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QUANTUM MECHANICS REQUIRES AN OBSERVER CONTEXT DISTINGUISHING BETWEEN REALITY AND ITS MENTAL REPRESENTATION

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Abstract

When phenomena in quantum mechanics are interpreted from the perspective of bio-psychology, wave function collapse from several to a single eigenstate must be plausibly explained. Quantum mechanics requires a context, yet the context of an observer is rarely considered. On the other hand, in bio-psychology, the observer context is examined to explain superposition and collapse by different mental functions used in everyday life. Three mental functions are described, one of which is responsible for observation, and the others for conservation and treatment of information in mental representation. Whereas observation produces information with certainty, the subsequent processes result in uncertain potentiality. In order to encompass uncertainty, multiple possibilities are simultaneously considered in mental superposition, one of which should represent the unknown future outcome. During observation, all suggested potentialities necessarily collapse to one real outcome. The collapse of superposition does not occur in observable physical reality, but in its mental representation. Some physical principles—such as superposition, infinity and nothingness before the Big Bang—are pure phenomena of mental representation, which will always remain unverifiable by observation. This argument proves that mental representation brought about by the observer context participates in the production of mental models for the best approximation of physical reality.

Keywords: Quantum mechanics; superposition; collapse; bio-psychology; observation, mental representation; reality; potentiality; infinity; nothingness;

1. Introduction

Many interpretations of quantum mechanics phenomena do not consider the context of an observer, who witnesses physical events, registers them on different kinds of support and finally interprets them as physical laws. Quantum mechanics is context dependent [1], but only some physicists are of view that the collapse of the wave function requires the context of an observer [2-4]. Nevertheless, they could not consider the bio-psychological mental functions of an observer, which might explain superposition of multiple likely events and their collapse to a single one as phenomena in mental representation, albeit unobservable in physical reality.

Bio-psychological interpretation of quantum mechanics with mental functions is based on limited knowledge on highly complex but deterministic interactions and resembles the quantum mechanical interpretation by Aerts and Sassoli de Bianchi [5, 6] Moreover, it provides an alternative approach toward meeting the objectives of the last EMQM 17 meeting pertaining to the role of an observer. Observable physical reality is distinguished from its mental representation by an observer. They are separated by a great gap. Whereas observable physical reality is certain, its mental representation is merely a potentiality, which still has to be verified if it is to be accepted as physical reality. Nevertheless, some phenomena used in applied mathematics, such as infinity, will always remain unverifiable, and may thus be used to describe that mathematics also use mental representation for uncertain potentiality. There are some discrepancies between physical formalism and perception of reality in mental representation. This might signify that physical formalism is not identical to physical reality, but rather provides mental models for its best approximation. In this context, mental representation by an observer appears to be crucial.

2. The Observer in Quantum Mechanics

In some interpretations of quantum mechanics, an observer is introduced to facilitate explaining the measurement problem, whereby possible outcomes of an experiment are represented by the wave function comprising of a superposition of a vast number of states that are yet to be realized. However, an observer cannot see the superposition and observes only one realization of multiple possibilities. Therefore, during observation, the wave function has to collapse into only one of all possible situations. Von Neumann [3] expected the collapse to be positioned somewhere in the causal chain between the measurement device and the subjective perception of a human observer. Wigner [4] proposed that human consciousness is the instance in which the wave function collapse is realized. Stapp [2] argued that conscious thought of a human observer ought to be causally connected to events happening in the brain. According to this view, our brains are an integral part of a quantum mechanical description of the physical universe. Although these theories are subject to criticism [7] unlike many alternative propositions, they imply observer participation in the measurement problem.

2.1 Compatibility of an observer with quantum mechanical interpretations

There are actually two contrasting ways of interpreting the laws of quantum mechanics—as indeterminism with superposition in physical reality or as highly complex determinism with limited knowledge of interactions. Adopting the first stance, Albert [8] described quantum mechanics as "concrete physical objects" (53) and Ney [9] interpreted the wave function as "a field in a high dimensional space" (2).
Aerts and Sassoli de Bianchi [5] on the other hand, took the second approach, which they supported by hidden-variable modeling, which produces:

> *interactions between the entity and the measuring system, which are actualized in different ways at every run of the measurement, because of the presence of irreducible fluctuations (so that a quantum measurement would in fact be a multi-measurement, expression of an average over different measurements which we have called a universal measurement).* (1022)
> *We also show that quantum probabilities can be generally interpreted as the probabilities of a first-order non-classical theory, describing situations of **maximal lack of knowledge** regarding the process of actualization of potential interactions, during a measurement.* (975)

A mechanism of selection of unobservable deterministic interactions was clearly described by Sassoli de Bianchi [6] :

> *According to this approach, when an experimenter observes a given property of a quantum entity, like, say, the position of an electron …, the process can be described as a mechanism of **selection of a specific deterministic interaction**, amongst a collection of possible ones. ... similarly to classical probabilities their nature would be **epistemic**, and **not ontic**. ... one can certainly defend that quantum probabilities are epistemic, as they are describable in terms of the*

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> *experimenter's lack of knowledge about the specific deterministic hidden interaction.* (78)

Bio-psychology corresponds to the view offered by Aerts and Sassoli de Bianchi [5], who posit that quantum mechanics could be explained as a complete lack of knowledge of deterministic interactions in both the microcosm and the macrocosm. As a result, superposition of exhaustive possibilities in a mental representation of the future could be considered as manifestations resembling quantum mechanics [10].

2.2 The observer context in quantum mechanics

In quantum mechanics, contextuality is a fundamental principle, as measurement results are influenced by the choice of the experimental setup. Thus, Grangier [2] claimed that "the appropriate conceptual framework for QM is contextual objectivity" (331). According to Zu et al. [11], contextuality represents the major difference between quantum mechanics and classical physics. The authors justified this assertion, stating:

> *the celebrated Kochen- Specker theorem … showed that noncontextual hidden variable theories are incompatible with the predictions of quantum theory. … the conflict between quantum theory and noncontextual realism resides in the structure of quantum mechanics instead of particular quantum states.* (1)

Auffève and Grangier [12] proposed, "to modify the quantum ontology, by requiring that physical properties are attributed jointly to the system, and to the context in which it is embedded" (122). Kirchmair et al. [13] reported results of an experiment with a system of trapped ions and demonstrated that, irrespective of the quantum state of the system, quantum mechanics conflicts with non-contextuality.

In sum, while quantum mechanics is considered within a context, the context of an observer is merely implied by some physicists [2-4]. To date, it has not been explored with respect to bio-psychological functions. The mental functions of an observer can indeed collapse multiple superposed potentialities to a single actuality simply by observation. However, the collapse does not occur in physical reality itself, as often claimed by physicists, but in its mental representation, which allows multiple potentialities to coexist in a superposition of infinite possibilities [14]. The "many-to-one collapse" can be explained by the different properties of three specialized mental functions designated for observation, memorization and abstract reflection.

2.3 Requirement for the presence of an observer from a bio-psychological perspective

Physical laws are explored by human observers. All physical laws are based on prior observations of physical reality by an observer that relies on the first mental function of *elementary sensation*. Observations are subsequently stored by the observer's second mental function of *memory imagery* or on mechanical or digital supports before they are finally transformed by the third mental function of *abstract reflection* into physical laws. This chain of processes clearly demonstrates that an observer is necessarily implicated as a gateway for all information from extra-mental reality, which is then stored in different kinds of memory before it is transformed by abstract reflection into physical laws. The requisite role of an observer in the establishment of physical laws is thereby clearly demonstrated. Nevertheless, this does not address the question of whether the deduction of physical laws by an observer from incoming information could have left important traces in the formalism, for instance in the laws of quantum mechanics. To answer this important question, the properties of the mental functions of an observer have to be studied.

3. Mental functions of an observer

From the perspective of bio-psychology, mental functions can be attributed to two opposing systems—an **open system** for observable physical reality and a **closed system** for its mental representation (Figure 1). Directly or indirectly observable reality needs an open system, which requires sense organs transmitting information from extra-mental reality to the brain. On the other hand, its mental representation is a closed system independent of the sense organ activity, which renders it detached from extra-mental reality. The presence or absence of sense organs between the open and the closed system creates a great gap between them. As information can flow from the open to the closed system unobstructed, it is simply stored in the latter for retrieval.

In contrast, any information located in the closed system that might be retrieved for prediction in the open system is uncertain, since the closed system is able to modify the information stored within, whereby it no longer faithfully reflects the actuality in the open system.

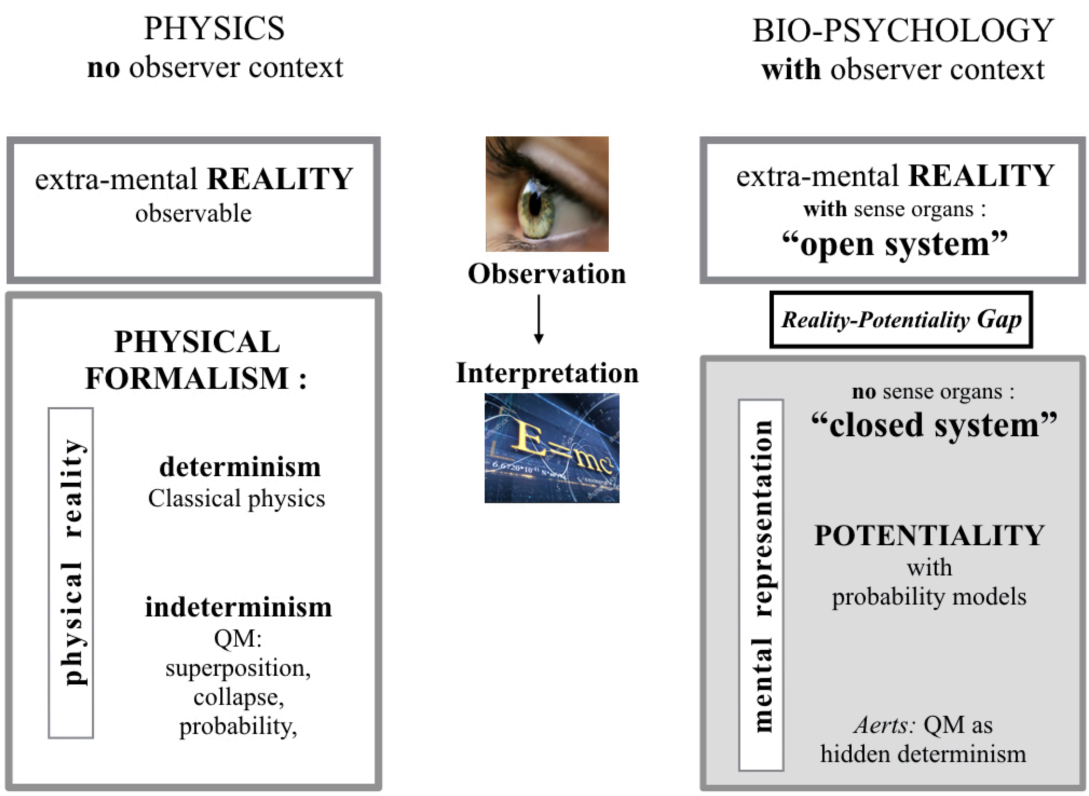

Figure 1: The observer context in physics and bio-psychology
In physics, the input observer receives is limited to perceivable information from extra-mental reality. Interpretation is thus based on physical formalism considered as reality. In bio-psychology, on the other hand, observation with sense organs represents an open system with a direct physical link between extra-mental reality and the brain. Due to the observer context, the absence of sense organs during interpretation obstructs the direct contact with extra-mental reality, so that interpretation does not always correspond to the information in the open system and has to be verified. Therefore, the closed system produces only potentiality that requires probability models to be quantified.

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3.1 Three mental functions

Observation is dependent on sense organs, which allow direct physical contact between the brain and the extra-mental reality in an open system. The corresponding mental function is called *elementary sensation.* For example, light reflected from a tree enters the eye and stimulates nerve cells in the retina, which transmit the corresponding electrical signals to nerve cells in certain brain regions designated for specific sense organs (Figure 2). Thus, there is a continuous chain of physical interactions from the tree in extra-mental reality to the brain, which corresponds to an open system (Figure 2, I). Information obtained through sense organs cannot be voluntary changed, as it is passively obtained and subsequently processed [15].

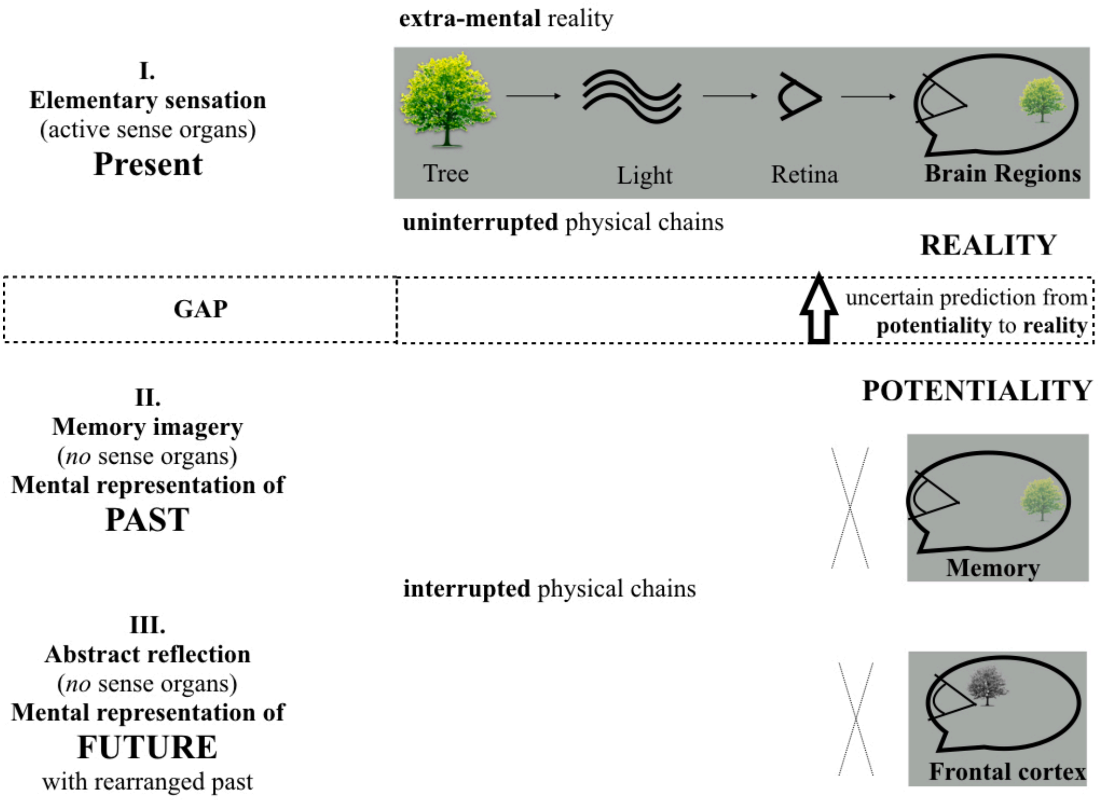

Figure 2: Three mental functions
Elementary sensation involving an uninterrupted physical chain linking extra-mental reality with the brain through sense organs indicates the PRESENT. Memory imagery does not involve sense organ activity, or an uninterrupted physical chain, and thus allows recalling the PAST. Abstract reflection similarly functions without involvement of sense organs, permitting prediction of a potential FUTURE based on a reassembly of past events.

The situation is completely different when the uninterrupted physical chain that starts with sense organs as a gateway is broken by closing the eyes. The tree used in the earlier example can still be visualized, but its imagined form is based on the mental copies of elementary sensation of the previously observed trees stored in memory imagery (Figure 2, II). Without the direct link in the present between extra-mental reality and brain through sense organs, memory imagery is a closed system. As a result, the information stored within may have changed with respect to the open system thereby creating a gap between the two systems. Whereas the open system warrants correct transmission of information from extra-mental reality, the closed system only retains past information, no longer actualized by sense organs.

In contrast to elementary sensation, memory imagery can be voluntarily changed by abstract reflection (Figure 2, III) that may involve rearrangement, recombination with other stored information or partial elimination, all of which play a role in predicting a potential future. As this process requires access to previously stored information, it is part of the closed system without direct contact with extra-mental reality. It is therefore a mental representation of potential observable reality, which can be true or false, and thus has to be verified by new observations in the open system [16].

3.2 Mental functions explaining past, present and future

McTaggert [17] proposed two distinct concepts for time, the A series comprising of past, present and future, and the B series that distinguishes prior and later events only. He claimed that an event like the death of Queen Anne could first lie in the future, then in the present and finally in the past. Thereby, the same event could have a different existence depending on the tense. As this notion is difficult to accept, it led him to the conclusion that time is unreal. Einstein [18] offered a similar explanation, noting that "the separation between past, present and future has only the importance of an admittedly tenacious illusion" (1).

Instead of considering past, present and future as illusions, the observer context allows them to be characterized simply as different mental representations [19]. The present necessarily requires presence of at least one observer witnessing physical events with the mental function of *elementary sensation* [15]. In contrast, the past no longer exists and can only be a mental representation of a prior present with simplified copies stored in *memory imagery*. The future has not yet materialized and therefore must also be a mental representation. The mental function of *abstract reflection* allows us to imagine a potential future in which a vast number of possible events coexist in superposition, which may or may not happen. Whereas the past is considered with certitude, the future is characterized by uncertainty.

3.3 Contradictory definitions of reality and potentiality in physics and bio-psychology

In his book *Our Mathematical Universe: My Quest of the Ultimate Nature of Reality*, physicist Max Tegmark [20] proposed "that our world not only is described by mathematics, but that it is mathematics, making us self-aware parts of a giant mathematical object" (6). He thereby concurred with the claim made by Galileo Galilei that nature is written in the language of mathematics, while also supporting Eugen Wigner's [21] "unreasonable effectiveness of mathematics in the physical sciences" (1). Countering these arguments, Stewart [22], a renowned mathematician, wrote "There is strong consensus that mathematics isn't reality, it just resembles reality in a useful way" (129).

The essential problem stemming from these opposing perspectives is the definition of the word reality. From a bio-psychological perspective, reality has a clear definition as physical reality directly or indirectly observable with sense organs, which is opposed to its mental representation without sense organs and therefore based on potentiality. Indirect verification includes all amplification instruments extending the capacity of our sense organs, such as the microscope, the ultra-microscope and the telescope for vision, the microphone for audition, the micro-manipulator for touching and moving, etc. The bio-psychological definition of reality is based on the fact that observation corresponds to the mental function of *elementary sensation*, which needs sense organs transmitting information by an uninterrupted chain of physical interactions from extra-mental

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reality to the brain, as an open system for the brain. In contrast, after observation, information is further interpreted for exploration and analysis, leading to the establishment of physical laws. The treatment of information is performed by the mental function of *memory imagery* for storage, and by the mental function of *abstract reflection* that allows interpretation of physical laws. As the latter mental functions no longer require sense organ activity, the physical chain of interactions is broken, leading to a closed system, no longer in contact with extra-mental reality. This interruption in the chain of physical interactions creates a great gap between the open and the closed system.

Still, information can pass freely from the open to the closed system, which only stores information. Yet, if information is transmitted in the inverse direction, as it is stored in the closed system, it can be voluntarily changed by abstract reflection. In this case, it may no longer correspond to extra-mental reality, which is only accessible through the open system. Moreover, interpretation in the closed system can require multiple superposed possibilities, only one of which will correspond to the information contained in the open system. Therefore, the information received from the open system through sense organs is considered reality, whereas interpretation in the closed system without sense organs corresponds to potentiality [14].

In physics, potentiality is often considered as ontic physical reality [23-29]. Only Heisenberg [30] and Aerts [31] declared them as potentiality. Bio-psychology characterizes potentiality as future events, which do not yet exist in their final form, for example the sunflower seeds. They have the potentiality with all necessary genetic properties to become a sunflower in the future. Nevertheless, their development depends on the availability of water, soil and sunshine, which is not warranted, so that only some of the seeds will become sunflowers. Thereby, potentiality indicates an uncertain future existence or non-existence, which is completely different from already existing reality. In order to avoid confusion, the physical and bio-psychological definitions have to be clearly distinguished. In bio-psychology, reality has to correspond to directly or indirectly observable physical factors, whereas potentiality concerns uncertain, not yet actualized, which still need to be verified by new observations.

3.4 Similarity between quantum mechanics and bio-psychological mental functions

Zurek [32] noted a significant difference between quantum mechanics and the everyday perception, as follows:

> *at the root of our unease with quantum theory is the clash between the principle of superposition … and everyday classical reality in which this principle appears to be violated….* (4)

However, when considering human mental functions, the supposed violation disappears. In quantum mechanics, the collapse of the wave function could be considered as a "multiple to one collapse" of exhaustive possibilities in superposition (Hilbert space) to a single realized observation. In bio-psychology, the same phenomenon arises due to two mental functions—*abstract reflection* in a closed system and *elementary sensation* in an open system with direct access to extra-mental reality.

Since events in the future and the distant past cannot be directly observed with *elementary sensation*, they can be predicted using the information stored in the closed system through *abstract reflection*. However, the closed system without sense organs can only predict with uncertainty what happens in the open system. This process requires considering multiple possibilities in superposition, only one of which will correspond to observable reality. Similar to quantum mechanics, verification by observation with elementary sensation requires a "multiple to one collapse" of all superposed possibilities to one observable reality. This can be explicated by using the moon as an example. During the day, and without any knowledge on the actual moon phase, one can only imagine with abstract reflection all possible moon phases in a kind of superposition. When during the next night the real moon phase can be observed with elementary sensation, there is necessarily a collapse of all imagined possibilities to the actual moon phase. A more complex situation concerns a mother who knows that her son underwent an earthquake but is not yet informed of his status. She imagines multiple possibilities, fearing that her son might be trapped in a car on a collapsing bridge, or be buried under a building. If the mother is finally informed, all imagined possibilities have to collapse to one, as her son is either dead or still alive. These examples seem to correspond to classical physics with a lack of knowledge on determinist physical interactions, but this is exactly the interpretation of quantum mechanics proposed by Aerts and Sassoli di Bianchi [5-6].

Since a closed system has no direct access to extra-mental reality via sense organs, it can compensate for the lack of knowledge by considering all logical potentialities, which also include the real one. The recourse to logical evaluations proves that such reasoning takes place in mental representation. The similarity to quantum mechanics suggests that superposition is also a mental representation phenomenon, not observable physical reality [14].

4. Unverifiable phenomena in mental representation

By considering the context of an observer in physics, bio-psychology differentiates between **observable reality** accessible with sense organs and its **mental representation** without access to extra-mental reality. This distinction is important due to the great gap imposed by the open and the closed system requiring verification by new observation. However, some phenomena of mental representation in physics can never be verified by observation and forever remain mental representation phenomena only. Although they may be extremely logical, they remain uncertain potentiality, such as superposition in quantum mechanics, as well as the notions of infinity or absolute nothingness.

4.1 Superposition in quantum mechanics

In quantum mechanics, superposition is not observable reality and is therefore not verifiable [33]. In addition, it allows simultaneously existing and non-existent physical facts to be combined, as exemplified by Schrödinger's cat thought experiment. The philosophical law of non-contradiction already established by Aristotle [34] prohibits simultaneous occupation of the same spatial location by existing and non-existing objects. Only potentiality, which is a mental representation of physical reality, allows superposition of existing and not yet existing events for the prediction of future events [14]. Therefore, Heisenberg [30] and Aerts [31] proposed that quantum mechanics should be interpreted as potentiality, which may or may not be actualized. Potentiality is a mental representation phenomenon.

4.2 Infinity in mathematics and physics

In mathematics, natural, real and rational number sets are infinite [22]. An unlimited repetitive process of adding 1 to 1 leads to an infinity of numbers. An unlimited repetitive division of the circumference of a circle by its diameter leads to Pi with an infinite number of digits without discernible patterns. Thus, infinity is characterized by repetition of an identical process without any limitation (Figure 3). Infinity imposed by mathematics on physical formalism sometimes leads to singularities, where physical laws lose their sense. According to the mathematician Ian Stewart [22] "Infinity is virtually indispensable in today's mathematics, but there it's a conceptual entity, not a real one. … Does infinity exist outside the human mind?" (91)

From a bio-psychological perspective, infinity is the mental representation of a virtual repetitive process without any limitation. If the process is executed in physical reality, it is finite, since it is limited by many factors, such as initial and final conditions. Filling repetitively a tank with gasoline during a long trip is limited by available gasoline at the station as the initial condition and the tank volume as the final condition. In addition, the process is limited by the achievement of the objective—arrival at the destination. However, the same process can also be imagined. In partial virtuality, initial and final conditions, as well as the virtual time required to reach the destination, become unlimited. The essential limiting factors are now the achievement of the objective and the necessary mental effort and duration, which depend on a functioning brain that remains reality. These limits render a partial virtual execution finite.

Infinity is only attained if the repetitive process no longer has to be executed in reality or partial virtuality, which can be achieved by reducing it to an if-then process, conceivable for the future. If-then conditions eliminate the time- and energy-consuming execution between the *if* and *then* conditions and constitute complete virtuality in mental representation. Time elimination and energy preservation reduce the repetitive process to a mental representation of a potential future. Now, absence of limitation renders the repetitive virtual process infinite. Since the future does not yet exist, infinity cannot be observable physical reality, but rather remains a mental representation phenomenon of uncertain potentiality.

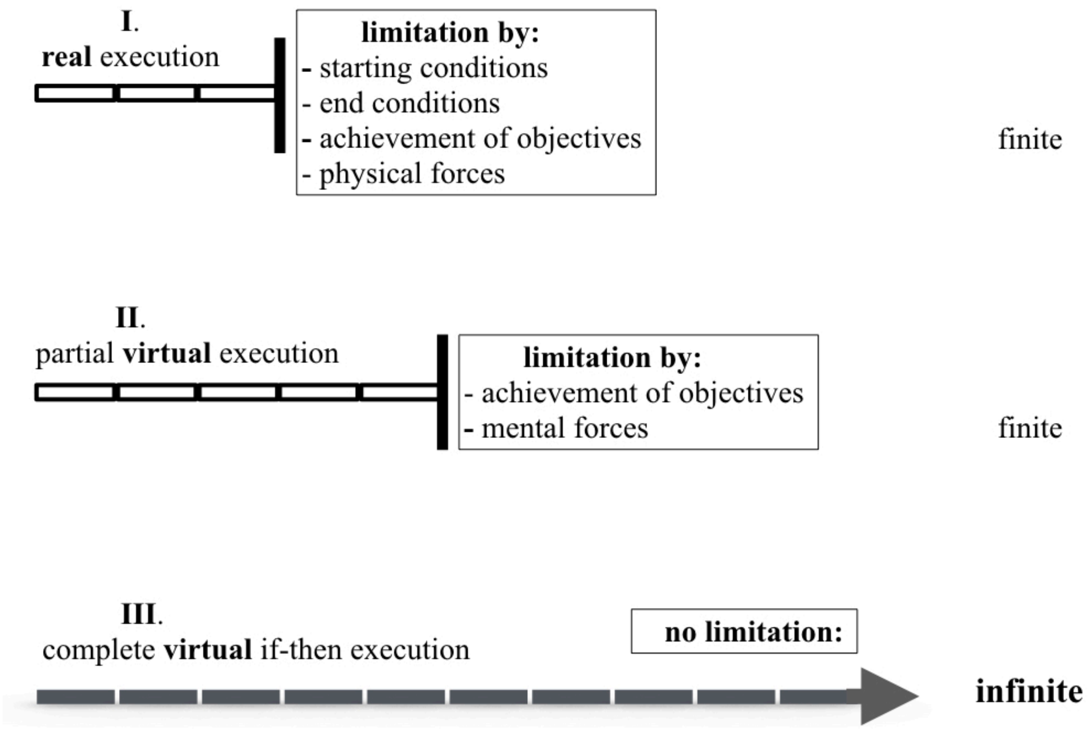

Figure 3: Repetitive proceedings ranging from finite to infinite
Execution of recurring events, if they occur in reality, is limited by several conditions and remains finite. The execution in partial virtuality is only limited by the mental forces involved and the achievement of set objectives. However, in a potential if-then repetition, the time necessary for execution disappears, so that all limitations are removed, allowing infinite continuity.

4.3 Nothingness before the Big Bang

The expansion of the Universe predicted by Alexander Friedmann and Georges Lemaître was experimentally proven by Edwin Hubble [35]. The extrapolation of the physical laws to the earliest moments of the Universe's existence has led to the theory of the Big Bang, which seems to indicate that the Universe with space and time was created 13,8 billion years ago [36]. This interpretation inevitably leads to the question of what existed before the Big Bang (often asked on the Quora Digest question-and-answer website).

The extrapolation of physical formalism to the beginning of the Universe leads to a singularity in which physical laws lose their meaning. Since the Big Bang is considered the precursor to both time [36] and space, this view presupposes that there was absolutely nothing before the singularity, suggesting that the Universe was created out of nothing. However, a creation from nothingness was already refuted by Ancient Greeks. As Sorensen [37] asserted, "All Greek philosophy had presupposed creation was from something more primitive, not nothing. … Creation out of nothing presupposes the possibility of total nothingness" (15). It indeed seems illogical that absolute nothingness would allow the creation of something. In terms of the bio-psychological definition of reality, total nothingness can never be observed and is therefore an unverifiable mental representation phenomenon relying on uncertain potentiality.

The problem of creation from nothing is shared by physics and most world religions. In order to avoid this paradox, more logical solutions have been proposed, involving the eternal existence of an uncaused cause or an eternal return of existence. In monotheist religions, eternity is attributed to God, as the creator of the Universe. In the Hindu philosophy, Vedanta—a prior existing impersonal pure consciousness—is also considered as eternal [38]. On the other hand, eternal return of existence was supported by the postulates of Indian and Egyptian philosophy. Physicists describe eternal existence by representing it as unending cyclic events. Gursadyan and Penrose ([39] detected violent pre-Big Bang activity by analyzing the Wilkinson Microwave Background Probe's (WMAP) data. This phenomenon is interpreted as the activity of an eon existing prior to ours and included in an unending succession of cyclic eons. The general refusal of creation from total nothingness is due to an illogical inference and entails the acceptance of eternal existence in religions as well as physics. Nevertheless, it also remains a logical but unverifiable mental representation phenomenon.

5. Partial discordance between physical laws and observable reality

Predictions based on physical laws can be certain, as in classical physics, whereas much more complex predictions require probability, as in quantum mechanics. Only verification of predictions by new observations allows laws to be considered reality [16]. Nevertheless, physical laws formed through abstract reflection remain potentiality, since apparently verified predictions in the past were much later found in discordance with new observations and had to be revised, such as Newton's laws on gravity by Einstein's relativity. This leads to the general conclusion that physical laws remain valid only until new laws provide better explanations.

Applied mathematics in physical formalism can be considered as mental representation of physical laws. However, when mathematical models are in discordance with observable facts, they become approximations of observable reality. This can be exemplified by considering singularity requiring infinity, where physical laws lose their sense. On this, Stewart [22] wrote: "Infinite quantities are usually referred as *singularities,* and their presence is evidence of defects in the model. … In virtually every area of the physical sciences infinity is an embarrassment. A theory that predicts infinities is wrong. That doesn't mean it's useless…" (91).

Another example of discordance is the physical formalism for time, which is based on the invariance of the affine time group requiring complete symmetry for time-scale, time-translation and time-reversal [40]. If the physical formalism is applied to everyday life, it means that there is no preferred present and no time arrow, which is in complete contradiction with the prevalent perception of the world. This gives rise to two possible interpretations. If physical time has complete symmetry as the formalism indicates, daily perceptions are illusions. Alternatively, if time symmetry is only a mathematical model for time, it has to be corrected by the introduction of initial conditions, that better correspond to everyday life as Atmanspacher indicated [40].

Partial discordance means that physical formalism is a mental representation model, which can differ from verified observable reality. However, mental models have to be clearly separated from physical models, in which reality is reproduced in much smaller dimensions, like the conditions of the early universe simulated in the LHR collider near Geneva. Whereas mental models are deductions from observations, physical models are sources for new observations requiring new mental deductions.

6. Discussion

Quantum mechanics is based on superposition of multiple potentialities in a Hilbert space, which leads to the measurement problem, since there is only one observable outcome for each experiment. To address this issue, multiple potential states in superposition have to collapse into a single event. More than 15 different physical interpretations have been put forth in an attempt to explain this phenomenon [41]. In many of these interpretations, superposition of the wave function is attributed to ontic physical reality, while epistemic knowledge is favored by others. Yet, few physicists have considered the participation of an observer [2-4]. Nevertheless, they could not define the biological functions of an observer necessary for collapsing the superposition of the wave function into a unique outcome.

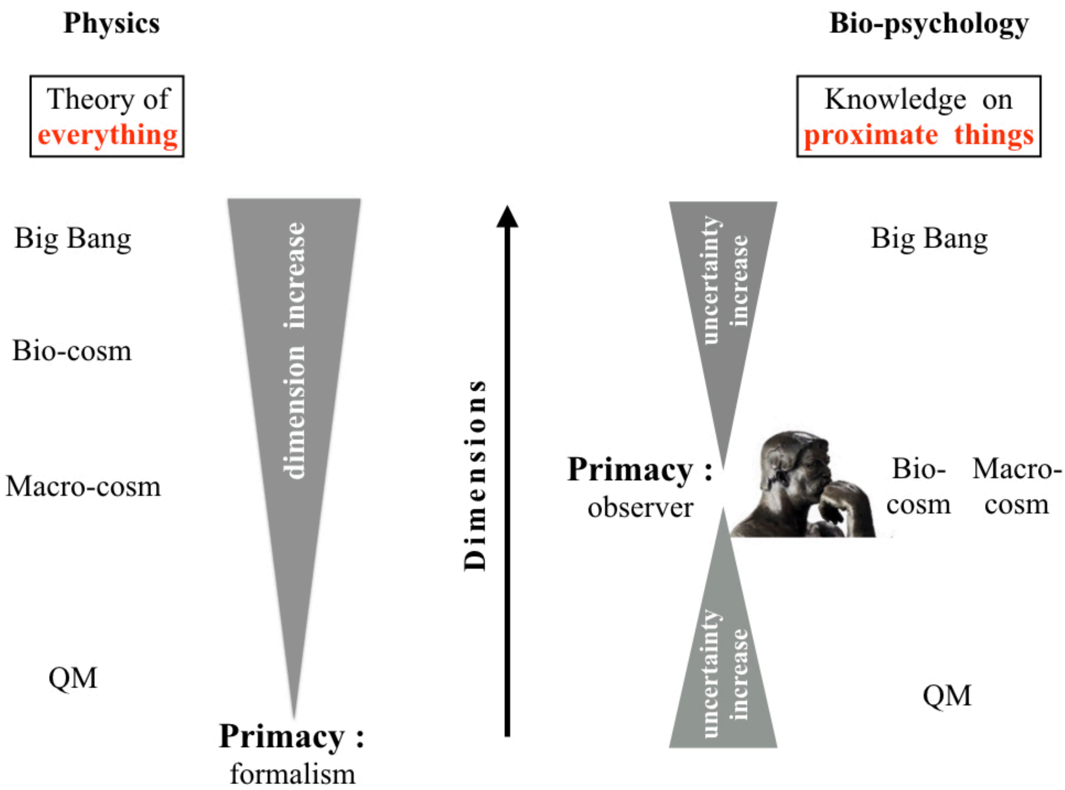

Figure 4: Primacy in physics and in bio-psychology
In physics, primacy is given to physical formalism with the aim of explaining all physical laws with a theory of everything. The mathematical formalism starts in the particle-cosm with quantum mechanics and covers the entire universe by including the bio-cosm. In bio-psychology, the observer is given absolute primacy, as he/she witnesses and interprets physical laws with potential models. The more they become remote from the observer, the more uncertain such events are. Thus, the knowledge an observer possesses remains more reliable for proximate things.

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In bio-psychology, three mental functions explain the perception of past, present and future. One of them can induce the superposition of multiple possibilities and another the collapse to a single outcome. In the present, e*lementary sensation* transmits information from extra-mental reality through all sense organs to the brain. This is an open system connecting extra-mental reality directly to the brain. The past is a copy of elementary sensation stored by *memory imagery*, which is a closed system with respect to extra-mental reality, since it does not involve sense organ activity in the information retrieval. Whereas incoming information from elementary sensation is immutable since only passively received, information stored in the memory is subject to change by simplification, omission or modification during recall. However, as past information does not always correspond to new information collected in the present, it represents uncertain potentiality. Finally, the future can be constructed with *abstract reflection*, permitting the imagination of a potential future through categorization and rearrangement of past information. It also participates in the closed system, so that prediction based on past events will not necessarily be identical to observable events in the present and thus remains uncertain potentiality. The gap between the open and the closed system imposes uncertainty on any prediction from the closed system, which therefore has to be verified for its correspondence with observable reality in the open system.

Bio-psychology limits the concept of physical **reality** to observation with all kinds of sense organs and their amplification, whereas mental representation is defined as **potentiality**, which may or may not be realized. Consequently, potentiality in mental representation does not correspond to ontic physical reality. However, there is a great discrepancy between physical and bio-psychological definitions, since potentiality is often interpreted as ontic physical reality [8-9], which leads to misunderstandings. If the observer context characterized by a significant gap between reality and potentiality disappears, physical laws acquire a high degree of certitude. Still, even laws that were previously deemed immutable had to be changed once new information refuting them became available, as was the case with Newton's and Einstein's laws.

Physical laws that account for the observer context depend partially on the open system with observation of physical facts and partially on the closed system with uncertain potentiality. The open system acquires information, the closed system transforms it into physical laws. Yet, it still requires input from the open system for verification. However, this feedback mechanism is sometimes interrupted, so that some physical principles cannot be verified as observable reality, such as superposition, infinity and total nothingness before the Big Bang. As a result, these phenomena are limited to mental representation, proving that physical laws are also dependent on mental functions with potentiality. In classical physics, prediction leads to precise outcomes of individual experiments, whereas in quantum mechanics prediction is limited to probable outcomes, which require a high number of individual experiments that would establish their likelihood. Physicists can perform a high number of identical experiments, but this would be difficult in biological sciences, where individual experiments require too much time, are often limited to two or three repetitions and have difficulties to warrant identical conditions in practice.

Mental representation provides exhaustive possibilities, which include possible as well as impossible realizations in observable reality. Logical reasoning helps distinguish possible from impossible realizations. Nevertheless, logical behavior of certain processes with respect to physical laws in mental representation does not signify that they correspond to their realization in observable reality. Although physical laws may be highly logical, such conditions are necessary but not sufficient for imagined events to correspond to observable reality.

The consideration of primacy in physics is completely different from its counterpart in bio-psychology (Figure 4). In physics, primacy is based on physical formalism, starting from the particle-cosm (quantum mechanics) and ending with Big Bang or Pre-Big-Bang theories. A theory of everything is expected to explain the whole universe by mathematics. In contrast, in bio-psychology, primacy is given to the observer in the macrocosm, where all information enters by observation and is further transformed by interpretation. Physical laws then become potential models for explaining the universe, which become more uncertain as the distance from the observer increases. Therefore, the knowledge an observer possesses cannot always be correct, as postulated by the theory of everything, as it is more certain for proximate than for extremely remote entities and events.

The aim of physics is to explain observable reality, transmitted by bio-psychological perception, with physical laws. Eugene Wigner [21] stated that mathematics exhibits an unreasonable effectiveness in natural sciences for the prediction of experimental outcomes. This confidence in mathematics has led to the conviction that mathematics is identical to reality [20] and is therefore sufficient for explaining the structure of the formalism to understand reality. If quantum mechanics is based on superposition, reality must also be in superposition, as proposed by Ney [9] who noted: "We would have to accept not just the existence of many slightly different chairs present in one approximate three-dimensional location, but also many tables and buildings and leopards…." (9).

The difference between physical and bio-psychological primacy leads to two possible interpretations:

a) If physical laws are true ontic reality, bio-psychological observations that do not correspond to them become illusions, as posited by some physicists [18, 20].

b) If physical laws are not ontic physical reality, but rather mental models with the best approximation for reality, they may only be partially true and might not explain all perceptions in bio-psychology. Classical statistics are generally accepted as models for better comparison of complex facts through means and standard deviations, although they are not considered ontic physical reality. Why could quantum mechanics not be considered in a similar way as a mathematical model for resolving complex indeterminate physical observations?

Most physicists would have a tendency to assign primacy to ontic physical laws. Thus, the translation of physical formalism, such as superposition, into everyday life would correspond to true ontic reality. From a bio-psychological perspective, the observer—rather than the physical formalism—has primacy, since he/she is the starting point for acquiring information and the endpoint for its interpretation and verification. Hence, the observer context might better explain physical laws based on superposition and its bio-psychological correspondence.

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