum states, crosses over to become real. We cannot use other quantum states as a causal explanation because they are just more quantum possibilities. They will simply shift the weight of the possibilities and change the odds for which state is selected. They will not trigger an end to all other quantum possibilities when only one becomes actualized.

It is also worth adding that the whole reason the Many Worlds Interpretation is proposed is because there has been no explanation in quantum theory for why many quantum states would suddenly collapse down to one actuality. Or to put this another way, there has been no explanation for why quantum possibilities should ever end. However, as Kastner explained above, as soon as we move to a fully relativistic model of quantum interactions we see that quantum possibilities are created and annihilated. They spring up and disappear because they are relationship possibilities, and some of those possibilities will indeed disappear when the wave function collapses.

The LoP Interpretation offers a full explanation for why and how the collapse process works at the human level. We see it happening every day in human society. For example, out of the countless cases of flirtation that take place in a university or a company, only some will turn into real friendships or affairs. The flirtations can be considered "offer waves." Obviously, most offers are not accepted, but the ones that generate a complementary response can grow into relationships.

However, friendships and even affairs are private exchanges. Only one out of hundreds will cross over to marriage. Marriage is different because it requires a public change of state. It is recorded in a court of law and legally changes the responsibilities of the couple when it comes to ownership and taxes, etc. Marriage also changes the relationships between families of both spouses. These are public changes, as Romeo and Juliet discovered. And all the other possibilities (flirtations) of marrying other people end abruptly in that moment when they make their wedding vows.

When looking at the shift from private relationships to public marriage, it is easy to see what is needed to make the change: Two people need to jointly make a decision together. Outside forces cannot make it happen. There are many outside influences, but the act must be made by the couple.

If these relationships at the human level are quantum states, and marriage represents a change of state in human society, then, according to the LoP Interpretation, relationships between quanta must follow the same pattern. Therefore, postulate 9 states that **a wave collapse is the shift in a second-person relationship from a private, personal possibility, to a third-person public actuality – from a quantum state to a space-time event. It requires two sentient agents jointly making first-person choices to change the state. This requires real energy and a change in momentum. And when it occurs, it brings an end to other possibilities.**

4.9.2 Problems Solved Using the Transactional Model

This model gives us added insights into a number of problems. Let's take a look.

4.9.2.1 Changes in Quantum States of Measuring Equipment

Quantum formalism says that, when a measurement takes place, the quantum state of the system being tested suddenly changes. The system being tested then evolves from that state until it is changed by another measurement. We can now see that this change is governed by the relationship between the system and the equipment because the equipment is designed to measure a specific state. This compels the system being tested to exactly match the state of the equipment, to make a "handshake." This gives us a valuable insight into understanding quantum formalism, as we will soon see.

4.9.2.2 The Mind-Body Problem

When psychologists observe the neurological process of "conscious access" (see section 2.2), they recognize the importance of attention. The human being must move their attention to a possible event before it can become conscious. However, from the above discussion we can now see that this is not the complete story. To create a physical action, a human being must jointly act in concert with the cells of their body. Both must agree to act jointly in order to exchange real energy. We cannot make our muscles move by ourselves.

This solves **the mind-body problem** that has troubled philosophers for centuries. It shows how a sentient agent works in concert with the cells of their body, when they jointly make possibilities become actualized events. Biologists can see the energy exchanged when muscles move. However, they have no good explanation for how that energy is triggered when a person decides to move.

Our new model shows that human beings cannot make this happen by themselves. A relationship between a human being and the cells of their body is needed. They must jointly agree before real energy can be exchanged. This is why neuroscientists see the brain getting ready before an action (Marman, 2016, pp. 299-307). Alignment between mind and body happens unconsciously, exactly as LoP theory suggests, because these are second-person quantum exchanges before the actualized exchange of energy. Thus, second-person relationships are dynamic, and they have a real impact, but they are intangible to outsiders. (More on this in section 6.2).

4.9.2.3 Schrödinger's Cat Paradox

Another problem solved by Kastner's model, and the Transactional Interpretation, is the famous **Schrödinger's Cat paradox**. Since it is so well known, I will only explain it briefly. The problem starts with a radioactive atom that is in a superposition state of being "decayed" and "not-decayed" at the same time. If this atom, when it decays, emits a radioactive particle, and this particle triggers a detector that releases a hammer that swings and breaks a vial of poison, killing a cat, then according to traditional interpretations of QM, the detector should also be in a superposition state, along with the hammer, the vial of poison and the cat. Does this mean the cat is both alive and dead at the same time? That seems ridiculous, and this is exactly the point Schrödinger was trying to make when he proposed this thought experiment.

The Transactional Interpretation settles this matter easily. The problem disappears as soon as you include the absorber's role. The absorber's side of the story changes everything. The superposition state of the atom collapses as soon as the radioactive particle is absorbed by the detector. Thus, the cat is not in a superposition state. Only the atom, which is the emitter, and the absorber in the detector are in superposition states, until the radioactive particle is emitted and absorbed (from Marman, 2016, p. 233).

The nine postulates, above, add even more clarity to this puzzle. The radioactive atom and the atoms in the detector are sentient agents that form relationship possibilities with each other. This is why they share the superposition states of "decayed" and "not-decayed" as possibilities. However, the hammer that breaks the vial of poison, and the vial, are both classical objects. In other words, they are conglomerates – not sentient agents, so they cannot form quantum relationships. Yes, each of the individual atoms in the hammer and vial can form quantum states with possibilities, but this in no way alters the behavior of the hammer, the vial, or the poison.

We also know that as long as the cat is alive, it is a sentient agent. But cats do not form personal second-person relationships with atoms, so it never shares the superposition states of "decayed" and "not-decayed." As I said before, we should not confuse a wave collapse at the level of quanta with a wave collapse at the level of living organisms. For the same reason, we should not confuse quantum relationships between living organisms and quantum relationships between atoms. The classical world emerges from conglomerates because they are far removed from the personal relationships of individual sentient agents. That is when third-person reactions become dominant.

4.9.2.4 Delayed Quantum Eraser Experiments

Kastner's model also solves one of the most confounding experiments in quantum physics: **the delayed quantum-eraser experiment**. In this experiment, it appears as if a measurement of a photon made later alters the state of a second photon measured earlier. In other words, it appears to act backwards in time. The key to understanding what is happening is that the photon detected later and the photon detected earlier must be entangled. If this is true, then the solution is simple. Yes, it seems as if information flows backwards in time, from the absorption of the first photon detected later, because a confirmation wave does appear to flow backwards in time. But, in fact, the quantum state that they share does not exist in space-time. Thus, the time paradox is resolved. (For a detailed, formal discussion, see Fearn, H., 2015).

4.9.2.5 Another Look at the Two-Slit Experiment

With this new insight, we can also give a more complete description of the two-slit experiment than what I gave in section 4.8.4: An emitter forms a second-person relationship with all potential absorbers on a screen. TI says that these offer waves look for matching confirmation waves. LoP theory says that these are vague perceptions and half-formed feelings that only form relationships when they align. These are second-person relationships, which are quantum states, that create static forces of attraction or repulsion. This is what happens when potential energy grows in the emitter.

A photon is not emitted until a perfect match is found with an absorber, and both the absorber and emitter form a "handshake" that couples their first-person choices together into one joint action. The virtual photon passing between them then crosses over to become a real photon that carries real energy and lights up the spot of absorption on the screen.

However, while both the location of the emitter and absorber become clearly defined by this action, the path that the photon takes is unknown, as I explained in section 4.8.5. As a result, the relationships between the emitter and all of the possible absorbers exist at the same time and influence the outcome. These are virtual photons that pass through all possible paths to all possible absorbers. And they act as superpositions that interfere with each other, creating the interference pattern.

This is why Feynman was right to say that we can calculate the probabilities by adding together all of the possible paths. This does not mean that a real photon actually takes all possible paths. The quantum states are only weighing all of the possibilities before one is selected and actualized.

This is consistent with what the “Taking Heisenberg’s Potentia Seriously” paper says:

> Feynman famously re-derived the quantum laws in his ‘sum over paths’ approach by taking a quantum system as taking ‘all possible paths’ from an initial prepared position to a final detected position.... Clearly, such a system does not *actually* take distinct and mutually exclusive paths; its ‘taking of all possible paths’ is properly regarded as a set of possibilities, not actualities… We suggest that the efficacy of his possibilist approach in yielding a formalism that was initially arrived at by heuristic mathematical data-fitting is evidence that it captures some ontological feature(s) of reality.
>
> Thus, we propose that quantum mechanics evinces a reality that entails both actualities (*res extensa*) and potentia (*res potentia*), wherein the latter are as ontologically significant as the former, and not merely an epistemic abstraction as in classical mechanics. (pp. 7-8)

Kastner (2013) noted this same confirmation of Feynman’s calculation of all possible paths (Kastner, pp. 84-87). And I (2016) also arrived at the same conclusion before reading Kastner’s book (Marman, 2016, pp. 222-224). So, you can see why Kastner’s solution was such a surprising discovery for me, because it offers a model that matches the postulates of perception that I had uncovered.

Kastner started from a completely different origin: John Cramer’s Transactional Interpretation and quantum formalism. She converted TI into a fully relativistic model. On the other hand, I started with similarities between the behavior of quanta and the behavior of living organisms, leading to principles of perception that underlie both of them.

Naturally, this complementary match between the LoP postulates of perception and RTI’s formal model struck me as powerful validation. (In other words, these two possibilities match so well that it increases the reality of both of them, the same way a quantum handshake crosses over to become an actuality). This sense of validation grew even stronger when I ran across this footnote in one of Kastner’s books: “One might wonder whether quantum entities are endowed with some rudimentary form of consciousness. Such considerations are interesting and important, but beyond the scope of this book” (Kastner, 2015, p. 127).

4.9.2.6 Space and Time Revisited

With this combination of underlying principles and a functional model, we can offer even more insight into what happens during a wave collapse. For example, when looking at this in terms of Einstein’s theory of relativity, we can see that no time passes for the photon, from the moment of emission to the moment of absorption, because it is traveling at the speed of light. The only thing that makes a photon real is that it carries real energy and changes the EM field (by creating a ripple), and it applies a quantum of real momentum that alters the field of space.

A transactional event is a unit of action. Bohr called it a quantum of action. What makes this even more interesting is that, even though the actual positions of the emitter and absorber are all relative, depending on the reference frame of outside observers, and the time of the event is also relative to outside observers, the space-time interval is the same for all outside observers. As Kastner (2015) explains below, this means that a space-time event is something that all observers can agree on. This makes sense, in LoP theory, because such an event changes the whole third-person field of space:

> If a well-defined time interval were applied to an object with well-defined energy, this would contradict the [Heisenberg uncertainty principle]. (p. 165)
>
> Thus, the most accurate way to understand the time-energy version of the [Heisenberg uncertainty principle] is not really in terms of time intervals, but rather in terms of change: if an entity has a completely precise energy value, there is no observable change in the entity characterized by that energy. However, there are changes in the emitter that emitted it and in the absorber that absorbed it: one lost energy, and the other gained it… This, in turn, allows us to define a time interval corresponding to the two events. This leads to the crucial point that a time interval is created by the transfer of some exact amount of energy from one entity to another in an actualized transaction. (pp. 165-166)
>
> We've noted above that, in the transactional picture, a time interval is created by the delivery of a quantum of energy from an emitter to an absorber. Interestingly, this corresponds to a more esoteric but standard physical account of the relationship between energy and time: Energy is the creator of time intervals. (p. 167)
>
> At this point, you may have guessed that a similar relationship holds for position and momentum. Indeed, it's also true that momentum is the creator of spatial intervals. As with energy and time, a transferred quantity of momentum (basically motion) corresponds to an interval of space; and without that momentum, there is no spatial interval. (p. 168)
>
> [R]elativity tells us that neither spatial nor temporal intervals, individually, are absolute quantities. They are defined only relative to the states of motion of observers who can see the emission and absorption events marking those intervals. And the quantum's amount of motion itself is not absolute; that is, whether or not a quantum has momentum depends on the frame in which it is described. (p. 169)
>
> Nevertheless, there *is* an absolute quantity, one which is the same for all observers regardless of their relative motions. It is the spacetime interval… The spacetime interval is basically the difference of the (squares) of the temporal and spatial intervals as measured in any particular frame. (You take the time interval between [emission and absorption], multiply that by the speed of light, square it, and then subtract from the square of the distance between [emitter and absorber]). It turns out that despite the differing perspectives of observers in different states of motion, the spacetime interval is the same in all of them. It is the one measurable spacetime quantity that they can all agree on… And the spacetime interval is what is created in an actualized transaction. (pp. 169-170)

According to Kastner, space-time is a tapestry woven from space-time events created by changes in momentum and exchanges of energy. As we can see, these events are quantized.

They are made from discrete transfers of energy and momentum. This means that space-time itself is quantized.

However, according to LoP theory, the field of space is not quantized because it is made from grey comparisons of outsider perceptions from third-person relationships. Yes, every field is made from a finite number of these relationships, but the experience of space and its effect on sentient agents is continuous. As you zoom down to smaller and smaller regions, the field of space does not become more discrete and quantized, it simply becomes weaker and weaker.

In fact, we already have a good example for how the field of space looks when it is weak because this is exactly what happens in two-slit experiments. The interference pattern gradually fades away as more particles enter the area of the experiment because the influence of the field of space increases gradually. This is how decoherence works. This shows that only space-time is granular, not space itself. Space-time is like a glove that fits over the hand of the field of space.

This resolves another obstacle that has been standing in the way of solving the mystery of quantum gravity (how to merge Einstein's theory of gravity with quantum theory). Smolin (2017) explains:

> These obstacles mainly had to do with showing that on scales much larger than the Planck length, a smooth classical spacetime emerges, which is described by Einstein's theory of general relativity. (p. 228)

A smooth classical space-time is evident at large scales because the field of space guides the positions and momentum of particles, just as the EM field guides electrically charged particles. This is also why water flows smoothly, even though the movement of water is made up of countless discrete actions. For the same reason we can run smoothly, without jerky movements because we are not stopping to think about each movement, but only about the relationship with our body that does the work. Relationships are the influences behind everything in life and nature that flow smoothly. How do we model this? We can build on Kastner's model.

The influence that fields have on particles is not through offer waves, because offer waves describe only what is happening in second-person relationships. There is no reaching out of hands like we see in personal relationships. The confirmation waves in third-person relationships come from every agent in the field. These are confirmations of other outsider perceptions. This is how a norm is created. No offer waves, only confirmations. The waves do not need to align exactly for them to converge because they are outsider perceptions, none are private, so they naturally converge. However, agents must be entangled through third-person relationships before a field affects them.

Putting this another way, the interactions between a field and the particles that live in that field only exist in the quantum realm, not in space-time. There are no potential emitters and absorbers, there is only third-person entanglement between all of the members of a field. This is what creates the field. Real energy is never exchanged. The inertia that a real particle experiences when it is coupled to the field of space is a "static" force, like attraction and repulsion between charged particles. However, the difference between inertia and static EM forces is that EM attraction and repulsion, when it grows strong enough, can cross over to become space-time events, but the static force of inertia only resists actions, so it can never cross over into space-time. This is how quantum fields work, according to LoP theory, using Kastner's model.

Most physicists say that we can look at fields as if they create quanta, or we can look at quanta as if they create ripples in a field. Both are mathematically equivalent. And the interactions between charged particles and the EM field can be modeled as a field effect, or as if the wave function of the particles interact with themselves (through offer and confirmation waves).

This is where the added constraints of the LoP Interpretation become clear: Only one of these two explanations is acceptable. According to LoP principles, only sentient agents can create ripples in fields through second-person relationships. Fields do not create quanta. And sentient agents do not have wave functions of themselves, so they cannot form relationships with themselves. The quantum state of a sentient agent, by itself, is its first-person perception, which is not visible to anyone else. Quantum wave functions only form between sentient agents because they are different from each other. Therefore, the EM field does have an influence on charged particles, but a charged particle has no way of sending an offer or confirmation wave to itself, because it cannot form a relationship with itself.

4.9.2.7 The Damping Effect in the Field of Space

This issue goes to the heart of the main conundrum of QM: Why is all of matter and energy quantized? Why is matter made up of individual particles? And why is energy always carried in packets? The problem here is not to explain bodies, it is about explaining the internal agency that we see in particles, the same as the internal agency that we see in living creatures. How can a field or a society create human beings or give even the simplest organisms their internal agency?

This is exactly the problem with the current theory of decoherence: It cannot explain how distinct forms emerge from the wave function. Nothing in the wave function can explain where distinctions come from. Yet those distinctions are necessary for entanglement – and, therefore, decoherence – to work. Therefore, fields are outcomes, according to LoP theory, they do not create particles.

This is interesting because it was Feynman who first discovered that the field effect could not be eliminated by absorber theory. Fields exist as something separate from emitter-absorber events.

> Feynman's motivation for his direct action approach (Wheeler–Feynman absorber theory) had been to eliminate the electromagnetic field as an independent entity, and he later decided that this could not be done because of the need for self-energy. (Kastner, 2013, p. 51)

> [T]he Wheeler–Feynman approach to dealing with classical radiation theory fell out of favor because it assumed that a radiation source could not interact with its own field; but this "self-interaction" or "self-energy" was found to be necessary, at least at the quantum level, for certain known empirical effects such as the Lamb shift. (Kastner, 2013, p. 50)

In other words, Feynman was hoping that the direct exchange between emitters and absorbers could account for all of the known aspects of EM radiation. However, he eventually came to realize that there was always a small residual field effect that created "radiative damping" that could not be eliminated.

> Dirac (1938) had proposed that damping can be explained by a free field (that is, a field not attributed to any source) in addition to the assumed…propagation due to the charge. While this seemed to account for the observed energy loss, [Wheeler and Feynman] were dissatisfied with its ad hoc character. (Kastner, 2013, p. 199)

Feynman's original assumption that a radiation source could not interact with its own field (with its own wave function) was right, according to the LoP Interpretation. However, the field that Dirac proposed, which creates a damping effect, no longer needs to be seen as ad hoc because we found its origin: It is created by third-person relationships. In fact, these relationships create exactly the damping effect that Dirac described because they resist forces of change.

4.9.2.8 The Uncertainty Principle Resolved

This new insight into how the field of space is altered by actualized exchanges of energy and momentum gives us an added explanation for Heisenberg's uncertainty principle, because it shows us that first-person choices and actions made in concert are stronger than any field.

It is impossible to nail down both the position and momentum of a particle for two reasons: First, because every measurement and wave-function collapse alters the field of space. Since actualized events are happening virtually all the time, the field of space is continually changing.

Notice that this is not about measurements altering the system being tested, which was the point that Heisenberg first proposed. Heisenberg's original view is not how physicists see it today:

> The modern version of the uncertainty principle proved in our textbooks today, however, deals not with the precision of a measurement and the disturbance it introduces, but with the intrinsic uncertainty any quantum state must possess, regardless of what measurement (if any) is performed. (Rozema, *et al.*, 2012. p. 1)

What I am describing is how the field of space itself is altered by measurements. And, as postulate 9 shows us, there is a minimum threshold to this alteration of space that is needed to create an actualized event. This minimum threshold is directly related to Planck's constant, which represents the quantum of action. This agrees with the fact that uncertainty and Planck's constant are related.

The second reason for uncertainty is that measuring position and momentum require two different relationships. This means two different designs of equipment. Each type of equipment gains its information by absorbing at least one particle. Therefore, as soon as one measurement is taken, the field of space is changed by at least one quantum of action, before the next measurement can be made. In other words, as the ancient saying goes, you can never step in the same river twice.

On top of this explanation, we must add what I showed in section 4.8.3, that there are no perfectly well-defined values for the position and momentum of particles before they are measured. As far as I know, this solution to the uncertainty principle, along with the above explanation of the wave collapse process, offers solutions that appear to make the theory of quantum mechanics complete.

And from what I can see, everything I have explained above validates Heisenberg's insight about potentia "standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality." This describes the transition from quantum possibilities to actual space-time events quite well. I agree that we should indeed take this idea about potentia seriously, as the paper (by the same name) suggests.

Also, we can better understand the meaning of potentia if we see that they represent the inner dynamics of relationships. Possibilities are the vitalizing source of life in all relationships.

4.9.2.9 Possible Insights for Quantum Gravity

In the 2017 postscript to his book, *Three Roads to Quantum Gravity*, Lee Smolin wrote:

> The fact that we haven't yet solved the problem of quantum gravity, despite much good work by hundreds of very smart and devoted people, is one that deserves some contemplation. Nature is a unity, so surely there is an answer out there. If we haven't found it, perhaps we are doing something wrong…
>
> Here is another way in which I suspect we have been off track. Einstein spoke of two kinds of theories, constitutive theories and principle theories. Constitutive theories posit what the world is made of; they are theories that describe particular phenomena, particular forces or particles. Maxwell's theory of electromagnetism and Dirac's theory of the electron are constitutive theories.
>
> Principle theories set out general principles whose universality requires that every particle and force in nature satisfies them. Special relativity and the laws of thermodynamics are principle theories.
>
> Einstein taught us that we deepen our understanding of nature when we discover new principles. The theories come after the principles.
>
> String theory and loop quantum gravity are both based on hypotheses about what the universe is made of. Thus, these and other of the main approaches to quantum gravity are constitutive theories.
>
> Perhaps we should heed Einstein's advice and look instead to discover new principles. (p. 230)

Postulate 8 is a principle that offers a new explanation for decoherence and how the field of space forms. It suggests that the field of space is a quantum state and it is different from space-time. This offers potential solutions to some of the obstacles in resolving how gravity emerges at the quantum level. Here is another big piece that might help put this puzzle together:

Postulate 9 tells us what happens when there is a wave collapse and there is an exchange of energy. The energy must be strong enough to alter the field of space. This suggests that there might be something else quite remarkable also happening at the same time. Let's look closer.

According to postulate 8, all fields are formed by third-person perceptions converging towards a norm. The influence of each individual outsider perception is weak, but outsider information gains strength when it agrees with other outsider perceptions. Perceptions that do not agree are ignored. They disappear because they do not seem to represent anything real.

One of the key lessons learned by scientists who are looking for a theory of quantum gravity is that gravity appears to be the only force that operates outside of the background of space-time (Smolin, 2007, pp. 80-83). This is one of the biggest reasons why gravity does not play well with quantum theory. Physicists explain it this way: Gravity is background-*independent*, while quantum theory and all the other forces are background-*dependent*.

Einstein proved this quirk of gravity when he showed that it warps space-time. In fact, he said that gravity is no more than a curvature of space-time. This is a valuable clue because LoP theory says that if gravity works this way, something besides third-person relationships must be affecting the shape of the field of space. Postulate 9 tells us that every time there is a wave collapse, the field of space adapts to the change. This is what an exchange of momentum does.

Every time there is an exchange of energy, there is a wave collapse. This means that exchanges of energy could be warping the field of space. This is a promising possibility because Einstein claims that "energy density" is the cause of the gravitational field (Padmanabhan, 2012, p. 8), and countless experiments have validated this.

The new speculative proposal I am offering here is that mass and energy density are followers, not drivers. In other words, mass and energy are gradually pulled in, along with the particles they belong to, by the curvature of space. The true causes of gravity are exchanges of energy. Since exchanges of energy are directly related to energy density in an area, the strength of gravity should be proportional to exchanges of energy as well. Thus, Einstein's formulas should still hold up.

How does space curve at the quantum level? That is the question that quantum gravity is trying to resolve. A possible answer can be seen if we look at what happens to the field of space when there is a sudden, instantaneous shift. If the locations and movements of sentient agents suddenly shift in a discontinuous way, what happens to outsider perceptions of where those agents are and where they are moving?

If LoP theory is right, the new perceptions will no longer agree with the norm. If this is true, they should be ignored. The field of space only exerts an influence when there is a consensus. This suggests that a small portion of space will stop engaging. It will fall off the map. This might be what happens when an area changes so suddenly that the field of space cannot adapt right away.

Decoherence experiments prove that the field of space adapts at the speed of light. This is how fast location and movement information ripple through the field. However, if there is a sudden shift that is discontinuous, there is no way the field can adapt immediately. This means there is a brief period of time in which that area of space disappears from the field.

What happens to particles that are far away from the disturbance? They will not feel the full brunt of the disruption. In fact, some distance away, particles will see only a gradual sea change, not a discontinuous jolt. So, the rest of the group experiences a contraction in space when a small portion of space disappears, followed by a bulge when it returns. In other words, exchanges of energy act like pebbles dropping through the smooth surface of space, creating ripples.

After I realized the way this seems to work, I was surprised to run across something Smolin (2007) wrote that sounded almost identical:

> [W]hen gravitational waves are very weak, they can be seen as tiny ripples disturbing a fixed geometry. If you drop a stone into a pond on a still morning, it causes tiny ripples that barely disturb the flat surface of the water, so it is easy to think that the ripples move on a fixed background given by that surface. But when water waves are strong and turbulent, as near a beach on a stormy day, it makes no sense to see them as disturbances of something fixed.
>
> General relativity predicts that there are regions of the universe where the geometry of spacetime evolves turbulently, like waves crashing on a beach. (pp. 84-85)

I am suggesting that we need to make one big exception to what Smolin says above: When the change is turbulent, it is lost from the field. Those are the regions of space that vanish. There is no roaring crash of waves, only the sound of silence. Third-person entanglement cannot handle shocks, only gradual changes. Anything too sudden falls off the map of space.

This does not mean that the particles stop existing. No, they clearly still exist. They have not gone anywhere. They simply disappear from the field of space for a while. A few moments later, once the field adapts to the change, a new map is created that reunites the missing agents to the field.

What would be the result of a small area of space suddenly disappearing for a few moments? Is it not the same as space shrinking for an instant? Of course, once the missing agents are restored to the field, space would expand again to make room for them.

However, if there is a continual stream of wave collapses, there will be a continual supply of holes in the field. And we know energy exchanges are happening all the time, because as John Bell asked above (quoted from Bowman, 2008): "are we not obliged to admit that more or less 'measurement-like' processes are going on more or less all the time more or less everywhere?" (p. 31). If this is true, it should create a continuing gradient in the field of space.

Can this be the cause of the curvature that quantum gravity is looking for?

If this principle is right, all particles should be affected equally by the movement of the field of space as it continually flows in to fill the holes. The mass of a particle should not matter. Every particle belongs to the field of space, so they should all follow curvatures in space. Even massless photons should be pulled along by the movement of space to fill the holes.

Where would gravity be the strongest, according to this theory? Where more energetic exchanges are present. All particles should be pulled along for the ride. This means that the mass and energy of those particles will be pulled in as well. Large planets and stars will continue to exert a stronger curvature on the field of space compared to the relatively empty space that surrounds them.

Of course, this idea is highly speculative. However, it does offer an intuitive explanation for why inertia and the force of gravity are equivalent, as Einstein proposed. Inertia is the result of particles being weakly tied to the field of space. This is what keeps them moving along. And gravity is what happens when particles are pulled along to follow the field. These are indeed equivalent.

This raises a number of questions. Here is one: If this happens to the field of space, then should we not see the same thing happening to the EM field? The answer is yes. But, the same charged particles that will disappear off the map of the EM field, when they are disturbed by an EM exchange of energy, should also disappear off the map of space as well. Thus, the EM field curvature will exactly match the curvature of space. This shows us why the EM field acts as if it is background-*dependent*.

This leads to a possible insight into what is called the "hierarchy problem," which asks why gravity is so much weaker than all of the other forces, and why gravity acts as if it operates on a lower level of a hierarchy? We now have a possible answer: Gravity is caused by the "peer pressure" of third-person relationships that are weak because they are impersonal. This is the force that nudges all particles to follow the *background* of space. It is a "static" quantum state influence. The EM force, on the other hand, does not even notice changes in the background, because the EM force is all about highly dynamic second-person relationships that must be strong enough to alter the field of space. This means that the EM force is made up of exchanges of energy, while gravity is not.

Here is another question: If gravity works this way with quanta, then should we not see the same gravitational effect at the level of living organisms? The answer is yes. Here is an example: What happens when there is a major disaster, such as a hurricane, earthquake, or terrorist attack? It creates a severe jolt to the fabric of society. This is no surprise. However, the response is always amazing to watch, because the disruption pulls communities together. People quickly move to help each other, to restore and strengthen the bonds that hold them together.

Another example is when there is a death, birth, or marriage, in a family. These are sudden major changes. A death is a discontinuous loss. Birth and marriage are discontinuous gains. And, in all these cases, family members feel the need to regroup, to welcome new members and acknowledge losses. They are pulled together to reinforce and adapt to sudden changes in the family.

This is of course a speculative theory, but it also turns out to be consistent with recent theories that suggest gravity may be an "emergent entropic force" caused by entropy density (Verlinde, 2011, Padmanabhan, 2011, and Padmanabhan, 2012). What I am proposing is consistent with those theories because entropy density is a good description of the degrees of freedom of all the particles in an area. And, when there is a loss of a region of space, the particles in that area will take their degrees of freedom with them. This creates a decrease in entropy density. So, entropy density is not the cause, but it is directly related to losses in the field of space. (I discuss this, along with many of the implications, in Marman, 2016, pp. 407-472).

To summarize, gravity resists being formulated as a quantum field theory because space is curved by abrupt first-person actions that disrupt fields. On the other hand, the dynamics of quantum states governed by wave functions are the result of second-person perception. All forces, except gravity, emerge from second-person exchanges. Every field is equally affected, but since they all follow the curvature of space, it looks as if they are dependent on the background of space.

4.9.2.10 Fewer Dimensions, Not More

It is now common to explore added dimensions, such as with super-symmetry and string theory, to uncover what is happening beneath the surface of reality, and to solve the problem of quantum gravity. The assumption behind all of this is that human beings can easily see and picture three spatial dimensions and one dimension for time, but we cannot see what is happening in higher dimensions directly. On the other hand, we can easily see what is happening in fewer dimensions, such as one or two dimensions of space, so there cannot be anything hiding there. Unfortunately, this assumption is only true when we look at dimensions through third-person lenses.

If the world evolves through sentience, then we need to consider perceptual dimensions. As soon as we do, we see that fewer dimensions *are* hidden to third-person lenses because outsiders cannot see first-person perceptions or the inner dynamics of second-person relationships. Therefore, the LoP Interpretation of QM suggests that not more dimensions, but fewer, need to be considered.

However, it is time to wrap up these speculations. With the above nine postulates, we are now ready to offer an explanation for why quantum formalism takes the form that it does.

5. Understanding Quantum Formalism

> The only consensual part of the [quantum] theory is a formal skeleton enabling one to calculate the probability of various experimental outcomes at any time, given the initial preparation. This formal skeleton is often complemented with bits and pieces of former pictures of the world borrowed from classical physics, but connected to one another in an unfamiliar and unruly way. A recurring complaint is that, as long as we are left without any truly coherent representation of the world and of its 'ontological furniture' compatible with the quantum formalism, we cannot claim that we truly 'understand' quantum mechanics. (Bitbol, 2010, pp. 54-55)

Why call this science quantum "mechanics" when there are no mechanical reactions – no cause-and-effect reactions at the quantum level? The reason is because there is one aspect of QM that is highly mechanical: quantum formalism itself. This is the mathematical process that physicists go through to determine statistical predictions. It has proven itself to be the single aspect of QM that physicists can depend on. No one has ever found a case where it has given a wrong answer. Therefore, the process of quantum formalism is seen as the true foundation of QM. And any new interpretation or theory must be tested by comparing it to the formalism.

This is why any formal interpretation of QM needs to explain what quantum formalism is trying to tell us. What does it mean? Why does the world work this way?

> Regarding its formal structure we could say that quantum mechanics seems to be a 'finished theory.' In terms of empirical adequacy, it provides outstanding results, its mathematical structure – developed in the first three decades of the 20th century by people like Werner Heisenberg, Pascual Jordan, Max Born, Erwin Schrödinger and Paul

> Dirac – seems able to provide until now the adequate modeling to any experiment we can think of. However, apart from its fantastic accuracy, even today its physical interpretation remains an open problem. In the standard formulation, quantum mechanics assigns a quantum mechanical state to a system, but 'the state' has a meaning only in terms of the outcomes of the measurements performed and not in terms of 'something' which one can coherently relate to physical reality. It is not at all clear, apart from measurement outcomes, what is the referent of this quantum state, in particular, and of the formal structure, in general. If we are to ask too many questions, problems start to pop up and simple answers seem doomed to inconsistency. (De Ronde, 2011, p. 9)

The Lenses of Perception Interpretation of Quantum Mechanics says that the reason it has been so hard to understand quantum formalism is because we have been trying to see it only through third-person lenses. There are no *observer-independent* quantum states. They do not exist. There is no valid *observer-independent* explanation for decoherence. As Smolin (2017) says, astrophysicists have come to the same conclusion about space: There is no *observer-independent* way of studying space or the universe. We can only study our universe from within the universe (pp. 17-26).

I believe this is what quantum formalism is trying to tell us: The foundation of reality is not built on a foundation of objective things and forces, but from dynamic relationships. Quantum states are relational, and this means we need a second-person lens to understand the "inner" dynamics between sentient agents.

We cannot understand organic life by studying it from the outside. As soon as we try to take an organism apart, we kill it. This is exactly the same message that quantum formalism tells us: The dynamic nature of quantum states comes from relationships that only exist between sentient agents.

If this interpretation is right, then everything that happens in QM relates to human relationships because we are sentient agents as well. This means that an intuitive understanding is possible that gives us a true and accurate description of quantum states and why they behave so strangely. As a result, the science of QM has a lot it can teach us about biology, sociology, and even psychology. Those sciences can also teach us valuable insights about QM as well.

Therefore, at a minimum, I need to show that the LoP Interpretation is consistent with quantum formalism. However, this seems like too low of a bar. What is really needed, as Rovelli said, is to show why the formalism takes the form that it does, from a set of basic postulates. But, there are quite a few questions raised by quantum formalism, as Matías Graffigna (2016) points out,

> [T]he primordial question should no longer be "how does nature decide the result of a measurement given a superposition?", but, rather, "what is a superposition and what can it do besides being actualized in a measurement?" It is not that the process of actualization through measurement were irrelevant or unimportant for QM, but it seems that some previous knowledge is necessary in order to tackle it. We do not yet fully understand what a superposition is, but we do have the formalism, and also the possibility of grounding this understanding in a different ontology from the one of classical Newtonian mechanics. (pp. 25-26)

Understanding what superpositions are is just one of the puzzle pieces we need to solve. There are many more questions embedded in the formalism that need to be answered.

There appear to be countless ways to present quantum formalism. They can all seem quite different at first. However, they eventually end up covering the same terrain. They just pick different places to start and take different paths to tie all the pieces together. I am going to follow an approach laid out by Albert (1992) because he focuses on what he calls the "algorithm," the mechanical process that gives quantum formalism the name of "mechanics." He says that "It pretty much all boils down to five principles" (p. 30). These principles represent the foundation of the formalism. However, a fair amount of added discussion is needed to understand these principles.

Following are the five principles, each summarized in my own words from Albert (1992, pp. 30-36), followed by explanations for why these principles are necessary elements of QM formalism:

5.1 Quantum States and Superpositions

Quantum states are represented by vectors called "state vectors." The state of every physical system is defined by a vector space that includes all of the possible states of the system, where each possible state corresponds to a vector and each vector has a length of 1 in that vector space. The vector space is complex (this means that both real and imaginary numbers are allowed). Each vector represents a quantum state, and all of the quantum states together represent the overall state of the system. Superpositions are represented by adding or subtracting state vectors using well-known vector math.

From this first principle you can see the mechanical nature of quantum formalism. But to see how truly bewildering it is, we need to dig deeper. Bowman (2008) raises the questions to ask: What sort of information about a system do quantum states represent? Is all of the information about a system represented by its quantum states? And what exactly are quantum states? Then he explains that all of these questions are still unresolved after 80 years of debate (pp. 7-8).

However, there are quite a few things that physicists do know about quantum states. For example, they know that they are not the same as states in classical physics, where states represent the values of a system's properties, such as mass, electrical charge, momentum, location, etc. The trajectory of a system can be measured in classical physics, and, based on the forces acting on it, the future path of that system can be predicted with great accuracy (as long as it is a large object). Thus, a state in classical physics has numerical values that describes how fast the system is moving or the direction it is traveling, etc.

Quantum states, on the other hand, do not represent values. They represent functions. This means that quantum states cannot be represented by numbers because they are responsive states. The point is not that quantum states continually change, because states in classical physics also change. No, this is telling us that quantum states are dynamic functions. This is why they are often called wave functions, not waves.

To understand how abstract this idea of a quantum state is, look at how a force is represented by a vector in classical physics. The direction of the vector (where the arrow of the vector is aiming) represents the direction of the force. The magnitude of the force is represented by the length of the vector. This is easy to relate to. But what does a quantum state vector represent if it is a function?

Does the direction of a vector represent the direction of the function? No, not really, because it makes no sense to say that a function moves in a certain direction. Does the length of the vector represent the magnitude of the function? No, because in quantum formalism state vectors are assigned a length of 1.

This shows that quantum states are abstractions that are so far removed from classical states that they are not the same at all. Except for one thing:

Quantum states do contain essential information about every particle and system tested.

The problem is that this information is contained in a dynamic function and physicists do not know what a quantum state is. They cannot even agree on whether quantum states represent something real or if they are simply mathematical tools.

However, the postulates outlined in section 4 offer an explanation for what quantum states are and why we need to treat them the way we do in quantum formalism: Quantum states represent the inner dynamics of relationships between sentient agents. They are indeed dynamic functions.

The postulates also tell us that there are two different types of relationships: second-person and third-person. The inner dynamics of second-person relationships come from private shared perceptions that pass back and forth between those involved in personal relationships. Being private means that they are independent. Third-person relationships, however, are public and impersonal, which means that they are shared by every agent coupled to that field.

The first principle of quantum formalism, described above, is telling us that all of the relationships that a system is involved in have an influence on that system. This defines the state of that system.

All possibilities in second-person relationships act as superpositions because they all influence the system at the same time. And the reason you can assign all of these vectors a length of 1 is because second-person relationships are linearly independent of each other. This means that they influence each other, but only indirectly, because they are all vying to become actualized. However, only one possibility can be selected. As a result, only the phases between possibilities are important in determining actualized events. This is why adding and subtracting vectors offers an accurate way to represent the influence of superpositions, as long as the vectors are independent of each other.

It is easier to understand this if you think about the example I gave earlier: Imagine you have been given a new job offer, but the job requires moving to another country. This means that you might have to move away from the person you have been dating. This illustrates the influence of two *independent* relationships, where both weigh on you and your choices. Your job offer has no *direct* effect on your partner, except in how much that offer means to you. And your relationship with your partner has no *direct* effect on the job offer, except on how important your partner is to you.

If your partner wants to move with you to another country, then the phases between these two relationships add together. They complement each other. This option is easy to choose. But, if your partner has ties that hold him or her back from moving with you, then the phases between the two relationships subtract, forcing you to choose one or the other. Every relationship possibility that influences you and your partner adds to the complexity, and so does the timing. Thus, phases are a perfect way of representing how independent possibilities in relationships influence each other.

All second-person relationships are represented by complex vectors because they must have an imaginary dimension, according to the postulates I have presented. Mathematically, this dimension is represented by $\sqrt{-1}$, which shows that it is a private relationship and does not exist in the real world defined by third-person perception. Second-person relationships also need to include real dimensions if they are going to have an impact on the "world out there."

If you have a vector with a length of 1, and it is a complex vector (with both imaginary and real dimensions), then that vector will only have a length of 1 in real dimensions if it has no imaginary component. Therefore, as the influences of relationship possibilities evolve, we see the shadow of the line that falls on the real dimensions growing larger, and then shrinking, as the phases change. This shows how the phases of wave functions are represented by quantum formalism and why this math is a good way of representing the influence of the inner dynamics of relationships.

LoP theory says that third-person influences are different. They have no imaginary dimension. They are only real functions because they represent information that only belongs to the field of space. The field of space is our reference for everything that exists in the objective "real" world. This is why space always appears to be in the background, while all measurements and energetic events take place in the foreground.

This means that third-person relationships do not act as superpositions in relation to each other. This is what quantum formalism has been missing. And the reason this has been missed is because third-person relationships never offer possibilities that become actualized in measurements. They act only as "static" outside forces that have an inertial dampening effect on changes.

Quantum theory, as I said before, is *background-dependent*. This means that it cannot see changes to the field of space because it uses the background (the field of space) as its reference in every measurement. EM field effects, and particle fields, are accounted for in quantum formalism by using relativistic models, but this cannot account for what causes the field of space to curve. If LoP theory is valid, then Einstein was right that quantum theory is not complete. However, it becomes complete if we include the effects of first-person and second-person perception.

To summarize this first principle of quantum formalism: All of the quantum states of a system are the relationship possibilities influencing that system. However, this, alone, does not capture all of the information needed to determine the outcome. We must include first-person perception to explain the uncertainty and indeterminate nature of quantum states, the curvature of the field of space, and, as we will see below, the outcome of measurements.

However, looking only at the relationship possibilities, as this first principle of quantum formalism asks us to do, we can represent the state of any system by a vector space that is made up of all the relationship possibilities, with each second-person relationship needing a linearly independent imaginary dimension of its own, and where each vector has a length of 1. This describes exactly the special type of vector space that physicists use, called Hilbert space. Hilbert space is an *n*-dimensional vector space, where "*n*" represents each of the independent quantum states. Each independent state can be represented by dimensions that are orthogonal to each other, just like *x*, *y*, and *z* dimensions of 3-dimensional space are orthogonal, since quantum states are independent.

5.2 Observables: Measurable Properties

The measurable properties of a system, called "observables," are represented by linear operators that act on the vector space that is associated with the system. If a vector that represents a quantum state happens to be an "eigenvector" of an operator associated with a particular observable, and that eigenvector has an "eigenvalue" of "a," then the state is said to be an "eigenstate" of that observable. And, in this case, if a measurement is made, that state will have the value "a" for that observable.

Once again, we see that this whole principle is a description of a mathematical process. It says that only some properties can be measured. Quantum states, for example, cannot be measured directly. But we can measure the location of a system or the momentum of a system.

In classical physics, we can obtain the momentum of an object by multiplying its mass times its velocity. Quantum states, however, do not have well-defined properties because they are functions. There is no way to determine the velocity of a quantum state because it is nothing more than a relationship possibility. The velocity of a relationship possibility does not even make sense.

Another problem with quantum mechanics is that we cannot measure both the momentum and the location of a quantum system at the same time because the momentum state and the location state are two different quantum states. This means that we need to use two very different relationships and two different types of equipment in order to measure them. This is represented mathematically by the use of two different mathematical "operators." Operators are mathematical functions.

Remember, a measurement, according to LoP theory (and the TI and RTI interpretations), requires an exchange of energy. And for this energy transaction to take place, both the emitter and absorber must both act in concert. This requires a second-person relationship between them, according to LoP theory.

This explains the meaning of this second principle. It is telling us that if a quantum state happens to be aligned with the measuring equipment, then that quantum state will be the state that defines the transaction. This means that the numerical value of that state will be the value that is measured.

For a quantum state to be "aligned" with the measuring equipment, it must be a vector that points in exactly the same direction (or the exact opposite direction) of the quantum state of the operator that represents the measuring equipment. This makes perfect sense because we already know that the emitter and absorber must have exactly the same wave function, except that the emitter wave function moves forward in time, while the absorber function moves backwards in time. Of course, they do not actually move through space-time, but the point here is that these two wave functions (quantum states) must be aligned exactly to couple together. This is what is needed to make the handshake that triggers the measurement event.

Whenever a quantum state is "aligned" with an operator that represents a specific observable (that represents the equipment used to measure that observable), then that quantum state is said to be an "eigenstate" of that observable. All that this is saying is that only a quantum state that has a vector that is aiming in exactly the same direction (or the exactly opposite direction) can be measured.

The reason this principle is important is because it tells us that when a quantum state is aligned with the measuring equipment, then if we make a measurement of a system, this aligned quantum state will dictate the value that we receive from our measurement. It also tells us that measurement affects the system. This is represented by the operator acting "on the vector space" of the system.

To picture what this means, imagine a two-slit experiment. The value measured will be indicated by the spot on the screen where the photon lands. This measurement result will be determined by the emitter-absorber relationship that becomes actualized. And that relationship can only become actualized if their wave functions are perfectly aligned with each other.

5.3 Wave Function Dynamics

Every quantum state changes and develops in a deterministic way, based on the forces and constraints acting on that state. There is a way to calculate what state that system will be in at a later time. The deterministic law that governs how a quantum state changes with time, for non-relativistic systems, is represented by the Schrödinger equation. Since every state vector must, by definition, be a vector of length one, and must remain a length of one as they change over time, the changes in state vectors dictated by the dynamical law are exclusively changes of direction, never of length. Thus, quantum states only change in a linear manner. This means that superposition states remain as superposition states, as they change over time.

Note: Using the Schrödinger equation means that only non-relativistic quantum theory is involved. This means, first of all, that it only represents the emitter's side of the story, not the absorber. And, secondly, it does not account for the creation and annihilation of quantum states.

What we see happening here is that quantum states evolve and change over time, but they do so only in a linear matter. This means that they never change suddenly and discontinuously. Since the creation and annihilation of quantum states are clearly cases of discontinuous change, the above description of how quantum states change is only valid when measurement is *not* involved.

Therefore, this principle of quantum formalism describes only the way quantum states change in "coherent" (unobserved) situations. In other words, relationship possibilities, by themselves, only *influence* other relationship possibilities through phase relationships (see 5.1). They cannot create discrete shifts or breaks. Thus, this process is not able to create a measurement transaction. Why is this process different from what happens during the process of measurement, which we will get to in principle 5, below? This is the question at the heart of "the measurement problem."

As a result, this principle says that superposition states should never disappear. They should continue on forever. This is why we see the Many Worlds Interpretation, which suggests that each possibility becomes an actuality in a different universe. All of these problems go away with the LoP Interpretation (and with RTI – the Relativistic Transactional Interpretation as well).

It is also worth mentioning that the Schrödinger wave function describes quantum states as being spread out across space. The wave function represents statistical probabilities of where a system will be located over time. Remember, quantum particles jump around. They do not follow simple paths. The question remains, however, what is this "function" that is waving? Or is it purely a mathematical tool? This is a question that bothered physicist, John Bell, for most of his life:

> What is the Schrödinger wave function? The standard interpretation tells us that the wave function provides information about a quantum mechanical system, such as the probability that, when measured, "observables" have some particular value. But is this all we have – "information"? Isn't there something else behind the scenes? Bell used to conjecture that – while physicists, when they teach or even use the quantum theory, seem to accept the idea that all we have is information – in their heart of hearts they really believe that the wave function is not the whole story. The information contained in it refers to something else, something not revealed – a hidden reality. (as cited in Berkenstein, 2009, pp. 144-145)

The LoP Interpretation says that this hidden reality is composed of relationship possibilities. That is what the waves are made of. They change continually, just like waves, because they are shared states that evolve back and forth in dynamic ways between those involved. Quantum states (wave functions) spread across space because sentient agents are involved in relationships with other sentient agents. Quantum states are non-local because the dynamics of second-person relationships exist only between sentient agents, not in dimensions defined by the field of space.

This third principle stands as an important description of how relationship possibilities evolve over time when no measurement is taking place. And it fits perfectly with the LoP Interpretation.

5.4 Relationships with the Measuring Equipment and Born's Rule

> *If a quantum state is not an "eigenstate" of the operator of an associated observable being measured (see 5.2 above), then, according to quantum mechanics, the outcome of such a measurement is a matter of probability. Born's Rule stipulates that the probability of each measurement outcome will be the absolute square ($|a|^2$), if the value of that state is "a." Also, any state that has a value of "-a" (which means the vector is pointing in exactly the opposite direction with the same length) will have precisely the same measurable outcome because $|a|^2 = |-a|^2$. Therefore, any vector with a value of "a" is considered precisely the same physical state as a vector with a value of "-a." All measured values must be real numbers, and all eigenstate vectors of an observable must be orthogonal (at right angles) to each other.*

In 5.2, we saw what happens when a quantum state is already in a relationship alignment with the measuring equipment before the measurement takes place. The quantum state is then said to be an eigenstate of the operator (the operator represents the measuring equipment and the observable being measured). This is generally not the case in most experiments, unless the same measurement was performed shortly before.

This raises an interesting question: If no measurement was made previously, is there any way of knowing if a quantum state is an eigenstate of an operator, based on the results of the experiment? The answer is no. Therefore, the case sited in 5.2 only applies to repeated experiments – when the same measurement is run immediately after it had just been run (before the quantum state has been influenced by other forces or other measurements).

This fourth principle of quantum formalism applies to all other cases. This principle simply states that we must use Born’s Rule (square the absolute value of the value of a quantum state), to find the probability that a state will become the actualized result of the measurement. Born’s Rule is stated as a postulate, but, as we have already seen, the reason for squaring the value is because the emitter “offer” wave and the absorber “confirmation” wave must both be perfectly aligned in order to couple together. This is why we need to multiply them.

The square must be of the “absolute” value because these values are complex numbers. Remember, they can only be real numbers if they are fully aligned with the field of space. Only third-person relationship “confirmation waves” are aligned with the third-person field of space because they have no imaginary dimensions, according to the LoP model (see section 4.9.2.6). However, only second-person relationships are able to create measurement events. Second-person relationships always have an imaginary dimension because their inner dynamics are not visible to third-person lenses. If you square an imaginary number, you get a negative number. Using the “absolute” value means treating negative numbers as positive. In other words, it is the length of the vector that matters, not its direction, because probabilities must always be positive numbers.

This tells us that the “value” of a quantum state is directly related to the likelihood of it becoming actualized. According to LoP postulates, this value represents the “level of interest” for that relationship possibility shared by the sentient agents involved. This makes sense because the level of interest is directly related to the choices made by sentient agents. And, just as with probabilities, level of interest is always a positive factor. This is true even when agents find themselves opposed to each other – their level of opposition is still a positive factor. This is why some people become so obsessed with beating their adversaries that they forget about their family and friends.

This principle also says that any quantum state with a value of a is the same quantum state if it has a value of $-a$. This makes sense because when we use the relativistic model that includes both the story of the emitter and the absorber, we see that relationships and handshakes are only possible when both are exactly the same wave function, except one appears to move forward in time while the other moves backward. This means the two vectors are pointing in opposite directions. Thus, every second-person quantum state has a matching opposite state, because both are necessary to create a shared state.

This principle then says that all measured values must be real numbers. This is exactly how it must be, according to the LoP postulates, because all measurements are the result of a wave collapse, and a wave collapse is nothing more than an exchange of energy and momentum that changes a third-person field. All changes to third-person fields must be represented by real numbers because third-person fields are objective realities that act as our reference for real numbers.

The last point raised by this fourth principle is that all eigenstate vectors of an operator associated with an observable must be at right angles to each other. The reason for this is simple: because they are independent of each other. As Bowman says (2008): “Orthogonality implies linear independence” (p. 38). These quantum states must be independent because they represent second-person relationship possibilities. Such possibilities exist only between the agents in a relationship.

5.5 Wave Function Collapse

> *Measuring an observable changes the state vector of a system being tested, collapsing it, or making it jump from whatever state it was in before into an eigenvector of the measured observable operator. Which eigenvector is selected is determined by the probabilities outlined in the fourth principle (5.4) above. It is at this point, and no other point than this, that an element of pure chance enters into the evolution of the state vector. Once a measurement is carried out, the state of the measured system must guarantee that if that measurement is repeated immediately afterwards, the same result will be obtained.*

We now come to the act of measurement itself. This does not just apply to experiments with human observers. This principle applies to every exchange of energy – to every actualized event.

This last principle of quantum formalism tells us that the overall state of the system, which means all of the relationship possibilities that are influencing it from all of its relationships, goes through a discontinuous change when it is measured. This is sometimes called a quantum leap, because it suddenly leaps into a new state.

As we saw in 5.3, this process cannot be the result of the wave dynamics that govern the evolution of quantum states. This is the second missing puzzle piece in quantum formalism, because it cannot account for why the measurement process is different.

The Copenhagen Interpretation of quantum mechanics, which is the most widely accepted, says that this is a reflection of the statistical nature of reality. In other words, the reason one quantum state is selected over all the other possible states is based purely on its probability. This is the point that Einstein refused to accept. Einstein has been criticized over his comment that “God does not play with dice,” because many physicists think that he was simply unable to give up the old idea of classical physics. But that was not his objection. Here are Einstein’s actual words:

> Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the ‘old one’. I, at any rate, am convinced that He is not playing at dice. (as cited in Born, M., 1971, p. 91)

If you cannot explain how a possibility is selected, then saying that quantum formalism is telling us that we live in a probabilistic world is meaningless. This is the point that I think Einstein was getting at. Quantum formalism does not tell us why probabilities govern the result of measurements in a statistical manner because the process that selects the outcome is hidden from third-person eyes. And if scientific equipment cannot see what is happening, then quantum formalism, which is nothing more than a formalism based on measurement results, tells us nothing about why or even how outcomes follow probabilistic laws.

The LoP Interpretation offers an intuitive answer: The possibilities of quantum states represent the influences of relationship possibilities. Which couples end up getting married? Clearly, those with the strongest level of interest in each other. But this is not always the case. Families have an influence. Some people meet and suddenly just decide to tie the knot on the spur of the moment. It is often surprising to see who decides to get married. Yes, statistically we can say that it follows their level of interest, but the fact is that we cannot know who one person will marry, or if they will marry at all. We cannot know because relationships are not simply the result of probabilities. Relationship possibilities are far more complex in the way they evolve.

Nonetheless, it is absolutely true that the moment a person marries all the other possible marriage opportunities vanish. Those possibilities disappear. Our lives *do* change when we get married. Our lives then suddenly start evolving and changing based on completely new possibilities. Thus, what this principle of quantum formalism is describing follows the LoP postulates perfectly.

The last point made in this principle of quantum formalism is that immediately after a measurement is made, if you measure the system again, you will get the same result. This also makes sense, because in the moment when an event becomes actualized, all of the other possibilities vanish. Over time, new possibilities will begin to emerge, but when you first find yourself in a new world, it takes time to get to know how to respond to that world.

The same is true with every major change of state. If you graduate from high school or college, or you join the military (whether by your choice or the government's choice), or retire, or when you go through puberty as a teenager, many of the possibilities in your life change at the same time. But it takes a while to see what this means. It takes time to relate to your new world.

This is why, after you measure a system, if you make the same measurement again, before it has a chance to evolve, you will find the same outcome. The reason for this is exactly what many physicists have said: It is because the superpositions have collapsed down to one actuality. The other relationship possibilities have disappeared, as they should if they are nothing more than possibilities.

This explains quantum formalism in an intuitive way, which is something that many have claimed is impossible. In fact, I believe it is clear that the postulates outlined in section 4 explain why quantum formalism takes the form that it does.

This, however, only brings us to the beginning. None of this is a conclusion or a proof. It only brings us to a starting point, where we have a new interpretation worth exploring. It needs further testing. It raises countless new questions. The implications are significant.

Fortunately, there are many ways to test this theory. It is not lacking in testability, as some other interpretations are. This will be explored briefly in the following section.

6. Challenges, Implications, and Opportunities for Testing

"The task is, not so much to see what no one has yet seen; but to think what nobody has yet thought, about that which everybody sees." This quote is often attributed to Erwin Schrödinger, but it was actually from the pen of Arthur Schopenhauer (as cited in O'Toole, 2015). After this quote, Schopenhauer continued by adding this: "For this reason, it takes much more to be a philosopher than a physicist."

When it comes to the interpretation of quantum mechanics, I would say that Schopenhauer is not quite right. The problem is not how to think about QM, but how to see it working in our everyday lives. As I said in another article, until we can do this, the revolution of QM will not be complete (Marman, 2016, April).

In order to see how quantum interactions work, we must add first-person and second-person lenses to the traditional third-person lens used in science. Each lens requires a different way of seeing, a challenge that is well-known to psychologists. Thus, in a strange way, to fully comprehend QM, if the LoP Interpretation is correct, we need to bring philosophy, physics, and psychology back together again. I say *again* because "natural philosopher" was the name for a scientist in Isaac Newton's day.

Trying to *think* about the problems of QM, in order to solve them, has obscured our way of seeing, because thinking "about" things uses third-person lenses. It starts with an assumption that we can solve these problems by looking at them from the outside. We cannot, because outsiders cannot see quantum states. Only those *involved* see the influence of relationship possibilities. Relationship dynamics are behind everything that happens in our daily lives and everything that happens in the universe. But we can only see this at the level of personal interactions. This is the quantum level.

The need to use added lenses is both the biggest opportunity for the LoP Interpretation and its biggest challenge, because learning to see through new lenses is not easy. To learn a new lens, we must set aside our normal way of looking at the world. It can feel confusing and uncomfortable switching to a new lens that is not familiar. It takes time for our unconscious to "catch it," but when it does, suddenly everything comes into focus, as we see clearly what the lens is showing us.

There are, however, quite a few other challenges. Too many to cover in this paper. For the last seven years, I have been looking for anything that might invalidate the LoP theory. I have studied physics, biology, psychology, neuroscience, and even some philosophy. I have found nothing that invalidates the premise of this paper. However, the following are the biggest challenges I have run across. They show where further research is needed and the opportunities they represent.

6.1 Hidden Variable Theories

When Einstein first began to question the implications of quantum entanglement, he wondered if there could be local hidden variables acting within entangled particles that caused them to behave as they did. The reason Einstein proposed this was because he could not see "action at a distance" as a possibility. No physical changes should be able to occur instantaneously across space.

In 1964, the physicist, John Bell, described an experiment that could determine whether it is possible for local hidden variables to produce the results of quantum entanglement.

Between 1981, when the first convincing test of Bell's Theorem was run, and 2015, when a test that closed all of the loopholes was completed, the results have shown convincingly that entanglement is a non-local phenomenon. These experiments have also been accepted as proof that local hidden variables cannot account for the behavior of quantum entanglement.

Since the LoP theory proposes that something within particles causes them to become entangled, the question can be raised: Is this simply a different type of local hidden variable theory? This is a good question, but the answer is no, for two reasons.

First, the postulates of perception show us that what happens within each particle is not enough to explain entanglement. In other words, first-person perception alone does not solve the problem. We need relationships to develop between particles. The dynamics of relationships do not exist in any one partner. They exist between partners. This means relationship dynamics are, by definition, non-local. In fact, this shows us the underlying reason why entanglement *is* non-local.

Second, the term "variable" has a specific meaning. It refers to a mechanism – a deterministic principle – that governs the outcome. This clearly is not what happens in relationships. There is no way to call relationships between sentient agents deterministic or mechanical. We never know exactly how they will turn out. Thus, the term "variable" does not apply either.

Physicists have taken the discussion about hidden variables in another direction, toward the question of realism. This is where it gets interesting. The current argument, as Gröblacher (2007) explains, is that the principle of realism is obeyed only if "external reality exists independent of observation" (p. 1).

Simon Gröblacher and his partners (2007) go on to show further that a broad class of *non-local* hidden variable theories fail to explain the results of quantum mechanics, as long as they hold onto traditional principles of realism.

> Most working scientists hold fast to the concept of 'realism' – a viewpoint according to which an external reality exists independent of observation. But quantum physics has shattered some of our cornerstone beliefs…. Here we show by both theory and experiment that a broad and rather reasonable class of such non-local realistic theories is incompatible with experimentally observable quantum correlations…. Our result suggests that giving up the concept of locality is not sufficient to be consistent with quantum experiments, unless certain intuitive features of realism are abandoned. (p. 1)

The point they make is that whether QM is local or non-local is less important. It is the principle of realism that matters the most. It is realism that is being put in doubt. They conclude their paper saying that any non-local extension of quantum theory, if it is right,

> has to be highly counterintuitive. For example,…consider the breakdown of other assumptions that are implicit in our reasoning.... These include Aristotelian logic, counterfactual definiteness, absence of actions into the past or a world that is not completely deterministic. We believe that our results lend strong support to the view that

any future extension of quantum theory that is in agreement with experiments must abandon certain features of realistic descriptions. (p. 7)

This paper illustrates how deeply strange quantum states are and how far they take us from the traditional idea of realism. However, the results of the experiments described by the paper do not cast doubt on realism. They only cast doubt on the third-person idea of realism. It is our idea of what is real that needs to change.

The results of this paper, along with all the other tests of Bell's Theorem, are consistent with the LoP Interpretation (and with Kastner's RTI model as well). The problem with realism disappears once quantum states are seen as relationship possibilities. It is then valid to say that relationship possibilities *are* real because they *do* exist independent of observation by outsiders. However, they do not exist in space-time. They exist only between the sentient agents involved.

Let's go through the list of realism features that the above paper says we must abandon. I have already shown that relationship possibilities defy Aristotelian logic in section 4.6, such as the Principle of Non-Contradiction and the Law of the Excluded Middle.

Now look at the next principle mentioned above: "counterfactual definiteness." This means that if something is real, it must exist even when it is not being measured. Is this true for quantum states? Yes, because they *do* exist, but not in space-time. This is exactly what it means to "take Heisenberg's potentia seriously." Relationship possibilities *do* exist, and they *do* affect us.

The next principle of realism that the paper says we must abandon is "absence of actions into the past," meaning that it should not be possible for us to influence the past from the future. I have shown how this is exactly what *appears* to happen in delayed quantum eraser experiments (see section 4.9.2.4). However, this illusion is easily explained once we realize that entanglement is a shared quantum state that exists outside of space-time. Therefore, there is no causation backwards in time. In fact, this has nothing to do with causation or "action" at a distance because it is only the quantum wave functions that are changing. Einstein was right: All true action – all exchanges of energy – must be local because they are space-time events, as we saw in section 4.9.

Lastly, the paper says that we must give up on a "world that is not completely deterministic." Many physicists are still not willing to accept this. However, when it comes to relationship possibilities, it is clear that they are *not* deterministic. We know this from our own day-to-day lives.

Therefore, we can state unequivocally that quantum states are "real" because they *do* exist independent of outside observation. Thus, realism survives. It only seems counterintuitive if we keep trying to look at the world *only* through third-person lenses. The moment you put on a pair of second-person goggles and look at quantum states as relationships, then quantum behavior makes perfect sense. Thus, Einstein's intuition was correct.

We know that relationship possibilities play significant roles in our lives. People who use third-person lenses to judge relationships based only on what they are now and refuse to consider the possibilities of what they can become are sentencing those relationships to death. Possibilities give our relationships life. Thus, there is no reason to cast doubt on the realism of quantum states.

6.2 The Combination Problem of Panpsychism

I will let the philosopher of consciousness, David Chalmers (2017), outline the problem here. It should be easy to see that this represents a serious challenge for the LoP Interpretation:

> Panpsychism, the view that fundamental physical entities have conscious experiences, is an exciting and promising view for addressing the mind–body problem. I have argued in "Panpsychism and Panprotopsychism" that it promises to share the advantages of both materialism and dualism and the disadvantages of neither. In particular, it can respect both the epistemological intuitions that motivate dualism and the causal intuitions that motivate physicalism.
>
> Nevertheless, panpsychism is subject to a major challenge: the combination problem. This is roughly the question: how do the experiences of fundamental physical entities such as quarks and photons combine to yield the familiar sort of human conscious experience that we know and love. (p. 1)

Chalmers breaks the combination problem down into three parts, based on three different aspects of conscious experience: First, the subjective nature of conscious experience because it belongs to a subject – the one who is having the experience. Second, the qualitative nature of conscious experience because experiences are composed of subjective qualities that combine together. Third, the structural nature of conscious experience because our experiences of the world have a complex materialistic structure that seems inconsistent with our subjective perception. Here is a summary of the three combination problems, in my words, from Chalmers' paper (pp. 4-6):

1. **The Subject Combination Problem:** How do micro-subjects, such as sentient quarks and photons that have conscious experiences (which means that they are subjects) combine to make macro-subjects, such as cells and living organisms, which are also sentient?

2. **The Quality Combination Problem:** How do micro-qualities, such as the experiential quality of redness, that we feel when seeing something red, form macro-qualities, such as when many micro-qualities come together to create our singular experience of a sunset?

3. **The Structure Combination Problem:** How do micro-experiential structures and micro-physical structures combine to create macro-experiential structures? For example, why does the macro-physical structure that we call a "brain" seem completely different from our experience of having a brain?

Chalmers adds an important note about these three problems. He writes:

> It is common for a proposed solution to the combination problem to address only one of these problems: most often the subject combination problem and occasionally the quality combination problem. It should be stressed that a satisfactory solution to the combination problem must address all of these problems. This raises the bar for a solution, as it is far from clear that any single proposal can solve all the problems at once. (p. 6)

The LoP Interpretation is able to offer a solution to all three of the combination problems. That is good news. And it leads to a simple, intuitive way of putting the three combination problems in perspective, which is also good news. For example, the LoP theory suggests that problem 1, the subject combination problem, is about first-person perception and the *impossibility* of combining first-person perception. Problem 2, the quality combination problem, on the other hand, is centered on the nature of second-person experiences and how they *do* combine. And problem 3, the structure combination problem, is about how third-person perceptions combine and why they are different.

This need for all three of the fundamental lenses of perception suggests that the LoP Interpretation is well-suited to understanding the combination problems of panpsychism. However, in order to resolve the underlying issue of problem 1, the postulates of section 4 lead to a truly surprising solution that goes against common wisdom. This presents us with another major way to test the validity of the LoP postulates. This is a significant challenge facing the LoP Interpretation. Let’s take a look.

6.2.1 The Nested Structure of Living Creatures

Let me begin by describing how the underlying issue of problem 1 hit me, some five or six years before Chalmers published his paper. I had already worked out the nine postulates of section 4. However, as I was studying the way these principles apply to living organisms, I noticed something important was missing.

The postulates listed in section 4 describe two fundamental types of relationships: second-person and third-person. The problem is that neither of them seem capable of creating the nested quality that we see everywhere in nature. This struck me when looking at the biology of the human body. We see cells working together so closely that they act as one functioning body. At the same time, within each cell, we see molecules and genes working together to keep each cell alive, so that cells are able to act as sentient agents.

As I have shown in section 4.9, second-person relationships are not always equal, because energy flows from a higher potential to a lower potential to create a wave collapse. We see the same thing with dance partners. They work best when one starts off leading and the other follows. However, as partners get to know each other, the gap between leading and following tends to become fluid and often shifts back and forth. What matters is that the back-and-forth alignment continues, as partners move with each other in a responsive way. This is where wave functions come from. However, I could see no way for nestedness to arise from these one-on-one relationships.

Third-person relationships create backgrounds, such as societies or cultures. They create a sense of what is normal in a way that applies pressure on agents who go against the norm. Thus, I could not see how third-person relationships could ever create the nested nature of living organisms.

It is possible, of course, that this nested quality that we see in biological organisms might only be a macro-level property. It might have nothing to do with quantum principles. After all, creatures have far more degrees of freedom than quanta, so it might not even be possible at the level of fundamental particles. However, if the LoP theory is valid, it should offer some explanation for how nestedness emerges. So, I went back to the postulates of perception. Is this something new, or can it be explained with LoP postulates? The answer was simpler than I expected.

As I looked closer at multicellular organisms and asked myself why cells work for an organism, I began to see that cells truly dedicate their lives to something larger than themselves, and they work so closely together that they act as one body. Considering this from a cell's point of view, I noticed that each cell seems to be entangled with the organism it belongs to. And animals and plants also depend completely on their cells to live. Organisms act as if they are inseparable from their bodies. Equally, the fate of their cells depends on the survival of their host. This struck me. It looked like a shared quantum state of some kind between sentient agents in a nested structure.

With second-person relationships, a shared state is formed when two agents perceive that they share an interest in each other and they both reinforce it. Is it possible that all the cells in our bodies share a common interest together?

According to the postulates of section 4, second-person relationships between cells are not enough to form bodies, they will only lead to attraction or repulsion between pairs, and exchanges of energy, as we see with electromagnetism. That is when it hit me; nesting is something different. Cells in an animal's body are not just involved in relationships with each other. They are also entangled with the animal itself. In other words, each cell forms a one-on-one relationship with the "being" who inhabits the body. That appears to describe what is happening. Can this be right?

It turns out that this is fully consistent with the postulates in section 4. For example, first-person perception always belongs to someone. This means that the first-person perception of the organism cannot be created by the cells. Secondly, entanglement is only possible between sentient agents.

As soon as I realized this, I saw something else: The distinction between the cells and the "being" who inhabits the body is black and white, because the cells of the body and the sentient agent who inhabits the body work at two different levels in the nest. This distinction is as black and white as photons in a spin-up or spin-down state, or electrons leaping from one energy shell to another in an atom. LoP postulates say that this black-and-white distinction should maximize the strength of their entanglement.

Differences between the cells in multicellular organisms, on the other hand, are not distinct because they are clones of each other. Their differences are grey, especially when embryos first start to develop. However, the being who inhabits a body works at a higher level than the cells. This should make the bond maximally strong. And this bond should significantly increase the entanglement between the cells as well, because the cells share this quantum state together with the being who inhabits the body. This does seem to describe why cells work as a unit for the sake of an organism.

I call this an "all-for-one" relationship, after the famous quote from The Three Musketeers who worked as a team for the sake of king and country: "All-for-one and one-for-all." This is clearly something that we experience as human beings when we join teams working for a higher purpose. We feel the added sense of empowerment that comes from working for a shared goal, especially when the goal is meaningful. This is indeed a different bond than one-on-one relationships.

However, this is where the Combination Problem raises its head, because the Three Musketeers did *not* create a new living entity by working together. Yes, the king does work at a different level in a hierarchy, so we do see some of the same traits of nestedness here, but the king is just another human being, and a “country” is not a sentient being.

When I looked closer at the details about how the postulates of perception apply, it became clear that, if this all-for-one relationship does exist as a quantum state, then we should see two types of all-for-one relationships: A strong bond should exist when the outer level of a nest is a sentient agent. And a key characteristic of this strong bond is that when the outer agent dies, so does its body. The cells cannot hold together for long after their shared purpose disappears.

A weak type of all-for-one relationship, on the other hand, should emerge when one sentient agent steps forward to lead a group. This bond is weaker because the only distinction between that one sentient agent and the others is that it is acting as a leader. This should never create a state of full entanglement because other agents can easily step forward to take over as leader. However, this weak bond plays a role that is just as important: It creates organizational structures that can survive for generations – longer than the lifetimes of any of the agents themselves.

Biologists do indeed see both of these types of nestedness in nature. This is a good sign. But, if this is truly a shared quantum state, then we must see the same pattern of behavior at the level of quanta as well. This is where the added constraints of the LoP Interpretation kick in. If all-for-one relationships are formed by a combination of second-person relationships at the organism level, then we should be able to find the same thing happening at the level of fundamental particles.

We do. The “strong force” of physics is activated when three quarks work so closely together as a group that they act as a single entity. This is how protons and neutrons are created. Protons and neutrons also bond together through the strong force to form the nuclei of atoms. We see this same trait of nesting at the quantum level.

This was my first test of this new conjecture about all-for-one relationships. I then studied the problem closer and was surprised to see how well it describes the “strong force.” The Standard Model of Particle Physics uses quantum field theory to explain how the strong force works. This is a relativistic model, which means that the strong force arises when virtual quanta are exchanged between particles, as we saw previously with the EM force (see section 4.9.1). In the case of the strong force, however, three quarks join together to trigger the strong force reaction.

All three quarks must come together at the same time. And each quark must carry a different “color” charge, and all three color charges must complement each other in a precise way that activates the bond. These “color” charges have nothing to do with visual colors. In fact, they cannot be seen or detected directly. The three charges are named “red,” “green,” and “blue” because, when you combine red, green, and blue light, they make white. In other words, “color charges” are only used to symbolize the invisible exchange between quarks and how all three need to come together to activate the strong force.

The moment the strong force activates, a new “baryon” particle is created, such as a proton or a neutron. And, because protons and neutrons both clearly act as if they are individual agents, we know that this is a *strong* all-for-one relationship. However, this gives us a truly bizarre way of looking at protons and neutrons because it suggests that sentient agents inhabit the bodies of protons and neutrons, just like we, as human beings, inhabit our bodies. Is this possible?

To pass this test, I needed to make sure that it aligns with all of the known properties of protons and neutrons. And the principles of the strong force must equally apply to organisms as well. This is a high bar. As far as I can see, it passes this bar. Let's take a brief look.

The fact that each quark must have a distinctly different charge makes sense because this enables strong entanglement between the quarks. This reveals an interesting aspect of all-for-one bonds that I did not notice at first with organisms. However, it explains why cells naturally differentiate and specialize from each other when an embryo develops – it makes the all-for-one bond stronger because it makes the entanglement between them stronger. In other words, diversity plays an important role in creating stronger teams. A team is more effective when each individual takes on a specialized role and those roles complement each other. This is the same way that color charges act with the strong force.

According to quantum field theory and Kastner's RTI model, three one-on-one relationships form between the quarks. For example, if the quarks are named A, B, and C, then the three relationships are: A-B, A-C, and B-C. And, between each of these pairs, "gluons" are emitted and absorbed. Gluons are force carriers for the strong force, just like photons are carriers of the EM force. So we see similar relationships to emitters and absorbers in electromagnetism, where virtual photons are emitted and absorbed, creating attraction or repulsion. However, with the strong force, a far more powerful attractive force emerges, but only when all three quarks align with each other in a shared state. Then, not only do the three quarks form attractions with each other, but so do the red, green, and blue gluons. This truly describes an "all-for-one and one-for-all" state. Remember, the strong force does not exist before it activates, and it only activates when three quarks unite.

The only thing that is missing, according to LoP theory, is the sentient agent who inhabits the proton. This should be no surprise because sentient agents are not visible to outsiders. We only see their bodies, not the agents themselves. The only visible evidence of sentient agents comes from seeing how they act as responsive individuals. This is an indication that internal agents are present. The fact that protons and neutrons act as singular particles is consistent with this. Indeed, protons and neutrons act as distinct individual particles in all of their interactions with other particles.

This describes a remarkable similarity between living organisms and quantum relationships. We can add it to the list that I started in section 1. However, this similarity may be the most surprising of all. The way quarks form protons and neutrons, and the way those protons and neutrons form atoms, displays the same property of nesting that we see between life forms in nature. And this also explains how communities, families, countries, and companies are formed, when people work together for common goals.

However, if our model is going to survive, it needs to pass a second test as well: We must see *weak* forms of all-for-one relationships at the quantum level as well. We do. This is truly surprising.

The exact same combination of quarks and gluons that create a proton (two "up" quarks, one "down" quark, one "red" gluon, one "green" gluon, and one "blue" gluon), combine to create another particle as well: the “delta+” particle. And the bond that holds the delta+ particle together is exactly what we would expect – extremely weak – because there is no sentient agent inhabiting the particle. One of the quarks simply steps forward to act as the leader. While the lifetime of a proton is so long that it has not yet been measured, delta+ particles quickly fall apart. They decay in less than a millionth of a second. Measurements show that the binding force holding the quarks together in delta+ particles is much weaker than in protons.

This is of course a speculative proposal, but the remarkable resemblance here between quanta and living organisms, once again, is breathtaking. More testing is clearly needed, especially because the Standard Model of Particle Physics says that the strong force cannot extend beyond the nucleus of atoms. This idea that the strong force could be involved in the relationship between organisms and their cells goes completely against common wisdom. Fortunately, this speculative theory leads to a number of surprising predictions that are confirmed by evidence, as I explain in my book (2016, pp. 248-270), and as we will see in some examples below. This adds more weight. But more validation and scrutiny is clearly needed for something this controversial.

Comparing protons to a living cell seems outrageous, until we see the remarkable similarities. For example, the biggest mystery about living cells is what makes them alive. How do all those highly *specialized* and different molecules keep the flow of energy moving within the cell? Biologists have not solved this problem. However, the energy that comes from quarks working together is quite similar.

In fact, the energy produced by the strong force in protons is so strong that it gives protons one hundred times more mass. In other words, if you add the mass of all the particles together inside the proton, they only add up to one percent of the mass of the proton. The rest of the mass comes from the energy that moves the quarks to spin as one unit, and the binding energy that pulls the quarks together.

The fact that quarks in a proton spin as one is another unsolved problem of physics. It is called the “proton spin crisis” (see Jaffe, 1995, and Hetherton, 2015). Yet, this flow of energy never stops inside of a proton, as long as that proton survives. This is similar to the flow of energy in cells.

I am now writing a paper, with the help of biologist Alan Rayner to explain in more detail how energy keeps flowing in cells. The nesting relationship between quarks and protons offers a bridge between the formation of atoms and the formation of cells that may also explain how the first cells emerged. This gives us a possible new way of looking at what it is that makes organisms alive and how cellular life began.

After seeing how well all-for-one relationships seem to describe behaviors at the quantum level and the level of organisms, I believe these relationships offer a viable solution to the first of the three combination problems. It does not tell us where “beings” come from when they are born into a body, or where they go when they die, but those are not new questions. However, it does tell us that the first-person perception of an organism is not made from a combination of cells. Sentient agents are not created from relationships any more than consciousness is created by the interactions of neurons. The opposite appears to be true: Sentient agents are needed *first* to create dynamic relationships.

Actually, the LoP theory can offer a scientific explanation of sorts for where sentient agents come from when "born" into a body: They come from the same place that virtual photons come from before crossing over to become real photons. They come from that same reality where first-person perception exists, even though it cannot be seen by outsiders. They come from the same place as the "imaginary" mathematical dimension where quantum states exist independent of observation.

The fact is that beings are always invisible because outsiders cannot see first-person perception. We only see sentient agents by their responsiveness – by what they *do* with matter and energy. We never see the agents themselves. This is why I said above that the subject combination problem is all about first-person perception. All-for-one relationships play crucial roles, but they are, after all, simply another type of relationship that sentient agents naturally form with each other.

6.2.2 The Unconscious Formation of New Lenses of Perception

The quality combination problem is about the way we unconsciously form new ways of relating. This describes what happens when we form new working lenses of perception.

I gave examples of this in section 3.3.2, when a child learns to walk on their hands or skate on ice. The child learns by trial and error until they finally get the hang of it. That is how they learn a new working lens of perception. As a result, they can walk on their hands without being able to explain how they do it. This is because learning a new skill is an unconscious process.

Babies learn to walk and talk through the same unconscious process, and how to distinguish their body from the rest of the world. One day they simply know how to do these things. Countless feelings and sensations come together to form a single meaningful way of relating to their body. This is how babies "get to know" their bodies. It is the same way we get to know another person by forming a relationship with them. We get to know them unconsciously by doing things together, talking with them, and laughing at each other's jokes. This is how we learn through experience.

This describes the unconscious process we go through to learn how to relate to others. We use the same approach in learning how to relate to situations and environments. And we need to learn a new working lens for how to raise children. This explains why we act and feel different when we are with our children compared to how we feel and act at work, or how we feel and act at a concert surrounded by hundreds of people we do not know.

Each situation brings countless feelings and sensations together into a singular experience because we have a working lens that shows us how everything fits together. We get to know those situations like a friend. This is what it means to form a new lens. We automatically and unconsciously switch lenses when we leave our family in the morning and go to work. We switch gears because each situation needs a different way of relating. Our personality and sense of self actually changes. This happens because our unconscious sees the whole situation as if it were a person. Our unconscious works this way because it uses the second-person lens to relate to everything.

Second-person perception begins with half-formed perceptions and emotions. These are superpositions that hit us all at the same time until it becomes clear how to relate to a situation.

Then, only when it becomes clear to us, we are able to act consciously. This is why quantum states form first before action is possible. Relationship dynamics must always develop first.

I believe this offers a way of explaining the quality combination problem. Seeing a sunset means something to us because it is more than just an amalgam of sensations. The sight of the sun sinking below the horizon, which is something that has happened for billions of years, connects us to something timeless: The end of another day. We experience the stillness between day and night, as we switch from one lens to another. We do, in a sense, make a change within ourselves when switching from day mode to night mode. This makes sunsets a moving experience. Without even thinking about it, the feeling is special.

6.2.3 The Outsider Experience

Why does seeing a brain with our eyes, or studying a brain scientifically, seem so different from the experience of living in a body with a brain? This is the structure combination problem. I believe this problem is all about why third-person perception is so different from first-person and second-person perceptions.

The "outsider" perspective has grown over the last few centuries. It dominates our modern world because science and technology has changed our lives so dramatically. Hundreds of years ago, people felt much more involved in their personal experience of life. However, if you go back thousands of years, or look at the lives of indigenous people, we know that they see themselves as a part of nature, not separate from the habitat they live in.

Third-person lenses are not able to see quantum states, the dynamics hidden in relationships, or first-person perception. This is why, when neuroscientists study the brain, they only see a piece of meat with no sign of the consciousness that is able to experience a sunset.

The use of third-person lenses has grown because it is the best lens for studying cause and effect. Thus, it has become a great tool for discovering scientific truth. Much of the macroscopic world can indeed be explained by forces acting on objects, and we can easily study these reactions as outsiders. However, each lens is limited. A lens is simply a way of seeing – a way of relating. Each lens forms unconsciously through experience.

We do experience the "outside" world, and we can indeed relate to outside forces because third-person fields play an important role in our universe. However, if we try to use third-person lenses to study relationships, we interfere with the spontaneous flow. This is why the scientific lens has not yet found a way to explain what it is that makes organisms alive. And if we try to objectively study ourselves – analyzing our first-person perception as outsiders – we see no sign of self.

If quantum behavior is indeed the result of relationship possibilities, then we must learn to set aside our outsider perspective if we want to grasp the meaning of what quantum mechanics is trying to teach us.

Our use of third-person lenses has taken us far. It has transformed our world. But we have hit a wall when it comes to understanding how everything works at the level of individual agents. In other words, how everything *really* works when you look closely. We cannot see what is happening before our own eyes if we insist on using the wrong lenses.

Our experience of living in a body with a brain is a first-person experience. We have learned how to use our body and brain through working relationships. We cannot explain how we actually move our muscles because our cells do the actual work through all-for-one relationships, but we do lead our cells, and they follow our lead when we decide to act, because our life is their life. We are in this together. This is what it means to live in a body. All-for-one relationships allow us to move our bodies as a single individual. However, our bodies are in fact legions of cells and helpful bacteria working together.

In other words, third-person lenses never see what is truly happening beneath the surface, even when it comes to purely mechanical reactions. The discovery of quantum mechanics is a door that leads to a new understanding of reality. We just need to "get to know it" like a friend and see the meaning of relationship possibilities. Analyzing it as an outsider is not enough.

That is the lesson of QM, if the LoP Interpretation is right. And it shows a possible solution to all three of the combination problems. The LoP postulates show us why we need three fundamentally different lenses. And once we use all three, all of the combination problems seem to be resolved.

Of course, this is just a brief look at these issues. A more thorough investigation is needed. There are many opportunities here to test the LoP Interpretation.

6.3 The Five Unsolved Problems of Physics

In the spirit of revealing the biggest challenges facing the LoP Interpretation, I need to include something physicist Lee Smolin (2007) wrote:

> The core of our failure to complete the present scientific revolution consists of five problems, each famously intractable. These problems confronted us when I began my study of physics in the 1970s, and while we have learned a lot about them in the last three decades, they remain unsolved. One way or another, any proposed theory of fundamental physics must solve these five problems. (pp. 3-4)
>
> These five problems represent the boundaries to present knowledge. They are what keep theoretical physicists up at night. Together they drive most current work on the frontiers of theoretical physics.
>
> Any theory that claims to be a fundamental theory of nature must answer each one of them. (pp. 16-17)

I took this challenge seriously. Before publishing anything about the postulates of perception that I had developed, I wanted to see if the LoP Interpretation could offer at least some form of solution to "The Five Unsolved Problems of Physics." It took me years to work through these five problems. I finally found a way to answer each of the problems (as I show in Marman, 2016, pp. 407-473). However, these answers should all be seen as speculations in serious need of validation.

The fact that postulates of perception can offer a way to make sense of these problems increased my confidence in the LoP Interpretation. However, more scrutiny is clearly needed.

Let's take a look at the five unsolved problems. These are very brief summaries that hardly do justice to the explanations behind them, or the experiments that support these proposals. Further information is available in the footnotes to each problem:

6.3.1 Problem One: Offer a Single Theory that Explains Both General Relativity and Quantum Mechanics.

The principle of relativity itself derives from first-person perception. All measurements are relative because all transactions of energy require first-person perceptions to collapse the wave function. This is why everything that happens is relative. QM, on the other hand, is all about second-person relationships. Thus, relativity and QM originate from two different lenses. Perception is the single underlying principle that ties them together.

However, the real issue created by the gap between relativity and QM is the problem of "quantum gravity": Why is it so hard to make gravity work with quantum field theory? This requires showing how gravity emerges from the behavior of quanta. Since I have discussed this in sections 4.8 and 4.9, I am offering only a brief summary here:

The story of gravity begins with the formation of the field of space. All the particles in our universe belong to this third-person field. It forms through the process I explained in section 4.8. However, every exchange of energy creates a shift in perception that disturbs the field of space (see section 4.9). The reason this happens is because the field of space is a public reality held together by the reinforcement of outsider perceptions. When energetic events happen, the public field must adapt. The field of space warps, as it adjusts to the changes created by wave-function collapses.

Gravity is a problem for quantum field theory because the wave function collapse is not explained by quantum formalism. We need a relativistic quantum theory to see the way that quantum states are created and annihilated. According to LoP theory, fields are not the causes of these events. Fields only adapt to them. The actual cause of gravity ties back to first-person perception. Both an emitter and absorber must work in concert to make a transaction of energy happen. Energy density is proportional to the force of gravity because energy transactions are proportional to energy density. Energy transactions are the true cause behind warps in the field of space.

An energetic event temporarily disrupts the field of space, causing some of the particles closest to the wave collapse to lose their connection with the field of space. The loss of these particles is short-lived because they soon rejoin the field of space. However, with a continual series of wave collapses, the field itself warps as it continually tries to fill the void. As a result, there is a drop in the entropy density in that region. This is why recent research has proposed that entropy density may explain the emergence of gravity.[7]

6.3.2 Problem Two: Resolve the Troubles of Quantum Mechanics, Either by Making Sense of the Theory, or by Inventing a New Theory that Gives a Deeper Understanding of Nature.

LoP theory shows that quantum behavior is the result of the hidden dynamics in relationships between sentient beings. These hidden dynamics come from the possibilities that

[7] See details in Marman (2016, pp. 411-429).

weigh on sentient agents in relationships. Thus, Heisenberg's "potentia" should be treated as something real.

Relationship possibilities are peculiar because they do not exist in space-time. That is why they are hidden from outsiders and from third-person perception. Quantum mechanics cannot explain why the wave function collapses or where particles and quanta come from until we include first-person and second-person perception. Adding those two lenses completes the picture.

To illustrate the power of this solution in my book,[8] I show how it resolves problems that physicists are struggling to understand, related to the nature of particles, and why particles act so weird at the quantum level. The answer is simple: Particles are not bits of matter; they are sentient agents. That is why they behave like individuals, not like chunks of matter in specific locations of space.

6.3.3 Problem Three: Can All Four of the Forces of Physics and All the Known Particles Derive from a Single Source?

LoP theory says that particles exist because sentient agents are responsive and receptive in how they relate to each other. The properties of matter-type particles come from particle fields that those particles belong to. For example, a particle cannot exist as an electron unless it belongs to the electron particle field. The properties of force-carrying particles, on the other hand, are defined by the relationships they are exchanging energy for. This offers an explanation for why photons and gluons are massless particles, while matter-type particles have mass.[9]

Forces, however, emerge from relationships. Each of the four forces are created by a different relationship: Electromagnetism is the result of one-on-one relationships. The strong force comes from all-for-one bonds. The weak nuclear force comes from relationships that particles have with particle fields. And gravity comes from joint first-person actions that warp the field of space.[10]

In the process of trying to solve Problem Three, I made an even more surprising discovery: LoP theory predicts that there should be six forces, not four. It says there should be two additional forces, but no others.

It turns out that both of these new forces are well supported by empirical science. They both describe phenomena that physicists are well aware of but have been unable to explain: The first added force is dark energy (see the explanation for this under Problem Five, below). The second force explains the strange practice of *renormalization* that physicists have been compelled to adopt, where matter-type particles are treated as if they are surrounded by clouds of virtual particles. Electrons, quarks, and neutrinos are all surrounded by virtual particles due to all-for-one relationships with those virtual particles. These virtual particles actually form the bodies of the electrons, quarks and neutrinos. Experiments have proven the validity of this model.[11]

[8] Marman, pp. 429-433.
[9] Marman, p. 445.
[10] Marman, pp. 433-465.
[11] Marman, pp. 462-465.

If LoP theory is right about where forces come from, then these added two forces must also exist. The fact that these two forces have already been detected provides a bit of nice validation.

6.3.4 Problem Four: How Are the Values of Constants Chosen in Nature?

LoP theory shows how the constants of nature emerge from relationships, but the answer is not what physicists were hoping for. They would like to find an equation that predicts the values of all constants. However, if the LoP Interpretation is right, there is no such formula, since the process of “spontaneous symmetry breaking” that creates the values of these constants is determined by choices made in relationships. The fixed nature of these constants, such as the mass of electrons and quarks, comes from third-person fields. LoP theory suggests that these values evolved over time – they were not always the same as they are today.[12]

6.3.5 Problem Five: Explain Dark Energy and Dark Matter. If They Do Not Exist, Why Does Gravity Act So Strangely on Large Scales?

Dark energy emerges as a new force from the way the field of space forms. This new force not only describes the properties of dark energy accurately; it shows that it should act like a “cosmological constant” as proposed by Einstein, which means that space should expand equally everywhere. To put it simply, dark energy comes from new particles that enter and join the field of space. Those particles originate from a virtual state. Virtual particles continually try to join our universe, but most are unable to pass the threshold of perception needed to join the field of space. In the rare cases when new particles do join our world, space everywhere expands.[13]

Space is not expanding due to the force of a big bang explosion. It is expanding because new particles continue to join the field of space. This is why the overall field of space remains flat.

The acceleration of this expansion is slowing down because, as the universe grows larger, it is more difficult for particles to join the field of space. It is more difficult because the threshold of perception needed to join a field is determined by how many members it has. Small fields are easy to join, which is why the universe grew so rapidly at first. Thresholds of perception play important roles with second-person and third-person relationships, and thus all of the forces as well. These thresholds also determine which forces will take priority.

Dark energy is a straightforward consequence of the LoP principles of perception. In fact, LoP theory cannot avoid it. If the LoP theory of gravity is right, then the dark energy force must also exist as a distinct force.

Dark matter is a different story. It is not a new force. It is a display of an already known force: the “strong force.” This is admittedly one of the strangest outcomes of the LoP model. It is directly related to all-for-one relationships and offers another way to test the LoP postulates of perception.

According to physicists, the strong force only works in the subatomic domain. However, the LoP Interpretation says that this force is caused by a group of quarks coming together to form

[12] Marman, pp. 465-467.
[13] Marman, pp. 467-471.

protons and neutrons that are bodies inhabited by sentient agents. This is why protons and neutrons act as individuals.

LoP postulates predict that this should happen at every level where sentient agents form group relationships. If this is true, then we should also see the same behavior in stars and galaxies, if, and only if, stars and galaxies are also the bodies of sentient agents. This is a deeply divergent idea that clearly goes against common wisdom. However, it describes the behavior of dark matter so much better than any other theory that it deserves a chance to be reviewed. Let me explain.

Physicists know that about 98 percent of the mass of an atom comes from the strong force. Less than two percent comes from the protons, neutrons and electrons that make up the atom. In other words, 98 percent of the mass inside an atom is "dark" because this mass is invisible when seen from the inside. Atoms have this added mass for one reason: They resist outer forces as a unified body. In other words, atoms act and move as individuals. Therefore, 98 percent of the mass of an atom comes from the strong force energy that binds atoms together. Physicists agree with this.

Inside the atom, this added mass is invisible – it is dark. According to LoP, the dark mass in galaxies comes from this same bond. Gravity is not the only force holding galaxies together.

This explains why physicists have found no trace of dark matter particles or measured any effects of dark matter in our solar system, even though there should be five times more mass from dark matter in our galaxy than ordinary matter (*MIT Technology Review*, 2013). The problem has grown since the LoP Interpretation was first published. A number of serious searches for dark matter have come up empty handed, as science journalist Eugene Bagashov (2017) explains.

Bruce Dorminey (2018), a writer who focuses on the latest research in astrophysics wrote recently:

> Decades after the first searches for dark matter's hypothetical exotic particle counterparts, researchers are mostly at a loss to explain why there still has been no direct detection….
>
> Either some 85 percent of the universe's matter is non-baryonic (or exotic) [dark matter particles], or there's something awfully wrong with our current understanding of how gravity works on the largest scales.
>
> Although most researchers won't state it publicly, more than two decades after writing my first article on the subject for the U.K.'s *Financial Times* newspaper, I sense an undercurrent of weariness with this vexing problem. (§ 1-3)

The reason why physicists proposed dark matter in the first place is because stars in the outer reaches of galaxies are moving too fast. These stars act as if there is five times as much matter in the galaxy than is visible. Unfortunately, this invisible dark matter is not distributed the way you would expect: It is spread out in the galaxy like a halo in such a way that the outer stars rotate as one body. Physicists cannot explain why matter would be distributed this way, but this is exactly what LoP theory predicts if the strong force is involved, because the strong force displays this exact pattern. The strong force acts linearly when inside the domain of its bond (Fritsch, 1983, p. 164).

This means that the force stays constant from near the center of its domain to the outer edges. Outside its domain, the strong force decreases at an exponential rate. The strong force is the only force that acts linearly, and this is exactly what we see happening with the outer stars in galaxies.

As a result, if dark matter is created by an all-for-one bond, then the stars should move as one, the same way that quarks spin as one inside of protons. See "proton spin crisis" in section 6.2.1 above.

This offers an explanation that is consistent with everything that physicists know about dark matter, and also, as far as I know, it offers a way to test the theory. We should not see any evidence of dark matter in our galaxy except for the added speed of stars, because we are looking at it from the inside. Also, the planets in our solar system should *not* move faster because planets are not inhabited by sentient agents. Only stars and galaxies are. Plus, we should only see the mass of dark matter in galaxies when looking at galaxies from the outside, such as with gravitational lensing effects (where light bends around galaxies – this is used to determine the location of dark matter).

However, if dark matter in galaxies is indeed caused by all-for-one relationships between the stars, then this means that those stars must also be bodies inhabited by sentient agents. Remember, all-for-one relationships can only exist between sentient agents. If this is true, then we must also see the evidence of dark matter in stars. If we cannot find evidence that this same behavior is at work in our sun, then the LoP theory of dark matter is wrong. This offers another test for the LoP theory of the strong force.

A recent study shows that there is evidence of dark matter in our sun. In fact, it explains a recently discovered problem that has stumped physicists: Why is the sun rounder than it should be? If atoms in the sun have joined together to form an all-for-one bond, because the sun possesses a sentient agent of its own, and this enables the sun to act as an individual unit, then we should see the atoms within the sun revolving together as one. This should make the sun noticeably rounder than gravity can account for. This is exactly what has been discovered (as reported in *Nature World News*, 2012). No theory of gravity or any other force is able to account for this added roundness.[14]

A number of recent discoveries have reinforced the reality of dark matter but have taken physicists by surprise because they are not things that a theory of "cold dark matter" particles would predict. All of these discoveries are consistent with the LoP theory, as far as I can see. To do this justice requires a dedicated study of its own.

Once again, we can see that the LoP Interpretation creates a number of surprising predictions that are testable. These all represent ways that LoP theory, or parts of the theory, can be challenged or even invalidated. The only reason I am presenting theories that sound so outrageous is because I have been looking for ways to prove them wrong over the last five years. They seem to hold up.

[14] See also Marman, 2016, pp. 258-270.

The case of dark matter is one of the most surprising examples, because confidence was strong, at first, that evidence of the missing dark matter particles would be found in tests at the Large Hadron Collider. Since then, test after test has reported a complete lack of dark matter particles, such as the recent experiment reported by Conover (2018).

However, that was just the beginning. Following are some more recent examples.

A galaxy has been recently found where little or no dark matter appears to exist. This is puzzling. Did the galaxy form in the first place with dark matter? If it did, then why did it suddenly lose all that dark matter? However, this makes sense according to LoP theory, because we should expect some galaxies to "die," just like atoms decay and creatures have lifetimes (Drake, 2018).

Another study shows a surprising number of galaxies "rotating in sync" with each other. This makes sense, because if stars can form galaxies, then galaxies should also be able to form all-for-one relationships as well (Tasoff, 2018).

A recent study shows that there appears to be less dark matter in the earliest galaxies. Plus, those galaxies were much more turbulent, meaning that the stars were not spinning together as strongly, and they were filled with more gases and fewer stars. Is this not what we should expect for "young" galaxies, where all-for-one relationships are still developing stars? (Max Planck Institute, 2017).

And another new study says that dark matter is much darker than physicists thought. This means that dark matter does not appear to respond in any way to the EM energy in gases. This also makes sense because the strong force should only affect the stars, not clouds of gases because those gases are conglomerates, not individuals at the same level as stars (Nelson, 2018).

This also explains the Bullet Cluster, a famous formation created by two galaxy clusters that crashed through each other. The clouds of gases clearly attracted each other, but the dark matter centers did not follow the same path. They followed the centers of the stars in the galaxies instead, as the dark matter should if it is formed by an all-for-one relationship between the stars and the galaxy (Marman, 2016, pp. 265-266).

All of these recent discoveries are consistent with a strong force theory of dark matter. However, the most compelling evidence is just to see how spiral galaxies keep their form almost indefinitely. If gravity alone was involved, without any dark matter, the spiral arms should spin away. In other words, galaxies should spin apart, but they do not. They maintain their forms, the same as we see with the bodies of all individuals. The arms of spiral galaxies are not transient features, as astrophysicists once thought (Harvard-Smithsonian Center for Astrophysics, 2013).

This theory of dark matter is, of course, a speculation. A crazy one. It may even be crazy enough to be right, as Niels Bohr put it. However, it does at least show that there are new possible ways to interpret our natural world. And it shows that it is possible to meet Lee Smolin's challenge: Any theory claiming to be a fundamental theory of nature must be able to explain all five problems.

6.4 Summary of Challenges and Opportunities

This shows what I believe are the biggest challenges that the LoP Interpretation faces. These issues represent areas where further research is clearly needed. Other opportunities can be found in my book, *Lenses of Perception* (Marman, 2016).

Presenting a theory that reaches across fields, such as quantum physics, biology, neuroscience, and psychology, creates problems of its own. However, the similarities across these fields suggests that we may have been missing something that a new interpretation of QM can help explain.

7. Conclusion

It is easy to assume that the lesson of quantum mechanics is that physics defines everything that happens in this world. After all, this is what classical physicists have been telling us for centuries. However, the LoP Interpretation arrives at a different conclusion: Physics is no closer to the foundation of reality than biology, psychology, or other social sciences.

In other words, biology and the social sciences can help us better understand quantum mechanics, just as much as quantum mechanics can now reveal important lessons for these other fields. Seeing the relationships between organisms and their habitat can give us a clearer idea of how particles live in this world. Seeing the way societies form among animals and insects gives us a deeper understanding of where quantum fields come from and what they are. Seeing the psychology of how we make decisions paints a richer picture of the wave collapse. The study of leadership not only gains new insights from the principles of quantum mechanics, it also gives us a more vivid sense of how the “strong force” works.

In other words, the LoP Interpretation shows us that there are huge benefits to be gained from cross-pollination between fields of study. Each uses a different lens and perspective. By comparing them, we gain added context and a deeper understanding.

The value of an interpretation should be judged by how useful it is in giving us new ways of looking at life and reality. Can it help make us more effective as leaders, as scientists, and even as people in search of meaningful lives? These are the real proving grounds for the LoP Interpretation.

If biology and social sciences gain something from a quantum understanding of relationships, then we have expanded the scope of science. It can now reach from the smallest particles to the study of human psychology, from the origin of life to the formation of organizations, from the forces that form atoms and molecules to the chemistry of societies and how they interact. This breathes a new sense of life and open-endedness into scientific disciplines that have normally been limited to the closed-system, mechanistic perspectives that come from third-person lenses.

This also suggests that there may be a common thread tying all fields of science together because everything that happens is governed by relationships between living agents. If nothing else, hopefully, this paper opens the door a bit to new ways of looking at our natural world.

Acknowledgments

Special thanks to the following for their helpful suggestions and comments, which helped lift this paper into something much better than how it began: Ruth Kastner, Alan Rayner, Markus Molz, Bonnitta Roy, Jonathan Reams, and Karla McMechan.

References

Note: All urls in this reference list are live links.

Adesso, G. (2007, June 2). The social aspects of quantum entanglement. *Ordint la Trama*, 56, [3 pages]. Retrieved August 1, 2018, from the arXiv database: arXiv:0706.0286v1

Albert, D. (1992). *Quantum mechanics and experience*. Cambridge, MA: Harvard University Press.

Bagashov, E. (2017). Forecast gets darker for dark matter. [YouTube video]. Space News from the Electric Universe, the Thunderbolts Project. Retrieved from https://www.youtube.com/watch?v=lmROfjgViLE&feature=youtu.be

Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do conscious thoughts cause behavior? *Annual Review of Psychology*, 62, 331-361.

Bernstein, J. (2009). *Quantum leaps*. Cambridge, MA: Harvard University Press.

Bitbol, M. (2010), Reflective metaphysics: Understanding quantum mechanics from a Kantian standpoint. *Philosophica*, N83, pp 53-83.

Bohr, N. (n.d.). Niels Bohr. Retrieved August 4, 2018, from https://en.wikiquote.org/wiki/Niels_Bohr

Born, M. (1971). *The Born-Einstein Letters: The correspondence between Max and Hedwig Born and Albert Einstein, 1916 to 1955.* Macmillan Press. Retrieved from https://archive.org/details/TheBornEinsteinLetters

Bowman, G. (2008). *Essential quantum mechanics*. New York, NY: Oxford University Press.

Bruner, J. S. & Postman, L. (1949). On the perception of incongruity: A paradigm. *Journal of Personality*, 18(2), 206-233. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.550.3911&rep=rep1&type=pdf

Cartlidge, E. (2011, May 25). Rounding the electron. *Nature.* Retrieved from https://www.nature.com/news/2011/110525/full/news.2011.321.html

Chalmers, D. (2017). The combination problem for pansychism. In Brüntrup, G., & Jaskolla, L. (Eds), *Psychism – contemporary perspectives*, pp.179-214. New York, NY: Oxford University Press. Retrieved from http://consc.net/papers/combination.pdf

Conover, E. (2018). Dark matter particles elude scientists in the biggest search of its kind. *ScienceNews*, May 28, 2018. Retrieved from https://www.sciencenews.org/article/dark-matter-particles-elude-scientists-biggest-search-wimps

Cramer, J. (1986). The transactional interpretation of quantum mechanics. *Reviews of Modern Physics*, 58(3), 647-688.

Dehaene, S. (2014). *Consciousness and the brain: Deciphering how the brain codes our thoughts*. New York, NY: Viking Penguin.

de Ronde, C. (2011). The contextual and modal character of quantum mechanics: A formal and philosophical analysis in the foundations of physics (Doctoral dissertation). Enschede, Netherlands: Utrecht University. Retrieved from Utrecht University Repository: https://dspace.library.uu.nl/handle/1874/212787

Dirac, Paul A. M. (1938). Classical theory of radiating electrons. *Proceedings of the Royal Society*, Series A 167(929), 148–68. Retrieved from http://rspa.royalsocietypublishing.org/content/royprsa/167/929/148.full.pdf

Dorminey, B. (2018, July 18). Is time running out on dark matter? *Forbes*. https://www.forbes.com/sites/brucedorminey/2018/07/18/is-time-running-out-on-dark-matter/#7540ce987578

Drake, N. (2018, March 28). This galaxy has almost no dark matter – and scientists are baffled. *National Geographic.* Retrieved from https://news.nationalgeographic.com/2018/03/dark-matter-galaxy-gravity-dragonfly-physics-space-science/

Dumé, B. (2007, November 8). Two is a crowd for quantum particles. *PhysicsWorld.com*. Retrieved from http://physicsworld.com/cws/article/news/2007/nov/08/two-is-a-crowd-for-quantum-particles

[For more information on the original experiment, see Akoury, D., Kreidi, K., Jahnke, T., Weber, Th., Staudte, A., Schoffler, M. . . . and Dorner, R, (2007, November 9). The simplest double slit: Interference and entanglement in double photoionization of H_2," *Science*, 318(5852), 949–952. Retrieved from https://www.osti.gov/scitech/servlets/purl/1001039]

Fearn, H. (2015). A delayed choice quantum eraser explained by the transactional interpretation of quantum mechanics. *Foundations of Physics*, 46(1), pp.44-69. Retrieved August 1, 2018, from the arXiv database: arXiv:1501.00970v5

Feynman, R. (1985). *QED: The strange theory of light and matter*. Princeton, NJ: Princeton University Press.

Fields, C. (2012). If physics is an information science, What is an observer? *Information*, 3(1), 92-123. Retrieved from http://www.mdpi.com/2078-2489/3/1/92

Fields, C. (2018, June 28). A model-theoretic interpretation of environmentally-induced superselection. *International Journal of General Systems*, 41(8), 847-859. Retrieved August 1, 2018, from the arXiv database: arXiv:1202.1019v2 [updated from 2012]

Flach, J. M., & Voorhorst, F. (2016). *What matters? Putting common sense to work.* Dayton, OH: Wright State University Libraries. Retrieved from http://corescholar.libraries.wright.edu/books/127/

Francis, M. (2011, June 7). What does the new double-slit experiment actually show? Guest blog, *Scientific American*. Retrieved from http://blogs.scientificamerican.com/guest-blog/2011/06/07/what-does-the-new-double-slit-experiment-actually-show/

Francis, M. (2012, May 21). Disentangling the wave-particle duality in the double-slit experiment. *Ars Technica*. Retrieved from http://arstechnica.com/science/2012/05/disentangling-the-wave-particle-duality-in-the-double-slit-experiment/

Fritsch, H. (1983). *Quarks: The stuff of matter*. New York, NY: Basic Books.

Gould, S. J. (2002). *The Structure of evolutionary theory.* Massachusetts: Harvard University Press.

Graffigna, M. (2016). The possibility of a new metaphysics for quantum mechanics from Meinong's Theory of Objects. In Aerts, D., de Ronda, C., Freytes, H., & Giuntini, R. (Eds) *Probing the meaning of quantum mechanics: Superpositions, dynamics, semantics and identity: Proceedings of the Young Quantum Meetings*, pp. 280-307. London, UK: World Scientific Publishing, Co. Retrieved from http://philsci-archive.pitt.edu/14414/1/The%20Possibility%20Of%20A%20New%20Metaphysics%20For%20Quantum%20Mechanics%20From%20Meinong%27s%20Theory%20Of%20Objects.pdf

Gröblacher, S., Paterek, T., Kaltenbaek, R., Brukner, C., Zukowski, M., Aspelmeyer, M., & Zeilinger, A. (2007, April 19). An experimental test of non-local realism. *Nature* 446, 871–875. Retrieved August 1, 2018, from the arXiv database: arXiv:0704.2529v2

Harris, S. (2011, Oct. 11). The mystery of consciousness. The blog. Retrieved from http://www.samharris.org/blog/item/the-mystery-of-consciousness/

Harris, S. (2011, Oct. 19). The mystery of consciousness II. The blog: Retrieved from http://www.samharris.org/blog/item/the-mystery-of-consciousness-ii/

Harris, S. (2012). *Free will.* New York, NY: Simon and Shuster.

Harvard-Smithsonian Center for Astrophysics. (2013, April 2). New insights on how spiral galaxies get their arms. *Astronomy.* Retrieved from www.astronomy.com/news/2013/04/new-insights-on-how-spiral-galaxies-get-their-arms

Heisenberg, M. (2009, May 14). Is free will an illusion? *Nature: International Journal of Science*, 459, 164-165.

Heisenberg, W. (1927/1983). Über den anschaulichen Inhalt der qauntentheorestischen Kinematik und Mechanik. *Zeitschrift fur Physik* 43(3-4), 172-198. Retrieved from http://www.informationphilosopher.com/solutions/scientists/heisenberg/ZfP-Uncertainty.pdf Translation:

Heisenberg, W. (1983). The actual content of quantum theoretical kinematics and mechanics. (SCITRAN, Scientific Translation Service, trans). *NASA Technical Memorandum* 77379, pp. 1-33. Retrieved from https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19840008978.pdf

Heisenberg, W. (1959). *Physics and philosophy: The revolution in modern science.* London: George Allen and Unwin. Retrieved from https://archive.org/details/PhysicsPhilosophy.

Hetherton, S. (2015, June 1). Are scientists finally on the brink of understanding where proton spin comes from? *Phys.org.* Retrieved from https://phys.org/news/2015-06-scientists-brink-proton.html

Jacques, V., Wu, E, Grosshans, F. , Treussart, F., Grangier, P., Aspect, A., & Roch, J.-F. (2006, October 28). Experimental realization of Wheeler's delayed-choice GedankenExperiment. *Science* 315(5814) (2007), 966. Retrieved August 1, 2018, from the arXiv database: arXiv:quant-ph/0610241v1.

Jaffe, R. L. (1995, September). Where does the proton really get its spin? *Physics Today*, p. 24-30. Retrieved from http://inpp.ohiou.edu/nuclear_lunch/archive/2007/jaffe-1995.pdf

James, W. (1899). *Talks to teachers on psychology: And to students on some of life's ideals*. New York, NY: Henry Holt and Company. Retrieved from https://archive.org/details/talkstoteacherso1899jame

Joos, E. (2003). Introduction. In Joos, E., Zeh, H.D., Kiefer, C., Giulini, D.J.W., Kupsch, J., & Stamatescu, I.-O, *Decoherence and appearance of a classival world in quantum theory*, pp. 1-5. Berlin: Springer-Verlag.

Kastner, R. E. (2013). *The transactional interpretation of quantum mechanics: The reality of possibility.* Cambridge, England: Cambridge University Press.

Kastner, R. E. (2015). *Understanding our unseen reality: Solving quantum riddles.* London, England: Imperial College Press.

Kastner, R. E. (2016, March 6). Beyond complementarity. In Kastner, R.E., Jeknić-Dugić, J., & Jaroszkiewicz (Eds), *Quantum structural studies: Classical emergence from the quantum level*, pp. 77-104. London: World Scientific. Retrieved August 1, 2018, from the arXiv database. arXiv: 1601.07545v4

Kastner, R. E., Kauffman, S., & Epperson, M. (2018). Taking Heisenberg's potentia seriously. *International Journal of Quantum Foundations* 4(2), 158-172. Retrieved August 1, 2018, from the arXiv database. arXiv:1709.03595v5

Landsman, N. P. (2009). Essay Review of Maximilian Schlosshauer, *Decoherence and the Quantum-to-Classical Transition*. *Studies in History and Philosophy of Modern Physics*, 40, p. 94-95. Retrieved from University of Pittsburg PhilSci Archive: http://philsci-archive.pitt.edu/9361/

Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential), *Brain* 106, 623-642. Retrieved from http://www.psiquadrat.de/downloads/libet1983.pdf

Ma, X.-S., Zotter, S., Kofler, J., Ursin, R., Jennewein, T., Brukner, Č., & Zeilinger, A. (2012, March 21). Experimental delayed-choice entanglement swapping. *Nature Physics* 8, 480-485. Retrieved August 1, 2018, from the arXiv database. arxiv.org:1203.4834

Many-worlds interpretation. (n.d.). Retrieved August 1, 2018, from https://en.wikipedia.org/wiki/Many-worlds_interpretation

Marman, D. (2016). *Lenses of perception: A surprising new look at the origin of life, the laws of nature, and our universe.* Ridgefield, WA: Lenses of Perception Press.

Marman, D. (2016, April). The unfinished revolution of quantum mechanics. Retrieved from http://lensesofperception.com/2016/04/the-unfinished-revolution-of-quantum-mechanics/

Marman, D., & Rayner, A. (2016). How can anything be half-alive? Retrieved from http://lensesofperception.com/2016/08/how-can-anything-be-half-alive/

Max Planck Institute. (2017). Less dark matter in distant galaxies? *Max Planck Institute for Extraterrestrial Physics*, March 16, 2017: Retrieved from www.mpe.mpg.de/6704880/news_publication_11170451?c=621604

Mermin N. D. (1990). *Boojums all the way through: Communicating science in a prosaic age.* New York, NY: Cambridge University Press.

Mermin, N. D. (1998). What is quantum mechanics trying to tell us? *American Journal of Physics*, 66, p. 753-767. Retrieved August 3, 2018, from the arXiv database: arXiv:quant-ph/9801057v2

MIT Technology Review. The Incredible dark matter mystery. Why astronomers say it is missing in action. (2013, July 3). Retrieved from www.technologyreview.com/view/516681/the-incredible-dark-matter-mystery-why-astronomers-say-it-is-missing-in-action/

Nature World News. (2012). The Sun is Perfectly Round and Slim (August 20, 2012). Retrieved from www.natureworldnews.com/articles/117/20120820/the-suns-perfect-shape-and-slimmer-dimension-leaves-scientists-confused.htm

Nauenberg, M. (2011). Does quantum mechanics require a conscious observer? *Journal of Cosmology*, 2011, Vol. 14. Retrieved from http://cosmology.com/Consciousness139.html

Nelson, B. (2018, April 6). Dark matter might be way darker than we previously thought. *Mother Nature Network, Earth Matters, Space.* Retrieved from www.mnn.com/earth-matters/space/stories/dark-matter-might-be-way-darker-we-previously-thought

O'Toole, G. 2015. Research is to see what everybody else has seen and think what nobody has thought. *Quote Investigator*, July 4, 2015: Retrieved from https://quoteinvestigator.com/2015/07/04/seen/

Padmanabhan, T. (2011). Grappling with gravity. *Scientific American*, India, January, p. 33.

Padmanabhan, T. (2012, July 2). Emergent perspective of gravity and dark energy. *Research in Astronomy and Astrophysics*, 12(8), 891-916. Retrieved from www.raa-journal.org/raa/index.php/raa/article/download/1191/855

Penrose, R. (1989). *The emperor's new mind: Concerning computers, minds, and the laws of physics.* Oxford, England: Oxford University Press.

Penrose, R. (2016). *Fashion, faith, and fantasy in the new physics of the universe.* Princeton, New Jersey: Princeton University Press.

Petersen, A. (1963). The philosophy of Niels Bohr. *Bulletin of the Atomic Scientists,* 19(7), 8-14.

Piaget, J. (1929). *The child's conception of the world.* London, England: Routledge & Kegan Paul Ltd.

Piaget, J. (1930). *The child's conception of physical causality.* London, England: Routledge & Kegan Paul Ltd.

Piaget, J. (1955). *The construction of reality in the child.* London, England: Routledge & Kegan Paul Ltd.

Quantum entanglement. (n.d.). Retrieved August 1, 2018, from https://en.wikipedia.org/wiki/Quantum_entanglement

Rayner, A. (2017). *The origin of life patterns: In the natural inclusion of space in flux*. (Springer Briefs in Technology). London, England: Springer.

Rozema, L., Darabi, A., Mahler, D., Hayat, A., Soudagar, Y., & Steinberg, A. (2012). Violation of Heisenberg's measurement-disturbance relationship by weak measurements. *Physical Review Letters*, 109(10), 100404. Retrieved August 1, 2018, from the arXiv database: arXiv:1208.0034v2

Rovelli, C. (2008, February 1). Relational quantum mechanics. *International Journal of Theoretical Physics*, 35 (1996), 1637-78. Retrieved August 1, 2018, from the arXiv database: arXiv:9609002v2 (updated from 1997)

Rovelli, C. (2017). *Reality is not what it seems: The Journey to Quantum Gravity*. New York, NY: Riverhead Books.

Schlosshauer, M. (2008). *Decoherence and the quantum-to-classical transition,* corrected 3rd printing, (Berlin: Springer-Verlag).

Schlosshauer, M., Kofler, J., & Zeilinger, A. (2013). A snapshot of foundational attitudes towards quantum mechanics. *Studies in History and Philosophy of Modern Physics,* 44, 222–230. Retrieved August 1, 2018, from asXiv database: arXiv:1301.1069v1

Schumm, B. A. (2004). *Deep down things. The breathtaking beauty of particle physics.* Baltimore, Maryland: John Hopkins University Press.

Smolin, L. (2007). *The trouble with physics: The rise of string theory, the fall of science, and what comes next,* New York, NY: Houghton Mifflin Company.

Smolin, L. (2017). *Three roads to quantum gravity*. New York, NY: Hachette Book Group.

Sperry, R. (1952). Neurology and the mind-brain problem. *American Scientist*, Vol. 40, No. 2, 1952. Retrieved from http://people.uncw.edu/puente/sperry/sperrypapers/50s/46-1952.pdf

Sperry, R. (1964, January). The great cerebral commissure. *Scientific American*, p. 41-52. Retrieved from http://people.uncw.edu/puente/sperry/sperrypapers/60s/105-1964.pdf

Sperry, R. (1968, October). Hemisphere deconnection and unity in conscious awareness. *American Psychologist*, 23(10), 723-733. Retrieved from http://people.uncw.edu/Puente/sperry/sperrypapers/60s/135-1968.pdf

Tasoff, H. (2018). Galaxies rotate in sync, Raising dark matter questions. *Space.com*, February 3, 2018: Retrieved from www.space.com/39577-rotating-galaxy-group-raises-questions.html

The Physics arXiv Blog. (2013, October 23). Quantum experiment shows how time 'emerges' from entanglement. Retrieved from https://medium.com/the-physics-arxiv-blog/quantum-experiment-shows-how-time-emerges-from-entanglement-d5d3dc850933

Verlinde, E. (2011). On the origin of gravity and the laws of Newton. *Journal of High Energy Physics* 1104:029. Retrieved August 1, 2018, from arXiv:1001.0785v1 (January 6, 2010).

von Neumann, J. (1955). *Mathematical foundations of quantum mechanics*. (Robert T. Beyer, Trans). Princeton, New Jersey: Princeton University Press.

von Neumann-Wigner _interpretation. (n.d.). Retrieved August 1, 2018, from https://en.wikipedia.org/wiki/Von_Neumann–Wigner_interpretation

Wheeler, A. (1978). The “past” and the “delayed-choice” double-slit experiment. In Marlow, A. R. (Ed.), *Mathematical foundations of quantum theory*, pp. 9-48. New York, N. Y., Academic Press.

Wigner, E. (1961). Remarks on the mind-body question. In Good, I. J., Mayne, A. J., & Smith, J. M. (Eds). *The scientist speculates*. London: William Heinemann. Reprinted in Wigner, E. P., *Symmetries and reflections: Essays of Eugene P. Wigner*. Bloomington, Indiana: Indiana University Press, 1967. The Information Philosopher: Retrieved from http://www.informationphilosopher.com/solutions/scientists/wigner/Wigner_Remarks.pdf

Wilson, T. D. (2002). *Strangers to ourselves: Discovering the adaptive unconscious.* Cambridge, MA: The Belknap Press of Harvard University Press.

Yu, S. and Nikolic, D. (2011). Quantum mechanics needs No consciousness. *Annalen der Physik*, (Berlin) 523, No. 11, 931–938. Retrieved from http://www.danko-nikolic.com/wp-content/uploads/2011/10/Yu-and-Nikolic-Qm-and-consciousness-Annalen-Physik.pdf

Zurek, W. H. (2009, March 29). Quantum darwinism. *Nature Physics* 5, 181-188. Retrieved August 1, 2018, from arXiv:0903.5082v1