Journal of Cosmology, 2011, Vol 14., online at JournalofCosmology.com

Quantum Physics, Advanced Waves and Consciousness

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Abstract
An essential component of the Copenhagen Interpretation of quantum mechanics is Schrödinger's wave equation. According to this interpretation, consciousness, through the exercise of observation, forces the wave function to collapse into a particle. Schrödinger's wave equation is not relativistically invariant and when the relativistically invariant wave equation (Klein-Gordon's equation) is taken into account, there is no collapse of the wave function and no justification for consciousness as a prerequisite to reality. Klein-Gordon's wave equation depends on a square root and yields two solutions: retarded waves which move forwards in time and advanced waves which move backwards in time. Advanced waves were considered to be unacceptable since they contradict the law of causality, according to which causes always precede effects. However, while studying the mathematical properties of Klein-Gordon's equation, the mathematician Luigi Fantappiè noted that retarded waves are governed by the law of entropy (from Greek en=diverge, tropos=tendency), whereas advanced waves are governed by a law opposite to entropy which leads to concentration of energy, differentiation, complexity, order and growth of structures. Fantappiè named this law syntropy (syn=converge, tropos=tendency) and noted that its properties coincide with the qualities of living systems, arriving in this way at the conclusion that life and consciousness are a consequence of advanced waves (Fantappiè, 1942).

KEY WORDS: Consciousness, Advanced waves, Syntropy, Feeling of Life, Free Will, Quantum Physics

1. Introduction

The Copenhagen Interpretation of quantum mechanics was formulated by Niels Bohr and Werner Heisenberg in 1927 during a joint work in Copenhagen, and explains the dual nature of matter (wave/particle) in the following way:

* Electrons leave the electronic cannon as particles.

* They dissolve into waves of superposed probabilities, in a superposition of states.

* The waves go through both slits, in the double slit experiment, and interfere, creating a new state of superposition.

* The observation screen, performing a measurement, forces the waves to collapse into particles, in a well defined point of the screen.

* Electrons start again to dissolve into waves, just after the measurement.

An essential component of the Copenhagen Interpretation is Schrödinger's wave equation, reinterpreted as the probability that the electron (or any other quantum mechanical entity) is found in a specific place. According to the Copenhagen Interpretation, consciousness, through the exercise of observation, forces the wave function to collapse into a particle. This interpretation states that the existence of the electron in one of the two slits, independently from observation, does not have any real meaning. Electrons seem to exist only when they are observed. Reality is therefore created, at least in part, by the observer.

In the paper *Quantum Models of Consciousness* it is argued that quantum models of consciousness can be divided in three main categories (Vannini, 2008):

1. models which assume that consciousness creates reality and that consciousness is a prerequisite of reality;

2. models which link consciousness to the probabilistic properties of quantum mechanics;

3. models which attribute consciousness to a principle of order of quantum mechanics.

Considering the criteria of scientific falsification and of biological compatibility Vannini (2008) notes that:

* Quantum models of consciousness which belong to the first category show a tendency towards mysticism. All these models start from the Copenhagen Interpretation of quantum mechanics and assume that consciousness itself determines reality. These models try to describe reality as a consequence of panpsychism, and assume that consciousness is an immanent property which precedes the formation of reality. The concept of panpsychism is explicitly used by most of the authors of this category. These assumptions cannot be falsified.

* Quantum models of consciousness which belong to the second category consider consciousness to be linked to a realm, for example that of the Planck's constant, which cannot be observed by modern science and which is impossible to falsify or test using experiments.

* Quantum models of consciousness which belong to the third group attribute consciousness to principles of order which have been already discovered and used for physical applications (laser, superconductors, etc.). The order principles on which most of these models are based require extreme physical conditions such as, for example, absolute zero temperatures (-273 C°). These models do not meet the criteria of biological compatibility.

Vannini concludes that only the models which originate from the Klein-Gordon equation, which unites Schrödinger's wave equation (quantum mechanics) with special relativity and are not pure quantum mechanical models, survive the selection of scientific falsification and biological compatibility.

2. Klein-Gordon's Equation

In 1925 the physicists Oskar Klein and Walter Gordon formulated a probability equation which could be used in quantum mechanics and was relativistically invariant. In 1926 Schrödinger simplified Klein-Gordon's equation in his famous wave equation (ψ) in which only the positive solution of Klein-Gordon's equation was considered, and which treats time in an essentially classical way with a well defined before and after the collapse of the wave function. In 1927 Klein and Gordon formulated again their equation (2) as a combination of Schrödinger's wave equation (quantum mechanics) and the energy/momentum/mass equation of special relativity (1).

$$E^2 = c^2p^2 + m^2c^4 \qquad 1)$$

Energy/momentum/mass equation

Where *E* is the Energy of the object, m the mass, p the momentum and c the constant of the speed of light. This equation simplifies in the famous $E=mc^2$ when the momentum is equal to zero ($p=0$).

$$E\psi = \sqrt{p^2 + m^2}\psi \qquad 2)$$

Klein-Gordon's wave equation

Klein-Gordon's wave equation depends on a square root and yields two solutions: the positive solution describes waves which diverge from the past to the future (retarded waves); the negative solution describes waves which diverge from the future to the past (advanced waves). The negative solution introduces in science *final causes* and*teleological tendencies*. Consequently, it was considered to be unacceptable.

In 1928 Paul Dirac tried to get rid of the unwanted negative solution by applying the energy/momentum/mass equation to the study of electrons, turning them into

relativistic objects. But, also in this case, the dual solution emerged in the form of electrons (e^-) and antiparticles (e^+). The antiparticle of the electron, initially named neg-electron, was experimentally observed in 1932 by Carl Anderson in cosmic rays and named *positron*. Anderson became the first person who proved empirically the existence of the negative energy solution; the negative solution was no longer an impossible mathematical absurdity, but it was an empirical evidence. Dirac's equation predicts a universe made of matter which moves forwards in time and antimatter which moves backwards in time. The negative solution of Dirac's equation caused emotional distress among physicists. For example Heisenberg wrote to Pauli: "The saddest chapter of modern physics is and remains the Dirac theory" (Heisenberg, 1928); "I regard the Dirac theory ... as learned trash which no one can take seriously" (Heisenberg, 1934). In order to solve this situation, Dirac used Pauli's principle, according to which two electrons cannot share the same state, to suggest that all states of negative energy are occupied, thereby forbidding any interaction between positive and negative states of matter. This ocean of negative energy which occupies all positive states is called the Dirac sea.

It is important to note that it appears to be impossible to test the existence of advanced waves in a laboratory of physics:

> * According to Fantappiè, advanced waves do not obey classical causation, therefore they cannot be studied with experiments which obey the classical experimental method (Fantappiè, 1942).
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> * According to Wheeler's and Feynman's electrodynamics, emitters coincide with retarded fields, which propagate into the future, while absorbers coincide with advanced fields, which propagate backward in time. This time-symmetric model leads to predictions identical with those of conventional electrodynamics. For this reason it is impossible to distinguish between timesymmetric results and conventional results (Wheeler & Feynman, 1949).
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> * In his Transactional Interpretations of Quantum Mechanics, Cramer states that "Nature, in a very subtle way, may be engaging in backwards-in-time handshaking. But the use of this mechanism is not available to experimental investigators even at the microscopic level. The completed transaction erases all advanced effects, so that no advanced wave signalling is possible. The future can affect the past only very indirectly, by offering possibilities for transactions" (Cramer, 1986).

3. The Law of syntropy

At the end of 1941, the mathematician Luigi Fantappiè was working on the equations of relativistic and quantum physics when he noted that the dual solution of the Klein-Gordon equation explains two symmetrical laws:

* $+E\psi$ (retarded waves) describes waves diverging from causes located in the past, governed by the law of entropy;

* $-E\psi$ (advanced waves) describes waves converging towards causes located in the future and governed by the law of syntropy.

According to Fantappiè the main properties of retarded and advanced waves are:

1. Retarded waves:

a. Causality: diverging waves exist as a consequence of causes located in the past.

b. Entropy: diverging waves tend towards the dissipation of energy (heat death).

2. Advanced waves:

a. Retrocausality: converging waves exist as a consequence of causes located in the future.

b. Syntropy:

* converging waves concentrate matter and energy in smaller spaces (ie this principle is well described by the large quantities of energy accumulated by living systems of the past and now available in the form of coal, petrol and gases).

* Entropy diminishes. Entropic phenomena are governed by the second law of thermodynamics according to which a system tends towards homogeneity and disorder. The inversion of the time arrow also inverts the second law of thermodynamics, so that a reduction in entropy and an increase in differentiation are observed.

* Final causes, attractors, which absorb converging waves are observed. From these final causes syntropic systems originate.

* Because syntropy leads to the concentration of matter and energy, and this concentration cannot be indefinite, entropic processes are needed to

compensate syntropic concentration. These processes take the form of the exchange of matter and energy with the environment. For example metabolism is divided into:

o *anabolism* (syntropy) which includes all the processes which transform simple structures into complex structures, for example nutritive elements into bio-molecules, with the absorption of energy.

o *catabolism* (entropy) which includes all the processes which transform higher level structures into lower level structures, with the release of energy.

Fantappiè noted that the properties of syntropy coincide with the qualities of living systems: finality, differentiation, order and organization.

Other authors suggested the existence of the law of syntropy associated to living systems. For example:

- Albert Szent-Gyorgyi (Nobel prize 1937 and discoverer of vitamin C) underlined that "One major difference between amoebas and humans is the increase in complexity, which presupposes the existence of a mechanism which is capable of contrasting the second law of thermodynamics. In other words a force must exist which is capable of contrasting the universal tendency of matter towards chaos, and of energy towards heat death. Life processes continuously show a decrease in entropy and an increase in inner complexity, and often also in the complexity of the environment, in direct opposition with the law of entropy." In the 1970s Szent-Gyorgyi concluded that in living systems there was wide evidence of the existence of the law of syntropy, even though he never managed to infer it from the laws of physics. While entropy is a universal law which leads towards the disintegration of all types of organization, syntropy is the opposite law which attracts living systems towards forms of organization which are always more complex and harmonic (Szent-Gyorgyi, 1977). The main problem, according to Szent-Gyorgyi, is that "a profound difference between organic and inorganic systems can be observed … as a man of science I cannot believe that the laws of physics lose their validity at the surface of our skin. The law of entropy does not govern living systems." Szent-Gyorgyi dedicated the last years of his life to the study of syntropy and its conflict with the law of entropy (Szent-Gyorgyi, 1977).

- Erwin Schrödinger talks about the concept of negative entropy. He was looking for the nutrient which is hidden in our food, and which defends us from

heat death. Why do we need to eat biological food; why can we not feed directly on the chemical elements of matter? Schrödinger answers this question by saying that what we feed on is not matter but neg-entropy, which we absorb through the metabolic process (Schrödinger, 1944).

- Ilya Prigogine, winner in 1977 of the Nobel prize for chemistry, introduced in his book "The New Alliance", a new type of thermodynamics, the "thermodynamics of dissipative systems", typical of living systems. Prigogine stated that this new type of thermodynamics cannot be reduced to dynamics or thermodynamics (Prigogine, 1979).

- Hermann Haken, one of the fathers of the laser, introduced a level that he named "ordinator", which he used to explain the principles of orders typical of living systems (Haken, 1983).

4. Experiments

According to the Copenhagen Interpretation no advance effects should be possible, since time flows from the past to the future. On the contrary Fantappiè's syntropy model suggests that life and consciousness are a consequence of advanced waves (Fantappiè, 1942) and should therefore show anticipatory reactions. Is it possible to devise experiments in order to test which of the two models is correct?

In 1981 Di Corpo extended Fantappiè's hypothesis suggesting that structures which support vital functions, such as the autonomic nervous system (ANS), should show anticipatory reactions since they need to acquire syntropy. Consequently, if the Advanced Waves Interpretation is correct the parameters of ANS, such as heart rate and skin conductance, should react before stimuli (Di Corpo, 1981, 2007; Vannini & Di Corpo, 2008, 2009, 2010), on the contrary if the Copenhagen Interpretation is correct no reactions before stimuli should be observed.

Since 1997, anticipatory pre-stimuli reactions in the parameters of the autonomic nervous system have been reported in several studies, for example:

1. The first experimental study was produced by Radin in 1997 and monitored heart rate, skin conductance and fingertip blood volume in subjects who were shown for five seconds a blank screen and for three seconds a randomly selected calm or emotional picture. Radin found significant differences, in these autonomic parameters, preceding the exposure to emotional versus calm pictures. In 1997 Bierman replicated Radin's results confirming the anticipatory reaction of skin conductance to emotional versus calm stimuli and in 2003 Spottiswoode and May, of the Cognitive Science Laboratory, replicated

Bierman and Radin's experiments performing controls in order to exclude artifacts and alternative explanations. Results showed an increase in skin conductance 2-3 seconds before emotional stimuli are presented (p=0.0005). Similar results have been obtained by other authors, using parameters of the autonomic nervous system (McDonough et al., 2002), (McCraty et al., 2004), (May Paulinyi & Vassy, 2005) and (Radin, 2005).

2. In the article "*Heart Rate Differences between Targets and Nontargets in Intuitive Tasks*", Tressoldi describes two experiments which show anticipatory heart rate reactions (Tressoldi et al., 2005). Trials were divided in 3 phases: in the *presentation phase* 4 pictures were shown and heart rate data was collected; in the choice phase pictures were presented simultaneously and the subject was asked to guess the picture which the computer would select; in the *target* phase the computer selected randomly one of the four pictures (target) and showed it on the monitor. In the first experiment a heart rate difference of 0.59 HR, measured in phase 1 during the presentation of target and non target pictures, was obtained ($t = 2.42$, $p=0.015$), in the second experiment the heart rate difference was 0.57 HR ($t = 3.4$, $p=0.001$).

3. Daryl Bem, psychology professor at the Cornell University, studies retrocausality using well known experimental designs in a "time-reverse" pattern. In his 2010 article "*Feeling the Future: Experimental Evidence for Anomalous Retroactive Influence on Cognition and Affect*" Bem describes 9 well-established psychological effects in which the usual sequence of events was reversed, so that the individual's responses were obtained before rather than after the stimulus events occurred. For example in a typical priming experiment the subject is asked to judge if the image is positive (pleasant) or negative (unpleasant), pressing a button as quickly as possible. The response time (RT) is registered. Just before the image a "positive" or "negative" word is briefly shown. This word is named "prime". Subjects tend to respond more quickly when the prime is congruent with the following image (both positive or negative), whereas the reaction times become longer when they are not congruent (one is positive and the other one is negative).

In retro-priming experiments Bem used IAPS (International Affective Picture System) emotional pictures. Results show the classical priming effect with reaction times faster when the prime is congruent with the image. Considering all 9 experiments, conducted on a sample of more than 1,000 students, the retrocausal effect size is $p = 1.34 \times 10^{-11}$.

4. In the article "Collapse of the wave function?" Vannini and Di Corpo describe 4 experiments which gradually control different types of artefacts and

show a statistical significance of prestimuli heart rate effects of $p=1/10^{27}$(Vannini & Di Corpo, 2010).

5. How Can These Results Be Interpreted?

Anticipatory pre-stimuli reactions seem to be incompatible with the Copenhagen Interpretation, since Schrödinger's wave equation treats time in an essentially classical way and rejects the possibility of pre-stimuli reactions (effects before causes). Dick Bierman tried to overcome this limit of the Copenhagen Interpretation with his CIRTS model (Consciousness Induced Restoration of Time Symmetry), presented at the PA 2008 conference (Bierman, 2008). This model states that almost all formalisms in physics are time-symmetric. Nevertheless the Copenhagen Interpretation of quantum mechanics, which postulates the collapse of the wave function, introduces a break of time symmetry at the point of collapse. The assumption of CIRTS is that the brain, when it is sustained by consciousness, is such a special system that it partially restores time-symmetry and therefore allows advanced waves to occur. The time symmetry restoring condition is not the brain per se but the brain sustained by consciousness. The restoration of time symmetry is suggested to be proportional to the brain volume involved in consciousness. CIRTS considers consciousness to be a pre-requisite of reality with special properties which restore time-symmetry. However, in CIRTS the rationale behind consciousness is missing and its special properties seem to arise from nothing. Contrary to Bierman's model, Luigi Fantappiè's syntropy model and Chris King's quantumtransactions model describe consciousness as a consequence of the properties of advanced waves: − Fantappiè states that, according to the converging properties of advanced waves, living systems are energy and information absorbers and that the "feeling of life" can be described as a consequence of these converging and absorbing properties of advanced waves. On the contrary it would be difficult to justify the feeling of life as a consequence of diverging and emitting properties which characterize retarded waves. The equivalence "feeling of life = advanced waves" leads to the conclusion that systems based on the retarded solution, as for example machines and computers, would never show the "feeling of life" independently from their complexity, whereas systems based on the advanced solution, as for example life itself, should always have a "feeling of life", independently from their complexity.

According to King, the constant interaction between information coming from the past and information coming from the future would place life in front of bifurcations. This constant antagonism between past and future would force life into a state of free will and consciousness. Consequently consciousness would be a property of all living structures: each cell and biological process would be forced to choose between information coming from the past and information coming from the future (King, 1996). This constant state of choice would be common to all levels of life and would

give form to chaotic behaviour on which the conscious brain would feed. King (1996) states that "The chaotic processes which are observed in the neuronal system can be the result of behaviour which is apparently random and probabilistic, since they are non local in space and time. This would allow neuronal networks to connect in a subquantum way with non local situations and explain why behaviour results in being non deterministic and non computational."

The followings are some of the fundamental differences between Bierman's CIRTS model and Fantappiè's syntropy model:

1. Fantappiè focused on the Klein-Gordon's equation and excluded other time-symmetric equations, such as the electromagnetic wave equation. The rational of this choice is that at the quantum level time would be unitary (past, present and future would coexist) whereas at the macro-level time flows forward and advanced waves would be impossible. This conclusion was reached considering the mathematical properties of retarded waves which obey classical causation and propagate from the past to the future, and of advanced waves which obey final causation and propagate from the future to the past. Fantappiè noted that in diverging systems, such as our expanding universe, entropy prevails forcing time to flow forwards and forbidding advanced solutions. On the contrary in converging systems, such as black holes, syntropy prevails, time flows backwards and retarded solutions would be impossible; whereas in systems balanced between diverging and converging forces, such as atoms, time would be unitary, past, present and future would coexist and both advanced and retarded waves would be possible. In the CIRTS model Bierman considers advanced solutions possible also at the macro level, without taking into account the restrictions posed by the law of entropy.

2. Fantappiè argued that, as a consequence of the fact that advanced waves exist at the quantum level, living systems need a way to "extract" advanced waves from the quantum level in order to sustain living functions and contrast the destructive effects of entropy. Fantappiè found this mechanism in water, in the hydrogen bridge, a bond among the hydrogen atom and two electrons, found by Maurice Huggins in 1920, which allows to explains the anomalous properties of water (Ball, 1999). The hydrogen bridge makes water totally different from other liquids, mainly by increasing its cohesive forces (syntropy) and this would be the reason why water is so essential to life, since it allows the flow of advanced waves from the micro to the macro level. Consequently, in the syntropy model advanced waves are not associated to the brain, but are considered a fundamental property of all living systems. On the contrary, CIRTS suggests that advanced waves are mediated by consciousness and therefore should be a consequence of conscious brain activities. Bierman

produces evidence in experiments conducted with meditators, but this evidence can be easily read as an increase of the role of the autonomic nervous system during meditation, and not as a consequence of consciousness. It is well known that, while meditating, subjects often experience a state of trance as a consequence of the fact that the aim is usually that of "turning off the mind".

3. In the CIRTS model consciousness is a pre-requisite of reality. In the syntropy model the feeling of life is a consequence of the cohesive and unitary properties of advanced waves. According to the syntropy model, any form of life has a feeling of life. Consequently we would have a feeling of life also when no brain activity is observed. This would explain why all forms of life, even the most simple ones, show anticipatory reactions (Rosen, 1985) and why, for example, patients during surgery in a state of anesthetic-induced unconsciousness tend to defend themselves and subjects with no brain activity react and defend themselves when their organs are removed for transplant. According to the syntropy model, the feeling of life does not reside in the brain; however, the brain provides memory which allows us to remember and reason regarding our conscious experiences.

4. CIRTS associates pre-stimuli reactions to coherence whereas the syntropy model associates pre-stimuli reactions to feelings and emotions. Coherence is a concept which is quite difficult to measure, whereas emotions can be easily measured using the parameters of the autonomic nervous system. Nevertheless Bierman introduces a formula in order to justify why pre-stimuli reactions are lower than post-stimuli reactions. In this formula the volume of the brain affected by coherence is divided by the total volume of the brain. The example reported by Bierman, relative to skin conductance, seems to support this formula. However, when using heart rate measurements pre-stimuli reactions and post-stimuli reactions tend to have the same size of effect. Even though effects vary greatly among subjects and generalization seems not to be appropriate, HR data contradicts Bierman’s formula.

6. Conclusion

According to the syntropy model the dual manifestation of the quantum world in the form of waves and particles is not the consequence of the collapse of the wave equation, but the consequence of the dual causality at the quantum level: retarded waves, past causality, and advanced waves, future causality (Cramer, 1986). The advanced waves model does not need the collapse of the wave function and, consequently, does not need a time-symmetry restoration system. Advanced waves would explain not only the dual manifestation particle/waves, but also non-locality and entanglement (De Beauregard, 1977). On the contrary the CIRTS model finds its

justification within the Copenhagen Interpretation of quantum mechanics and requires the collapse of the wave function.

The Copenhagen Interpretation was formulated in 1927 and can be considered the expression of the Zeitgeist, "the spirit of the time", since it reflects the idea of men as semi-Gods who, through the exercise of consciousness, can create reality. When Erwin Schrödinger discovered how Heisenberg and Bohr had used his wave equation, with ideological and mystical implications which provided powers of creation to consciousness, he commented: "I don't like it, and I am sorry I ever had anything to do with it" (Schrödinger, 1944).

References

Anderson C.D. (1932). The apparent existence of easily deflectable positives, Science, 76:238. Ball P. (1999). H_2O A Biography of Water, Weidenfeld & Nicolson, London.

Bem D.J. (2010). Feeling the Future: Experimental Evidence for Anomalous Retroactive Influence on Cognition and Affect. Journal of Personality and Social Psychology (in press), DOI: 10.1037/a0021524, http://dbem.ws/FeelingFuture.pdf

Bierman D.J., Radin D.I. (1998). Conscious and anomalous non-conscious emotional processes: A reversal of the arrow time? Toward a Science of Consciousness, Tucson III. MIT Press, 367-386.

Bierman D.J. (2008). Consciousness Induced Restoration of Time-Symmetry (CIRTS), a Psychophysical Theoretical Perspective, Proceedings of the PA Convention, Winchester, England, 13-17 August 2008.

Cramer J.G. (1986). The Transactional Interpretation of Quantum Mechanics, Reviews of Modern Physics, 58: 647-688.

De Beauregard C. (1977). Time Symmetry and the Einstein Paradox, Il Nuovo Cimento, 42(B).

Di Corpo U. (1981), Un nuovo approccio strutturale ai fondamenti della psicologia. Ipotesi teoriche ed esperimenti. Dissertation, University of Rome "La Sapienza".

Di Corpo U. (2007). The conflict between entropy and syntropy: the vital needs model. SSE Proceedings, Norway, 132-138.

Dirac P. (1928). The Quantum Theory of the Electron, Proc. Royal Society, London, 117: 610-624; 118: 351-361.

Fantappiè L. (1942). Sull'interpretazione dei potenziali anticipati della meccanica ondulatoria e su un principio di finalità che ne discende. Rend. Acc. D'Italia, 4(7).

Haken H. (1983). Synergetics, an Introduction: Nonequilibrium Phase Transition and Self- Organization in Physics, Chemistry, and Biology, Springer-Verlag.

Heisenberg W. (1928). Letter to W. Pauli, PC, May 3, 1: 443.

Heisenberg W. (1934). Letter to W. Pauli, PC, February 8, 2: 279.

King C.C. (1996). Quantum Mechanics, Chaos and the Conscious Brain. Journal of Mind and Behavior, 18: 155-170.

May E.C., Paulinyi T., Vassy Z. (2005). Anomalous Anticipatory Skin Conductance Response to Acoustic Stimuli: Experimental Results and Speculation about a Mechanism, The Journal of Alternative and Complementary Medicine, 11(4): 695-702.

McCratly R., Atkinson M., Bradely R.T. (2004). Electrophysiological Evidence of Intuition: Part 1, Journal of Alternative and Complementary Medicine, 10(1): 133-143.

McDonough B.E., Dons N.S., Warren C.A. (2002). Differential event-related potentials to targets and decoys in a guessing task, in Journal for Scientific Exploration, 16: 187-206.

Prigogine I. and Stengers I. (1979). La Nouvelle Alliance, Gallimard.

Radin D.I. (1997). Unconscious perception of future emotions: An experiment in presentiment. Journal of Scientific Exploration, 11(2): 163-180.

Radin D.I., Schlitz M. J. (2005). Gut feelings, intuition, and emotions: An exploratory study, Journal of Alternative and Complementary Medicine, 11(4): 85-91.

Rosen R. (1985). Anticipatory Systems, Pergamon Press, USA.

Schrödinger E. (1944). What is Life? The Physical Aspects of the Living Cell, Cambridge University Press.

Szent-Gyorgyi A. (1977). Drive in Living Matter to Perfect Itself, Synthesis, 1(1): 14-26.

Spottiswoode P., May E. (2003). Skin Conductance Prestimulus Response: Analyses, Artifacts and a Pilot Study, Journal of Scientific Exploration, 17(4): 617-641.

Tressoldi P. E., Martinelli M., Massaccesi S., Sartori L. (2005). Heart Rate Differences between Targets and Nontargets in Intuitive Tasks, Human Physiology, 31(6): 646–650.

Vannini A. (2005). Entropy and Syntropy. From Mechanical to Life Science, NeuroQuantology, 3(2): 88-110.

Vannini A. (2008). Quantum Models of Consciousness, Quantum Biosystems, 2: 165-184.

Vannini A. and Di Corpo U. (2008). Retrocausality and the Healing Power of Love, NeuroQuantology, 6(3): 291-296.

Vannini A. and Di Corpo U. (2009). A Retrocausal Model of Life, in Filters and Reflections. Perspective on Reality, ICRL Press, Princeton, NJ, USA, 231-244.

Vannini A. and Di Corpo U. (2010). Collapse of the wave function? Pre-stimuli heart rate reactions. NeuroQuantology, 8(4): 550-563.

Wheeler J.A. and Feynman R. (1949). Classical Electrodynamics in Terms of Direct Interparticle Action. Reviews of Modern Physics, 21: 425-433.