OPINION AND PERSPECTIVES

Partial Isomorphism of Superposition in Potentiality Systems of Consciousness and Quantum Mechanics

Franz Klaus Jansen

Abstract

Superposition of physical states in the wave function of quantum mechanics is difficult to transpose to the macrocosm, as illustrated by "Schrödinger's cat" thought experiment. Nevertheless, in this example, consciousness does not seem to be shown in its complete reality, when evaluated from a biological view-point. Although consciousness functions with reality systems, it also uses potentiality systems, which essentially consist in superposition of several probable situations. Some examples of superposition in consciousness are described, to illustrate the requirement of potentiality systems in order to predict situations in the future or to complement events in the past. Incomplete observations, such as lacking time or space coordinates, automatically induce potentiality systems in the consciousness, in order to complete the lacking coordinates by only potential but most probable coordinates. In contrast, reality systems are only present, when complete observations with exact time and space coordinates can be obtained. Potentiality systems in human consciousness also show the characteristics of Heisenberg's uncertainty principle, as well as non-locality and entanglement and are compatible with interfering conditions. Superposition in potentiality systems is an essential function of consciousness and is the only way to allow a perception of future and past events. The basic concept of superposition without corresponding mathematical formalism, seems demonstrate partial isomorphism in the larger sense of Douglas Hofstadter, between consciousness and quantum mechanics.

Key Words: Quantum mechanics; consciousness; isomorphism; uncertainty principle; non-locality

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Introduction

The wave function of quantum mechanics is generally a superposition (or linear combination) of different physical states of elementary particles. Quantum superposition of macroscopic states has also been shown by Wal (2000), but as illustrated by the famous cat thought-experiment from Schrödinger (1935), superposition in macroscopic systems is more difficult to demonstrate. In the formalism of quantum mechanics superposition of opposite states, this is easily acceptable, as demonstrated by intact or disintegrated radioactive atoms with their corresponding probabilities. In contrast, a simultaneously living and dead cat in the macrocosm seems to be unacceptable (Tesche, 2000). Superposition of quantum mechanics entails different consequences: an apparent

Corresponding author: Franz Klaus Jansen
Address: 126 chemin des Fesquets, F-34820 ASSAS, France
Tel and Fax: 0033 467 597675
e-mail: jansen-editor@interdisciplinary-discussion.com

collapse to one of the superposed states after observation, as well as uncertainty, non-locality and entanglement. Several theories have tried to explain these phenomena by contradictory approaches (De Broglie, 1927; Bohm, 1952; von Neumann, 1955; Everett, 1957; De Witt, 1973; Wigner, 1979; Stapp, 1999; Primas, 2003; Espagnat, 2003)

The aim of this approach is to evaluate, if the general concept of superposition may have a partial isomorphic correlation in the macrocosm from a purely biological viewpoint without mathematical formalism, knowing that superposition is successfully applied in quantum mechanics and includes uncertainty, non-locality and entanglement. With respect to mathematics, the term isomorphism is used in a larger sense, corresponding to the definition of Douglas Hofstadter (1979). "The word 'isomorphism' applies, when two complex structures can be mapped onto each other in such a way that to each part of one structure there is a corresponding part on the other structure, where 'corresponding' means that the two parts play similar roles in their respective structures." The concept of partial isomorphism in this approach only concerns the methodological concept of superposing different states in physics or different events in consciousness, which both create uncertainty, non-locality and entanglement.

Bitbol (2000; 2002) indicated that there are structural correlations between the distinctive features of quantum mechanics and the science of consciousness. Atmanspacher (2004) conceived a weak quantum mechanical formalism for bi-stable perception of the Necker cube in human consciousness, showing that there was isomorphism between human consciousness and quantum mechanics. Here, no attempt was made to introduce mathematical formalism like Atmanspacher (2004), but rather, to illustrate with some examples that in consciousness, potentiality systems function through the superposition of multiple possibilities as the only way to predict future events or to understand situations of the past. A partial isomorphism of the general concept of superposition in the macrocosm and in quantum mechanics may represent an educational support to contribute to a better understanding of one of the quantum mechanical concepts by non-physicists.

Results and Discussion

1. Schrödinger's Cat Revisited

Quantum mechanics defined as the superposition of different physical states does not appear to correspond to situations in the macrocosm. "Schrödinger's famous *Gedanken experiment* asks the question: when does a quantum system stop existing as a mixture of superposed states and become only one of them? (More technically, when does the quantum state stop being a linear combination of states, each of which resemble different classical states, and instead, begins to have a unique classical description?)." In the *atomocosm*, simultaneous superposition of opposite situations seems to be acceptable, although in the macrocosm, such superposition is rejected. Schrödinger's thought-experiment illustrates the simultaneous superposition of two contradictory physical states, such as intact and disintegrated radioactive molecules in quantum mechanics, which he tries to transpose on to the macrocosm to a simultaneously living and dead cat. Disintegration of radioactive molecules should kill a cat by a transmission system, in which a Geiger counter detects disintegration, inducing a hammer to fall on a capsule liberating a toxic gas, which then, kills the cat. According to quantum mechanics radioactive atoms are considered to be within a certain probability, existing simultaneously in an integrated and disintegrated state. Therefore, as long as the cat cannot be observed from the outside of the cage, it should be considered as simultaneously living and dead. Logically, the cat could not be living and dead at the same time, so Schrödinger argues that the formalism of quantum mechanics may not be transposable on to the macrocosm.

However, human consciousness in the macrocosm is also capable of conceiving opposite situations by superposition for the same lapse of time. If one replaces the cat in Schrödinger's thought-experiment by a soldier, radioactive molecules leading to the release of a toxic gas by killing with a gun in a dangerous war and the observer of the cat by the mother of the soldier living in a far away country, the mother will be extremely anxious about the fate of her

son and simultaneously think, like in a sort of superposition, that he might be dead or alive. Only direct contact between mother and son by a telephone call, similar to the opening of the cage to the observer of the cat, could collapse the superposition of the two anticipated situations, dead and live. Without any new observation, the consciousness of the mother is unable to be aware of reality. She is only capable of imagining potentiality, which consists in the superposition of sometimes opposite, but equally possible situations, such as the life and death of her son. Since reality is undetectable in the absence of any observation, human consciousness compensates lack of information by imagining potential situations. Thereby, superposition in consciousness corresponds to the perception of potentiality in the macrocosm, which is the only way to substitute reality when it cannot be directly observed. A potentiality system could then be defined as a system in which one of the coordinates, such as space or time coordinates, is lacking, whereas in a reality system all necessary time and space coordinates are present and need not to be imagined as potential parameters.

2. Functions in Consciousness

Besides this exceptional example, potentiality systems represent one of the fundamental functions of consciousness. First, they represent the only way to conceive the future by superposition of possible situations with the help of potentiality systems. In the totally different reality system, there is no superposition of possible situations but only the presence of one already realized situation. Biologically, the vision of reality is crucial for every living being to detect dangers in the present. The vision of potentiality, however, becomes necessary to have a hunch of the danger in the future in order to be able to avoid it. Both kinds of vision are therefore fundamental functions of consciousness and are used permanently to recognize on the one side, reality in the present and on the other side, potentiality in the future.

In contrast to the future, the past was directly observed and could therefore be a reminiscence of reality. Often, observations of the past are partially forgotten, totally lost or even falsified and then, they no longer represent an equivalent to reality. Although history and archaeology try to reconstitute events of the past, they do not always find evidence for their assumptions. Reconstitution of the past is also partially dependent on potentiality systems representing all possible situations, which might have happened. Therefore, in general, potentiality becomes necessary when direct and complete observations of reality become impossible. It thereby represents the only way to complete an incomplete vision of reality. In this sense, potentiality can be considered as the necessary complement of incomplete or missing observations.

Moreover, even the present requires the function of potentiality, when reality is inaccessible i.e. by distances that are too long. Although potentiality is unable to replace reality, superposition of different possibilities in human consciousness necessarily includes reality. The soldier in the far away country has the potential to be alive or dead and his real situation is included in a potentiality system, although it cannot be verified without direct observations. Three important functions can be distinguished in human consciousness: a vision of reality, a vision of potentiality and a vision of impossibility. If reality becomes inaccessible, potentiality represents a framework, which includes reality and also allows distinguishing between potential or impossible situations. Within a framework of potentiality, all information remains only probable, but the framework, itself possesses an extremely precise structure including precise space and time coordinates, which represent a clear separation from impossible situations. Although reality is invisible in potentiality systems, it is nevertheless included within the limits of the potentiality framework, whereas impossibility is excluded from the same framework.

3. Probability

Potentiality is intimately linked to probability. This would lose any sense, if reality can be directly observed, for instance when the mother has direct contact to her son in the foreign country. In a potentiality framework, events in superposition may have equal probabilities. Nevertheless, in general, each event has its own different probability. In human consciousness, future events are primarily associated to the

event with the highest probability. For instance, summer is expected to represent sun and heat, which has the highest probability even though summers may show a long series of cold days without any sun. Since the latter situation has a much lower probability, it is not automatically associated to the concept of summer. The mother of the soldier also thinks in terms of probability. When her son is posted to the reserve forces, the probability to remain alive becomes much higher and the mother will be less fearful and postpone her thoughts on her son's death. Thus, potentiality and probability have complementary functions and cannot exist without each other.

Superposition in potentiality systems of consciousness and superposition of the wave function in quantum mechanics may show partial isomorphism, since both predict future or past behavior, whereas direct observations are unavailable or insufficient. In quantum mechanics, Heisenberg's uncertainty principle indicates that direct observations are incomplete, in a similar way that human consciousness observations may be incomplete and are then complemented with a prevision of the future and reconstitution of the past.

4. Visible Potentiality Systems in The Macrocosm

Potentiality systems in the macrocosm are superpositions of multiple possible situations for an expected event. Superposition allows the construction of a potentiality framework around an invisible reality. Examples of potentiality systems in the macrocosm also show Heisenberg's principle of uncertainty, which was initially described for quantum mechanics.

A visible example of a potentiality system in the macrocosm would be a juggler, who holds a ball on fire by a rope and turns it in the night. In the beginning, when the ball does not turn rapidly yet, one can see the fireball as a single point turning within a circle at precise but changing locations. As soon as it turns very rapidly, it no longer appears as a point, but as a whole circle on fire against the dark sky. At low speed the fireball can be localized as one point, whereas at high speed it forms a whole circle, as if the initial point was multiplied so as to become 360 points mapping the ball of fire to all degrees of a complete circle. Since our eyes observe a circle, can we consider our observation, i.e. the circle, as "reality"? With a logical explanation one would say that the circle is an artifact, due to a limitation of our eyes to follow rapid movements. This signifies that we doubt the capacity of our observation; the only intermediary between autonomous reality and human consciousness.

Following logical reasoning, the fireball cannot be localized at the same time at every point of the circle. Therefore, the observed circle does not represent the reality of the location of the fireball, but the potentiality of its location, i.e. all positions, which the ball can take, even if it does not occupy all of them at any one time. The human eye cannot follow movements that are too rapid but retains them as a line instead of an isolated point. At increasing rotation rates both ends of the line have a tendency to join each other to form a whole circle. Therefore, the circle on fire does not reflect reality, but becomes, due to insufficient observations by the human eye, an illustration of potentiality of all possible movements of the ball. Other examples can also illustrate potentiality by an artifact, such as the white line left behind an airplane in the blue sky. Such a line is an incomplete observation, because it only shows precise locations of an airplane in the past, but not its precise timing. Therefore, the white line can be considered as the potentiality of many locations of the plane in the past. Equally so, the circle of the fireball also only shows positions of the past, but since the movements of the fireball are totally repetitive, the circle provides a preview of future events.

5. Potentiality a Framework Including Reality

By accepting the idea that the fireball could not be present at every place in the circle at the same time, the circle of fire cannot be a reality but rather, an illustration of potentiality for all movements of the ball. With the system of the fireball, one can regress in the macrocosm from a potentiality system to a reality system with precise space and time coordinates when the juggler diminishes the speed of the fireball and when it becomes visible as a single point again. In contrast to the fireball in the macrocosm, quantum mechanics does not allow any verification of precise location, as Heisenberg's principle of uncertainty does not permit any

precise determination of location and speed for the same moment.

Potentiality systems have the advantage of indicating a precise framework in space-time, where movements are possible when observations become limited. All potential movements of the fireball are limited to a circle, which represents a framework with high precision, allowing the prediction of where movements can be expected, although inside the framework consisting of the circumference of the circle, all locations remain uncertain, giving the impression of non-locality. The potentiality system has the great advantage of limiting the movements of the fireball to a framework with precise space coordinates, which exclude all other possible and also impossible locations. When the precise localization of the ball becomes impossible, potentiality systems allow an approximation close to reality, since it is necessarily included.

6.Analogy to Heisenberg's Uncertainty Principle

A macroscopic potentiality system as illustrated by the circle of a fireball, also demonstrates the uncertainty principle concerning simultaneous localization and speed. When the juggler turning the fireball, shortens the cord at a precise moment, the fireball produces a smaller circle. In this case, shortening of the cord is the cause and a smaller circle is the effect. At the precise moment when the cord is shortened, its effect becomes visible by a smaller circle, but the precise location of the ball at that moment is not detectable by the human eye. Thereby, the relationship between cause and effect is no longer directly visible at the precise moment when shortening the cord leads to delocalization of the ball. In a potentiality system, the relationship between cause and effect is represented in a different way, since a smaller circle follows the shortened rope. Although there is no doubt that in the beginning, the fireball is on the larger circle, the precise location at the moment, when the juggler shortens the cord, cannot be observed. Since the observation is incomplete in this example, the time of action is precise, but the location of the ball is uncertain. This is analogous to Heisenberg's uncertainty principle in quantum physics, although not for the same reasons.

In a complementary approach, one may stop the movement of the fireball at a precise location within the circle by introducing a board. In this way, the location of the impact with the ball will be precise, but now, the interval between the introduction of the board and the impact with the ball will vary considerably and therefore, becomes uncertain. If the fireball is very near to the board at the moment of introduction, the interval of impact will be short; but if it has yet to complete ½ or ¾ of a turn, the interval will be much later and therefore, uncertain. By imposing a precise location of the ball, the time interval before impact becomes uncertain. This is another analogy to the uncertainty principle of Heisenberg in quantum physics, where precise location and speed of elementary particles for the same moment cannot be described.

7. Relationship between Superposition and Observation

In the macrocosm, superposition in potentiality systems is a superposition of different possible situations, similar to superposition of physical states in the wave function of quantum mechanics. The potentiality system of the fireball induces uncertainty, when superposition of multiple locations on a circle is reduced to single point location. When uncertainty is maximal, there is an equal chance for all possible locations within the established framework of the circle. This corresponds to high speed for the fireball, when the fire is in a homogeneous distribution over the whole circle, which gives an identical chance for location of the ball at all 360 degrees of the circle.

In contrast to such a homogeneous situation, a potentiality system in the macrocosm can become heterogeneous when the ball turns less quickly and then, shows only a partial circle; one great bright line of fire followed by a dark part without fire. The bright spot represents higher probability for the presence of the ball, whereas in the dark part of the circle, the probability tends to zero. Consequently, heterogeneity diminishes the number of possible locations in superposition. At the beginning, there was superposition of 360 possibilities according to all degrees of a homogeneous fire circle. At lower speeds of the fireball, the bright circle decreases to only part

of a circle, thereby proportionally diminishing the number of possible superpositions. Finally, at low speed, when the ball is again seen as one precise bright spot and the rest of the circle is dark, all superpositions are reduced to one unique position, which now reaches maximal probability as expected in a reality system.

Therefore, homogeneity and heterogeneity of observation have a direct influence on the number of possible superpositions. Homogeneous observation corresponds to a maximum of possibilities of superposition, while increasing heterogeneity reduces the number of potential situations of superposition proportionally down to only one possibility.

8. Entanglement and Non-locality

In the potentiality system of the fireball, the circle is directly dependent on its environment and shows entanglement with it. First of all, the length of the cord determines the diameter of the circle, the movements of the juggler influences the stability of the fire circle (i.e. its higher or lower positioning in space), and finally, the presence of an unsteady wind can move the whole circle. In a reality system such influences are not of importance, since only their final effects, the resulting space coordinates, are observed. In a potentiality system, such environmental influences determine the location of the circle and must be taken into account.

In the macrocosm, potentiality systems are frequent and attempt to reconstitute incomplete or a total lack of observation through the substitution with potentiality systems of high probability. In this situation, non-locality can be found as shown for the fireball with its apparent non-locality for the human eye, which is restricted to the periphery of the circle. Observations may consist of orientation in space and time, like pedestrian crossing traffic at a precise place and a precise moment, or the observation of a cause to effect relationship, like a car hitting the pedestrian. When an observation of orientation is incomplete or even absent, human consciousness tries to reconstitute its coordinates. An example of this is in the case of a plane lost in the Amazon river region in South America. Specialists will make a maximal effort to locate the plane to rescue the survivors. In order to locate the lost plane, all lack of observation of orientation has to be reconstituted by substitution with potentiality systems. By tracing several probable routes of the plane on a geographical chart, specialists will choose several zones with higher or lower probabilities to find the plane. Within a zone of high probability, the presence of the lost plane will have an identical probability for the whole zone, which might give it a status of *non-locality* within that zone.

In addition, localization in a potentiality system is no longer as simple as a real observation, because other indications have to be included in order to increase the probability of localization such as events in and around the plane. Storms at the moment of disappearance, the presence of high mountains in the region, the results of the last revision of the plane, and the frequent errors of planes of the same series, have to be considered in parallel. This shows *entanglement* between the plane and its exterior environment (storms and mountains) as well as with its interior environment (last revision and frequent errors). When the plane is finally detected, all superposition of the potentiality system is simultaneously lost and replaced by a reality system permitting simple localization with precise space and time coordinates. Thus, when an insufficient observation of orientation becomes completed by observation, all superposition in the high probability zone becomes eliminated. However, if the plane is never detected, so that complete observation will never be obtained, the plane will remain present in human consciousness within the whole zone of maximal probability, similar to *non-locality* within this zone.

In this example the plane did not leave any trace of its movements, such as a white line in the blue sky, which could help its localization, so that the observation of orientation for an event in the past is insufficient. Incomplete observation of orientation is frequently found in all research in the past, for instance when dinosaur tracks were detected. Although localization of the tracks is very precise, the time when the dinosaurs passed is uncertain, thus making the observation incomplete. By superposition of probable dates proposed by different specialists, a framework for the time of the passage can be established, even though the extreme lapse of time of millions of years cannot

reach the precision of reality systems with its complete observation of orientation. Nevertheless, potentiality systems are an important tool for science allowing approximate reconstitution of incomplete or a lack of observation, where it can no longer be obtained.

The exotic character of these examples should not hide the permanent and dominant use of potentiality systems in human consciousness. All incomplete observations will automatically induce potentiality systems in the case of observation of orientation and for observation of relationships between cause and effect. For instance, when an observer finds car tracks of a crashed car on a mountain road, he immediately imagines several causes in superposition for the same accident: speed, a very narrow road, a health incident or others. Another every day example is a car that does not start in the morning? A specialist will create his own potentiality system by considering a number of causes by superposition, such as a run-down battery, old spark plugs, no fuel and so on. Verification of each of the causes, which are in superposition in the consciousness of the specialist, will lead to eliminate all but one of them. When the remaining real cause of the problem is found, the potentiality system has become a reality system.

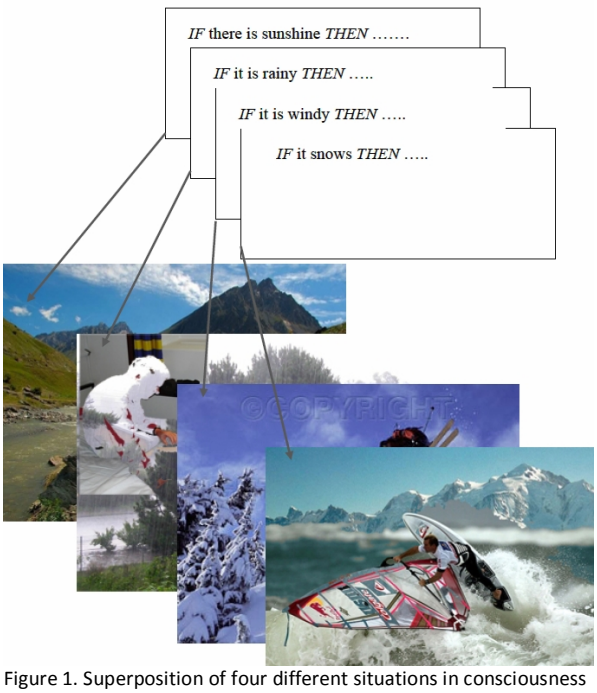

Figure 1. Superposition of four different situations in consciousness dependant on climatic conditions

9. Interfering and Non-interfering Superposition

In quantum mechanics, a distinction is made between statistical mixtures of physical states in superposition without interference on the one hand and on the other hand, superposition of pure physical states with interference. In the macro-predictor of potentiality systems, similar kinds of superposition can also be found. Limited to a certain space-time static non-interfering superposition or dynamic superposition with interference can exist. Non-interfering static superposition have been described in detail by a mother worrying about her son sent to war, a turning fireball or a lost airplane.

In contrast, dynamic superposition with interference in potentiality systems represents a prediction of evolving situations, depending on possible not yet determined conditions in the future. Superposed dynamic situations depend on IF-THEN rules, similar to artificial intelligence, where they are used in the software of rule-based expert systems. When several well defined IF conditions are in superposition, their existence in reality remains uncertain. Nevertheless, they have a stable link to defined THEN successions. The superposed IF conditions for the same space and time will have different probabilities.

An example of a dynamic potentiality system could be the day-to-day planning of a vacation itinerary of a tourist, when he creates his own IF-THEN system. Four possible, but yet unknown climatic conditions will interfere with his different plans and determine the final decision. He imagines his plans in parallel, as if they were in superposition with each other (Figure 1):

IF there is sunshine, *THEN* I will have a walk in the countryside;
IF it is rainy *THEN* I will read my recently acquired book;
IF it is windy, *THEN* I will go on the sea with my windsurfer;
IF it snows, *THEN* I will go skiing.

These four plans constitute the whole framework for a defined space-time, the day of tomorrow, but only one will be selected with a certain probability, which will be determined depending on uncertain climatic conditions, whereas all the other possibilities will collapse. The final outcome could be: "*If* the climate tomorrow is as nice as today, which has a high

probability, *then* I will have a walk in the countryside." Uncertainty is only limited to the four possible climatic conditions, whereas the framework consisting of the whole program with its possible events in superposition remains precise and certain, i.e., the tourist will not do anything else than, "walking, reading, windsurfing or skiing," but it still depends on the uncertain climatic conditions.

The example of a mother worrying about her son in the war was described as a static potentiality system considering only end stage situations of a living or dead son. This same example can also be imagined as an evolving dynamic situation, in which conditions imposed by the army on her son, interfere with the later consequences. When the son is no longer at the front, but posted to the reserve forces or when he is allowed to take some holidays with his family, there is a great probability that he will be alive. Thus, a dynamic potentiality system interferes through several possible but yet uncertain conditions with the final outcome, by selecting only one possibility: dead or alive, whereas the other will collapse.

Dynamic potentiality systems with interference are more frequent than the static systems. Interference may be found in all interacting and often conflicting situations, as shown in the following examples.

In politics a candidate for an election has to explain his concept to his electors and to respond to their embarrassing questions. Before his talk, he prepares answers to all probable questions with the help of IF-THEN rules. Once his mind is prepared for the questions, it represents a dynamic potentiality system with a great number of superposed answers. Questions from the audience will interfere with the prepared answers, but only elicit the corresponding ones. Other more embarrassing answers may remain unpronounced. The framework of this potentiality system is precise, since it is limited to the defended program.

In sports, a tennis player that is familiar with the strengths and weaknesses of his opponent will prepare various strategies to outwit his opponent, which represents his own interfering potentiality system. Then, the response of his opponent will interfere by eliciting the practiced counterattacks according to prior established IF-THEN rules. The framework is precise, since it is limited by the tennis rules, which are severely applied by the referees.

In macro-science, a researcher has to imagine different hypothesis in superposition for the same experimental problem, when he tries to find a solution. The result of a crucial experiment will interfere with all superposed hypothesis and select the most adequate one, whereas all the others will collapse immediately.

Interfering and non-interfering potentiality systems, always include uncertainty factors otherwise, they would be reality systems. There is no total ignorance, but only uncertainty within the limited framework allowing possible interfering factors, such as the described climatic conditions. Interference then induces a selection of one of the superposed possibilities and simultaneously, the collapse of all the other possibilities. Although, uncertainty factors are expected to interfere with different possibilities in superposition within a specified framework, the framework itself represents a precise structure without uncertainty.

Conclusion and Outlook

The formalism of quantum mechanics predicts the behavior of elementary particles in atomic systems, but it also turns out to be valid to successfully describe phenomena in the macrocosm such as macroscopic persistent-current states (Wal, 2000) or super fluidity according to Atmanspacher (2004). Therefore, the general theoretical concept of quantum mechanics could have a broader validity, even outside of physics so that non-locality and entanglement might be found in non-physics areas such as consciousness. According to Bitbol (2002), there is a structural parallel between the science of consciousness and distinctive features of quantum mechanics. The parallel concerns the mind-body problem and the measurement problem of quantum mechanics.

Atmanspacher (2004) tried to explain bi-stable perception in consciousness by a weak quantum theory with linear structure. They used the example of a Necker cube, in which the three-dimensional perception of the drawing of a cube can switch between two different aspects: one with the upper side becoming apparent and the other with the same side hidden by the rest of the cube. This

phenomenon is a bi-stable perception, which Atmanspacher (2004) successfully described with the formalism of a two-state quantum system. Switching between both perceptions corresponds to the quantum transition between the two states, each representing a particular perception, which is unstable under time evolution of the system.

In quantum physics, Heisenberg (1958) made the distinction between the potential and the actual. The letter corresponds to the measurement including its indeterminate principle and the potential to a situation before the measurement. In this article, an attempt was made from a biological point of view and without mathematical formalism to describe an equivalent to the potential of Heisenberg by superposition in human consciousness, which functions with potentiality systems. Astonishingly, in such systems of the macrocosm, superposition was also accompanied by the presence of uncertainty, non-locality and entanglement, thereby leading to the impression of a partial isomorphism between potentiality systems of consciousness and the potential described by Heisenberg for quantum mechanics. No attempt was made to introduce quantum mechanical formalism as described by Atmanspacher (2004), but rather, only the general concept of superposition.

In human consciousness, potentiality systems are a necessary complement of reality systems and clearly distinguished from each other. They complete observations of orientation in time and space, as well as the relationship of cause to effect and are superpositions of several potentialities with their corresponding probabilities. The opposite of potentiality systems are reality systems, in which all observations of space and time coordinates are directly accessible, thus permitting complete information. When observations are incomplete, human consciousness tries to complete lacking information by creating potentiality systems. Such systems allow imagining future, past and present situations in human consciousness, when they are not yet or no longer accessible to direct observation. Potentiality systems for future events can predict multiple projects in superposition, out of which only one will be realized. Events that have occurred in the past for which complete information can never be gathered, such as in archaeology or history, require potentiality systems to complete the knowledge on what had probably existed in the past. Even events in the present, which cannot be directly observed, need potentiality systems to imagine potential behavior, such as an anxious mother wondering if her son that was sent to fight in the war is still alive or dead. This can also be seen in scientific research where various hypotheses on mechanisms are superpositions of different possibilities. *Potentiality systems are a necessary function in human consciousness for completion of insufficient or lacking information by probable but yet uncertain information.* In quantum mechanics, Heisenberg's uncertainty principle leads to uncertain coordinates, which can be compensated by potential coordinates provided by superposition of physical states. Thus, superpositions in potentiality systems of consciousness appear to show partial isomorphism to superposition in quantum mechanics, especially since uncertainty, non-locality and entanglement are also found in potentiality systems.

Schrödinger's thought experiment (1935) was the starting point of this paper, since from a biological viewpoint, human consciousness was not correctly interpreted with all its functions. Therefore, deeper examinations of those functions using superposition in consciousness have been described in this study. Schrödinger transposed superposition of an intact and a disintegrated state of radioactive molecules in the macrocosm to a simultaneously alive and dead cat, which was difficult to accept (Tesche, 2000). In his example, the open cage corresponded to a reality system, where a cat could not be dead and alive at the same time. When the door of the cage was closed, thereby prohibiting any observations, Schrödinger still suggested a reality system, which was no longer possible and had to be replaced by a potentiality system with superposition. Thus, Schrödinger transposed superposition of potential physical states in quantum mechanics into a reality system without superposition in the macrocosm and did not consider that superposition is also a major function of consciousness. Everett's (1957) many-worlds interpretation and Wigner's (1979) friend example are based on the same supposition that consciousness does not allow

superposition, leading to the conclusion that wave function collapse had to occur within human consciousness. On the other hand, when superposition of quantum mechanics is transposed to the described potentiality system showing superposition in consciousness and corresponding to a closed door, all contradiction disappears. Therefore, the closed door of the cage in the macrocosm signifies a situation with lacking information, only allowing potentiality systems, similar to a mother without news from her son in the war, whereas the open door signifies complete information of all coordinates, no longer requiring superposition of multiple possibilities.

Superposition of physical states in quantum mechanics as well as situations in human consciousness require probability estimations for each superposed possibility, which is only approximate in human consciousness, such as: improbable, probable, highly probable or certain. In physics, due to mathematic formalism, probability can be precisely calculated as a factor between 0 and 1, in which 0 represents no probability, 1 complete realization, and the intermediary degrees lower or higher probabilities. In any case superposition requires probability estimations.

Potentiality systems as macro-predictors can be static or dynamic. In static systems, only final situations are represented in superposition. In dynamic systems, future superposed but yet uncertain IF conditions show interference by selecting the corresponding THEN succession and by collapsing all the other possible successions. *Consciousness shows for the same space-time interfering as well as non-interfering potentiality systems with their respective possibilities in superposition*.

If partial isomorphism between quantum mechanics and human consciousness can be accepted, this might signify that one of the basic concepts of quantum mechanics, i.e. superposition entailing non-locality and entanglement reflects fundamental mechanisms in human consciousness. Could such a partial isomorphism be so surprising, since the wave function was created by human intelligence? Could wave function not be an expression of essential functions of human consciousness transformed into mathematical formalism? Then, wave function would reflect a mirror image of a part of human consciousness. Nevertheless, isomorphism of superposition does not signify identity between these highly different domains nor reduction of one to another. A partial isomorphism might help non-physicists to better understand one of the underlying general concepts of quantum mechanical formalism.

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