Matter and Information - Objectivity and Subjectivity

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ABSTRACT

Quantum phenomena seem to blur the distinction between matter and information, and objectivity and subjectivity. A quantum particle cannot be observed directly and needs to be 'observed' in a suitably designed measurement experiment. Even in such an experiment, what we actually observe (by means of senses) is the measuring device, which is said to be 'classical'. The position and other 'observable' properties of a quantum particle (QP) are only inferred from the devices' readings. Quantum Mechanics tells us that a QP is a packet of de Broglie's phase waves, each of which carries no energy and goes faster than light. Clearly, the phase wave is a mathematical abstraction, an idea in physicists' minds; it cannot be observed for example, like light, or heard like a wave of an oscillating string. However, the phase wave's wavelength can be measured in a suitably designed experiment. So, one may call the de Broglie phase wave as a piece of 'objective information'! Since classical matter, i.e., matter which is observable directly by senses is supposed to be made of numerous QPs also, it seems that all matter is made of 'objective information', i.e., information, which is not observable directly but some of whose properties can be measured and verified in some way and agreed upon by a group of people. Considering the brain to be a quantum system, we will explain why a sensory experience is both objective and subjective at the same time whereas other conscious experiences such as those of emotions and judgments are subjective but not objective. For this purpose, we note the neuroscience finding that it is necessary and sufficient that one's brain (a quantum system) builds a neural record which is a faithful representation of the sensory input it receives from the outside world, for one to have the corresponding conscious sensory experience.

Key Words: Matter and Information, Subjectivity, Objectivity, Intersubjective agreement, De Broglie Phase Wave, 'Objective' information

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Introduction

Matter and mind differ in that the observation of the former requires senses and the latter cannot be observed by senses. One's thoughts or experiences cannot be seen, heard, etc., by oneself or by others, nor can they be accessed by any material instruments; one's thoughts are not known to others unless one conveys them verbally or by other physical means. If we call the content of all our conscious experience as information, we may say that matter is accessible to senses and that information is not. This inaccessibility is implied when we say that our experiences are all subjective.

Quantum mechanics (QM) appears to blur the distinction between matter and information, and objectivity and subjectivity. A quantum particle (QP) is not directly accessible to senses and needs to be 'observed' in a suitably designed measurement experiment. Even in such an experiment, what we actually observe is the 'classical' measuring device. The position and other 'observable' properties of a QP are only inferred from the devices' readings. QM tells us that QPs are packets of de Broglie's phase waves,

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each of which is supposed to have a speed greater than that of light. Clearly, the phase wave is a mathematical abstraction, an idea in physicists' minds and the wave cannot be heard like a wave on an oscillating string or seen as an electromagnetic wave perceived as light. But at the same time, the phase wave's wavelength can be measured in a suitably designed experiment. So, we may say that the de Broglie's phase wave is 'objective information'! Since the measuring device, and in general, 'classical' matter is supposed to be made of numerous QPs, all matter is made of 'objective information' (Hari 2017) i.e., information, which is not observable directly by senses but some of whose properties can be measured and verified in some way, and agreed upon by a group of people. That the measuring device is "classical" implies that any reading on the device produces an unambiguous experience in the mind of the observer. Since all observers reading the device would agree upon the value of the reading for sure, we say that the results of the experiment are objective or that the theory can be verified objectively.

Note however that the experience itself, of any observer is private/subjective in that one observer would not know the experience of another unless the latter communicates it to the former. Moreover, if one assumes that the brain is a quantum system, because of the inherent indeterminacy in QM, it is not obvious why different observers looking at the same measuring device should reach intersubjective agreement about the reading on the device (Shimony 1963).

In this article, we define the concepts of objectivity and subjectivity and their relation to matter and information; consider how our definitions are compatible with those of others, for example, those of Searle (2000). We will explain why observing the measuring device's reading, and in general, any sensory experience is both subjective and objective at the same time whereas other conscious experiences such as those of emotions and judgements are subjective but not objective. Whether interpretations of QM can explain why the reading on the measuring device, or a sensory experience in general is amenable to intersubjective agreement is also discussed taking into account the neuroscience finding (Mormann and Koch 2007) that it is necessary and sufficient that one's brain (a quantum system) builds a neural record which is a faithful representation of the sensory input it receives from the outside world, for one to have the corresponding conscious sensory experience.

Matter and Information

Some Definitions

Hereafter, for brevity, we will use the word **physical** to mean accessible to, or observable directly by senses.

According to this definition, time is unphysical because time is not accessible to senses. Hence what we usually call 'physical time' is the time in Special Relativity, i.e., what a physical clock shows.

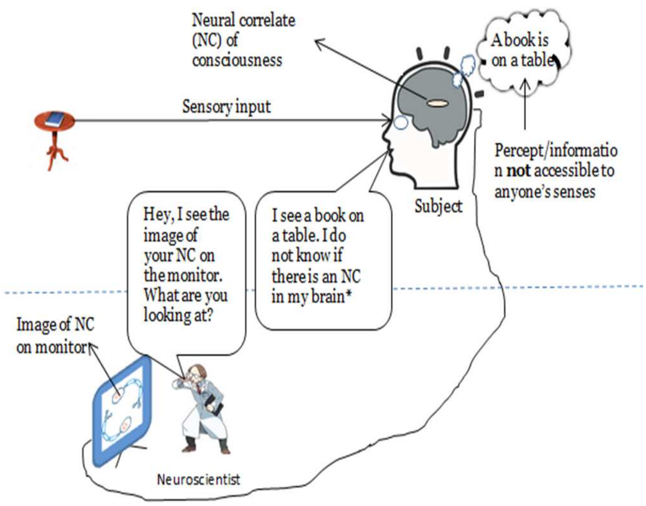
We propose to call whatever can be perceived via senses directly or indirectly via physical instruments as **matter.**

By something '**real**', we will mean something that exists and may or may not be physical. Hence matter is real but something nonmaterial may also be real.

Real information (RI), the content of a conscious experience

In our lives, we have many conscious experiences. In any such experience, there is awareness of something, which may be an emotion, a desire, a thought etc., or awareness of seeing, hearing, touching, tasting, or smelling an external object accessed by one's senses. We may call this something information. There seems to be a subject, which we report as 'I' and there is ability to be aware/conscious, which seems to be available when we are awake but not in deep sleep; in dream sleep, there is ability to be aware of some imaginations but not of the sensory contacts with the outside world. Hence a conscious experience has three components to it: 1) the subject, 'I'; 2) some 'real information' (why we add the qualifier 'real' will be explained in the following paragraphs); 3) the act of knowing or being aware/conscious.

In the case of a sensory experience, for example, seeing an apple, the perceived information is different from both the apple and its biological/neural map created in the brain/body of the human (living) being. It is useful to note this difference because according to modern neuroscience, every subjective (conscious) state such as a conscious intention or conscious emotion, or perception of an external object, occurs only if a required and correlated neural process takes place. Each conscious state has its associated neural correlates of consciousness: one for seeing a red patch, another one for seeing grandmother, yet a third one for hearing a siren, etc. (Mormann and Koch 2007). Interestingly, one is never aware of the existence of the neural correlate (NC) in one's own brain. One is only aware of the NC's 'meaning', which must have been created along with the NC. In contrast, a neuroscientist monitoring the brain can see an image of the NC on the monitor but does not directly know the NC's 'meaning' (namely, what the owner of the brain is aware of). The neuroscientist will have to accept whatever the brain's owner (the first person) reports as his/her experience. Observation of matter involves senses; thought or RI is not accessible to senses, in other words, RI is non-physical/unphysical/nonmaterial. Note that *although unphysical, RI does exist.*



*These words are **not** identical with the information existing in the subject's mind. The information is merely **assigned** to these words, which are then mapped to sounds.
The NC is **not** identical with its 'meaning' either. The first person is aware of only the 'meaning' but not aware of the NC whereas the neuroscientist sees only the NC's picture but does not know the 'meaning' because the monitor cannot transmit it.

Figure 1. Sensory experience and its neural correlate in the brain

Real' Information (RI) is different from matter

In Figure 1, we see that the percept of a book being on a table is different from the NC because the monitoring neuroscientist does not have the perception of seeing a book on a table by looking at a picture of the NC on the monitor unless he sees the book on the table with his own eyes. On the contrary, the first person is aware of the percept only but not of the NC. Hence the NC and its associated percept or 'meaning' are not identical. The first person's announcement that he/she sees a book on a table is not identical with the percept either. We (human beings) can report our conscious experiences to others, if we wish to do so. When we do, we use a language and any of several means: sounds, electrical signals, write on a paper, and so on. Every means of communication requires human (living) beings to ASSIGN meaning or information that is in our heads, to structures of matter or material energy. These structures carry a mapping of the RI; the structures themselves are not identical with the RI[1]. Yet, in our daily lives, we do not distinguish between RI and the means we use to communicate or store it outside our heads. For example, we say "the book has good information about the city" whereas the book only has words whose meanings exist in our heads but not in the book. Hence hereafter, we may call the information content of any of our experiences as 'real' information, to emphasize that it is different from the language or energy signals used for its storage and communication or the corresponding neural/biological activity in the body.

Fortunately for us, no means of communication, or information storage device, or a computer ever creates or assigns any new RI overwriting what we intended it to carry! Hence, we may assume that lifeless matter does not create RI all by itself. On the other hand, as long as we are awake, we experience more and more, thereby keep on accumulating more RI in our memory and this memory has two components: biological and mental. The mental component consists of RI; the biological component is what a monitoring instrument can convey physically/scientifically. We have to infer that the living matter in brain/body not only creates a biophysical map of a material object accessed by its senses but also creates a 'meaning' of the map, i.e., the associated RI.

Two kinds of matter

A quantum particle (QP) is a micro-particle and not accessible to senses but we do not call it unphysical! - Perhaps because we can design a suitable experiment to 'observe' its position and some other properties. But do we really observe it directly by senses? No. We only 'infer' its position or a property from the reading on the measurement device! Moreover, our experience with QPs is that the outcome of a measurement

[1]To begin with, a word in any language is not identical with its meaning because the same meaning may be conveyed by different words in different languages. A language is a mapping of PI into words (symbols) which become sound energy when pronounced, particles of matter when written on paper, and become electrical energy when transmitted over a telephone line, and so on.

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(what reading the measurement device produces) is not definite but only one of many possible outcomes the probabilities of which are predictable by quantum mechanics (QM). We call such matter whose existence and properties can be inferred by us in certain circumstances (in suitably designed experiments) as quantum matter. The 'observability' aspects of quantum systems are analyzed by QM. Let us emphasize however that 'what is actually observed' in any QM experiment is only what the measuring device offers. *In a QM measuring experiment, the measuring device is said to be macroscopic and classical; it means that the device can be accessed by a sentient observer by senses and produces an unambiguous and unique experience in his/her mind.* Hence we may say that matter is of two kinds: quantum and classical. While we say classical matter is physical, it seems that we may say that quantum matter is semi/quasi/pseudo-physical.

We may recall here that when Special Relativity (SR) was originally formulated, it was concerned with only classical matter. Lorentz transformations were derived only for classical matter but de Broglie, the first physicist to propose wave-particle dual nature of quantum matter implicitly assumed their applicability to quantum matter in his doctoral thesis (1925), leaving the consistency between SR and QM a topic to be debated during the development of QM.

Defining Subjectivity and objectivity

Subjective: We propose that 'subjective' is synonymous with 'nonmaterial'. Since one's thoughts or experiences cannot be seen, heard, etc., by oneself or by others, nor can they be accessed by any material instruments (one's experiences are not known to others unless one conveys them verbally or by other physical means), all RI is subjective. All conscious states i.e., those states of awareness, sentience or feeling when we are awake, are subjective; dreams some of which we remember are also subjective.

Searle (2000) defines subjectivity as follows: Conscious states are subjective in the sense that they have first-person ontology (mode of existence) because they exist only when they are experienced by some human or animal agent. An example he gives is that a pain cannot exist unless it is experienced, whereas a mountain can exist without being experienced and therefore that a pain is subjective and a mountain is objective. Searle agrees that a conscious experience is accessible only to the subject/first-person and not equally accessible to any observer. Our definition of subjectivity differs from that of Searle's in that a conscious experience is subjective not because it necessarily has a subject but because all three components of the experience (the subject 'I', the information which one is aware of in the experience, and the act of knowing) are not accessible to other observers. They are also not accessible to any one's senses as pointed out in Figure 1. Thus, our definition of subjectivity includes that of Searle[2].

In a context not related to consciousness research, the word subjectivity is commonly used to describe conditioning of experience or knowledge by personal mental characteristics or states, specific to individuals, and perceptions affected by personal views, experience, or background rather than being independent of the mind. Because experience is never without a subject, perception is not independent of the individual perceiving it but conditioned by personal attitudes, personal views, previous experience or background. Thus, our definition of subjectivity is consistent with the definitions in dictionaries.

Objective: We propose that whatever that exists and is not 'subjective' is 'objective'. Hence all matter and material processes are objective. Usually, perception of matter is amenable to intersubjective agreements although the experience itself is subjective; at least, the possibility for one to verify whether one can have the same perception of a given material object as that of another or not, usually exists. Because of this property, we consider matter as being real, i.e., that it exists; we usually consider all imagination as unreal but imagination also exists!

Searle (2000) defines ontological objectivity as existence *as such* and not merely relative to observers. His frequent example is that "mountains and molecules can exist even if no living creature exists". Our definition of objectivity

[2]Searle distinguishes between two kinds of subjectivity. He mentions pains and anxieties as examples of ontologically subjective states and a judgement such as "Clinton is a good President" as an example of epistemic subjectivity. Probably, the difference he sees between a person's bodily pain and a judgement is that the latter depends upon the knowledge and impressions gained by the subject whereas the bodily pain is due to the condition of the body and not as much dependent upon the subject's knowledge and feelings. Clearly, in both cases, the subjective state is not accessible to the senses of sentient observers.

above would be Searle's ontological objectivity because matter and material processes are assumed to exist whether those who observe them exist are not.

Intersubjective agreements and epistemic objectivity: Usually, report of a sensory experience is said to be 'epistemically objective' (Searle 2000)[3], which is short for saying that in spite of being unable to access the experience itself, it is possible for other sentient observers to verify the report by some material means and reach intersubjective agreement. For example, a group of observers at rest with respect to one another agree upon something such as a book on a table, which all of them have just seen with their own eyes, although the seeing experience itself is private i.e., subjective. The observers will be able to agree or disagree on what they have seen upon communicating with each other using speech, writing, or other physical means. On the other hand, no such verification is possible for example, in the case of dreams some of which we remember; one cannot verify another's dream using any physical means, unless one exercises paranormal mind reading abilities.

Note that ontological objectivity does not necessarily imply epistemic objectivity if one assumes that the brain is a quantum system, because of the inherent indeterminacy in QM. Shimony (1963) analyzed various arguments by von Neumann, Bohr, and others using different assumptions (such as that the measuring device used in QM measurement experiment is a macroscopic object, or that consciousness brings the brain and the entangled device into unique classical states) to claim that intersubjective agreement about the reading on the measuring device is possible. Shimony does not seem to believe that the arguments made are entirely satisfactory.

Objective information: While all RI is subjective, statements/reports of sensory experiences, which are not influenced by personal judgements and opinions are considered objective because they can be agreed upon by others upon verification. Since science is information obtained by material methods, and agreed upon by a community of people, it may be called 'objective information'.

[3]Searle says that epistemic objectivity is based on gained knowledge. As an example, he says that the claim "Bill Clinton weighs 210 pounds" is epistemically objective as opposed to the claim that "Bill Clinton is a good president" which is epistemically subjective. The first is objective because its truth or falsity can be settled in a way that is independent of the feelings and attitudes of the investigators. The second is subjective because it cannot be so settled.

Two kinds of Information

Bernard Carr (2013) puts RI in our minds into the following categories:

a) RI generated by sensory stimuli and stored for use in replay of images and events experienced in the past;
b) RI generated and controlled by imagination, related to creativity; examples: desires, concept of infinity. Thoughts which at least directly, do not depend upon sensory stimuli seem to exist in the mind.
c) RI in dreams possibly generated by the interplay of memory and imagination.

The above list shows that any of our conscious experiences is one of two kinds:

1. a sensory experience (SE), or
2. an experience of imagining (EI) an object or event without direct use of senses.

As said before, although the information content of both an SE and an EI is subjective, an SE allows other individuals to seemingly verify its information content whereas an EI clearly prohibits any such verification. Events in imagination (EI) occur apparently without requiring receipt of signals via senses. It is not possible to associate space and time with EI-type events. For example, our dreams some of which we may be able to report to others are of this kind; an event in a dream may not have happened and may never happen when we are awake. Examples of EI are the mathematical concept of infinity and the desire to pluck a flower when you see it.

According to our definition of matter, we may say that science is RI about matter and created by matter in the minds of scientists; it is the information content of experiences involving senses, the RI being information that is already communicated, and agreed upon, by one particular human community.

Is Quantum matter made of 'objective' RI? (Hari 2017)

De Broglie's phase wave is unphysical but objective

The nondeterministic behavior of quantum matter is found to be a consequence of its wave-like nature. QM tells us that QPs are packets of de Broglie's phase waves, each of which is supposed to have a speed greater than that of light in vacuum. De Broglie (1925) postulated the phase wave and described it mathematically. He considered a QP as a quantum of energy with a mass spread over all space. Hence in QP's rest frame, its associated clock is also spread all over space, or one may say that there is a clock at every point of space and all clocks are synchronized to show the same time always. The oscillation may be described as a wave with infinite speed and infinite wavelength or alternatively as a standing wave consisting of one outgoing spherical wave and one incoming spherical wave. Hence this wave certainly cannot be observed directly by senses or via a physical measuring device, by a sentient observer SO1, who is at rest relative to the QP. Relative to an observer SO2, w.r.t whom the QP moves with velocity $\upsilon < c$, the phase wave propagates with velocity $c^2/\upsilon > c$; so the phase wave is not accessible to the senses of SO2 either[4]. Wavefunctions which are solutions of Schrodinger equation governing the dynamics of a quantum system, although they describe packets of phase waves associated with real particles such as electrons, are nothing more than mathematical descriptions of probability of occurrence. They are not physical disturbances in a physical medium. The wave function which represents probability is not observable but only calculated from the Schrodinger equation. An electron or some other particle is supposed to be a wave packet and is only indirectly accessible to senses, i.e., via the reading on the measuring device. The double-slit experiment depicts the intriguing nature of quantum particles because the interference phenomenon shows both probabilistic and observable behaviors of the particle; the observed interference patterns actually show that each electron hits one localized region of the detector, while any of the hits, whose gradual accumulation builds the interference pattern, is not predictable with certainty but occurs only as a probabilistic event. In his first 1923 paper on phase waves, de Broglie considers them as 'fictitious'. In his next paper, he described them as 'non-material'. A gradual change in de Broglie' view about the reality of his phase waves took place over time and can be seen when he finally says in his Nobel lecture (de Broglie 1929): "The electron can no longer be conceived as a single, small granule of electricity; it must be associated with a wave and this wave is no myth; its wavelength can be measured and its interferences predicted. It has thus been possible to predict a whole group of phenomena without their actually having been discovered." The reality or existence of phase waves is not in question because of the extraordinary *success of quantum mechanics* in numerous applications. One may conclude that de Broglie waves are not directly accessible to senses but *they have effects which can be observed in experiments, i.e., by senses*.

Thus while the phase wave is an idea in physicists' minds and does not carry any energy, one may say that the phase wave is subjective. But at the same time, its wavelength can be measured in a suitably designed experiment, say, the double slit experiment. So, we may say that the de Broglie's phase wave is 'objective information'! Since all matter is supposed to be made of QPs, it follows that classical matter, i.e., matter which is observable directly by senses is also made of 'objective information', i.e., the kind of RI, which is not observable directly by senses, but has properties that can be measured by classical devices and verified in some way, and agreed upon by a group of people.

Light behaves as if it is both subjective and objective in the double-slit experiment

When a beam of monochromatic light is shone through two narrow holes in a screen, the light spreading out from the two holes interferes, to produce a characteristic pattern on a photoelectric detector plate behind the double-slit-screen. Since light can also be described as a stream of photons, the light source in this experiment can be turned down to the point where it consists of individual photons going through the apparatus, one after the other. If the spots of light made by individual photons arriving at the detector are added together, they still form an interference pattern as if each photon goes through both holes and interferes with itself on the way through the experiment. Any attempt to determine which hole the photon goes through, however, destroys the interference pattern. Although each photon is found to strike the detector at a localized point, one cannot predict in

[4] In section 1.3 of his thesis, where de Broglie tries to prove that the phase velocity of the phase wave is > c, he says: "if the line $ox1$ in Figure 1 represents the space of the observer fixed at t =1, for him $aa0 = c$. The phase that for t=0 one finds at a, is now found at $a1$; for the stationary observer (SO2), it is therefore displaced in his space by the distance $a0a1$ in the direction ox by a unit of time." Clearly, SO2 could not have actually received a light signal from a_1 because the distance a_1a_0 >c; he can only infer in his mind (like de Broglie) that the phase-mark at a moved from a to $a1$ in space and took one unit of time to do so. Hence clearly, neither the wavelength nor the speed of the phase wave can be measured directly by flashing light at two points of space and therefore the phase wave is not directly observable by senses.

advance, where the next photon will appear. One can only say that the next photon is more likely to strike in one area than in another. In the classical view, the square of the electromagnetic wave at any point in space is a measure of the energy density at that point. Einstein suggested that the square of the electromagnetic wave at a particular point (that is, the sum of the squares of the electric and magnetic field magnitudes) be taken as the probability density for finding a photon in the volume element around that point because the intensity of light at a position on the detector plate is a measure of the number of photons arriving at that position and therefore tells the probability that an individual photon will be detected at that position. Thus, the classical notion of energy having a definite and smoothly varying distribution is replaced by the idea of a smoothly varying probability density for finding an atomistic packet of energy. Thus, *by acting as probability waves it seems that electromagnetic waves are on the border between the physical/objective and the unphysical/subjective*.

Interpretations of Quantum Mechanics- Intersubjective agreement on Sensory Experience

As seen earlier, that Bill Clinton's weighs 210 pounds is accepted by everyone who looks at the weighing machine on which Clinton stands because they all see the same reading on the machine. On the other hand, in the well-known murder-trial of OJ Simpson, from the same evidence presented in the court and witnessed on television by the public, most blacks concluded that he did not murder his wife and most whites concluded that he did so. We can understand this difference intuitively, although not scientifically, using an analogy between the brain and the computer, which is used by many scientists for example, by JZ Young (1978) to describe the brain's structural-functional organization.

In the book, "Programs of the Brain", JZ Young recognizes that information is stored or communicated using physical entities, such as books or sound waves or brains, but that information itself is not material (just as we did earlier). He says that what we call information in a living system is a feature of the order and arrangement of its parts, which arrangement provides the symbols that constitute a 'code' or 'language'. What he calls 'a program of the brain' is a plan of action decided beforehand to achieve some end. It is chosen from a set of possible plans arranged beforehand and with specific objectives. Every human action, whether breathing, eating, sleeping, speaking etc., and every mental event, whether loving, hating, thinking, imagining, dreaming, believing, worshipping, is guided by the brain's programs which are written in neural scripts like a task performed by a computer following the instructions encoded in its software although there are many differences between programs of the brain and those in a computer. The 'social programs' take into account not only sensory signals received from the objects that we encounter but also signals arising from our memories.

In Young's analogy, the detailed characteristics of brain cells provide 'codes' for features of the world, such as a particular line or sound, or the color red so that some physical events in the nerves together provide a faithful representation of events outside, and a detailed model of the world. In the example of Figure 1, if we have a computer equipped with a camera instead of a human subject, then the computer creates a record of the book on the table in its memory just as the brain creates the NC which is a neural map of the observed object. The computer can send a picture of them onto the monitor screen also. It can even announce that it took a picture of a book on a table if it is equipped with a suitable program in advance but it does not have the conscious experience of seeing the book on the table (at least so far, computers are not capable of conscious experience). The computer is not aware of the 'meaning' of the record which it creates because it never creates the 'meanings' of its records; the programmer assigns the 'meanings' to the computer's hardware elements. Unlike the computer, the brain does create the 'meaning' of the neural map along with the map of an event from which it receives sensory inputs.

Now, if we think of the minds of two living beings as software capable of processing light signals received from say from the book on the table in Figure 1, then two digital computers loaded with the same software produce the same/similar records when they receive the same signals. So both individuals agree that they see a book on a table. (In the case of material computers, the records are also material; they have no RI/'meaning'. In the case of living beings the produced records have two aspects: the physical neural map and the mental RI/'meaning'.) That is how intersubjective agreement occurs.

However, thinking is organized partly around signals received from the objects that we encounter, partly by signals arising from our memories. Our values, experiences, emotions, desires etc. already existing in our memories take part in making a judgement on, or inference from, or interpretation, etc. of what is observed, in addition to the brain's processing the sensory input and recording the observed event. If two computers are loaded with two pattern-recognition programs encoding two different heuristics, then they recognize two different patterns even if the same data are presented to them. Instead of outputting the exact input data, the pattern-recognition program outputs a pattern inferred from the input and to do that it uses the heuristics already existing in the memory. Similarly, two observers with different individual memories make different value-judgements about the same event/s they both observe. The programs of the brain which do not contain 'heuristics' usually provide us with a view of the world that agrees with that of others and is 'correct' enough.

The above argument assumes that the brain's behavior is deterministic like that of a digital computer in that a program started in the same initial conditions produces the same output when supplied with the same input. If one assumes that the brain is a quantum system, the following question arises: In spite of brains of different observers being identical quantum systems, because of the inherent indeterminacy in QM they need not produce the same reportable message; is it possible to show that in the case of a sensory experience, different observers report the same experience although the experience itself is private and subjective? Below, we will consider this question with help from two consciousness-not-required-for-collapse interpretations of QM developed later than the QM interpretations discussed by Shimony.

In the possibilist transactional interpretation (PTIQM) of Kastner (2012), macroscopic detectors are composed of huge numbers of individual potential absorbers, virtually assuring the generation of a confirmation wave (CW) somewhere in the detector. This prevents the propagation of quantum superpositions to the observable level (i.e., it prevents a macroscopic object from being in a superposition), because it is overwhelmingly likely that a CW will be generated before the point that, say, a cat would need to be described by a superposition of states of its physical health. Hence any physical macroscopic object O would send a unique offer wave say |O1> to the brains of all observers watching the object.

The two-time interpretation of QM (TTIQM) also claims to characterize the classical-quantum boundary. According to this interpretation, a macroscopic object O ends up in a unique state |O1> although the authors only consider the case when O is a measuring device in a quantum measurement experiment (Aharonov *et al*., 2017). Thus, in both interpretations, O sends the same input to every observer's brain. But of course, if the quantum brains of two observers receive the same input, can they still produce different responses? We will find that the answer is no if we follow Aharonov *et al.,* (2005). The claims by neuroscience that 1) a completed neural record of the input (neuronal adequacy) is necessary and sufficient for awareness of seeing the object, and 2) the neural correlate is a faithful representation of the state of O, provide the same post boundary condition for the brains of all observers of O. We will find that this post boundary condition leads to intersubjective agreement among them.

Let the classical object O have two eigen states |O1> and |O2> belonging to a particular observable and let the |O1> be the state input the quantum brain (QB). The brain has neural mechanisms ready to record the received input and has speech, motor, and other mechanisms N to report the 'meaning' of the neural correlate/record. We assume that the measurement is ideal, that is, when N communicates an observable state of QB to the outside world, it does so with minimal disturbance to the QB state. Let the state of the combined system S consisting of QB, N, and environment E at t=t0, when QB receives the input be

$$|\psi_0\rangle = (a|1\rangle + b|2\rangle)|N0\rangle|E0\rangle,$$

where, |1> and |2> are QB states corresponding to |O1> and |O2>, |N0> is the state of N, and |E0> is the state of E at t=t0. Following the conventional QM scheme, at time t = t1 > t0, let there be entanglement between the QB state and that of the reporting mechanism N. Hence at time t = t1,

$$|\psi(t1)\rangle = (a|1\rangle|N1\rangle + b|2\rangle|N2\rangle)E0\rangle$$

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is the state of S. The state of the object which is also in the environment is assumed not to change by looking at it. After decoherence in the environment in a short time ϵ, at time t = t1+ ϵ,

|ψ(t1+ ϵ)>| = a|1>|N1>|E1> + b|2>|N2>|E2>.

Because of neuroscience, there is a post boundary condition on the combined system N&E, within the two-state vector formalism: for t_f > t1+ ϵ, the state of N&E is <N1|<E1| because <N1|is the state that reports that the neural record representing the object is |O1>. Hence the backward-evolving state for t_f > t1+ ϵ, contains only a single term <ψ(t_f)| = <φ|< N1|<E1|where <φ| is the final state of the QB. In TTIQM, for t_f > t1+ ϵ, the brain will be described by the two-state vector TSV:

[<φ|<N1|<E1|, (a|1>|N1>|E1> + b|2>|N2>| E2>)]

The approximate orthogonality of |E1> and |E2> assures that after reducing the density matrix by tracing out environment degrees of freedom, only the first term in TSV will contribute, accounting for the neural correlate which is observed by a neuroscientist monitoring the brain and whose ‘meaning’ is reported by the first person, the brain’s owner. The final condition that |N1> should be a map of the object’s state |O1> ensures that all brains record and report the same state.

Summary

How the concepts of objectivity and subjectivity are related to matter and information is discussed. Quantum mechanics seems to be smearing the distinction between subjectivity and objectivity by proposing that a quantum particle is a packet of de Broglie phase waves each of which is unphysical. Quantum matter and therefore all matter may be said to consist of ‘objective information’ because some properties of a quantum system can be measured in a suitably designed experiment although the quantum itself is not directly observable. Whether interpretations of QM can explain why the reading on the measuring device, or a sensory experience in general is amenable to intersubjective agreement is also discussed.

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