Informational Monism: A Phenomenological Perspective on the Nature of Information

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June 28, 2021

Abstract

Although a substantial number of papers is published on the topic of consciousness, there is still little consensus on what its nature is and how the physical and phenomenal worlds are connected. Most published research establishes a causal relation between the brain and the mind, but it lacks a cogent theory of how this relation comes to be. In contrast, this paper uses a set of thought experiments grounded in quantum information theory to derive a framework for resolving the hard problem of consciousness. Despite the common tendency to treat the problem purely philosophically, in this paper, consciousness and qualia are analyzed through established formal theory deriving conclusions regarding their relation which provide counter-arguments for the commonly held dualist view. Through the informational monism framework, a case is made for a fundamentally phenomenal nature of information.

Keywords: hard problem of consciousness, monism, quantum information theory, mind-body problem

1 Introduction

The hard problem of consciousness, as formulated by (Chalmers 1996), is the problem of how and why qualia, phenomenal experiences attributed to sentient organisms, come about. Despite numerous attempts at resolution, it remains an elusive philosophical problem and one of the central questions in the philosophy of mind.

The nature of human living experience, our awareness, sentience and consciousness, is often treated as separate from the physical world, all the while inexorably correlated with it. However, the nature of this correlation and mutual causation between body and mind remains fundamentally unknown. This may be why the processes pertaining to the mind and thought are often described as manifesting phenomena – a result or an emergent effect (Broad 1925) of a collection of underlying physical processes. Most scientific research, as argued in more detail by (Hoffman 2008), is premised on the assumption that physical processes give rise to consciousness and that consciousness stems from a specific neural substrate.

Given the vast research in this field, including (Place 1956) and (Smart 1959) type-physicalist approaches which identify distinct correlates between physical processes and mental experiences, (J. A. Fodor 1974) who identifies correlated neural-state and mental-state tokens, and approaches such as (Tye 2000) who similarly identifies correlations between mental states and physical world states, it is becoming clear that mental processes bear little independence from physical ones.

Similar results have been derived by causal reduction in (Searle 2005) and (Block and J. Fodor 1972). No matter the methodology, it has been patently demonstrated that the two domains, physical and phenomenal, must be highly correlated. However, the exact mechanism by which these two domains interact remains contended.

Some testable aspects of the problem have so far been addressed in numerous ways, including the introduction of an elaborate theory of living systems (Miller 1978) which relies on clearly defined mental processes and mental relationships to model the workings of living systems. However, this kind of empirical analysis does not give way for exploring the fundamental relation between what is and what is felt. On the other hand, as outlined by (Hoffman 2008), purely philosophical treatments of the problem without significant scientific rooting, cannot yield a methodically testable theory. Nonetheless, many of these purely philosophical approaches generate similar results, as exemplified by (Davidson 1970) with anomalous monism, and type-identity theory and mental causation presented by (Kim 1993) as supervenience, both implying direct correlation between mental and physical processes. Clearly, dualist approaches suffer from the same detriment, as they cannot explain the interaction between the physical and the mental domain without introducing new variables.

Further, many proposed mental causation solutions exist, including physicalist interpretations that unify body and mind into a single entity. As (Smart 1959) suggests, monist interpretations may be superior for their lack of "nomological danglers". A deeper monist framework, the conscious realism theory of (Hoffman 2008), attempts to show that the mental representations of the physical world are not the exact correlates of the physical world, by employing a "multimodal user interface" to explain the difference between the internal object representation and the actual object in the physical world. However, this approach does not contradict type-physicalism directly, but rather shows that the mind and body token correlates do not contain an accurate representation of outside world tokens. In other words, the internal representation that serves as an MUI may have its physical correlate in a brain, while not accurately modeling the outside environment being perceived. Still, the work introduces an important concept of conscious realism which states that the universe consists of mutually interacting mental entities which may be subjected to methodical scientific analysis to finally arrive at the conclusion that "*consciousness is fundamental*". However, the underlying mechanism of what constitutes consciousness and how conscious agents interact is left unexplored. While (Hoffman 2008) states that reality fundamentally consists of conscious agents, he makes no connection between that conscious domain and external observation. Although the claim is that these agents can be subjected to scientific analysis, there is no clear description of phenomena an outside conscious observer should interpret as conscious.

To provide a more formal scientific explanation for consciousness, a theory of quantum consciousness first proposed in (Hameroff and Penrose 1996), and reanalyzed in (Hameroff and Penrose 2014) suggests, based on measurable observation of physical processes, that the consciousness cannot arise from classical systems, but rather requires a quantum-mechanical foundation. The work analyzes the emergence of consciousness from physical processes. Although this result has been contested (M. 2000), it makes an important point about the quantum-mechanical foundation of consciousness, but is in itself insufficient to reconcile the argument of (Hoffman 2008). A thought experiment introduced by (Wigner 1961) provides more evidence towards quantum information being an essential component for resolving the hard problem of consciousness.

Arguably the most successful monist approaches are the ones closely relating the phenomenal experience to the mathematical definition of information and the way information is exchanged between systems. Beginning with the work of (Sayre 1976) and his "neutral monism" a foundation was created for exploring monism as a solution to the hard problem of consciousness. Although

(Dretske 1981) also relies on concepts from information theory, his work introduces explicit new definitions that alter the premises of the theory. Similarly, (Tononi et al. 2016) proposes a more formal integrated information theory based on classical information theory, but is also not complete from the standpoint of quantum information theory. The problem has been explored in recent years with significant breakthroughs that seem to confirm both the quantum-mechanical nature of consciousness and lend more credence to the panpsychist or neutral monist interpretation, most prominently to the resonance theory of consciousness (Hunt 2011). It is clear that information theory promises to be a solid framework for analyzing the relation between the phenomenal and the physical world, but it is relatively poorly integrated in most contemporary theories of consciousness.

One cannot disregard the overwhelming evidence of the correlation between the phenomenal experiences and the described physical world. However, the intuition may be deceiving, as the dualist explanation of the physical and phenomenal may, in fact, contain a redundancy – an identical manifesting description arising from the phenomenal experience, in the form of a perceived physical reality. Thus, given that one can consciously attest to the existence of the phenomenal, one might assert that the physical is merely a model of the phenomenal, and so attempt to reduce the dichotomy to a monist description consistent with the known physical model, in accordance with quantum information theory.

1.1 Definitions and Axioms

The scientific method is predicated upon an assumption that physical laws do not change. This provides a reasonable reassurance that the laws of nature observed in one region of space will hold anywhere else in the universe. Fundamentally, this invariance of physical laws states that the laws of nature do not make localized exceptions. The argument made here rests on this premise and is bounded by known experimental results, forgoing metaphysical explorations akin to modal realism(Lewis 1986) or modal actualism(Stalnaker 1976), which cannot be reasonably and practically aligned with the observed laws of nature.

During the last century, formal models have been developed for evaluating microscopic physical processes, including the original undulatory theory (Schrodinger 1926) and quantum field theory (P. A. M. Dirac 1927), with quantum electrodynamics extended with strong (Yang and Mills 1954) and weak (Glashow 1961) forces and quantum chromo-dynamics (Tavkhelidze 1965) being the most prominent and well-studied examples. Of crucial importance for the field of quantum-mechanics was the validation of quantum entanglement (Freedman and Clauser 1972) (Einstein, Podolsky, and Rosen 1935), an essential component for tackling the measurement problem. The phenomenon of quantum entanglement is essential for the fields of quantum information theory and quantum computing(Nielsen and Chuang 2000). Informational dependence between entangled entities was originally discussed by (Schrödinger 1935) and has been later connected to the mind-body problem by (Wigner 1961) and (Deutsch 1985). In the original discussion, (Schrödinger 1935) states that *"By the interaction the two representatives [the quantum states] have become entangled."*, equating the idea of measurement with entanglement. This idea has since become universally accepted as a scientific fact (Susskind and Friedman 2015) – measurement, entanglement and interaction are fundamentally the same phenomenon.

Another aspect of the physical world relevant to this analysis is the fact that individual particles of the same kind (i.e. particles with the same intrinsic properties, such as electrons) cannot be distinguished by observation from one another. This is a fundamental property of nature observed through renowned experiments (Larkoski 2019).

Using these scientific facts as presuppositions, parts of the discussion are addressed in two distinct domains: the physical domain, a purely physical perspective, describing objective mathematically modellable phenomena, and the phenomenal domain, referring to processes from a subjective perspective and the quality and nature of the experienced phenomena or, in other words, the qualia or the "manner in which reality is felt" from the perspective of an entity that can sustain a phenomenal experience.

Within the consciousness literature, the term "consciousness" is widely ambiguous and tends to refer to many aspects of the phenomenal experience, including cognition, awareness and self-awareness, and is often narrowed further in definition for the purposes of specific analyses(Rochat 2003)(Farthing 1992). Here, the therm "consciousness" will be used in its general form, as suggested by (Antony 2001), fundamentally referring to the subjective phenomenal experiences or qualia.

1.2 Quantum Entanglement and the Measurement Problem

Regardless of the interpretation of quantum mechanics, it is considered that any quantum system is fully described by its corresponding wave function before the event of measurement. The paradox only arises when measurement is made on the system, which seemingly causes the wave function to "collapse" to one of the eigenstates of the coupled system. However, the mathematics of quantum information theory strongly indicates a fundamental equivalence between the act of measurement and the process of quantum entanglement, as outlined by (Schrödinger 1935) and shown more analytically by (Cerf and Adami 1998) and (Garret 2001).

In essence, when two physical systems interact, they become entangled to a degree proportional to the informational exchange between the systems. Upon interaction, systems continue evolving under a unitary propagator. In other words, they continue evolving in a linked state. This applies equally to particle interactions and interactions between a measurement apparatus and its measured particle. Any measurement produces entanglement between the measurement apparatus and the measured system(Deutsch 1985) – the apparatus must interact with the particle to obtain information from it and, in doing so, becomes entangled with it. However, from the perspective of any of the individual systems, at the instant of measurement, the other system appears to collapse randomly to an eigenstate of the coupled system.

Less formally, when two systems interact, they become informationally linked to one another, whereby the coupled system contains more information that the two systems viewed independently. In other words, after interaction the two systems share information – they have both "measured" one another. This is summarized by (Schrödinger 1935) in the statement "*the best possible knowledge of a whole does not necessarily include the best possible knowledge of all its parts*" when referring to entanglement after interaction. This is true of both microscopic and macroscopic systems. For example, in the Wigner's friend thought experiment (Deutsch 1985), the observer of the Schrödinger's cat knows exactly in what state the cat is, but his friend, who has not made any observations of either the cat or the observer must consider the entire system (the radioactive isotope, the cat and the observer) as being in a superposition of states. Only by observing either the isotope, the cat or the initial observer, will the observer's friend know the exact state of the system. In other words, by the act of observation (i.e. measurement) the friend becomes entangled with the rest of the system and becomes a part of it. Only after interacting does he gain knowledge of the system's inner state.

Within the framework of quantum information theory, the apparent randomness only exists as a manifesting phenomenon of the classical interpretation (i.e. the squaring of the wave function amplitude). After entanglement, the two systems randomly present themselves to each other, with the remaining information from the other eigenstates becoming inaccessible to the coupled system. From the no-hiding (S. L. Braunstein and A. K. Pati 2007) and no-deleting (Arun Kumar Pati and Samuel L. Braunstein 2000) theorems, this information is said to be transferred to the environment. The nature of this randomness is pertinent to the measurement problem, but its resolution may not be necessary for describing consciousness. More importantly, accepted theory clearly establishes the equivalence of measurement with quantum entanglement – when two systems interact, they become entangled (i.e. observe or measure one another) until they lose coherence and become entangled with the environment. In other words, interaction is the act of sharing information between the affected systems and that information cannot be deleted or cloned.

In more detail, when two physical systems interact, they share information and, conversely, no information may be shared between physical systems unless they interact. This implies that the transfer of information is mediated by interaction, or, more importantly, that informational exchange and interaction may be defined as identical. This, of course, must apply at the classical limit, as discussed in detail by (P. Dirac 1933) and (Feynman 1942).

The universe, when described through this framework, consists of quantum systems exchanging information. Individual systems' constituents (e.g. particles), as they evolve through time, become disentangled and entangled with other systems, conserving the total information. These systems may be independent particles that have become disentangled from the rest, or entangled sets of particles.

Fundamentally, all interactions can be modeled as information exchanges and, in fact, the mathematical formalism used in quantum information theory relies on this fact. Thus, from a quantum information point of view, the fundamental building block, the substance that comprises the physical world is information.

Since physical systems can only exchange information through interaction and cannot clone one another, a system may only "know" of another what it has acquired through interaction. This reasoning extends the argument of (Nagel 1974) to any physical system and alludes to a fundamental subjectivity of information rendering the dualism between first and third person information void.

2 Deriving Informational Monism

2.1 Thought Experiments

2.1.1 The Impenetrable and Semi-penetrable Barriers

Consider a conscious being enclosed into a container that disallows any type of physical interaction between the inside of the container and outside world, forgoing the existence of social bonds this being must have had prior to their isolation in the container. In this way, the being is isolated both spatially and temporally, instantiated within the container with arbitrary memories of its existence (akin to a Boltzmann brain (Albrecht and Sorbo 2004)). Because no interaction is permitted, for the outside observers this container would not exhibit any behavior that would in any way tell of the existence of a conscious being within (or any matter or process within). Conversely, the being enclosed inside would be able to think, but its thought processes would not be steered by outside influence, meaning that it could think and make decisions based only on the knowledge obtained prior to isolation. Given the lack of ability to interact with the outside world, no information would be passed through the barrier, but both the inside of the container and its outside would host sentient beings unaware of others' existence across the barrier. From a physical point of view, the inside and outside of the barrier may be treated as two distinct universes, as they can never interact and thus never exchange information. For the same configuration, the beings' qualitative experiences within the phenomenal domain may be reasonably hypothesized: the enclosed being would witness an empty space, confined only to its own thoughts, without any sensory input, while the beings outside would not know of the existence of this space, as they would have no way of interacting with it. The barrier that constitutes the container's boundary itself would be invisible to both sides since it would otherwise reveal the existence of the container. From this setup, it is reasonable to deduce that a barrier that would prevent physical interaction would prevent interaction in the phenomenal domain – two beings separated by a physical impenetrable barrier will never experience knowledge of one another.

The experiment may be expanded to a physically plausible phenomenon: A semi-penetrable barrier that filters the passage of information and, thus, allows some interactions to occur. The number and type of particles that could pass through the barrier would determine the degree of entanglement between the inside and outside physical systems.

For example, we could further consider a human being placed into a walled container that disallows information from passing through, and place the container into a room with a human examiner. The examiner would see the container but would be unable to penetrate its walls or probe the contents of the container, as the walls would absorb any signal coming from the inside or outside. For any interaction that the examiner attempts, the enclosed person would not experience any sensation and would continue their existence oblivious to the fact that the container is placed in a laboratory. If the container's walls were permitted to pass a limited amount of information, then the subjective experiences of the examiner and the enclosed person would reflect that (e.g. if the examiner was only able to shine light into the container, the enclosed person would experience only the shining of light and no other stimulus). Clearly, to pass information from one conscious entity to the other in the phenomenal domain, information must be passed in the physical domain.

For two conscious beings, one behind the barrier and the other outside, the weaker the barrier, the more visceral the interaction, within the phenomenal domain, between the inside being and the outside being and the stronger the entanglement between the two physical systems. Furthermore, the weaker the barrier, the more detailed the knowledge the outside and inside beings have of one another. Fundamentally, the nature of the informational exchange across the barrier in the physical domain would correlate with the nature of the visceral experience of this exchange in the phenomenal domain, in accordance with supervenience, type-physicalism and reductionism. The beings would know and understand more of one another, the more they interacted and the more information is passed through the barrier. The information contained within the phenomenal domain for each of the entities correlates fully with the information contained within the physical domain. Information is equally exchanged in both domains. However, the mind-body correlates here are not single-sided, but rather imply that a physical event across the barrier correlates with both beings' phenomenal experiences.

To further abstract the idea, let the enclosed entity be a minimal system (simplest in the amount of constituting information) necessary to give rise to a conscious process and let this physical system be called a minimal conscious entity (MCE). From a quantum-mechanical point of view, a physical system is an entangled set of particles that can be viewed separately from the rest of the universe, as it is informationally separated. Thus, the enclosed entity is a minimal set of particles conventionally presumed to generate a subjective experience in the phenomenal domain, with the necessary physical structure to allow the emergence of consciousness.

Even if the generated conscious entity contained more information than the underlying physical system (similarly to the epiphenomenal qualia argument (Jackson 1982)), this information could not be brought back into the physical world, as it would violate information conservation laws. Thus, this additional information could never be observed from the physical world, and so could not be discussed or evaluated by agents in the physical world, as it would remain unreachable to them. For each distinct physical event across the barrier, in which the enclosed entity receives information from outside, the physical system that represents the entity must change. Based on observations of the human brain, from multiple studies including consciousness pattern mapping (Demertzi et al. 2019) and neuronal activity probing (Gelbard-Sagiv et al. 2018) (al. 2021) (Wenzel et al. 2019), it is clear that changes in thinking must be correlated with the changes in the physical structure or interaction. This implies that the same physical system should generate the same phenomenal experience and that for each phenomenal experience, there exists a representing physical system.

The same principle may be extrapolated to the behavior of the enclosed MCE. This suggests that the relationship between the phenomenal domain and the physical domain is injective: any unique event in phenomenal domain is fully complemented by a unique event in the physical domain.

In more concrete terms, such a semi-penetrable barrier might be the size of a retina, or the number of nerve endings in the tips of someone's fingers, or a spatial distance that separates two conscious entities. A concrete physical process, such as a strong magnetic field, can act as a barrier for information transfer, and as such impose a restriction on the degree of entanglement between two systems or on the degree of perceived connection between two separate consciousnesses, increasing their mutual independence and decreasing their knowledge of one another. For example, observing a distant galaxy through a telescope reveals information about it and entangles the observer with exactly the sources of that information – the vast spatial distance that limited the informational exchange for the observation is a kind of a semi-penetrable barrier.

2.1.2 The Merging Minds

Building on the barrier experiment, the following examination also considers two MCEs separated by an externally controlled semi-penetrable barrier. Let the two MCEs be exact copies of each other. Since individual particles of the same kind cannot be distinguished from one another, two MCEs could be constructed with the same kinds and arrangements of particles and, since nature would not distinguish one entity from the other, both would have to be conscious.

If the two systems are allowed to interact through the barrier, they, or their parts, would become entangled. As stated previously, every interaction of an MCE with an outside system is accompanied by a corresponding change in the phenomenal domain. Physically, the outcome of an interaction between two MCEs would be a formation of one or more entangled systems with the total amount of information preserved. If the interaction results in a formation of a smaller separate system, by definition of an MCE, this system cannot be conscious. Thus, the outcome for the two MCEs would either be merger into or creation of a larger conscious entity or death (or deletion) of one or both MCEs.

Given that the previous argument established that for each distinct phenomenal experience there must exist a corresponding physical system that gives rise to it and given the vast number of distinct phenomenal experiences, there would have to exist a large number of distinct physical configurations that are predisposed in nature to give rise to a phenomenal experience. When a physical system transitions from a configuration that generates a phenomenal experience to a configuration that does not, the generated consciousness can be assumed to have been deleted. This would require the laws of nature to designate specific physical state configurations that give rise to consciousness or specific laws that govern those states which may produce consciousness. Given that physical states may consist of many entangled particles which cannot be described separate from the system, due to entanglement, configuration-specific laws would have to exist for the purpose of determining whether a system resulting from an interaction should generate consciousness. Since quantum field theory describes the interactions between such systems as well as interaction outcomes, the laws describing phenomenal experiences would be independent from such analysis, which contrasts what is observed. Although it is not unreasonable to assume that a complex set of physical laws could govern solely the production of consciousness, that line of argument would introduce new variables into the model of the physical world and complexify it in order to explain a phenomenon that is otherwise assumed to be manifesting.

By invoking parsimony, in accordance to (Smart 1959), we may conclude that a consciousness can either be split or merged, but never destroyed, which could be considered as a more intuitive formulation of quantum information conservation within the phenomenal domain.

A similar experiment may be considered on a pair of human brains, by placing a semi-penetrable barrier between them, each with their own respective mind and independent life experience. If each of these two humans is fully unaware of the existence of the other and the barrier is such that it allows an axon of a single neuron from the brain on one side to be arbitrarily passed into the brain on the other side, a question may be posed: If the connections are made carefully, can the two minds be merged into a single one after a number of connections has been made?

Obviously, the higher the number of connections, the more intricately are the two brains linked. Only when signals are sent through the axons that pass through the barrier are the two brains, and hence the two consciousnesses, exchanging information. Only through that channel may one brain access the memories of the other. This could, depending on the connections made, fool one consciousness into a “false memory” retrieved from the other brain. The conscious entity would not understand that the memory it is experiencing is not its own.

In neurological literature, the term “consciousness” is usually taken to represent what one may call the ego and is usually localized within specific regions of the brain where information converges (Tononi et al. 2016). This approach yields insights into the physical system that is said to produce the conscious experience. Depending on the region where the information flows, the quality of conscious experience changes. The more information is contained within a coupled system, the greater the quality and vibrance of the corresponding phenomenal experience. A person’s entire brain is not a single entangled system, but rather a set of different mutually interacting systems, one of which the person would refer to as the ego, while others continually evolve, merge and split with the consciousness of the ego as it undergoes changes in qualia. These changes in qualia, as the consciousness evolves through time, are directly reflected with the changes in the underlying physical system. More broadly, the more information the ego’s coupled systems contain, the richer the phenomenal experience of the conscious existence. It should be noted that the neural coherence (Keppler 2018) (Bowyer 2016) (Engel and Fries 2016) (Thatcher 1997) demonstrated to be related to arousal of consciousness only supports this conclusion.

2.1.3 Partitioning Induction

For a neural substrate that gives rise to consciousness, one could arbitrarily partition the set of its neurons into two connected subsets. If connections between the two subsets are considered as connections passing through a barrier, where connections imply axons, dendrites and other neural communication channels, then the substrate could be further recursively partitioned with such barriers until mutually independent sets of particles whose combination constitutes the substrate are obtained. By applying information conservation, we can conclude that each of these independent sets constitutes an MCE, as it cannot be further subdivided without disentangling. This way, a free particle or a set of entangled particles would give rise to an elementary consciousness within the phenomenal domain, equivalently microscopic in the phenomenal domain as the set itself in the physical. Thus, every kind of elementary particle that can comprise a neural substrate of a consciousness must be such a substrate itself.

In other words, for a substrate that is said to give rise to the consciousness of the ego, we may pose the question of how many individual neurons may be removed for the corresponding consciousness to stop existing. The removal of substantial portions of brain tissue has been proven to affect the character and behavior of the individual, with retaining the existence of the mind, or, in other words, with keeping the individual alive and conscious (Ueki 2008). However, neurons are comprised of hundreds of trillions of elementary particles, which, when considered independently of the encapsulating neuron, do not individually hold information about their relation to the neuron, unless the higher-level structural information is propagated to individual constituents by some unknown means (local hidden variables (Clauser et al. 1969) are shown not to exist, and thus specific group-related information cannot exist at the level of any individual particle). Hence, each constituent particle cannot contain information about the encapsulating structure of the neuron, unless entangled with the remainder of the particles forming the structure. Considering entangled systems as particles, for the sake of simplicity, this observation generalizes the problem to asking how many individual particles may be removed for a consciousness to stop existing.

Without the binary restriction on the existence of a consciousness, the question reduces to counting the particles that may be added or removed from a working brain to exert an effect on the state of the consciousness. The particles themselves are unlikely to abide to an exceptional rule that implies giving rise to a consciousness only if they are a constituent part of a specifically named neural substrate, as this would either violate physical law invariance or require local hidden variables. Thus, for a functioning brain, any elementary particle can be added or removed without affecting the existence of consciousness but affecting the phenomenal experience of the conscious entity related to the brain. In other words, a microscopic change in the physical domain must be accompanied by a (microscopic) change in the phenomenal domain, in line with the barrier experiments.

To answer the general question, it is necessary to determine the exact boundary at which events in the phenomenal domain seize to correlate with the events in the physical domain. Although, on the surface, this line of reasoning may appear to be a type of Sorites argument (Sorensen 2009), the Sorites argument is fundamentally a linguistic problem and does not apply to the presented induction, since the physical reality and the observed physical laws must be described precisely.

To validate this reasoning, we will consider a Sorites-style linguistic counterargument to the partitioning induction, by which one might, for example, ask the question of how many particles may be removed from a computer before it loses its ability to compute. On the surface, the process of removing particles from a physical system presumed to give rise to consciousness may seem analogous to the mentioned process of removing particles from a computer. However, the latter depends on a linguistic definition of the term “compute”. Certainly, removing particles from individual transistors’ gates would affect the computational ability of a computer in some way. However, the exact linguistic boundary at which the remaining physical process would no longer be called computation does not exist. On the other hand, any sentient being can testify to the fact that qualia exist and that the act of conscious thought has a different modality to the act of computing. In other words, the act of conscious thought is a factual reality, while the act of computing is a linguistic denomination.

Similarly, one might argue that through similar reductionist reasoning, by counting particles, an apple could be reduced to encompass the entire universe, by adding particles to it. However, the term “apple” is dependent on human perception and human object-recognition capabilities. In order to avoid the reductionist conclusion, one must either adopt a precise mathematical definition for an “apple” or agree on an acceptable level of epistemic uncertainty. In either case, the problem must be resolved on a linguistic level, which cannot be the case with the reductionist argument in the case of consciousness. In simpler words, a consciousness experiences consciousness, while an apple does not experience “appleness”.

Therefore, one can conclude that the induction must proceed to the level of a single free particle or entangled system. Hence, for every system in the physical domain, there must be a system in the phenomenal domain, regardless of size, further implying that the relationship between the phenomenal and physical domains is surjective. Based on the conclusions of the barrier experiments, this relationship must also be bijective, which implies that every distinct physical system correlates to a distinct set of qualia.

2.2 The Leap to Informational Monism

Any experience a consciousness undergoes within the phenomenal domain is fully described by the entanglement of the corresponding physical system with another system in the physical domain, with the level and nature of entanglement in the physical domain fully correlating with the clarity and quality of the subjective experience within the phenomenal domain.

The three thought experiments provide a foundation for formulating the premise of informational monism. Since every physical interaction must have an equivalent phenomenal interaction, and since every information transfer, or a change in the state of consciousness, must have a corresponding physical interaction, we may invoke parsimony.

Given that events cannot happen in the phenomenal domain without their counterparts in the physical and vice versa, the two domains must contain information about the same events. The fundamental leap in understanding the relation between the subjective experience and objective reality is forgoing the dichotomy between the physical and phenomenal domains to arrive at a fundamentally monist conclusion this paper is presenting.

In essence, the question of what consciousness is, is the question of what the qualitative content of it is. The information that is contained within the entangled system is the same information contained within the corresponding conscious entity and since only the entity is the witness to its own qualia, we can postulate that the qualia are that very information. The phenomenal experience of the world is the actual nature of information. In other words, the subjective information, per (Nagel 1974), which can be obtained only through measurement (i.e. interaction) is the fundamental substance of reality.

It is impossible to consciously know or perceive something that has not entered the consciousness through the physical system’s informational exchange, so it is now reasonable to conclude that the physical system is the consciousness itself. As (Hoffman 2008) points out, the universe consists of mutually interacting conscious entities. However, what is clear from this analysis is that quantum information theory is already modeling these entities. Whether they are called physical systems or conscious entities is less relevant than the fact that the actual nature of the constituent parts of the universe is phenomenal. The very information that makes up the universe exists as qualitative experience. The choice of the word “information” here is made because this is the base term used in quantum information theory, but the same conclusion would apply for the term “particle” as well.

In this way, there is no dichotomy – a mind is merely a denomination for a specific informational cluster, and the science which is said to model the “physical world” implicitly models the phenomenal world, as the two are identical.

Seemingly, this contradicts the findings of (Hoffman 2008), who suggests that the internal representations of the physical world do not mirror the actual physical world. However, the internal representations stem from what would typically be described as neural circuits, which are adapted for survival and not accurate representation of the outside world, as (Hoffman 2008) himself has shown. The phenomenal experience of the ego and all its internal representations are equivalent to the entangled physical systems of the neural circuitry, not the system that the circuitry observes. However, some information, arguably the information most important for the organism's survival, about the external system that the neural circuitry is observing is embedded in the phenomenal experience equivalent to the circuitry, since the circuitry itself could be described as containing that information.

What we experience as sentient beings is not a reflection of reality, it is the reality – the portion of reality our system is entangled with (informationally linked with). It could be said that the ego is experiencing the world from the perspective of the entangled physical system that would be modeled as a token corresponding to the ego. Fundamentally, there is no "physical world" – it is merely a representation, an effective model of the phenomenal world conceptualized within a consciousness from the information available to it from observation. The question "*What is it like to be a bat?*" posed by (Nagel 1974) may be extended to any system, bats and pebbles alike and it is easy to conclude that it is impossible to gain the perspective of any outside system without becoming that system (without assuming exactly the same configuration). So, the "physical world", for any given consciousness, remains only a representation of the outside phenomenal world which it can never fully perceive and internalize. Nevertheless, that outside world consists of qualia, much like the observing consciousness itself.

2.3 Micro-consciousness and a Falling Pebble

Under this framework, all systems are conscious, even those which would be physically represented as the smallest – though they are conscious in a way that can never be fully subjectively perceived. Physically, minute changes such as individual electron interactions within a brain do not noticeably affect the cognitive process, but nonetheless, those changes constitute thoughts, whether separate from the ego or part of it.

Although the term *consciousness* is used throughout this paper, the implication is clearly not that the non-living objects possess awareness or sentience or that their conscious experience resembles human, but rather that the substance that makes up their existence must be phenomenal. Since all modeled physical systems can be said to fundamentally comprise of information, the claim here is that that very information is phenomenal in nature. To explore the kind of conscious experience a non-living system may experience, we will consider a more intuitive example.

A pebble falling onto the ground creates a physical interaction that may be considered a kind of thought or a change in qualia. The impact interaction of the pebble would spread through the ground and the stone until the information about the impact is distributed to the surrounding structures whose constituent parts would continue interacting. From the phenomenal perspective, the stone's systems had perceived a qualitative experience of colliding with the ground and this experience had dispersed into the qualia of momentum spreading through the ground, though this experience is unlikely to be explained in language, as humans lack the phenomenal perspective of pebbles. Clearly, the pebble is not a single entangled system, but a collection of loosely coupled systems and these systems and the ground will remain entangled, but the web of entanglement may never propagate to a system that has the capacity to store and continually retrieve information about this event (to remember it), though it is still embedded in the environment, having to obey the laws of quantum information conservation.

To further elucidate, if a human being found themselves at the scene of the pebble's impact after the pebble had fallen, they would be able to deduce a part of the original event since the information would have been embedded in the environment. This act of deduction must be done by performing a kind of a measurement (by interacting with the scene). Clearly, this measurement is made on a macroscopic scale, but any measurement requires that the observer be entangled with the thing measured, since information must be exchanged between the two systems. The amount of information an observer is able to extract from the system is equivalent to the degree of their entanglement. This applies both at the quantum level and at the classical limit.

From the phenomenal perspective, the information transferred from the event of collision to the observer's brain's system was the continuation of a part of the pebble's consciousness that merged with the observer's, creating an effect between the observer and the pebble similar to the "false memory" illustrated in the merging brains experiment – observer's deduction of the pebble's fall is a kind of a recall from an outside memory storage, what a false memory would be between two brains.

Of course, given enough time, the pebble's systems would lose coherence by slowly becoming entangled with the environment. However, this entanglement would be so weak, that even if it eventually propagated to a human being, they would not obviously perceive it, even though the pebble would, in a very minute way, become a part of that human's consciousness. The ability of the observing human to deduce facts about the pebble is equivalent to the amount and kind of informational exchange that happened between them and the pebble. One cannot conceive or bring into existence a fact that had not been propagated to them by the laws in which matter (and thus qualia or information) interacts. As a result, thinking may be viewed as a way of combining information, and so the notion of thinking may extend beyond the boundaries of a single human brain, as discussed by (Jung 1979).

This suggests that the words used to describe subjective experiences may be, to a certain extent, applicable to physical systems. For example, the constituent systems of an object falling in Earth's gravitational field might be said to experience their own kind of "urge to accelerate" if their structure was such that it enabled encoding information about the object accelerating, which aligns, in part, with the views of (Dretske 1995). Although a pebble may not have the capacity to store and retrieve the information about its experience, at the instant of interaction, it (its comprising systems) undergoes a distinct phenomenal experience. Similarly, on a microscopic scale, an electron which exchanges a photon with another particle experiences the informational exchange as a distinct qualitative flavor.

3 Consciousness and Free Will

The fact that the human brain is never fully active at an arbitrary point in time corresponds to the fact that human beings are not constantly aware of all their memories (Herzog, Drissi-Daoudi, and Doerig 2020). The memories are stored, decoupled from the consciousness of the ego and require lookup, and when the ego entangles with them, they fundamentally change the momentary sentient experience.

It is clear that the conscious experience of the ego is localized in specific regions of the brain (Tononi et al. 2016). This means that any arbitrary snapshot of the ego does not contain all information of the encapsulating brain. For example, processing of visual information is not necessarily a part of that consciousness (Crick and Koch 1995). Based on the argument thus far, the information contained within the brain, outside the ego still constitutes a kind of consciousness. The interactions of the ego with the rest of the brain's systems result in merger or splitting of these individual conscious entities, forming new phenomenal experiences. For example, evoking a memory into the ego consciousness is equivalent to the physical system corresponding to the ego becoming entangled with the stored information.

The boundary of an individual's entangled system may reach beyond the confines of their brain. When interacting with an outside object, the level of physical control over the object is equivalent to the observer's subjective experience felt as a distinct ability to affect it. The stronger the entanglement, the richer the phenomenal experience of the object and vice versa. When an observer feels loss of perception or knowledge of an object, they are, in fact, becoming disentangled from it. Since the act of observation is considered measurement, then a change in conscious experience is the act of measurement. Given that measurement is symmetric, at the point of interaction, the "observer" is an observer of the object and the object is an observer of the "observer", consistent with quantum information theory. As objects interact, they become a single entity to a degree proportional to the degree of entanglement.

The idea that the phenomenal experiences are themselves the information exchanged during interaction poses an important question about the information contained within an ego consciousness. For example, a book only contains information to a human being that can read, since only they would be entangled with the information on how to interpret the writing and even what a book represents as an object. To an alien, a book would hold no information unless they became entangled with human history or somehow extracted the information from the environment (the two are arguably similar from the alien's perspective) – the alien would become more human in order to read human writing.

This argument substantiates the idea of symbolic interaction between the ego and the *collective unconscious* (Jung 1981). In (Jung 1979), Jung recognized and described that the ego, as the subject of all personal acts of consciousness, does not correlate to the entirety of the human brain, but is rather in communication with what he described as the *unknown*. Although he states, "*The unknown falls into two groups of objects: those which are outside and can be experienced by the senses, and those which are inside and are experienced immediately.*", the two aspects need not be separated, except for the convenience of psychoanalysis. More formally, since full entanglement of the systems that comprise a human brain could at best be argued as weak due to monogamy of entanglement, one could assert that a single brain could harbor multiple conscious entities that experience a kind of a sentience. The archetypes presented to the ego, entering its field of consciousness, may be physically modeled as the system of the ego exchanging information with other brain's systems.

3.1 Free Will and the Measurement Problem

Several behavioral experiments have demonstrated that human perception of choice may be preceded by a measurable activity in the brain, suggesting that true choice may be an illusion (Bear and Bloom 2016) (Wegner and Wheatley 1999) (Gelbard-Sagiv et al. 2018). Although this style of experiment (Libet 1994) has recently been contested (Papanicolaou 2017), other research (Schurger 2015) argues that the origin of actions must be within the causal web of the brain, which may not be confined to the central nervous system, but rather reach outside the body through complex feedback networks. If the laws of nature are deterministic and they govern the phenomenal domain, then free will must be no more than a distinct phenomenal experience corresponding to an equally distinct information exchange pattern.

When free will is defined in accordance to the Cambridge Dictionary as "*the ability to decide what to do independently of any outside influence*", in order for free will to exist within the presented framework, laws of nature would have to be nondeterministic. From a quantum-mechanical perspective, every system is fully and deterministically described by its wave-function and the apparent randomness only manifests from within individual entangled systems at the moment of entanglement. In other words, the measurement problem only exists at the level of participating interacting systems.

Put simply, a planet orbiting a sun can no less make the choice to veer off course than a human being can make the choice to fly. It must abide to the laws of nature that govern it and in order to choose against them the laws would have to allow for nondeterminism. Similarly, in a case of two particles exchanging a photon, it may be said that the particles choose, or agree upon through yet unknown means, the classical state to resolve to upon interaction.

However, in order for two interacting systems to resolve to a new configuration that cannot be determined from the previous one by simulating physical laws, the systems must introduce new information after interaction. The source of this information must, therefore, exist outside the perceivable universe. In other words, if the laws of nature are deterministic, free will cannot exist unless information can be added to the universe by an outside effect that cannot be measured. If the source was accountable for by any means of analysis, then it would, by definition, exist within the universe and would abide by the laws of nature and therefore be subject to this same argument. Then, it is reasonable to postulate that the degree to which a system is able to exert free will is proportional to the degree the universe is nondeterministic.

4 Conclusion

Answering one of the most important questions that has puzzled philosophers for more than two thousand years, "*What is the relationship between the mind and the body?*", may not be feasible solely through philosophical efforts, but rather require reliance, or faith, on the scientifically observed facts about the universe. Informational monism presented here offers an answer to the hard problem of consciousness relying specifically on the formalism and experimental data fundamental to the quantum information theory.

The undeniable scientific validity of the connection between the phenomenal and physical worlds seems to sway the intuition towards a dualist interpretation of reality, but it may be that the connection is inviolable merely because the physical world is no more than an accurate description of the phenomenal one. There is no way to witness the outside world other than to measure it, and to measure it entails bringing the measured information into the phenomenal experience of the observer. Thus, the physical world is merely a mathematical, conceptual model of reality existing within our phenomenal experience, where we faithfully expect that the next measurement will be consistent with the previously made ones. Yet, the system we observe also observes us, and so, if we are conscious, so is it. Based on the observations and postulates of quantum information theory in conjunction with thought experiments, we finally arrive at the conclusion that the substance of reality is phenomenal. That is, the fundamental building blocks of the universe are qualia – qualia are what information theory calls information.

Physical processes do not underlie the nature of experience, the experience itself constitutes reality. Consciousness is not a manifestation of the physical world, but rather the essential reality that can be effectively modeled as interacting quantum systems, but the model itself can only exist as qualia or phenomenal information. Thus, to pose the question of what causes consciousness to arise from the physical world is meaningless.

Clearly, informational monism only provides a phenomenological background to the current scientific knowledge. Using the scientific apparatus to evaluate and predict the behavior of quantum systems in no way affects the view that the actual nature of the evaluated systems is phenomenal. Although, rethinking physical systems as conscious entities may make it more intuitive to bring them to ethical discussion. While giving rise to novel ethical considerations as well as new perspectives on the problem of free-will, this framework simplifies the connection between the phenomenal and the physical and provides a coherent explanation for the nature of substance of reality while reducing the number of assumptions and variables.

Despite the implied, one may derive a brighter prospect from the view that similar physical interaction patterns must be similar-in-quality phenomenal experiences, in that any being who imitates the behavior, or whose constituent parts replicate the behavior of another, essentially experiences the same emotions and thoughts, and any thought patterns that are copied are phenomenally equivalent to the original ones, to the extent the patterns can be considered similar. Thus, a person whose behavior begins to imitate that of a partner, a parent or a friend, in part becomes the person imitated at the point in time when the replicated thought pattern emerges.

References

al., Mohsen Afrasiabi et (2021). “”Consciousness depends on integration between parietal cortex, striatum, and thalamus””. In: *Cell Systems*.

Albrecht, A. and L. Sorbo (2004). “Can the universe afford inflation?,” in: *Physical Review* 70.

Antony, Michael V. (2001). “”Is consciousness ambiguous?”” In: 8.2, pp. 19–44.

Bear, A. and P. Bloom (2016). *A Simple Task Uncovers a Postdictive Illusion of Choice*, Psychological Science.

Block, N. and J. Fodor (1972). “What psychological states are not”. In: *Philosophical Review* 81, pp. 159–181.

Bowyer, S.M. (2016). “Coherence a measure of the brain networks: past and present”. In: *Neuropsychiatr Electrophysiol* 2.1.

Braunstein, S. L. and A. K. Pati (2007). “Quantum Information Cannot Be Completely Hidden in Correlations: Implications for the Black-Hole Information Paradox,” in: *Physical Review Letters* 98.8.

Broad, C. D. (1925). *The Mind and its Place in Nature*. London: Routledge and Kegan Paul.

Cerf, N. J. and C. Adami (1998). “Quantum Information theory of quantum entanglement and measurement,” in: *Physica D: Nonlinear Phenomena* 120.2, pp. 62–81.

Chalmers, David J. (1996). *The Conscious Mind: In Search of a Fundamental Theory*.

Clauser, J. F. et al. (1969). “Proposed Experiment to Test Local Hidden-Variable Theories,” in: vol. 23.

Crick, F. and C. Koch (1995). “Are we aware of neural activity in primary visual cortex?,” in: *Nature* 375, pp. 121–123.

Davidson, D. (1970). “Mental events.,” in: pp. 79–101.

Demertzi, A. et al. (2019). “Human consciousness is supported by dynamic complex patterns of brain signal coordination”. In: *Science Advances* 5.2.

Deutsch, D. (1985). “Quantum theory as a universal physical theory,” in: *International Journal of Theoretical Physics* 24.1, pp. 1–41.

Dirac, P. A. M. (1927). “The Quantum Theory of the Emission and Absorption of Radiation.,” in: *Royal Society* 114.767.

— (1933). “”The Lagrangian in quantum mechanics””. In: *Physikalische Zeitschrift der Sowjetunion.* 3, pp. 64–72.

Dretske, Fred (1981). *Knowledge and the Flow of Information*. The MIT Press.

— (1995). *Naturalizing the Mind*. The MIT Press.

Einstein, A., B. Podolsky, and N. Rosen (1935). “Podolsky and Rosen, ”Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?,”” in: vol. 47.

Engel, Andreas K. and Pascal Fries (2016). “Chapter 3 - Neuronal Oscillations, Coherence, and Consciousness”. In: *The Neurology of Conciousness (Second Edition)*. Ed. by Steven Laureys, Olivia Gosseries, and Giulio Tononi. Second Edition. San Diego: Academic Press, pp. 49–60. ISBN: 978-0-12-800948-2. DOI: https://doi.org/10.1016/B978-0-12-800948-2.00003-0. URL: https://www.sciencedirect.com/science/article/pii/B9780128009482000030.

Farthing, G. William (1992). *”The Psychology of Consciousness”*. Prentice Hall.

Feynman, R. P. (1942). “”The Principle of Least Action in Quantum Mechanics””. PhD thesis.

Fodor, J. A. (1974). “Special sciences: Or, the disunity of science as a working hypothesis”. In: *Synthese* 28, pp. 97–115.

Freedman, S. J. and J. F. Clauser (1972). “Experimental Test of Local Hidden-Variable Theories,” in: *Physical Review Letters* 28.938.

Garret, R. (2001). *Quantum Mysteries Disentangled*.

Gelbard-Sagiv, Hagar et al. (2018). “”Human single neuron activity precedes emergence of conscious perception””. In: *Nature Communications* 9.1.

Glashow, S. L. (1961). “Partial-symmetries of weak interactions,” in: *Nuclear Physics* 22.4, pp. 579–588.

Hameroff, S. and R. Penrose (1996). “Conscious Events as Orchestrated Space-Time Selections”. In: *Journal of Consciousness Studies*, pp. 36–53.

— (2014). “Consciousness in the universe: A review of the ‘Orch OR theory’”. In: *Physics of Life Reviews*, pp. 39–78.

Herzog, Michael H., Leila Drissi-Daoudi, and Adrien Doerig (2020). “All in Good Time: Long-Lasting Postdictive Effects Reveal Discrete Perception”. In: *Trends in Cognitive Sciences* 24.10, pp. 826–837.

Hoffman, D. D. (2008). “Conscious Realism and the Mind-Body Problem”. In: *Mind & Matter* 6.1, pp. 87–121.

Hunt, T. (2011). “Kicking the Psychophysical Laws into Gear A New Approach to the Combination Problem”. In: *Journal of Consciousness Studies* 18.11.

Jackson, F. (1982). “Epiphenomenal Qualia,” in: *The Philosophical Quarterly* 32.127, pp. 127–136.

Jung, C. G. (1979). *Aion: Researches into the Phenomenology of the Self*. Princeton University Press.

— (1981). *The Archetypes and the Collective Unconscious*. Princeton University Press.

Keppler, Joachim (2018). “The Role of the Brain in Conscious Processes: A New Way of Looking at the Neural Correlates of Consciousness”. In: *Frontiers in Psychology* 9, p. 1346. ISSN: 1664-1078. DOI: 10.3389/fpsyg.2018.01346. URL: https://www.frontiersin.org/article/10.3389/fpsyg.2018.01346.

Kim, J. (1993). *Supervenience and Mind*. Cambridge University Press.

Larkoski, A. J. (2019). *Elementary Particle Physics: An Intuitive Introduction*. Cambridge University Press.

Lewis, David K. (1986). *On the Plurality of Worlds*. Oxford, Blackwell.

Libet, B. (1994). “A TESTABLE FIELD THEORY OF MINDñBRAIN INTERACTION”. In: 1.1, pp. 119–126.

M., Tegmark (2000). “Why the brain is probably not a quantum computer”. In: *Information Sciences* 128.3-4, pp. 155–179.

Miller, J. G. (1978). *Living systems, New*. York: McGraw-Hill.

Nagel, Thomas (1974). “What Is It Like to Be a Bat?” In: *The Philosophical Review* 83.4, pp. 435–450.

Nielsen, Michael A. and Isaac L. Chuang (2000). *Quantum Computation and Quantum Information*. Cambridge University Press.

Papanicolaou, A. C. (2017). “The myth of the neuroscience of will”. In: 4.3, pp. 310–320.

Pati, Arun Kumar and Samuel L. Braunstein (2000). “Impossibility of Deleting an Unknown Quantum State,” in: *Nature* 404, p. 164.

Place, U. T. (1956). “Is consciousness a brain process?” In: *British Journal of Psychology* 45, pp. 243–255.

Rochat, Philippe (2003). “”Five levels of self-awareness as they unfold early in life””. In: 12.4, pp. 717–731.

Sayre, Kenneth M. (1976). *Cybernetics and the Philosophy of Mind*.

Schrodinger, E. (1926). “An Undulatory Theory of the Mechanics of Atoms and Molecules,” in: *Physical Review* 28.6, pp. 1049–1970.

Schrödinger, E. (1935). “”Discussion of probability relations between separated systems,”” in: *Mathematical Proceedings of the Cambridge Philosophical Society* 31.4, pp. 555–563.

Schurger, Aaron (2015). “Nowhere and Everywhere: The Causal Origin of Voluntary Action”. In: *Review of Philosophy and Psychology* 6.4, pp. 761–778.

Searle, J. R. (2005). *Mind: A Brief Introduction (Fundamentals of Philosophy Series)*. Oxford University Press.

Smart, J. (1959). “Sensations and brain processes.” In: *Philosophical Review* 68, pp. 141–156.

Sorensen, R. A. (2009). *A Companion to Metaphysics*.

Stalnaker, Robert (1976). “Possible Worlds”. In: *Nous* 10, pp. 65–75.

Susskind, L. and A. Friedman (2015). *Quantum Mechanics: The Theoretical Minimum*. Basic Books.

Tavkhelidze, A. (1965). “Seminar on High Energy Physics and Elementary Particles,” in:

Thatcher, Robert W. (1997). “Neural Coherence and the Content of Consciousness”. In: *Consciousness and Cognition* 6, pp. 42–49.

Tononi, G. et al. (2016). “Integrated information theory: from consciousness to its physical substrate,” in: *Nature Reviews Neuroscience* 17, pp. 450–461.

Tye, M. (2000). *Consciousness, Color, and Content (Representation and Mind)*. A Bradford Book.

Ueki, K. (2008). “Hemispherectomy in the Human with Special Reference to the Preservation of Function,” in: *Progress in Brain Research*.

Wegner, D. M. and T. Wheatley (1999). *Apparent mental causation: Sources of the experience of will.*, American Psychologist.

Wenzel, Michael et al. (2019). “”Reduced Repertoire of Cortical Microstates and Neuronal Ensembles in Medically Induced Loss of Consciousness””. In: *Cell Systems*.

Wigner, E. (1961). *”Remarks on the mind-body question,” in The Scientist Speculates, I*. Ed. by J. GoodHeineman.

Yang, C. N. and R. L. Mills (1954). “Conservation of Isotopic Spin and Isotopic Gauge Invariance,” in: *Physical Review* 96, pp. 191–195.