Consciousness and Free Will

It also ought to be impossible to predict the future for a system that acts with free will. And free will is very different than simply having random occurrences. Free will is not yet defined by either deterministic theory or current probability theory as developed by Kolmogorov where each event in a sample space has an *a priori* probability measure assigned to it. If free will is different than random occurrences, even conventional quantum mechanics with Born indeterminacy may not be sufficient to explain free will. This is because the probabilities are determined by a law of causality, hence the conventional quantum theory would seem to be problematic in terms of free will. However, the insistent focus on freedom of choice in the measurement settings of the quantum Bell experiments naturally touches on the long contentious concepts of free will, consciousness, mind, and even the concept of the soul [509]. The concept of free will would allow two potential courses of action under identical initial circumstances. The identical circumstances would inevitably encompass both external conditions and the internal states of consciousness. The consciousness of inner mental life follows us during our waking hours, but experience suggests that it is banished during dreamless sleep, anesthesia, coma, and death [510]. The long-debated question is whether these phenomena are an illusion or alternatively are they our most intimate examples of genuine freedom of choice? After all, we appear to know almost from birth that while our mind is evident to itself, it is impervious to outside observers.

In what way can any of this be encompassed by physical theory, particularly without having first addressed the problem of measurement as discussed in Chapter 4? And how is it impacted by the questions of the nondeterminism versus determinism of particular physical processes? The so-called *hard problem* [511] of qualia of experiences—the redness of red, the painfulness of pain—is understanding how these could arise from physical processes [512], presumably including those associated with the living body and with the brain in particular. An inductive view of the universe has led some to dismiss this as insignificant; e.g., Gell-Mann has said that the hard problem consists only of the "redness of herrings" [513], which is contrary to the deductive approach argued in this book necessary to address problems of consciousness and measurement. There have long been attempts to locate within "thinking matter" the origins of consciousness, mind or soul, leading within cognitive neuroscience to the quest to identify the *neural correlates of consciousness* (NCC) [510], the minimal neural mechanisms that are sufficient for any one conscious perception, thought or memory, given the necessary background conditions to maintain consciousness. There are currently both reductionist and holistic approaches to studying these aspects of consciousness, with the reductionist focusing on genetic, synaptic and cellular levels and the holistic attempting to understand large neural networks underlying cognition, actions, and emotion [514]. Neuroimaging methods, such as positron emission tomography and functional magnetic resonance imaging (fMRI), have recently allowed observation of neurons in human subjects under conditions where they attempt to focus on awareness, thoughts, and feelings. Craig

Venter et al. in the paper presenting the first sequencing of the human genome commented on its future significance [515]:

See the print edition of The Quantum Measurement Problem for quotation.

Those aspects of consciousness related to *awareness* and *volition* have benefitted from these neuroscience approaches, though much remains to be understood. The remaining hard problem of *subjectivity* or qualia can be expected to be resistant and inconclusive without a fundamental understanding and resolution of the measurement problem. However, unjustified conclusions have been drawn from these neuroimaging studies; e.g., Stephen Hawking's insistence on determinism in biological processes and that agency and free will are illusions [516, pp. 31-32],

> *…the molecular basis of biology shows that biological processes are governed by the laws of physics and chemistry and therefore are as determined as the orbits of the planets. Recent experiments in neuroscience support the view that it is our physical brain, following the known laws of science, that determines our actions and not some agency that exists outside those laws…so it seems that we are no more than biological machines and that free will is just an illusion.*

Neuroscience researchers have indeed interpreted some experiments as showing that the brain initiates conscious movements and free will before we are consciously aware of the will to move. The neuroscience experiment that initially raised suspicions about free will was a now classic paper by Libet et al. [517]. These experiments attempted to observe a person making a deliberate decision and use the timing of a physical event to capture the moment of the mental act and its associated brain activity. They studied participants using an electroencephalogram (EEG) and asked them to watch a clock face on which the point of a bright light was sweeping. The subjects were instructed to spontaneously but deliberately flex their wrist or finger as soon as they *felt the urge* to do so and note the light position. Significantly, their conscious decision to move was preceded by 550ms of a particular electrical change in the brain (*readiness potential*, RP) that originates in a region involved in motor preparation, the supplementary motor area (SMA). Since SMA activity preceded the conscious decision, it was argued that the subjects were found to exhibit *unconscious* activity via the EEG *before* reporting their conscious awareness. The subjects became aware of intention to move 350-400ms after the RP starts but 200 ms before the motor act. Apparently, their brains had already decided before the subjects were even aware of making a choice rather than the brain and body acting only after the mind has willed it!

How could this be possible? A neuroscientist might wonder how an underlying mechanics of precognition within the brain could play out in the situation of these experiments in terms of pulses released via synaptic vesicles toward the premotor cortex signaling the motor cortex and spinal cord to trigger muscle responses, and finally the emergence of a *decision to move.* Libet's experiments were widely

discussed and criticized but also replicated with many variations in the experimental methods [518]. Does the actual decision to move occur before awareness? Libet has also reported that the RP was consistent with motor preparation even on occasions in which the subject decided to veto the prepared action and did not actually move [519] [520], some saying that this at least leaves the door open for "free won't," if not free will [518]. Actual human volition though can be described as *deliberating and acting on a dichotomy.* The world is divided into two possibilities and a deliberate choice of preference is made for one of them. There are two separate characteristics associated with free will: *willing* and *self-agency* [521]. The freely made decision for movement is the sense of willing, whereas the sense that "I am responsible for the movement" is the sense of self-agency. It has been argued that what Libet has called *self-paced voluntary acts* [520], where subjects are told to respond whenever they *feel an urge to act*, may not correspond to free will. Other Libet-type experiments have examined the difference between an intention to move in the future and an actual immediate movement and found an RP-like intention potential [522] associated with the intention to move. This would suggest that the brain is unconsciously active before a *thought*, and not just a movement. An RP-like potential has also been found associated with decision making, at the time of the selection of a letter without any associated movement [523].

These and related neuroscience experiments are a great beginning and may lead to a more fundamental understanding of consciousness and free will, but many issues still need to be resolved [521]. That is, it has not yet been shown convincingly at the neurophysiological level that a neural decision sufficient to cause movement occurs before the time of awareness of the decision to move [524]. Moreover, the discrimination of free will acts that require deliberation from those that are simply spontaneous or reflex is a key issue that has not been yet achieved by these experiments. It is of interest to note that the discrimination of actions that are reflex or spontaneous versus those that require deliberation can be traced to Aristotle [353]:

> *Thus an inanimate thing … cannot do anything by chance, because it is incapable of choice …The spontaneous on the other hand is found both in the lower beasts and in many inanimate objects.* [Physics II.6]

As flicking a wrist or moving a body part is something a lower animal is capable of, the current experiments clearly have not sufficiently investigated free will in a manner consistent with Aristotle's view of deliberate intention in 350 BCE, let alone today. Before these details are understood, we should be cautious regarding statements in the neuroscience literature that appear to be drawing premature conclusions, such as [518]:

> *…modern neuroscience is shifting towards a view of voluntary action being based on specific brain processes…*

As both the physics of consciousness and volition are in its infancy, conclusions of neuroscientists against nondeterminism may be seen as reflective of an inductive approach and that a problem of this fundamental importance, which has remained unsolved from the time of Aristotle, requires a deductive approach. Conclusions in this area that are reached using an inductive approach should be viewed with the utmost suspicion.

We are certainly far from being able to make a conclusion regarding the determinism of mental activities. The deductive researcher keeps all options in play, particularly when facing a problem within an unfamiliar terrain. Consider Niels Bohr, who as early as the 1930s was considering the prospects of how a physicist would confront the issues of phenomena in living organisms and the possibility that non-causality should not be ruled out [213][Kindle location 5185] (letter to Pascal Jordan 1931):

See the print edition of The Quantum Measurement Problem for quotation.

Bohr considered the comparison of measurement of atomic phenomena with the tinge of conscious inner experience [319, p. 100],

> *The unavoidable influence on atomic phenomena caused by observing them here corresponds to the well-known change of the tinge of the psychological experiences which accompanies any direction of the attention to one of their various elements.*
>
>

Bohr did not draw final conclusions regarding the scale at which quantum phenomena might play a role in living or conscious systems. He did keep track of progress in biology, particularly from discussions with his colleague Max Delbrück (1906-1981) who had begun as a physicist but later pioneered the new area of molecular biology, finally winning the Nobel Prize in Physiology/Medicine for his work on the replication and genetics of viruses. It was the discovery of helical DNA by Crick and Watson in 1953 that convinced Bohr that at least DNA did not require knowledge of what happens at the atomic level in organisms. The mechanism of replication required no new laws and could be accounted for by physical and chemical explanations. Bohr then turned to the possibility that the fundamental unit of life might be the cell rather than the chromosomes and that the functions of the cell must be regulated by information from the organism as a whole.

Bohr believed that both the tinge or impressions felt during conscious experience as well as volition are contrary to a mechanistic deterministic description and as well, that the conscious process of the nervous system is not open to introspection by the external observer,

> *The fact that consciousness, as we know it, is inseparably connected with life ought to prepare us for finding that the very problem of the*

> *distinction between the living and the dead escapes comprehension in the ordinary sense of the word. That a physicist touches upon such questions may perhaps be excused on the ground that the new situation in physics has so forcibly reminded us of the old truth that we are spectators as well as actors in the great drama of existence.*
>
> Niels Bohr, Atomic Theory and the Description of Nature: Four essays with an Introductory Survey, Cambridge University Press, Reissue Edition 2011, p. 119.

> *From a biological point of view, we can hardly interpret the characteristics of psychical phenomena except by concluding that every conscious experience corresponds to a residual impression in the organism, amounting to an irreversible recording of the outcome of processes in the nervous system which are not open to introspection and hardly adapted to exhaustive definition by mechanistic approach.*
>
> Reprinted by permission of Dover Publications, N. Bohr, Atomic Physics and Human Knowledge, Dover Publications 2010, p.77.

> *To illustrate such argumentation, we may refer to the old problem of the freedom of will. In an unrestricted deterministic approach this concept, of course, finds no place, but it is evident that the word volition is indispensable in an exhaustive description of psychical phenomena.*
>
> Reprinted by permission of Dover Publications, N. Bohr, Atomic Physics and Human Knowledge, Dover Publications 2010, p.89.

There have also been particular attempts to include consciousness within the framework of quantum measurement. Von Neumann (1932) demonstrated within his framework for measurement that it makes no difference whether the measurement projections are applied on the system immediately prior to the measurement, at the measurement apparatus, or anywhere within the brain of the observer [13]. Shortly afterward, London and Bauer (1939) developed this further with a measurement theory in which measurement occurs at the point when the observer becomes conscious of the particular outcome [525]. Eugene Wigner (1961) explored the role of consciousness with his *Wigner's Friend* thought experiment in which the example of Schrödinger's Cat is supplemented with a conscious *friend* who intervenes as Wigner attempts to carry out a measurement [217].

In David Deutsch's variant of Wigner's Friend, the friend answers in the affirmative when Deutsch asks the friend whether he sees a definite state of the cat but Deutsch does not ask the friend for the result [142]. Therefore, the state of the "cat and friend" has not yet been collapsed. As discussed in Chapter 4, these explorations have stimulated much discussion and alternative developments. However, ultimately measurement, consciousness, and free will must be understood on a fundamental basis before questions such as Wigner's Friend can be answered.