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# A Quantum Theory of Consciousness

**Shan Gao**

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**Abstract** The relationship between quantum collapse and consciousness is reconsidered under the assumption that quantum collapse is an objective dynamical process. We argue that the conscious observer can have a distinct role from the physical measuring device during the process of quantum collapse owing to the intrinsic nature of consciousness; the conscious observer can know whether he is in a definite state or a quantum superposition of definite states, while the physical measuring device cannot "know". As a result, the consciousness observer can distinguish the definite states and their quantum superposition, while the physical measuring device without consciousness cannot do. This provides a possible quantum physical method to distinguish man and machine. The new result also implies that consciousness has causal efficacies in the physical world when considering the existence of quantum collapse. Accordingly consciousness is not reducible or emergent, but a new fundamental property of matter. This may establish a quantum basis for panpsychism, and make it be a promising solution to the hard problem of consciousness. Furthermore, it is suggested that a unified theory of matter and consciousness includes two parts: one is the psychophysical principle or corresponding principle between conscious content and matter state, and the other is the complete quantum evolution of matter state, which includes the definite nonlinear evolution element introduced by consciousness and relating to conscious content. Lastly, some experimental schemes are presented to test the proposed quantum theory of consciousness.

**Keywords** Quantum collapse · Consciousness · Causal efficacies of consciousness · Quantum effects of consciousness · To distinguish man and machine · Panpsychism · Unified theory of matter and consciousness

S. Gao (✉)
Institute of Electronics, Chinese Academy of Sciences, LongZeYuan 24-3-501, ChangPing District, Beijing 102208, P.R. China
e-mail: rg@mail.ie.ac.cn

## Introduction

Consciousness is the most familiar phenomenon. There are two distinct processes relating to the phenomenon: one is the objective matter process such as the neural process in the brain, and the other is the concomitant subjective conscious experience. The relationship between matter process and conscious experience presents a well-known hard problem for science (Chalmers 1996). It retriggers the debate about the long-standing dilemma of panpsychism versus emergentism recently (Strawson et al. 2006). Panpsychism asserts that consciousness is a fundamental feature of the world that exists throughout the universe. Emergentism asserts that consciousness appears as an emerging result of complex matter process. It is generally accepted that an essential separation of consciousness and matter will preclude any real integration of consciousness with the present scientific picture of the physical world, and panpsychism and emergentism are two main positions that can complete the integration. Thus we must decide whether and how consciousness emerges from mere matter or whether consciousness is a fundamental property of matter.

Emergentism is the most popular solution to the hard problem of consciousness. But many doubt that it can bridge the explanation gap ultimately (Chalmers 1996; Seager 1999, 2001; Strawson 2006). On the other hand, although panpsychism may provide an attracting and promising way to solve the hard problem, it also encounters some serious problems. It is widely argued that the physical world is causally closed, and the consciousness property assigned by the panpsychism must lack all causal efficacies, i.e., there is a purely physical explanation for the occurrence of every physical event and the explanation doesn't refer to any consciousness property (see, e.g., McGinn 1999). But if panpsychism is true, the fundamental consciousness property should take part in the causal chains of the physical world and should present itself in our investigation of the physical world. Then do the causal efficacies of consciousness exist? How to find them if they do exist?

In this paper, we will mainly study the possible physical effects of consciousness. The new analysis may have some deep implications for the nature of consciousness; especially it may provide a promising solution to the hard problem of consciousness. Under the assumption that quantum collapse (i.e. the collapse of the wave function) is an objective dynamical process, we argue that the conscious observer can distinguish the definite states and their quantum superposition, while the usual physical measuring device without consciousness cannot do. This result implies that the causal efficacies of consciousness may exist when considering the existence of quantum collapse, and thus consciousness is not reducible or emergent, but a new fundamental property of matter. Lastly, we also propose some experimental schemes to test the predicted quantum effects of consciousness.

## Consciousness and Physical Measurement

We will first analyze the role of consciousness in physical measurement process (Gao 2004b, 2006c). Physical measurement generally consists of two processes: (1)

the physical interaction between the observed object and measuring device; (2) the psychophysical interaction between the measuring device and the observer. In some special situations, measurement may be the direct interaction between the observed object and the observer.

Even though what physics commonly studies are insensible objects, the consciousness of the observer must take part in the last phase of measurement. The observer is introspectively conscious of his perception of the measurement result. Here consciousness is used to end the infinite chains of measurement. This is one of the main differences between the functions of a physical measuring device and a conscious observer in the measurement process. But unfortunately the difference seems unidentifiable using physical methods. Then does the consciousness of the observer have some physically identifiable effects that are lacking for the physical measuring device? In the following, we will give a primary analysis.

In classical theory, the influence of the measuring device or the observer on the observed object can be compensated for in principle during a measurement process, and the psychophysical interaction between the observer and the measuring device does not influence the reading of the pointer of the measuring device either. Thus measurement is only an ordinary one-to-one mapping from the state of the observed object to the pointer state of the measuring device and then to the perception state of the observer, or a direct one-to-one mapping from the state of the observed object to the perception state of the observer. The consciousness of the observer has no physically identifiable functions that are different from those of the physical measuring device in classical theory.

However, the measurement process is no longer ordinary in quantum theory. The influence of the measuring device on the observed object cannot be omitted or compensated for in principle during a quantum measurement owing to the existence of quantum superposition. It is just this influence that generates the definite measurement result to some extent. Since the measuring device has generated a definite measurement result, the psychophysical interaction between the observer and the measuring device is still an ordinary one-to-one mapping, and the process is the same as that in classical situation. But when the observed object and the observer directly interact, the existence of quantum superposition may introduce a new element to the psychophysical interaction between the observer and the measured object. In the next section, we will argue that, under the assumption that quantum collapse is an objective dynamical process, the consciousness of the observer in a superposition state can have a physically identifiable effect that is lacking for the physical measuring device.

## A Quantum Effect of Consciousness

Quantum theory is the most basic physical theory of nature. But as to the evolution of the wave function during measurement, the existing quantum theory provides by no means a complete description, and the projection postulate is just a makeshift (Bell 1987). It is generally expected that a complete quantum theory should describe the projection as a dynamical collapse process of the wave function and provide a unified evolution law of the wave function. Revised quantum dynamics (Ghirardi et al. 1986; Pearle 1989; Diosi 1989; Ghirardi et al. 1990; Penrose 1996; Gao 2000, 2001, 2003a, 2006a, b, c) and many-worlds theory (Everett 1957; Dewitt et al. 1973; Deutsch 1985) are two main alternatives to a complete quantum theory. Here we will discuss the possible quantum effects of consciousness in the framework of revised quantum dynamics. Our analysis will only rely on the common character of revised quantum dynamics, i.e., that the collapse of the wave function is one kind of objective dynamical process, and it takes a finite time interval to finish.

In both the existing quantum theory and the revised quantum dynamics, it is a well-known result that the usual measurement using physical measuring device cannot distinguish the definite states and their quantum superposition, which are called nonorthogonal states. Yet, when the physical measuring device is replaced by a conscious observer and considering the influence of consciousness, the nonorthogonal states can be distinguished in principle in revised quantum dynamics according to a recent analysis (Gao 2004a, b, c). Accordingly, the distinguishability of nonorthogonal states will reveal a quantum effect of consciousness, which is lacking for the physical measuring device without consciousness. In the following, we will give a detailed explanation.

Let the measured state be $\psi_1 + \psi_2$ and the initial state of the physical measuring device be $\varphi_0$. After interaction the resulting entangled state of the whole system is $\psi_1\varphi_1 + \psi_2\varphi_2$, and the result state of the physical measuring device after collapse will assume $\varphi_1$ or $\varphi_2$ with the same probability 1/2 in a purely random way. The physical measuring device cannot "know" the input state is a superposition state, and can but identify it as a definite state $\psi_1$ or $\psi_2$. In other words, the physical measuring device cannot distinguish the definite states and their quantum superposition.

Now let the state $\psi_1 + \psi_2$ input to a conscious being. For example, $\psi_1$ and $\psi_2$ are respectively the states of a small number of photons with a certain frequency entering into the eyes of the conscious being from two different directions, which can trigger different definite perceptions of the conscious being, and the state $\psi_1 + \psi_2$ is a quantum superposition of such states. Let the initial perception state of the conscious being be $\chi_0$. After interaction the resulting entangled state of the whole system is $\psi_1\chi_1 + \psi_2\chi_2$, where $\chi_1$ and $\chi_2$ are respectively the perception states of the conscious being for the states $\psi_1$ and $\psi_2$. Suppose the conscious being satisfies the following condition, i.e., that the collapse time $t_C$ of the entangled state is longer than the normal conscious time $t_P$ of the conscious being for the definite states, and the time difference is long enough for him to identify. This condition ensures that consciousness can take part in the process of quantum collapse, otherwise consciousness can only appear after the collapse and will surely have no influence upon the collapse process.

We first assume that the conscious being has no distinct effect from the physical measuring device. This means that his result state after collapse will exactly assume $\chi_1$ or $\chi_2$ with the same probability 1/2 in a purely random way; especially he doesn't know the input state is a superposition state, and think it is a definite state $\psi_1$ or $\psi_2$. This further requires that the state of the conscious being has become $\chi_1$ or $\chi_2$ immediately after the conscious time $t_P$, otherwise he will know the input state is not a definite state. For an input definite state the conscious being will form a definite perception of the input state after the conscious time $t_P$. Since the conscious time $t_P$ is shorter than the collapse time $t_C$, the requirement will mean that the conscious being knows the random collapse result *beforehand*! This is impossible.[1] As thus, the above assumption must be wrong, and the conscious being must have a distinct effect from the physical measuring device. Moreover, the argument has shown that the distinct effect of consciousness is to distinguish the definite states (e.g., $\psi_1$ or $\psi_2$) and their quantum superposition (e.g., $\psi_1 + \psi_2$).[2] When the input state is a superposition state such as $\psi_1 + \psi_2$, the conscious being is able to know the input state is a superposition state, not a definite state, while the physical measuring device cannot "know".

According to the above analysis, after the conscious time $t_P$, the state of the whole system will turn to be $\psi_1\chi_{1,S} + \psi_2\chi_{2,S}$, where $\chi_{1,S}$ and $\chi_{2,S}$ are not only the conscious perception states of the conscious being for the states $\psi_1$ and $\psi_2$, but also denote that the conscious being is conscious that the input state is a superposition state, not a definite state. After the longer collapse time $t_C$, the superposition state $\psi_1\chi_{1,S} + \psi_2\chi_{2,S}$ collapses to the definite state $\psi_1\chi_{1,S}$ or $\psi_2\chi_{2,S}$ with the same probability 1/2 in a purely random way. Since the collapse state $\chi_{1,S}$ or $\chi_{2,S}$ for the input superposition state $\psi_1 + \psi_2$ is different from the normal perception state $\chi_1$ or $\chi_2$ for the input definite state $\psi_1$ or $\psi_2$, the conscious being can distinguish the nonorthogonal states $\psi_1 + \psi_2$ and $\psi_1$ or $\psi_2$.

The conclusion that the consciousness being can distinguish the definite states and their quantum superposition is also consistent with the postulate that the conscious being in a superposition state has no definite conscious perception about the state. For an input definite state the conscious being forms a definite perception of the input state after the time interval $t_P$, whereas for the input superposition state $\psi_1 + \psi_2$, the conscious being has not formed such a definite perception after the time interval $t_P$ yet. As thus, the consciousness being can distinguish the definite states and their quantum superposition. As we will see in the penultimate section, the above conclusion and the postulate can both be tested by experiment.

The above quantum effect of consciousness can be illustrated by a black box system. We define a simple rule, i.e. that the outputs of the system are respectively '0' and '1' for the input states $\psi_1$ and $\psi_2$. If a physical measuring device is in the box, the output of the device will be a random series of '0' and '1' with the same distribution probability 1/2 after measuring a large number of input states $\psi_1 + \psi_2$. But if a consciousness being is in the box, since he can identify the input state $\psi_1 + \psi_2$ as a superposition state, the output will be different from '0' and '1' according to the rule, for example, it can be set to '2'. It is just the distinct quantum effect of consciousness that results in the different outputs for man and machine. This quantum physical test can be used to test the existence of consciousness, and further differentiate man and machine (Fig. 1).

[1] Even though this is possible for a conscious being, it is impossible for a physical measuring device according to the existing physical theories. As thus, the conscious being also has a distinct effect from the physical measuring device, i.e., that he can know the random collapse result *beforehand*.

[2] Gao (2004a) gave a more detailed demonstration of this conclusion.

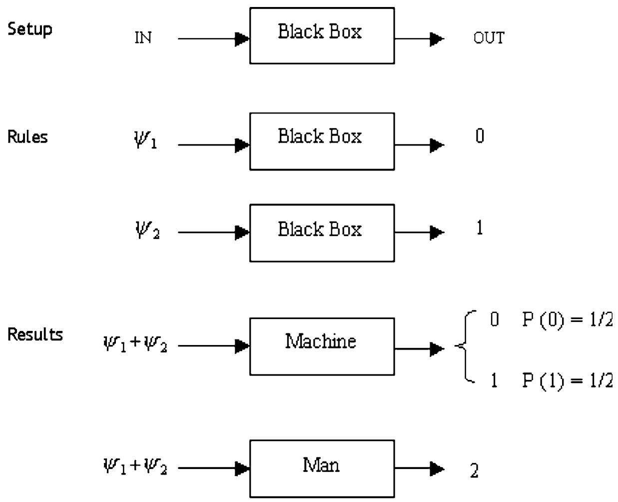


**Fig. 1** A quantum physical method to distinguish man and machine

It should be noted that the above quantum effect of consciousness relies on an unusual condition, i.e., that the conscious time of the conscious being for definite states is shorter than his conscious time for the superposition of the definite states (i.e., the collapse time of the whole entangled state), and the time difference is long enough for him to identify. Since the collapse time of a single superposition state is an essentially stochastic variable, the condition can be in principle satisfied for some collapse events with non-zero probability. For these stochastic collapse processes, the collapse time $t_C$ of the single superposition state is longer than the normal conscious time $t_P$ as well as the average collapse time.

## Consciousness is a Fundamental Property of Matter

Consciousness has a basic quantum effect that is lacking for mere matter. This means that consciousness has causal efficacies in the physical world, and the physical world is not causally closed without consciousness. What does this imply for the nature of consciousness? In this section, we will further argue that consciousness is not reducible or emergent, but a fundamental property of matter on the basis of the quantum effect of consciousness. This may provide a quantum basis for panpsychism, and make it be a promising solution to the hard problem of consciousness.

If consciousness is reducible or emergent, then consciousness will have no causal efficacies in the physical world, and the physical world will be causally closed. But this contradicts the existence of the above quantum effect of consciousness, which implies that consciousness has causal efficacies in the physical world, and the physical world is not causally closed without consciousness. So consciousness must be not reducible or emergent, but a new fundamental property of matter. We can reach this conclusion by another concrete argument. If consciousness is reducible or emergent, then the matter with consciousness should also follow the basic physical principles of matter such as the principle of energy conservation etc. According to the existing quantum principle, the nonorthogonal states cannot be distinguished. However, as we have argued, the conscious observer or the matter with consciousness can distinguish the nonorthogonal states in principle. This indicates that consciousness violates the existing quantum principle, which is a basic physical principle of matter. Thus consciousness should be not reducible or emergent, but a new fundamental property of matter, which is defined as the ability of being conscious of something. It should be not only possessed by the observers, but also possessed by atoms as well as physical measuring devices. The difference mainly lies in the conscious content. The conscious content of a human being can be very complex, while the conscious content of a physical measuring device, if it exists, may be extremely simple. Such simple conscious content cannot help to distinguish the nonorthogonal states. In order to distinguish the nonorthogonal states, the conscious content of the measuring system should be complex enough to contain the conscious perceptions of the nonorthogonal states. If the conscious content of a system is null, we usually say that it has no consciousness.

On the other hand, if consciousness is a new fundamental property of matter, then it is very natural that it has causal efficacies in the physical world, and it may violate some existing basic physical principles of matter, which don't include it as a fundamental property of matter. It is expected that a complete theory of matter must describe all properties of matter, thus consciousness, the new fundamental property of matter, must enter the theory from the start. Since the distinguishability of nonorthogonal states violates the basic linear superposition principle in quantum theory, the consciousness property of matter will introduce a new nonlinear evolution element to the complete equation of the wave function when the conscious content is complex enough. The nonlinearity is not stochastic, but definite. It has been argued that the nonlinear quantum evolution introduced by consciousness is logically consistent and may exist (Czachor 1995; Gao 2004a). In addition, we may use the definite nonlinearity element in the complete evolution equation of matter to define the consciousness property of matter. Then just like the other properties of matter such as mass and charge etc, consciousness is also a fundamental property of matter that can be strictly described in mathematics to some extent.

The above argument provides a possible quantum basis for panpsychism (Gao 2003a, 2006c), which may be a promising solution to the hard problem of consciousness. As we know, a severe problem of panpsychism is the apparent lack of evidence that the fundamental entities of the physical world such as electrons and protons possess any consciousness features. Certainly, such "no evidence" argument can be reasonably disputed by noting that there may not exist any signs of complex consciousness at the simplest level (e.g. the conscious content is very simple or even null), and it may be very difficult to see them even when they do exist there. The existence of gravitation is a good example. Its extreme weakness between the fundamental entities doesn't disconfirm that gravitation is not a fundamental feature of the physical world (Seager 1999, 2001). Now the existence of the definite nonlinear evolution introduced by consciousness may further help to solve the above problem. Since the definite nonlinearity can be experimentally tested even for the evolution of the fundamental entities such as electrons and protons, it may provide a possible physical method to test the panpsychism doctrine.

It should be noted that the above argument for panpsychism depends on an assumption that the wavefunction collapse is an objective dynamical process. In fact, the conclusion is independent of the origin of the wavefunction collapse. If the wavefunction collapse is caused by the consciousness of the observer (von Neumann 1955; Wigner 1967; Stapp 1996), then consciousness will have the basic quantum effect of collapsing the wave function, and thus consciousness should be also a fundamental property of matter. In addition, we stress that the above conclusion is also independent of the interpretations of quantum theory (Gao 2004a). It only relies on two firm facts: one is the existence of indefinite quantum superpositions, the other is the existence of definite conscious perceptions.

## A Unified Theory of Matter and Consciousness

Since consciousness is a fundamental property of matter, it is expected that a unified theory of matter and consciousness will essentially comprise two parts: one is the psychophysical principle or corresponding principle between conscious content and matter state, and the other is the complete quantum evolution of matter state. The complete evolution may include three evolution terms: the first is the linear Schrödinger term as in the existing quantum theory, the second is the stochastic nonlinear term resulting in the dynamical collapse of the wave function, and the last is the definite nonlinear term introduced by consciousness and relating to the concrete conscious content.

Undoubtedly, it is very difficult to find the corresponding principle between conscious content and matter state. Some primary analyses have been presented (Crick 1994; Chalmers 1996; Edelman and Tononi 2000). It is expected that the corresponding principle will naturally solve the problem of combination for panpsychism. Here we will mainly discuss the definite nonlinear term introduced by consciousness. Although the final form of the definite nonlinear evolution term has not been found, we may give a primary analysis of its possible characteristics. As we have shown in the previous example, the definite nonlinear evolution appears in the following quantum process:

$$(\psi_1 + \psi_2)\chi_0 \rightarrow \psi_1\chi_{1,s} + \psi_2\chi_{2,s} = (\psi_1\chi_1 + \psi_2\chi_2)\chi_s, \tag{1}$$

where $\chi_S$ denotes the state in which the conscious being is conscious that the input state $\psi_1 + \psi_2$ is a superposition state, and its appearance indicates that the evolution is nonlinear. First, as we have noted, the definite nonlinear evolution introduced by consciousness will result in the distinguishability of two given nonorthogonal states. This will further permit the existence of nonlocal communication between two entangled quantum systems (Gao 2004a, 2006c). Especially, the nonlocal communication can exist between two entangled conscious systems such as human brains. It seems that some primary evidences of such communication have been found in experiments (Duane and Behrendt 1965; Targ and Puthoff 1974; Wackermann et al. 2003).

Next, since the definite nonlinear evolution doesn't preserve the orthogonality of states, the evolution can change the coherence of the branches of the state of an external system entangled with the conscious system, and can further change the statistic behavior of the external system. As a result, the definite nonlinear evolution introduced by consciousness may in principle influence the statistic distribution of the measurement results of an external random process, and there may also exist a correlation between the influenced results and the conscious content. We note that some experiments may have primarily revealed this kind of quantum effect of consciousness (Radin and Nelson 1989; Jahn et al. 1997).

Lastly, it can be seen that during the definite nonlinear evolution consciousness results in some special change of matter state, which cannot be brought by the usual properties of matter. Since the change of matter state generally corresponds to the change of energy distribution among the parts of the system, the definite nonlinear evolution introduced by consciousness will change the energy distribution inside the system. If a conscious observer is entangled with another system, the definite nonlinear evolution introduced by consciousness may then change the energy distribution among the parts of the entangled system; especially it may change the energy of the external system in a nonlocal way. Some primary evidences of this effect might have been found in experiments (Radin 1997).

The above analysis presents a very primary framework for a unified theory of matter and consciousness. Especially, it implies that the definite nonlinear evolution term introduced by consciousness may possess some kind of fundamental form, and the corresponding evolution may also bring some more basic effects. The unified theory, if it is available, will not only tell us how the matter state evolves, but also tell us what conscious experience the matter state corresponds to. As a prediction of the theory, since consciousness is a fundamental property of matter, and there exists a corresponding relation between the conscious content and the matter state, a conscious machine can be constructed in principle. It can be reasonably guessed that a very simple conscious machine can also distinguish two given nonorthogonal states. Certainly, in order to build up a complete theory of matter and consciousness, we need the organic combination of quantum theory, information science, neuroscience, cognitive science and psychology etc. This may be the biggest challenge to science in the 21st century.

## Some Suggested Experiments

We have argued that consciousness may have some basic quantum effects if the collapse of the wave function is an objective dynamical process. The result is unusual according to the present scientific understanding of consciousness. Although it seems that there are some inklings in our ordinary experience and some faint evidences in experiments for the similar effects of consciousness (see, e.g., Radin 1997), their concrete relations with the quantum effects of consciousness predicted here are still unclear. No doubt, these effects need to be tested by more strict experiments. In the following, we will propose some experimental schemes to test our theoretical analysis. The experiments can be conducted using human beings, animals (e.g., frogs) and even microorganisms.

First, we will give a theoretical estimate of the experimental feasibility. As we know, the predicted quantum effects of consciousness rely on a stringent condition, i.e., that the normal conscious time of the conscious being for the definite state is shorter than the collapse time of the superposition state of his different conscious perceptions, and the time difference is long enough for him to identify. This condition seems unavailable for human observer, as it is generally argued that human brain's neurons seem unsuitably warm and wet for sustaining delicate quantum superpositions that would be susceptible to thermal noise and environmental decoherence (Tegmark 2000). However, the criterion of quantum collapse is essentially different from that of quantum decoherence. Especially, the collapse time is usually much longer than the decoherence time for the same quantum superposition. The following calculation based on a model of revised quantum dynamical will show that the above condition can be available for human beings at least in a certain probability.

For a human brain, the number of neurons that can form a definite conscious perception is approximately in the levels of $10^4$. In each neuron, the main difference of activation state and resting state lies in the motion of $10^6$ $Na^+$ s passing through the membrane. Since the membrane potential is in the levels of $10^{-2}$ V, the energy difference between activation state and resting state is approximately $10^4$ eV. According to one kind of revised quantum dynamics (Percival 1994; Hughston 1996; Fivel 1997; Gao 2000, 2001, 2006a, b, c; Adler and Brun 2001), the (average) collapse time of the quantum superposition of activation state and resting state of one neuron is

$$\tau_c \approx \frac{\hbar E_p}{(\Delta E)^2} \approx \left(\frac{2.8\,\text{Mev}}{0.01\,\text{MeV}}\right)^2 \approx 10^5\ \text{s}, \tag{2}$$

where $\hbar$ is Planck constant divided by $2\pi$, $E_p \approx 10^{19}$ Gev is Planck energy, and $\Delta E$ is the energy difference between the states in the quantum superposition. Thus the (average) collapse time of the quantum superposition of two different conscious perceptions is

$$\tau_c \approx \left(\frac{2.8\,\text{Mev}}{100\,\text{MeV}}\right)^2 \approx 1\ \text{ms} \tag{3}$$

In this superposition state, one conscious perception state approximately contains $10^4$ neurons in the activation state, and the other conscious perception state approximately contains $10^4$ neurons in the resting state, and their energy difference is approximately 100 Mev.[3] As a result, the (average) collapse time of the superposition state of different conscious perceptions may usually in the levels of several milliseconds for human beings. On the other hand, the measured value of the normal conscious time of human brain is in the levels of several hundred milliseconds

[3] We note that the calculation here is still very crude. We omit the influence of other factors (e.g. thermal noise) on the energy difference between the two conscious perception states, which is assumed to be small enough at least in some controllable situations.

(Libet 1993). Since the collapse time of a single superposition state is an essentially stochastic variable, it can be larger than the (average) collapse time and the conscious time with a certain probability. Thus the above stringent condition can be satisfied for human observer in some collapse events with a certain probability. Furthermore, the condition may be more easily satisfied for human beings in some special conscious states (e.g. meditation state) or for some small brain animals. For example, if the number of neurons that can form a definite conscious perception is in the levels of $10^3$ and other parameters are not changed, the (average) collapse time will be in the same levels with the conscious time. Then the precondition for the appearance of unusual quantum effects of consciousness can be naturally satisfied.

Next, we will present some experimental schemes to test the actual availability of the condition for generating the unusual quantum effects of consciousness. The single superposition state can be the superposition state of one photon with two different frequencies or the space superposition state of one photon with the same frequency etc. The number of incident photons should be large enough so that the subject can see the light clearly.

### Control Experiment

Input some photons with a given frequency (e.g., red light) to the eyes of the subject. Record the conscious time of the subject through EEG (electroencephalograph) or his oral description.

### Quantum Perception Experiment I

Input one branch of each superposition state to the eyes of the subject, and let the other branch freely spread (i.e., not input to a measuring device). Test whether the subject perceives the photons during the normal conscious time.

### Quantum Perception Experiment II

Input both branches of each superposition state to the eyes of the subject from the same direction. Test whether the subject perceives the photons during the normal conscious time.

### Perceptions Entanglement Experiment I

Input the two branches of each superposition state to the eyes of two independent subjects respectively. Test whether the subjects perceive the photons during the normal conscious time.

If we find that the subjects perceive the photons after a time interval longer than their normal conscious time in any case of the above experiments after eliminating the experimental errors, then we will have confirmed the existence of the unusual condition that can result in the quantum effects of consciousness. In addition, it is suggested that the subjects in the above experiments should include three independent groups at least. The subjects in the first group are in normal state, the subjects in the second group are in meditation state, and the subjects in the third group are in qigong state.

Perceptions Entanglement Experiment II

Input the two branches of each superposition state to the eyes of two independent and isolated subjects respectively.[4] Then stimulate one of the subjects using flashes or visual patterns at random intervals. Record his evoked potentials and the corresponding brain electrical activities of the other subject. Test whether there exists statistical relevance between them. At the same time, ask the unstimulated subject whether he (or she) has some kind of conscious perceptions relating to the stimulations. The appearance of the statistical relevance will confirm the existence of the unusual condition as well as its resulting quantum effect of consciousness.

## Conclusions

The relationship between quantum collapse and consciousness has been debated since the founding of quantum mechanics. Quantum collapse is a big puzzle, and consciousness is another great riddle. It might be expected that discovering their actual connection may help to solve both problems. There are two main viewpoints which assert that quantum collapse and consciousness are essentially connected. The first view holds that consciousness causes quantum collapse (von Neumann 1955; Wigner 1967; Stapp 1996). The second view holds that quantum collapse generates consciousness (Hameroff and Penrose 1996). It can be seen that these two completely contrary views are actually two extremes concerning the relationship between quantum collapse and consciousness. It seems more natural and reasonable that quantum collapse and consciousness are essentially independent with each other. In fact, this point of view is held by most physicists. But does this mean that quantum collapse and consciousness have no connection? The answer is surprisingly negative. As we have argued, their combination will generate an unexpected new outcome, which can indeed help to solve both puzzles.

Although quantum collapse is an objective dynamical process, and its origin is irrelevant to consciousness, the conscious observer can have a distinct role from the physical measuring device during the quantum collapse owing to the intrinsic nature of consciousness. A conscious observer is able to be conscious of his own state, while the state of a physical measuring device can only be measured by another measuring system. As a result, the conscious observer can know whether he is in a

[4] The subjects should be unfamiliar with each other before the experiment. This can be tested by the phase incoherence of their brain waves.

definite state or a quantum superposition of definite states, while the physical measuring device cannot "know". This then results in the existence of a definite nonlinear evolution element in the complete quantum evolution of matter state, which is introduced by consciousness and relates to the conscious content. The definite nonlinear evolution can generate some quantum effects of consciousness, for example, the distinguishability of nonorthogonal states, nonlocal communication, and consciousness influencing random process etc.

The existence of the definite nonlinear evolution introduced by consciousness, if it is confirmed by experiment, will help to solve the hard problems of quantum collapse and consciousness, and have some profound implications for physics (including quantum theory and relativity), the science of consciousness and the research of psi phenomena (Gao 2006c). First, it implies the actual existence of objective quantum collapse, and will help to complete the existing quantum theory. Besides, its resulting nonlocal communication will reveal the limits of the principle of relativity. Next, it implies that consciousness has basic causal efficacies in the physical world. As thus, consciousness is not reducible or emergent, but a new fundamental property of matter. This will establish a quantum basis for panpsychism, and make it be a promising solution to the hard problem of consciousness. Lastly, it may provide a possible scientific explanation for the psi phenomena. This will help to mitigate the enmity between the scientists with different viewpoints, and further facilitate the study of the nature of consciousness.

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